

Mendel Cooper

```
Terminal
File Edit View Terminal Help
1 #!/bin/bash
2 # var-match.sh:
3 # Demo of pattern replacement at prefix / suffix of string.
4
5 v0=abc1234zip1234abc # Original variable.
6 echo "v0 = $v0" # abc1234zip1234abc
7 echo
8
9 # Match at prefix (beginning) of string.
10 v1=${v0/#abc/ABCDEF} # abc1234zip1234abc
11 # |-|
12 echo "v1 = $v1" # ABCDEF1234zip1234abc
13 # |----|
14
15 # Match at suffix (end) of string.
16 v2=${v0/%abc/ABCDEF} # abc1234zip123abc
17 # |-|
18 echo "v2 = $v2" # abc1234zip1234ABCDEF
19 # |----|
20
21 echo
22
23 # -----
20,0-1 Top
```

Authorized Edition

Advanced Bash-Scripting Guide

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Advanced Bash-Scripting Guide

An in-depth exploration of the art of shell scripting

Version 10

10 Mar 2014

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This tutorial assumes no previous knowledge of scripting or programming, yet progresses rapidly toward an intermediate/advanced level of instruction . . . *all the while sneaking in little nuggets of UNIX® wisdom and lore*. It serves as a textbook, a manual for self-study, and as a reference and source of knowledge on shell scripting techniques. The exercises and heavily-commented examples invite active reader participation, under the premise that **the only way to really learn scripting is to write scripts**.

This book is suitable for classroom use as a general introduction to programming concepts.

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Dedication

For Anita, the source of all the magic

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Part 1. Introduction

Script: A writing; a written document. [Obs.]

--Webster's Dictionary, 1913 ed.

The shell is a command interpreter. More than just the insulating layer between the operating system kernel and the user, it's also a fairly powerful programming language. A shell program, called a *script*, is an easy-to-use tool for building applications by "gluing together" system calls, tools, utilities, and compiled binaries. Virtually the entire repertoire of UNIX commands, utilities, and tools is available for invocation by a shell script. If that were not enough, internal shell commands, such as testing and loop constructs, lend additional power and flexibility to scripts. Shell scripts are especially well suited for administrative system tasks and other routine repetitive tasks not requiring the bells and whistles of a full-blown tightly structured programming language.

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Shell Programming!

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Chapter 1. Shell Programming!

No programming language is perfect. There is not even a single best language; there are only languages well suited or perhaps poorly suited for particular purposes.

--Herbert Mayer

A working knowledge of shell scripting is essential to anyone wishing to become reasonably proficient at system administration, even if they do not anticipate ever having to actually write a script. Consider that as a Linux machine boots up, it executes the shell scripts in `/etc/rc.d` to restore the system configuration and set up services. A detailed understanding of these startup scripts is important for analyzing the behavior of a system, and possibly modifying it.

The craft of scripting is not hard to master, since scripts can be built in bite-sized sections and there is only a fairly small set of shell-specific operators and options [1] to learn. The syntax is simple -- even austere -- similar to that of invoking and chaining together utilities at the command line, and there are only a few "rules" governing their use. Most short scripts work right the first time, and debugging even the longer ones is straightforward.

In the early days of personal computing, the BASIC language enabled anyone reasonably computer proficient to write programs on an early generation of microcomputers. Decades later, the Bash scripting language enables anyone with a rudimentary knowledge of Linux or UNIX to do the same on modern machines.

We now have miniaturized single-board computers with amazing capabilities, such as the [Raspberry Pi](#). Bash scripting provides a way to explore the capabilities of these fascinating devices.

A shell script is a quick-and-dirty method of prototyping a complex application. Getting even a limited subset of the functionality to work in a script is often a useful first stage in project development. In this way, the structure of the application can be tested and tinkered with, and the major pitfalls found before proceeding to the final coding in *C*, *C++*, *Java*, [Perl](#), or *Python*.

Shell scripting harkens back to the classic UNIX philosophy of breaking complex projects into simpler subtasks, of chaining together components and utilities. Many consider this a better, or at least more esthetically pleasing approach to problem solving than using one of the new generation of high-powered all-in-one languages, such as *Perl*, which attempt to be all things to all people, but at the cost of forcing you to alter your thinking processes to fit the tool.

According to [Herbert Mayer](#), "a useful language needs arrays, pointers, and a generic mechanism for building data structures." By these criteria, shell scripting falls somewhat short of being "useful." Or, perhaps not. . . .

When not to use shell scripts

- Resource-intensive tasks, especially where speed is a factor (sorting, hashing, recursion [2] ...)
- Procedures involving heavy-duty math operations, especially floating point arithmetic, arbitrary precision calculations, or complex numbers (use *C++* or *FORTRAN* instead)

- Cross-platform portability required (use *C* or *Java* instead)
- Complex applications, where structured programming is a necessity (type-checking of variables, function prototypes, etc.)
- Mission-critical applications upon which you are betting the future of the company
- Situations where *security* is important, where you need to guarantee the integrity of your system and protect against intrusion, cracking, and vandalism
- Project consists of subcomponents with interlocking dependencies
- Extensive file operations required (*Bash* is limited to serial file access, and that only in a particularly clumsy and inefficient line-by-line fashion.)
- Need native support for multi-dimensional arrays
- Need data structures, such as linked lists or trees
- Need to generate / manipulate graphics or GUIs
- Need direct access to system hardware or external peripherals
- Need port or [socket](#) I/O
- Need to use libraries or interface with legacy code
- Proprietary, closed-source applications (Shell scripts put the source code right out in the open for all the world to see.)

If any of the above applies, consider a more powerful scripting language -- perhaps *Perl*, *Tcl*, *Python*, *Ruby* -- or possibly a compiled language such as *C*, *C++*, or *Java*. Even then, prototyping the application as a shell script might still be a useful development step.

We will be using Bash, an acronym [\[3\]](#) for "Bourne-Again shell" and a pun on Stephen Bourne's now classic *Bourne* shell. Bash has become a *de facto* standard for shell scripting on most flavors of UNIX. Most of the principles this book covers apply equally well to scripting with other shells, such as the *Korn Shell*, from which Bash derives some of its features, [\[4\]](#) and the *C Shell* and its variants. (Note that *C Shell* programming is not recommended due to certain inherent problems, as pointed out in an October, 1993 [Usenet post](#) by Tom Christiansen.)

What follows is a tutorial on shell scripting. It relies heavily on examples to illustrate various features of the shell. The example scripts work -- they've been tested, insofar as possible -- and some of them are even useful in real life. The reader can play with the actual working code of the examples in the source archive (`scriptname.sh` or `scriptname.bash`), [\[5\]](#) give them *execute* permission (**`chmod u+rx scriptname`**), then run them to see what happens. Should the [source archive](#) not be available, then cut-and-paste from the [HTML](#) or [pdf](#) rendered versions. Be aware that some of the scripts presented here introduce features before they are explained, and this may require the reader to temporarily skip ahead for enlightenment.

Unless otherwise noted, [the author](#) of this book wrote the example scripts that follow.

His countenance was bold and bashed not.

--Edmund Spenser

Notes

- [\[1\]](#) These are referred to as [builtins](#), features internal to the shell.
- [\[2\]](#) Although [recursion is possible in a shell script](#), it tends to be slow and its implementation is often an [ugly kludge](#).
- [\[3\]](#) An *acronym* is an *ersatz* word formed by pasting together the initial letters of the words into a tongue-tripping phrase. This morally corrupt and pernicious practice deserves appropriately severe punishment. Public flogging suggests itself.
- [\[4\]](#) Many of the features of *ksh88*, and even a few from the updated *ksh93* have been merged into Bash.

[5] By convention, user-written shell scripts that are Bourne shell compliant generally take a name with a `.sh` extension. System scripts, such as those found in `/etc/rc.d`, do not necessarily conform to this nomenclature.

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Chapter 2. Starting Off With a Sha-Bang

Shell programming is a 1950s juke box . . .

--Larry Wall

In the simplest case, a script is nothing more than a list of system commands stored in a file. At the very least, this saves the effort of retyping that particular sequence of commands each time it is invoked.

Example 2-1. *cleanup*: A script to clean up log files in /var/log

```
1 # Cleanup
2 # Run as root, of course.
3
4 cd /var/log
5 cat /dev/null > messages
6 cat /dev/null > wtmp
7 echo "Log files cleaned up."
```

There is nothing unusual here, only a set of commands that could just as easily have been invoked one by one from the command-line on the console or in a terminal window. The advantages of placing the commands in a script go far beyond not having to retype them time and again. The script becomes a *program* -- a *tool* -- and it can easily be modified or customized for a particular application.

Example 2-2. *cleanup*: An improved clean-up script

```
1 #!/bin/bash
2 # Proper header for a Bash script.
3
4 # Cleanup, version 2
5
6 # Run as root, of course.
7 # Insert code here to print error message and exit if not root.
8
9 LOG_DIR=/var/log
10 # Variables are better than hard-coded values.
11 cd $LOG_DIR
12
13 cat /dev/null > messages
14 cat /dev/null > wtmp
15
16
17 echo "Logs cleaned up."
18
19 exit # The right and proper method of "exiting" from a script.
20     # A bare "exit" (no parameter) returns the exit status
21     #+ of the preceding command.
```

Now *that's* beginning to look like a real script. But we can go even farther . . .

Example 2-3. *cleanup*: An enhanced and generalized version of above scripts.

```
1 #!/bin/bash
2 # Cleanup, version 3
3
4 # Warning:
```

```

5 # -----
6 # This script uses quite a number of features that will be explained
7 #+ later on.
8 # By the time you've finished the first half of the book,
9 #+ there should be nothing mysterious about it.
10
11
12
13 LOG_DIR=/var/log
14 ROOT_UID=0      # Only users with $UID 0 have root privileges.
15 LINES=50       # Default number of lines saved.
16 E_XCD=86       # Can't change directory?
17 E_NOTROOT=87   # Non-root exit error.
18
19
20 # Run as root, of course.
21 if [ "$UID" -ne "$ROOT_UID" ]
22 then
23     echo "Must be root to run this script."
24     exit $E_NOTROOT
25 fi
26
27 if [ -n "$1" ]
28 # Test whether command-line argument is present (non-empty).
29 then
30     lines=$1
31 else
32     lines=$LINES # Default, if not specified on command-line.
33 fi
34
35
36 # Stephane Chazelas suggests the following,
37 #+ as a better way of checking command-line arguments,
38 #+ but this is still a bit advanced for this stage of the tutorial.
39 #
40 #     E_WRONGARGS=85 # Non-numerical argument (bad argument format).
41 #
42 #     case "$1" in
43 #         ""          ) lines=50;;
44 #         *[!0-9]*) echo "Usage: `basename $0` lines-to-cleanup";
45 #             exit $E_WRONGARGS;;
46 #         *          ) lines=$1;;
47 #     esac
48 #
49 #* Skip ahead to "Loops" chapter to decipher all this.
50
51
52 cd $LOG_DIR
53
54 if [ `pwd` != "$LOG_DIR" ] # or   if [ "$PWD" != "$LOG_DIR" ]
55                             # Not in /var/log?
56 then
57     echo "Can't change to $LOG_DIR."
58     exit $E_XCD
59 fi # Doublecheck if in right directory before messing with log file.
60
61 # Far more efficient is:
62 #
63 # cd /var/log || {
64 #     echo "Cannot change to necessary directory." >&2
65 #     exit $E_XCD;
66 # }
67
68
69
70

```



```

71 tail -n $lines messages > mesg.temp # Save last section of message log file.
72 mv mesg.temp messages                # Rename it as system log file.
73
74
75 # cat /dev/null > messages
76 #* No longer needed, as the above method is safer.
77
78 cat /dev/null > wtmp # ': > wtmp' and '> wtmp' have the same effect.
79 echo "Log files cleaned up."
80 # Note that there are other log files in /var/log not affected
81 #+ by this script.
82
83 exit 0
84 # A zero return value from the script upon exit indicates success
85 #+ to the shell.

```

Since you may not wish to wipe out the entire system log, this version of the script keeps the last section of the message log intact. You will constantly discover ways of fine-tuning previously written scripts for increased effectiveness.

* * *

The *sha-bang* (`#!`) [\[1\]](#) at the head of a script tells your system that this file is a set of commands to be fed to the command interpreter indicated. The `#!` is actually a two-byte [\[2\]](#) *magic number*, a special marker that designates a file type, or in this case an executable shell script (type **man magic** for more details on this fascinating topic). Immediately following the *sha-bang* is a *path name*. This is the path to the program that interprets the commands in the script, whether it be a shell, a programming language, or a utility. This command interpreter then executes the commands in the script, starting at the top (the line following the *sha-bang* line), and ignoring comments. [\[3\]](#)

```


1 #!/bin/sh
2 #!/bin/bash
3 #!/usr/bin/perl
4 #!/usr/bin/tcl
5 #!/bin/sed -f
6 #!/bin/awk -f

```

Each of the above script header lines calls a different command interpreter, be it `/bin/sh`, the default shell (**bash** in a Linux system) or otherwise. [\[4\]](#) Using `#!/bin/sh`, the default Bourne shell in most commercial variants of UNIX, makes the script [portable](#) to non-Linux machines, though you [sacrifice Bash-specific features](#). The script will, however, conform to the POSIX [\[5\]](#) **sh** standard.

Note that the path given at the "sha-bang" must be correct, otherwise an error message -- usually "Command not found." -- will be the only result of running the script. [\[6\]](#)

`#!` can be omitted if the script consists only of a set of generic system commands, using no internal shell directives. The second example, above, requires the initial `#!`, since the variable assignment line, `lines=50`, uses a shell-specific construct. [\[7\]](#) Note again that `#!/bin/sh` invokes the default shell interpreter, which defaults to `/bin/bash` on a Linux machine.

 This tutorial encourages a modular approach to constructing a script. Make note of and collect "boilerplate" code snippets that might be useful in future scripts. Eventually you will build quite an extensive library of nifty routines. As an example, the following script prolog tests whether the script has been invoked with the correct number of parameters.

```

1 E_WRONG_ARGS=85
2 script_parameters="-a -h -m -z"
3 #           -a = all, -h = help, etc.
4

```

```
5 if [ $# -ne $Number_of_expected_args ]
6 then
7     echo "Usage: `basename $0` $script_parameters"
8     # `basename $0` is the script's filename.
9     exit $E_WRONG_ARGS
10 fi
```

Many times, you will write a script that carries out one particular task. The first script in this chapter is an example. Later, it might occur to you to generalize the script to do other, similar tasks. Replacing the literal ("hard-wired") constants by variables is a step in that direction, as is replacing repetitive code blocks by [functions](#).

2.1. Invoking the script

Having written the script, you can invoke it by `sh scriptname`, [8] or alternatively `bash scriptname`. (Not recommended is using `sh <scriptname`, since this effectively disables reading from `stdin` within the script.) Much more convenient is to make the script itself directly executable with a `chmod`.

Either:

```
chmod 555 scriptname (gives everyone read/execute permission) [9]
```

or

```
chmod +rx scriptname (gives everyone read/execute permission)
```

```
chmod u+rx scriptname (gives only the script owner read/execute permission)
```

Having made the script executable, you may now test it by `./scriptname`. [10] If it begins with a "sha-bang" line, invoking the script calls the correct command interpreter to run it.

As a final step, after testing and debugging, you would likely want to move it to `/usr/local/bin` (as `root`, of course), to make the script available to yourself and all other users as a systemwide executable. The script could then be invoked by simply typing `scriptname` [ENTER] from the command-line.

Notes

- [1] More commonly seen in the literature as *she-bang* or *sh-bang*. This derives from the concatenation of the tokens *sharp* (#) and *bang* (!).
- [2] Some flavors of UNIX (those based on 4.2 BSD) allegedly take a four-byte magic number, requiring a blank after the `! -- #! /bin/sh`. [According to Sven Mascheck](#) this is probably a myth.
- [3] The `#!` line in a shell script will be the first thing the command interpreter (`sh` or `bash`) sees. Since this line begins with a #, it will be correctly interpreted as a comment when the command interpreter finally executes the script. The line has already served its purpose - calling the command interpreter.

If, in fact, the script includes an *extra* `#!` line, then `bash` will interpret it as a comment.

```
1 #!/bin/bash
2
3 echo "Part 1 of script."
4 a=1
5
6 #!/bin/bash
7 # This does *not* launch a new script.
8
9 echo "Part 2 of script."
10 echo $a # Value of $a stays at 1.
```

- [4] This allows some cute tricks.

```
1 #!/bin/rm
2 # Self-deleting script.
3
4 # Nothing much seems to happen when you run this... except that the file disappears.
5
6 WHATEVER=85
7
8 echo "This line will never print (betcha!)."
9
10 exit $WHATEVER # Doesn't matter. The script will not exit here.
11                # Try an echo $? after script termination.
12                # You'll get a 0, not a 85.
```

Also, try starting a README file with a `#!/bin/more`, and making it executable. The result is a self-listing documentation file. (A [here document](#) using `cat` is possibly a better alternative -- see [Example 19-3](#)).

- [5] **Portable Operating System Interface**, an attempt to standardize UNIX-like OSes. The POSIX specifications are listed on the [Open Group site](#).
- [6] To avoid this possibility, a script may begin with a `#!/bin/env bash sha-bang` line. This may be useful on UNIX machines where `bash` is not located in `/bin`
- [7] If `Bash` is your default shell, then the `#!` isn't necessary at the beginning of a script. However, if launching a script from a different shell, such as `tcsh`, then you *will* need the `#!`.
- [8] Caution: invoking a `Bash` script by `sh scriptname` turns off Bash-specific extensions, and the script may therefore fail to execute.
- [9] A script needs `read`, as well as execute permission for it to run, since the shell needs to be able to read it.
- [10] Why not simply invoke the script with `scriptname`? If the directory you are in (`$PWD`) is where `scriptname` is located, why doesn't this work? This fails because, for security reasons, the current directory (`.` / `/`) is not by default included in a user's `$PATH`. It is therefore necessary to explicitly invoke the script in the current directory with a `./scriptname`.

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2.2. Preliminary Exercises

1. System administrators often write scripts to automate common tasks. Give several instances where such scripts would be useful.
2. Write a script that upon invocation shows the [time and date](#), [lists all logged-in users](#), and gives the system [uptime](#). The script then [saves this information](#) to a logfile.

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Preliminary Exercises

Special Characters

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Chapter 3. Special Characters

What makes a character *special*? If it has a meaning beyond its *literal meaning*, a meta-meaning, then we refer to it as a *special character*. Along with commands and keywords, *special characters* are building blocks of Bash scripts.

Special Characters Found In Scripts and Elsewhere

#

Comments. Lines beginning with a # (with the exception of #!) are comments and will *not* be executed.

```
1 # This line is a comment.
```

Comments may also occur following the end of a command.


```
1 echo "A comment will follow." # Comment here.
2 #                               ^ Note whitespace before #
```


Comments may also follow whitespace at the beginning of a line.

```
1     # A tab precedes this comment.
```

Comments may even be embedded within a pipe.

```
1 initial=( `cat "$startfile" | sed -e '/#/d' | tr -d '\n' | \
2 # Delete lines containing '#' comment character.
3     sed -e 's/\./\./g' -e 's/_/_/g'` )
4 # Excerpted from life.sh script
```

 A command may not follow a comment on the same line. There is no method of terminating the comment, in order for "live code" to begin on the same line. Use a new line for the next command.

 Of course, a quoted or an escaped # in an echo statement does *not* begin a comment. Likewise, a # appears in certain parameter-substitution constructs and in numerical constant expressions.

```
1 echo "The # here does not begin a comment."
2 echo 'The # here does not begin a comment.'
3 echo The \# here does not begin a comment.
4 echo The # here begins a comment.
5
6 echo ${PATH#*;} # Parameter substitution, not a comment.
7 echo $(( 2#101011 )) # Base conversion, not a comment.
8
9 # Thanks, S.C.
```

The standard quoting and escape characters (" ' \) escape the #.

Certain pattern matching operations also use the #.

;

Command separator [semicolon]. Permits putting two or more commands on the same line.

```
1 echo hello; echo there
2
3
4 if [ -x "$filename" ]; then # Note the space after the semicolon.
5 #+                         ^^
6     echo "File $filename exists."; cp $filename $filename.bak
7 else #                       ^^
8     echo "File $filename not found."; touch $filename
9 fi; echo "File test complete."
```

Note that the ";" sometimes needs to be escaped.

;;

Terminator in a case option [double semicolon].

```
1 case "$variable" in
2   abc) echo "\$variable = abc" ;;
3   xyz) echo "\$variable = xyz" ;;
4 esac
```

;;&,;&

Terminators in a case option (version 4+ of Bash).

"dot" command [period]. Equivalent to source (see Example 15-22). This is a bash builtin.

"dot", as a component of a filename. When working with filenames, a leading dot is the prefix of a "hidden" file, a file that an ls will not normally show.

```
bash$ touch .hidden-file
bash$ ls -l
total 10
-rw-r--r--  1 bozo      4034 Jul 18 22:04 data1.addressbook
-rw-r--r--  1 bozo      4602 May 25 13:58 data1.addressbook.bak
-rw-r--r--  1 bozo       877 Dec 17  2000 employment.addressbook

bash$ ls -al
total 14
drwxrwxr-x  2 bozo bozo      1024 Aug 29 20:54 ./
drwx----- 52 bozo bozo      3072 Aug 29 20:51 ../
-rw-r--r--  1 bozo bozo      4034 Jul 18 22:04 data1.addressbook
-rw-r--r--  1 bozo bozo      4602 May 25 13:58 data1.addressbook.bak
-rw-r--r--  1 bozo bozo       877 Dec 17  2000 employment.addressbook
-rw-rw-r--  1 bozo bozo         0 Aug 29 20:54 .hidden-file
```

When considering directory names, *a single dot* represents the current working directory, and *two dots* denote the parent directory.

```
bash$ pwd
/home/bozo/projects

bash$ cd .
bash$ pwd
/home/bozo/projects

bash$ cd ..
bash$ pwd
/home/bozo/
```

The *dot* often appears as the destination (directory) of a file movement command, in this context meaning *current directory*.

```
bash$ cp /home/bozo/current_work/junk/* .
```

Copy all the "junk" files to \$PWD.

"dot" character match. When matching characters, as part of a regular expression, a "dot" matches a single character.

partial quoting [double quote]. "STRING" preserves (from interpretation) most of the special characters within STRING. See [Chapter 5](#).

full quoting [single quote]. 'STRING' preserves all special characters within STRING. This is a stronger form of quoting than "STRING". See [Chapter 5](#).

comma operator. The *comma operator* [\[1\]](#) links together a series of arithmetic operations. All are evaluated, but only the last one is returned.

```
1 let "t2 = ((a = 9, 15 / 3))"
2 # Set "a = 9" and "t2 = 15 / 3"
```

The *comma operator* can also concatenate strings.

```
1 for file in /{,usr/}bin/*calc
2 #           ^      Find all executable files ending in "calc"
3 #+         in /bin and /usr/bin directories.
4 do
5     if [ -x "$file" ]
6     then
7         echo $file
8     fi
9 done
10
11 # /bin/ipcalc
12 # /usr/bin/kcalc
13 # /usr/bin/oidcalc
14 # /usr/bin/oocalc
15
16
17 # Thank you, Rory Winston, for pointing this out.
```

Lowercase conversion in parameter substitution (added in [version 4](#) of Bash).

escape [backslash]. A quoting mechanism for single characters.

`\X` escapes the character X. This has the effect of "quoting" X, equivalent to 'X'. The `\` may be used to quote " and ', so they are expressed literally.

See [Chapter 5](#) for an in-depth explanation of escaped characters.

Filename path separator [forward slash]. Separates the components of a filename (as in `/home/bozo/projects/Makefile`).

This is also the division [arithmetic operator](#).

command substitution. The ``command`` construct makes available the output of **command** for assignment to a variable. This is also known as [backquotes](#) or backticks.

null command [colon]. This is the shell equivalent of a "NOP" (*no op*, a do-nothing operation). It may be considered a synonym for the shell builtin [true](#). The ":" command is itself a *Bash builtin*, and its [exit status](#) is *true* (0).

```
1 :
2 echo $? # 0
```

Endless loop:

```

1 while :
2 do
3     operation-1
4     operation-2
5     ...
6     operation-n
7 done
8
9 # Same as:
10 #     while true
11 #     do
12 #         ...
13 #     done

```

Placeholder in if/then test:

```

1 if condition
2 then : # Do nothing and branch ahead
3 else # Or else ...
4     take-some-action
5 fi

```

Provide a placeholder where a binary operation is expected, see [Example 8-2](#) and [default parameters](#).

```

1 : ${username=`whoami`}
2 # ${username=`whoami`} Gives an error without the leading :
3 # unless "username" is a command or builtin...
4
5 : ${1?"Usage: $0 ARGUMENT"} # From "usage-message.sh example script.

```

Provide a placeholder where a command is expected in a [here document](#). See [Example 19-10](#).

Evaluate string of variables using [parameter substitution](#) (as in [Example 10-7](#)).

```

1 : ${HOSTNAME?} ${USER?} ${MAIL?}
2 # Prints error message
3 #+ if one or more of essential environmental variables not set.

```

[Variable expansion / substring replacement](#).

In combination with the > [redirection operator](#), truncates a file to zero length, without changing its permissions. If the file did not previously exist, creates it.

```

1 : > data.xxx # File "data.xxx" now empty.
2
3 # Same effect as cat /dev/null >data.xxx
4 # However, this does not fork a new process, since ":" is a builtin.

```

See also [Example 16-15](#).

In combination with the >> redirection operator, has no effect on a pre-existing target file (: >> **target_file**). If the file did not previously exist, creates it.



This applies to regular files, not pipes, symlinks, and certain special files.

May be used to begin a comment line, although this is not recommended. Using # for a comment turns off error checking for the remainder of that line, so almost anything may appear in a comment. However, this is not the case with :.

```

1 : This is a comment that generates an error, ( if [ $x -eq 3] ).

```

The ":" serves as a [field](#) separator, in [/etc/passwd](#), and in the [\\$PATH](#) variable.

```

bash$ echo $PATH
/usr/local/bin:/bin:/usr/bin:/usr/X11R6/bin:/sbin:/usr/sbin:/usr/games

```

A *colon* is [acceptable as a function name](#).

```
1 :()
2 {
3   echo "The name of this function is "$FUNCNAME" "
4   # Why use a colon as a function name?
5   # It's a way of obfuscating your code.
6 }
7
8 :
9
10 # The name of this function is :
```

This is not [portable](#) behavior, and therefore not a recommended practice. In fact, more recent releases of Bash do not permit this usage. An underscore `_` works, though.

A *colon* can serve as a placeholder in an otherwise empty function.

```
1 not_empty ()
2 {
3   :
4 } # Contains a : (null command), and so is not empty.
```

!

reverse (or negate) the sense of a test or exit status [bang]. The `!` operator inverts the [exit status](#) of the command to which it is applied (see [Example 6-2](#)). It also inverts the meaning of a test operator. This can, for example, change the sense of *equal* (`=`) to *not-equal* (`!=`). The `!` operator is a Bash [keyword](#).

In a different context, the `!` also appears in [indirect variable references](#).

In yet another context, from the *command line*, the `!` invokes the Bash *history mechanism* (see [Appendix L](#)). Note that within a script, the history mechanism is disabled.

*

wild card [asterisk]. The `*` character serves as a "wild card" for filename expansion in [globbing](#). By itself, it matches every filename in a given directory.

```
bash$ echo *
abs-book.sgml add-drive.sh agram.sh alias.sh
```

The `*` also represents [any number \(or zero\) characters](#) in a [regular expression](#).

*

arithmetic operator. In the context of arithmetic operations, the `*` denotes multiplication.

****** A double asterisk can represent the [exponentiation](#) operator or [extended file-match globbing](#).

?

test operator. Within certain expressions, the `?` indicates a test for a condition.

In a [double-parentheses construct](#), the `?` can serve as an element of a C-style *ternary* operator. [2]

condition?result-if-true:result-if-false

```
1 (( var0 = var1<98?9:21 ))
2 #           ^ ^
3
4 # if [ "$var1" -lt 98 ]
```

```
5 # then
6 #   var0=9
7 # else
8 #   var0=21
9 # fi
```

In a [parameter substitution](#) expression, the `?` [tests whether a variable has been set](#).

wild card. The `?` character serves as a single-character "wild card" for filename expansion in [globbing](#), as well as [representing one character](#) in an [extended regular expression](#).

[Variable substitution](#) (contents of a variable).

```
1 var1=5
2 var2=23skidoo
3
4 echo $var1      # 5
5 echo $var2      # 23skidoo
```

A `$` prefixing a variable name indicates the *value* the variable holds.

end-of-line. In a [regular expression](#), a `"$"` addresses the [end of a line](#) of text.

[Parameter substitution](#).

[Quoted string expansion](#). This construct expands single or multiple escaped octal or hex values into ASCII [\[3\]](#) or [Unicode](#) characters.


[positional parameters](#).

exit status variable. The [\\$?](#) variable holds the [exit status](#) of a command, a [function](#), or of the script itself.

process ID variable. The [\\$\\$](#) variable holds the *process ID* [\[4\]](#) of the script in which it appears.

command group.

```
1 (a=hello; echo $a)
```

 A listing of commands within *parentheses* starts a [subshell](#).

Variables inside parentheses, within the subshell, are not visible to the rest of the script. The parent process, the script, [cannot read variables created in the child process](#), the subshell.

```
1 a=123
2 ( a=321; )
3
4 echo "a = $a"      # a = 123
5 # "a" within parentheses acts like a local variable.
```

array initialization.

```
1 Array=(element1 element2 element3)
```

```
{xxx,yyy,zzz,...}
```

Brace expansion.

```
1 echo \"{These,words,are,quoted}\" # " prefix and suffix
2 # "These" "words" "are" "quoted"
```

```

3
4
5 cat {file1,file2,file3} > combined_file
6 # Concatenates the files file1, file2, and file3 into combined_file.
7
8 cp file22.{txt,backup}
9 # Copies "file22.txt" to "file22.backup"

```

A command may act upon a comma-separated list of file specs within *braces*. [5] Filename expansion ([globbing](#)) applies to the file specs between the braces.

❗ No spaces allowed within the braces *unless* the spaces are quoted or escaped.

```
echo {file1,file2}\ :{\ A," B",' C'}
```

```
file1 : A file1 : B file1 : C file2 : A file2 : B
file2 : C

```

{a..z}

Extended Brace expansion.

```

1 echo {a..z} # a b c d e f g h i j k l m n o p q r s t u v w x y z
2 # Echoes characters between a and z.
3
4 echo {0..3} # 0 1 2 3
5 # Echoes characters between 0 and 3.
6
7
8 base64_charset=( {A..Z} {a..z} {0..9} + / = )
9 # Initializing an array, using extended brace expansion.
10 # From vladz's "base64.sh" example script.

```

The *{a..z}* [extended brace expansion](#) construction is a feature introduced in [version 3](#) of *Bash*.

{ }

Block of code [curly brackets]. Also referred to as an *inline group*, this construct, in effect, creates an *anonymous function* (a function without a name). However, unlike in a "standard" [function](#), the variables inside a code block remain visible to the remainder of the script.

```

bash$ { local a;
        a=123; }
bash: local: can only be used in a
function

```

```

1 a=123
2 { a=321; }
3 echo "a = $a" # a = 321 (value inside code block)
4
5 # Thanks, S.C.

```

The code block enclosed in braces may have [I/O redirected](#) to and from it.

Example 3-1. Code blocks and I/O redirection

```

1 #!/bin/bash
2 # Reading lines in /etc/fstab.
3
4 File=/etc/fstab
5
6 {

```

```

7 read line1
8 read line2
9 } < $File
10
11 echo "First line in $File is:"
12 echo "$line1"
13 echo
14 echo "Second line in $File is:"
15 echo "$line2"
16
17 exit 0
18
19 # Now, how do you parse the separate fields of each line?
20 # Hint: use awk, or . . .
21 # . . . Hans-Joerg Diers suggests using the "set" Bash builtin.

```

Example 3-2. Saving the output of a code block to a file

```

1 #!/bin/bash
2 # rpm-check.sh
3
4 # Queries an rpm file for description, listing,
5 #+ and whether it can be installed.
6 # Saves output to a file.
7 #
8 # This script illustrates using a code block.
9
10 SUCCESS=0
11 E_NOARGS=65
12
13 if [ -z "$1" ]
14 then
15     echo "Usage: `basename $0` rpm-file"
16     exit $E_NOARGS
17 fi
18
19 { # Begin code block.
20     echo
21     echo "Archive Description:"
22     rpm -qpi $1          # Query description.
23     echo
24     echo "Archive Listing:"
25     rpm -qpl $1         # Query listing.
26     echo
27     rpm -i --test $1    # Query whether rpm file can be installed.
28     if [ "$?" -eq $SUCCESS ]
29     then
30         echo "$1 can be installed."
31     else
32         echo "$1 cannot be installed."
33     fi
34     echo                # End code block.
35 } > "$1.test"          # Redirects output of everything in block to file.
36
37 echo "Results of rpm test in file $1.test"
38
39 # See rpm man page for explanation of options.
40
41 exit 0

```



Unlike a command group within (parentheses), as above, a code block enclosed by {braces} will *not* normally launch a [subshell](#). [6]

It is possible to [iterate](#) a code block using a [non-standard for-loop](#).

{}

placeholder for text. Used after [xargs -i](#) (*replace strings* option). The {} double curly brackets are a placeholder for output text.

```
1 ls . | xargs -i -t cp ./{} $1
2 #           ^^           ^^
3
4 # From "ex42.sh" (copydir.sh) example.
```

{}

pathname. Mostly used in [find](#) constructs. This is *not* a shell [builtin](#).

Definition: A *pathname* is a *filename* that includes the complete [path](#). As an example, /home/bozo/Notes/Thursday/schedule.txt. This is sometimes referred to as the *absolute path*.



The ";" ends the `-exec` option of a **find** command sequence. It needs to be escaped to protect it from interpretation by the shell.

[]

test.

[Test](#) expression between []. Note that [] is part of the shell *builtin* [test](#) (and a synonym for it), *not* a link to the external command /usr/bin/test.

[[]]

test.

Test expression between [[]]. More flexible than the single-bracket [] test, this is a shell [keyword](#).

See the discussion on the [\[\[...\]\] construct](#).

[]

array element.

In the context of an [array](#), brackets set off the numbering of each element of that array.

```
1 Array[1]=slot_1
2 echo ${Array[1]}
```

[]

range of characters.

As part of a [regular expression](#), brackets delineate a [range of characters](#) to match.

\$(...)

integer expansion.

Evaluate integer expression between \$[].

```
1 a=3
2 b=7
3
4 echo $[${a+$b}] # 10
5 echo $[${a*$b}] # 21
```

Note that this usage is *deprecated*, and has been replaced by the [\(\(...\)\)](#) construct.

(())

integer expansion.

Expand and evaluate integer expression between (()).

See the discussion on the [\(\(...\)\) construct](#).

> &> >& >> <<

[redirection](#).

scriptname >filename redirects the output of `scriptname` to file `filename`. Overwrite `filename` if it already exists.

command &>filename redirects both the [stdout](#) and the `stderr` of `command` to `filename`.



This is useful for suppressing output when testing for a condition. For example, let us test whether a certain command exists.

```
bash$ type bogus_command &>/dev/null
```

```
bash$ echo $?  
1
```

Or in a script:

```
1 command_test () { type "$1" &>/dev/null; }  
2 # ^  
3  
4 cmd=rmdir # Legitimate command.  
5 command_test $cmd; echo $? # 0  
6  
7  
8 cmd=bogus_command # Illegitimate command  
9 command_test $cmd; echo $? # 1
```

command >&2 redirects `stdout` of `command` to `stderr`.

scriptname >>filename appends the output of `scriptname` to file `filename`. If `filename` does not already exist, it is created.

[i]<>filename opens file `filename` for reading and writing, and assigns [file descriptor](#) `i` to it. If `filename` does not exist, it is created.

[process substitution](#).

(**command**)>

<(**command**)

[In a different context](#), the "<" and ">" characters act as [string comparison operators](#).

[In yet another context](#), the "<" and ">" characters act as [integer comparison operators](#). See also [Example 16-9](#).

<<

redirection used in a [here document](#).

<<<

redirection used in a [here string](#).

<, >

[ASCII comparison](#).

```
1 veg1=carrots
2 veg2=tomatoes
3
4 if [[ "$veg1" < "$veg2" ]]
5 then
6     echo "Although $veg1 precede $veg2 in the dictionary,"
7     echo -n "this does not necessarily imply anything "
8     echo "about my culinary preferences."
9 else
10    echo "What kind of dictionary are you using, anyhow?"
11 fi
```

<, >

[word boundary in a regular expression](#).

```
bash$ grep '\<the\>' textfile
```

|

pipe. Passes the output (stdout) of a previous command to the input (stdin) of the next one, or to the shell. This is a method of chaining commands together.

```
1 echo ls -l | sh
2 # Passes the output of "echo ls -l" to the shell,
3 #+ with the same result as a simple "ls -l".
4
5
6 cat *.lst | sort | uniq
7 # Merges and sorts all ".lst" files, then deletes duplicate lines.
```

A pipe, as a classic method of interprocess communication, sends the stdout of one [process](#) to the stdin of another. In a typical case, a command, such as [cat](#) or [echo](#), pipes a stream of data to a *filter*, a command that transforms its input for processing. [\[7\]](#)

```
cat $filename1 $filename2 | grep $search_word
```


For an interesting note on the complexity of using UNIX pipes, see [the UNIX FAQ, Part 3](#).

The output of a command or commands may be piped to a script.

```
1 #!/bin/bash
2 # uppercase.sh : Changes input to uppercase.
3
4 tr 'a-z' 'A-Z'
5 # Letter ranges must be quoted
6 #+ to prevent filename generation from single-letter filenames.
7
8 exit 0
```

Now, let us pipe the output of **ls -l** to this script.

```
bash$ ls -l | ./uppercase.sh
-RW-RW-R-- 1 BOZO BOZO      109 APR  7 19:49 1.TXT
-RW-RW-R-- 1 BOZO BOZO      109 APR 14 16:48 2.TXT
```

 The `stdout` of each process in a pipe must be read as the `stdin` of the next. If this is not the case, the data stream will *block*, and the pipe will not behave as expected.

```
1 cat file1 file2 | ls -l | sort
2 # The output from "cat file1 file2" disappears.
```

A pipe runs as a [child process](#), and therefore cannot alter script variables.

```
1 variable="initial_value"
2 echo "new_value" | read variable
3 echo "variable = $variable" # variable = initial_value
```

If one of the commands in the pipe aborts, this prematurely terminates execution of the pipe. Called a *broken pipe*, this condition sends a `SIGPIPE` [signal](#).

>
||
&

force redirection (even if the [noclobber option](#) is set). This will forcibly overwrite an existing file.

[OR logical operator](#). In a [test construct](#), the `||` operator causes a return of 0 (success) if *either* of the linked test conditions is true.

Run job in background. A command followed by an `&` will run in the background.

```
bash$ sleep 10 &
[1] 850
[1]+ Done sleep 10
```

Within a script, commands and even [loops](#) may run in the background.


Example 3-3. Running a loop in the background

```
1 #!/bin/bash
2 # background-loop.sh
3
4 for i in 1 2 3 4 5 6 7 8 9 10 # First loop.
5 do
6   echo -n "$i "
7 done & # Run this loop in background.
8       # Will sometimes execute after second loop.
9
10 echo # This 'echo' sometimes will not display.
11
12 for i in 11 12 13 14 15 16 17 18 19 20 # Second loop.
13 do
14   echo -n "$i "
15 done
16
17 echo # This 'echo' sometimes will not display.
18
19 # =====
20
21 # The expected output from the script:
22 # 1 2 3 4 5 6 7 8 9 10
23 # 11 12 13 14 15 16 17 18 19 20
24
25 # Sometimes, though, you get:
26 # 11 12 13 14 15 16 17 18 19 20
27 # 1 2 3 4 5 6 7 8 9 10 bozo $
28 # (The second 'echo' doesn't execute. Why?)
```

```

29
30 # Occasionally also:
31 # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
32 # (The first 'echo' doesn't execute. Why?)
33
34 # Very rarely something like:
35 # 11 12 13 1 2 3 4 5 6 7 8 9 10 14 15 16 17 18 19 20
36 # The foreground loop preempts the background one.
37
38 exit 0
39
40 # Nasimuddin Ansari suggests adding sleep 1
41 #+ after the echo -n "$i" in lines 6 and 14,
42 #+ for some real fun.

```

 A command run in the background within a script may cause the script to hang, waiting for a keystroke. Fortunately, there is a [remedy](#) for this.

&&

AND logical operator. In a [test construct](#), the && operator causes a return of 0 (success) only if *both* the linked test conditions are true.

option, prefix. Option flag for a command or filter. Prefix for an operator. Prefix for a [default parameter](#) in [parameter substitution](#).

COMMAND `-[Option1] [Option2] [...]`

ls -al

sort -dfu \$filename

```

1 if [ $file1 -ot $file2 ]
2 then #      ^
3   echo "File $file1 is older than $file2."
4 fi
5
6 if [ "$a" -eq "$b" ]
7 then #      ^
8   echo "$a is equal to $b."
9 fi
10
11 if [ "$c" -eq 24 -a "$d" -eq 47 ]
12 then #      ^      ^
13   echo "$c equals 24 and $d equals 47."
14 fi
15
16
17 param2=${param1:-$DEFAULTVAL}
18 #      ^

```

--

The *double-dash* -- prefixes *long* (verbatim) options to commands.

sort --ignore-leading-blanks

Used with a [Bash builtin](#), it means the *end of options* to that particular command.

 This provides a handy means of removing files whose *names begin with a dash*.

```

bash$ ls -l
-rw-r--r-- 1 bozo bozo 0 Nov 25 12:29 -badname

bash$ rm -- -badname

bash$ ls -l
total 0

```

The *double-dash* is also used in conjunction with [set](#).

set -- \$variable (as in [Example 15-18](#))

redirection from/to stdin or stdout [dash].

```

bash$ cat -
abc
abc
...

Ct1-D

```

As expected, **cat -** echoes stdin, in this case keyboarded user input, to stdout. But, does I/O redirection using **-** have real-world applications?

```

1 (cd /source/directory && tar cf - . ) | (cd /dest/directory && tar xpvf -)
2 # Move entire file tree from one directory to another
3 # [courtesy Alan Cox <a.cox@swansea.ac.uk>, with a minor change]
4
5 # 1) cd /source/directory
6 #     Source directory, where the files to be moved are.
7 # 2) &&
8 #     "And-list": if the 'cd' operation successful,
9 #     then execute the next command.
10 # 3) tar cf - .
11 #     The 'c' option 'tar' archiving command creates a new archive,
12 #     the 'f' (file) option, followed by '-' designates the target file
13 #     as stdout, and do it in current directory tree ('.').
14 # 4) |
15 #     Piped to ...
16 # 5) ( ... )
17 #     a subshell
18 # 6) cd /dest/directory
19 #     Change to the destination directory.
20 # 7) &&
21 #     "And-list", as above
22 # 8) tar xpvf -
23 #     Unarchive ('x'), preserve ownership and file permissions ('p'),
24 #     and send verbose messages to stdout ('v'),
25 #     reading data from stdin ('f' followed by '-').
26 #
27 #     Note that 'x' is a command, and 'p', 'v', 'f' are options.
28 #
29 # Whew!
30
31
32
33 # More elegant than, but equivalent to:
34 #     cd source/directory
35 #     tar cf - . | (cd ../dest/directory; tar xpvf -)
36 #
37 #     Also having same effect:
38 #     cp -a /source/directory/* /dest/directory
39 #     Or:

```

```
40 # cp -a /source/directory/* /source/directory/.[^.]* /dest/directory
41 #     If there are hidden files in /source/directory.
```

```
1 bunzip2 -c linux-2.6.16.tar.bz2 | tar xvf -
2 # --uncompress tar file--          | --then pass it to "tar"--
3 # If "tar" has not been patched to handle "bunzip2",
4 #+ this needs to be done in two discrete steps, using a pipe.
5 # The purpose of the exercise is to unarchive "bzipped" kernel source.
```

Note that in this context the "-" is not itself a Bash operator, but rather an option recognized by certain UNIX utilities that write to `stdout`, such as **tar**, **cat**, etc.

```
bash$ echo "whatever" | cat -
whatever
```

Where a filename is expected, `-` redirects output to `stdout` (sometimes seen with **tar cf**), or accepts input from `stdin`, rather than from a file. This is a method of using a file-oriented utility as a filter in a pipe.

```
bash$ file
Usage: file [-bciknvzL] [-f namefile] [-m magicfiles] file...
```

By itself on the command-line, [file](#) fails with an error message.

Add a "-" for a more useful result. This causes the shell to await user input.

```
bash$ file -
abc
standard input:                ASCII text

bash$ file -
#!/bin/bash
standard input:                Bourne-Again shell script text executable
```

Now the command accepts input from `stdin` and analyzes it.

The "-" can be used to pipe `stdout` to other commands. This permits such stunts as [prepending lines to a file](#).

Using [diff](#) to compare a file with a *section* of another:

```
grep Linux file1 | diff file2 -
```

Finally, a real-world example using `-` with [tar](#).


Example 3-4. Backup of all files changed in last day

```
1 #!/bin/bash
2
3 # Backs up all files in current directory modified within last 24 hours
4 #+ in a "tarball" (tarred and gzipped file).
5
6 BACKUPFILE=backup-$(date +%m-%d-%Y)
7 #     Embeds date in backup filename.
8 #     Thanks, Joshua Tschida, for the idea.
9 archive=${1:-$BACKUPFILE}
10 # If no backup-archive filename specified on command-line,
11 #+ it will default to "backup-MM-DD-YYYY.tar.gz."
```

```

12
13 tar cvf - `find . -mtime -1 -type f -print` > $archive.tar
14 gzip $archive.tar
15 echo "Directory $PWD backed up in archive file \"$archive.tar.gz\"."
16
17
18 # Stephane Chazelas points out that the above code will fail
19 #+ if there are too many files found
20 #+ or if any filenames contain blank characters.
21
22 # He suggests the following alternatives:
23 # -----
24 #   find . -mtime -1 -type f -print0 | xargs -0 tar rvf "$archive.tar"
25 #       using the GNU version of "find".
26
27
28 #   find . -mtime -1 -type f -exec tar rvf "$archive.tar" '{}' \;
29 #       portable to other UNIX flavors, but much slower.
30 # -----
31
32
33 exit 0

```

 **Files** beginning with "-" may cause problems when coupled with the "-" redirection operator. A script should check for this and add an appropriate prefix to such filenames, for example ./-FILENAME, \$PWD/-FILENAME, or \$PATHNAME/-FILENAME.


If the value of a variable begins with a -, this may likewise create problems.

```

1 var="-n"
2 echo $var
3 # Has the effect of "echo -n", and outputs nothing.

```

previous working directory. A cd - command changes to the previous working directory. This uses the [\\$OLDPWD environmental variable](#).

 Do not confuse the "-" used in this sense with the "-" redirection operator just discussed. The interpretation of the "-" depends on the context in which it appears.

Minus. Minus sign in an [arithmetic operation](#).

Equals. [Assignment operator](#)

```

1 a=28
2 echo $a # 28

```

In a [different context](#), the "=" is a [string comparison](#) operator.

Plus. Addition [arithmetic operator](#).

In a [different context](#), the + is a [Regular Expression](#) operator.

Option. Option flag for a command or filter.

Certain commands and [builtins](#) use the + to enable certain options and the - to disable them. In [parameter substitution](#), the + prefixes an [alternate value](#) that a variable expands to.

modulo. Modulo (remainder of a division) [arithmetic operation](#).

```
1 let "z = 5 % 3"
2 echo $z # 2
```

In a [different context](#), the % is a [pattern matching](#) operator.

~

home directory [tilde]. This corresponds to the [\\$HOME](#) internal variable. `~bozo` is bozo's home directory, and `ls ~bozo` lists the contents of it. `~/` is the current user's home directory, and `ls ~/` lists the contents of it.

```
bash$ echo ~bozo
/home/bozo

bash$ echo ~
/home/bozo

bash$ echo ~/
/home/bozo/

bash$ echo ~:
/home/bozo:

bash$ echo ~nonexistent-user
~nonexistent-user
```

~+

current working directory. This corresponds to the [\\$PWD](#) internal variable.

~-

previous working directory. This corresponds to the [\\$OLDPWD](#) internal variable.

=~

regular expression match. This operator was introduced with [version 3](#) of Bash.

^

beginning-of-line. In a [regular expression](#), a "^" addresses the [beginning of a line](#) of text.

^, ^^

Uppercase conversion in parameter substitution (added in [version 4](#) of Bash).

Control Characters

change the behavior of the terminal or text display. A control character is a **CONTROL + key** combination (pressed simultaneously). A control character may also be written in *octal* or *hexadecimal* notation, following an *escape*.

Control characters are not normally useful inside a script.

◇ **Ct1-A**

Moves cursor to beginning of line of text (on the command-line).

◇ **Ct1-B**

Backspace (nondestructive).

◇

Ct1-C

Break. Terminate a foreground job.

◇

Ct1-D

Log out from a shell (similar to [exit](#)).

EOF (end-of-file). This also terminates input from `stdin`.

When typing text on the console or in an *xterm* window, **Ctl-D** erases the character under the cursor. When there are no characters present, **Ctl-D** logs out of the session, as expected. In an *xterm* window, this has the effect of closing the window.

◇ **Ctl-E**

Moves cursor to end of line of text (on the command-line).

◇ **Ctl-F**

Moves cursor forward one character position (on the command-line).

◇

Ctl-G

BEL. On some old-time teletype terminals, this would actually ring a bell. In an *xterm* it might beep.

◇

Ctl-H

Rubout (destructive backspace). Erases characters the cursor backs over while backspacing.

```
1 #!/bin/bash
2 # Embedding Ctl-H in a string.
3
4 a="^H^H"                # Two Ctl-H's -- backspaces
5                        # ctl-V ctl-H, using vi/vim
6 echo "abcdef"          # abcdef
7 echo
8 echo -n "abcdef$a "    # abcd f
9 # Space at end ^      ^ Backspaces twice.
10 echo
11 echo -n "abcdef$a"     # abcdef
12 # No space at end    ^ Doesn't backspace (why?).
13                      # Results may not be quite as expected.
14 echo; echo
15
16 # Constantin Hagemeyer suggests trying:
17 # a=${'\010\010'}
18 # a=${'\b\b'}
19 # a=${'\x08\x08'}
20 # But, this does not change the results.
21
22 #####
23
24 # Now, try this.
25
26 rubout="^H^H^H^H^H"    # 5 x Ctl-H.
27
28 echo -n "12345678"
29 sleep 2
30 echo -n "$rubout"
31 sleep 2
```

◇ **Ctl-I**

Horizontal tab.

◇

Ctl-J

Newline (line feed). In a script, may also be expressed in octal notation -- `'\012'` or in

hexadecimal -- '\x0a'.

◇ **Ctl-K**

Vertical tab.

When typing text on the console or in an *xterm* window, **Ctl-K** erases from the character under the cursor to end of line. Within a script, **Ctl-K** may behave differently, as in Lee Lee Maschmeyer's example, below.

◇ **Ctl-L**

Formfeed (clear the terminal screen). In a terminal, this has the same effect as the [clear](#) command. When sent to a printer, a **Ctl-L** causes an advance to end of the paper sheet.

◇

Ctl-M

Carriage return.

```
1 #!/bin/bash
2 # Thank you, Lee Maschmeyer, for this example.
3
4 read -n 1 -s -p \
5 '$Control-M leaves cursor at beginning of this line. Press Enter. \x0d'
6           # Of course, '0d' is the hex equivalent of Control-M.
7 echo >&2   # The '-s' makes anything typed silent,
8           #+ so it is necessary to go to new line explicitly.
9
10 read -n 1 -s -p '$Control-J leaves cursor on next line. \x0a'
11           # '0a' is the hex equivalent of Control-J, linefeed.
12 echo >&2
13
14 ###
15
16 read -n 1 -s -p '$And Control-K\x0bgoes straight down.'
17 echo >&2   # Control-K is vertical tab.
18
19 # A better example of the effect of a vertical tab is:
20
21 var='\x0aThis is the bottom line\x0bThis is the top line\x0a'
22 echo "$var"
23 # This works the same way as the above example. However:
24 echo "$var" | col
25 # This causes the right end of the line to be higher than the left end.
26 # It also explains why we started and ended with a line feed --
27 #+ to avoid a garbled screen.
28
29 # As Lee Maschmeyer explains:
30 # -----
31 # In the [first vertical tab example] . . . the vertical tab
32 #+ makes the printing go straight down without a carriage return.
33 # This is true only on devices, such as the Linux console,
34 #+ that can't go "backward."
35 # The real purpose of VT is to go straight UP, not down.
36 # It can be used to print superscripts on a printer.
37 # The col utility can be used to emulate the proper behavior of VT.
38
39 exit 0
```

◇ **Ctl-N**

Erases a line of text recalled from *history buffer* [8] (on the command-line).

◇ **Ctl-O**

Issues a *newline* (on the command-line).

◇ **Ct1-P**

Recalls last command from *history buffer* (on the command-line).

◇ **Ct1-Q**

Resume (**XON**).

This resumes `stdin` in a terminal.

◇ **Ct1-R**

Backwards search for text in *history buffer* (on the command-line).

◇ **Ct1-S**

Suspend (**XOFF**).

This freezes `stdin` in a terminal. (Use `Ctl-Q` to restore input.)

◇ **Ct1-T**

Reverses the position of the character the cursor is on with the previous character (on the command-line).

◇ **Ct1-U**

Erase a line of input, from the cursor backward to beginning of line. In some settings, **Ct1-U** erases the entire line of input, *regardless of cursor position*.

◇ **Ct1-V**

When inputting text, **Ct1-V** permits inserting control characters. For example, the following two are equivalent:

```
1 echo -e '\x0a'
2 echo <Ct1-V><Ct1-J>
```

Ct1-V is primarily useful from within a text editor.

◇ **Ct1-W**

When typing text on the console or in an xterm window, **Ct1-W** erases from the character under the cursor backwards to the first instance of [whitespace](#). In some settings, **Ct1-W** erases backwards to first non-alphanumeric character.

◇ **Ct1-X**

In certain word processing programs, *Cuts* highlighted text and copies to *clipboard*.

◇ **Ct1-Y**

Pastes back text previously erased (with **Ct1-U** or **Ct1-W**).

◇ **Ct1-Z**

Pauses a foreground job.

Substitute operation in certain word processing applications.

EOF (end-of-file) character in the MSDOS filesystem.

Whitespace

functions as a separator between commands and/or variables. Whitespace consists of either *spaces*, *tabs*, *blank lines*, or any combination thereof. [9] In some contexts, such as [variable](#)

[assignment](#), whitespace is not permitted, and results in a syntax error.

Blank lines have no effect on the action of a script, and are therefore useful for visually separating functional sections.

[\\$IFS](#), the special variable separating *fields* of input to certain commands. It defaults to whitespace.

Definition: A *field* is a discrete chunk of data expressed as a string of consecutive characters. Separating each field from adjacent fields is either *whitespace* or some other designated character (often determined by the `$IFS`). In some contexts, a field may be called a *record*.

To preserve *whitespace* within a string or in a variable, use [quoting](#).

UNIX [filters](#) can target and operate on *whitespace* using the [POSIX](#) character class `[:space:]`.

Notes

- [1] An *operator* is an agent that carries out an *operation*. Some examples are the common [arithmetic operators](#), `+ - * /`. In Bash, there is some overlap between the concepts of *operator* and [keyword](#).
- [2] This is more commonly known as the *ternary* operator. Unfortunately, *ternary* is an ugly word. It doesn't roll off the tongue, and it doesn't elucidate. It obfuscates. *Trinary* is by far the more elegant usage.
- [3] American Standard Code for Information Interchange. This is a system for encoding text characters (alphabetic, numeric, and a limited set of symbols) as 7-bit numbers that can be stored and manipulated by computers. Many of the ASCII characters are represented on a standard keyboard.
- [4] A *PID*, or *process ID*, is a number assigned to a running process. The *PIDs* of running processes may be viewed with a [ps](#) command.

Definition: A *process* is a currently executing command (or program), sometimes referred to as a *job*.

- [5] The shell does the *brace expansion*. The command itself acts upon the *result* of the expansion.
- [6] Exception: a code block in braces as part of a pipe *may* run as a [subshell](#).

```
1 ls | { read firstline; read secondline; }
2 # Error. The code block in braces runs as a subshell,
3 #+ so the output of "ls" cannot be passed to variables within the block.
4 echo "First line is $firstline; second line is $secondline" # Won't work.
5
6 # Thanks, S.C.
```

- [7] Even as in olden times a *philtre* denoted a potion alleged to have magical transformative powers, so does a UNIX *filter* transform its target in (roughly) analogous fashion. (The coder who comes up with a "love philtre" that runs on a Linux machine will likely win accolades and honors.)
- [8] Bash stores a list of commands previously issued from the command-line in a *buffer*, or memory space, for recall with the [builtin history](#) commands.
- [9] A linefeed (*newline*) is also a whitespace character. This explains why a *blank line*, consisting only of a linefeed, is considered whitespace.

Basics

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Introduction to Variables and
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Chapter 4. Introduction to Variables and Parameters

Variables are how programming and scripting languages represent data. A variable is nothing more than a *label*, a name assigned to a location or set of locations in computer memory holding an item of data.

Variables appear in arithmetic operations and manipulation of quantities, and in string parsing.

4.1. Variable Substitution

The *name* of a variable is a placeholder for its *value*, the data it holds. Referencing (retrieving) its value is called *variable substitution*.

\$

Let us carefully distinguish between the *name* of a variable and its *value*. If **variable1** is the name of a variable, then **\$variable1** is a reference to its *value*, the data item it contains. [1]

```
bash$ variable1=23

bash$ echo variable1
variable1

bash$ echo $variable1
23
```

The only times a variable appears "naked" -- without the \$ prefix -- is when declared or assigned, when *unset*, when [exported](#), in an arithmetic expression within [double parentheses \(\(...\)\)](#), or in the special case of a variable representing a [signal](#) (see [Example 32-5](#)). Assignment may be with an = (as in *var1=27*), in a [read](#) statement, and at the head of a loop (*for var2 in 1 2 3*).

Enclosing a referenced value in *double quotes* (" ... ") does not interfere with variable substitution. This is called *partial quoting*, sometimes referred to as "weak quoting." Using single quotes (' ... ') causes the variable name to be used literally, and no substitution will take place. This is *full quoting*, sometimes referred to as 'strong quoting.' See [Chapter 5](#) for a detailed discussion.

Note that **\$variable** is actually a simplified form of **\${variable}**. In contexts where the **\$variable** syntax causes an error, the longer form may work (see [Section 10.2](#), below).

Example 4-1. Variable assignment and substitution

```
1 #!/bin/bash
2 # ex9.sh
3
4 # Variables: assignment and substitution
5
6 a=375
7 hello=$a
8 #   ^ ^
9
10 #-----
11 # No space permitted on either side of = sign when initializing variables.
12 # What happens if there is a space?
13
14 # "VARIABLE =value"
15 #           ^
16 #% Script tries to run "VARIABLE" command with one argument, "=value".
17
18 # "VARIABLE= value"
19 #           ^
20 #% Script tries to run "value" command with
21 #+ the environmental variable "VARIABLE" set to "".
22 #-----
23
24
```

```

25 echo hello      # hello
26 # Not a variable reference, just the string "hello" ...
27
28 echo $hello     # 375
29 #      ^           This *is* a variable reference.
30 echo ${hello}  # 375
31 #              Likewise a variable reference, as above.
32
33 # Quoting . . .
34 echo "$hello"   # 375
35 echo "${hello}" # 375
36
37 echo
38
39 hello="A B C D"
40 echo $hello     # A B C D
41 echo "$hello"  # A B C D
42 # As we see, echo $hello and echo "$hello" give different results.
43 # =====
44 # Quoting a variable preserves whitespace.
45 # =====
46
47 echo
48
49 echo '$hello'  # $hello
50 #      ^      ^
51 # Variable referencing disabled (escaped) by single quotes,
52 #+ which causes the "$" to be interpreted literally.
53
54 # Notice the effect of different types of quoting.
55
56
57 hello=         # Setting it to a null value.
58 echo "\$hello (null value) = $hello"      # $hello (null value) =
59 # Note that setting a variable to a null value is not the same as
60 #+ unsetting it, although the end result is the same (see below).
61
62 # -----
63
64 # It is permissible to set multiple variables on the same line,
65 #+ if separated by white space.
66 # Caution, this may reduce legibility, and may not be portable.
67
68 var1=21 var2=22 var3=$V3
69 echo
70 echo "var1=$var1 var2=$var2 var3=$var3"
71
72 # May cause problems with legacy versions of "sh" . . .
73
74 # -----
75
76 echo; echo
77
78 numbers="one two three"
79 #      ^      ^
80 other_numbers="1 2 3"
81 #      ^      ^
82 # If there is whitespace embedded within a variable,
83 #+ then quotes are necessary.
84 # other_numbers=1 2 3 # Gives an error message.
85 echo "numbers = $numbers"
86 echo "other_numbers = $other_numbers" # other_numbers = 1 2 3
87 # Escaping the whitespace also works.
88 mixed_bag=2\ ---\ Whatever
89 #      ^      ^ Space after escape (\).
90

```

```

91 echo "$mixed_bag"           # 2 --- Whatever
92
93 echo; echo
94
95 echo "uninitialized_variable = $uninitialized_variable"
96 # Uninitialized variable has null value (no value at all!).
97 uninitialized_variable=    # Declaring, but not initializing it --
98                             #+ same as setting it to a null value, as above.
99 echo "uninitialized_variable = $uninitialized_variable"
100                             # It still has a null value.
101
102 uninitialized_variable=23    # Set it.
103 unset uninitialized_variable # Unset it.
104 echo "uninitialized_variable = $uninitialized_variable"
105                             # uninitialized_variable =
106                             # It still has a null value.
107 echo
108
109 exit 0

```



An uninitialized variable has a "null" value -- no assigned value at all (*not zero!*).

```

1 if [ -z "$unassigned" ]
2 then
3     echo "\$unassigned is NULL."
4 fi     # $unassigned is NULL.

```

Using a variable before assigning a value to it may cause problems. It is nevertheless possible to perform arithmetic operations on an uninitialized variable.

```

1 echo "$uninitialized"           # (blank line)
2 let "uninitialized += 5"        # Add 5 to it.
3 echo "$uninitialized"          # 5
4
5 # Conclusion:
6 # An uninitialized variable has no value,
7 #+ however it evaluates as 0 in an arithmetic operation.

```

See also [Example 15-23](#).

Notes

- [1] Technically, the *name* of a variable is called an *lvalue*, meaning that it appears on the *left* side of an assignment statement, as in **VARIABLE=23**. A variable's *value* is an *rvalue*, meaning that it appears on the *right* side of an assignment statement, as in **VAR2=\$VARIABLE**.

A variable's *name* is, in fact, a *reference*, a *pointer* to the memory location(s) where the actual data associated with that variable is kept.

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4.2. Variable Assignment

=

the assignment operator (*no space before and after*)

⚠ Do not confuse this with `=` and `-eq`, which [test](#), rather than assign!

Note that `=` can be either an *assignment* or a *test* operator, depending on context.

Example 4-2. Plain Variable Assignment

```
1 #!/bin/bash
2 # Naked variables
3
4 echo
5
6 # When is a variable "naked", i.e., lacking the '$' in front?
7 # When it is being assigned, rather than referenced.
8
9 # Assignment
10 a=879
11 echo "The value of \"a\" is $a."
12
13 # Assignment using 'let'
14 let a=16+5
15 echo "The value of \"a\" is now $a."
16
17 echo
18
19 # In a 'for' loop (really, a type of disguised assignment):
20 echo -n "Values of \"a\" in the loop are: "
21 for a in 7 8 9 11
22 do
23     echo -n "$a "
24 done
25
26 echo
27 echo
28
29 # In a 'read' statement (also a type of assignment):
30 echo -n "Enter \"a\" "
31 read a
32 echo "The value of \"a\" is now $a."
33
34 echo
35
36 exit 0
```

Example 4-3. Variable Assignment, plain and fancy

```
1 #!/bin/bash
2
3 a=23                # Simple case
4 echo $a
5 b=$a
6 echo $b
7
```

```
8 # Now, getting a little bit fancier (command substitution).
9
10 a=`echo Hello!` # Assigns result of 'echo' command to 'a' ...
11 echo $a
12 # Note that including an exclamation mark (!) within a
13 #+ command substitution construct will not work from the command-line,
14 #+ since this triggers the Bash "history mechanism."
15 # Inside a script, however, the history functions are disabled by default.
16
17 a=`ls -l` # Assigns result of 'ls -l' command to 'a'
18 echo $a # Unquoted, however, it removes tabs and newlines.
19 echo
20 echo "$a" # The quoted variable preserves whitespace.
21 # (See the chapter on "Quoting.")
22
23 exit 0
```

Variable assignment using the `$(...)` mechanism (a newer method than [backquotes](#)). This is likewise a form of [command substitution](#).

```
1 # From /etc/rc.d/rc.local
2 R=$(cat /etc/redhat-release)
3 arch=$(uname -m)
```

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4.3. Bash Variables Are Untyped

Unlike many other programming languages, Bash does not segregate its variables by "type." Essentially, *Bash variables are character strings*, but, depending on context, Bash permits arithmetic operations and comparisons on variables. The determining factor is whether the value of a variable contains only digits.

Example 4-4. Integer or string?

```
1 #!/bin/bash
2 # int-or-string.sh
3
4 a=2334                # Integer.
5 let "a += 1"
6 echo "a = $a "       # a = 2335
7 echo                 # Integer, still.
8
9
10 b=${a/23/BB}        # Substitute "BB" for "23".
11                    # This transforms $b into a string.
12 echo "b = $b"       # b = BB35
13 declare -i b        # Declaring it an integer doesn't help.
14 echo "b = $b"       # b = BB35
15
16 let "b += 1"        # BB35 + 1
17 echo "b = $b"       # b = 1
18 echo                 # Bash sets the "integer value" of a string to 0.
19
20 c=BB34
21 echo "c = $c"       # c = BB34
22 d=${c/BB/23}        # Substitute "23" for "BB".
23                    # This makes $d an integer.
24 echo "d = $d"       # d = 2334
25 let "d += 1"        # 2334 + 1
26 echo "d = $d"       # d = 2335
27 echo
28
29
30 # What about null variables?
31 e=''                # ... Or e="" ... Or e=
32 echo "e = $e"       # e =
33 let "e += 1"        # Arithmetic operations allowed on a null variable?
34 echo "e = $e"       # e = 1
35 echo                 # Null variable transformed into an integer.
36
37 # What about undeclared variables?
38 echo "f = $f"       # f =
39 let "f += 1"        # Arithmetic operations allowed?
40 echo "f = $f"       # f = 1
41 echo                 # Undeclared variable transformed into an integer.
42 #
43 # However ...
44 let "f /= $undecl_var" # Divide by zero?
45 # let: f /= : syntax error: operand expected (error token is " ")
46 # Syntax error! Variable $undecl_var is not set to zero here!
47 #
48 # But still ...
49 let "f /= 0"
50 # let: f /= 0: division by 0 (error token is "0")
51 # Expected behavior.
52
53
```

```
54 # Bash (usually) sets the "integer value" of null to zero
55 #+ when performing an arithmetic operation.
56 # But, don't try this at home, folks!
57 # It's undocumented and probably non-portable behavior.
58
59
60 # Conclusion: Variables in Bash are untyped,
61 #+ with all attendant consequences.
62
63 exit $?
```

Untyped variables are both a blessing and a curse. They permit more flexibility in scripting and make it easier to grind out lines of code (and give you enough rope to hang yourself!). However, they likewise permit subtle errors to creep in and encourage sloppy programming habits.

To lighten the burden of keeping track of variable types in a script, Bash *does* permit [declaring](#) variables.

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4.4. Special Variable Types

Local variables


Variables [visible](#) only within a [code block](#) or function (see also [local variables](#) in [functions](#))

Environmental variables

Variables that affect the behavior of the shell and user interface

-  In a more general context, each [process](#) has an "environment", that is, a group of variables that the process may reference. In this sense, the shell behaves like any other process.

Every time a shell starts, it creates shell variables that correspond to its own environmental variables. Updating or adding new environmental variables causes the shell to update its environment, and all the shell's *child processes* (the commands it executes) inherit this environment.


-  The space allotted to the environment is limited. Creating too many environmental variables or ones that use up excessive space may cause problems.

```
bash$ eval "`seq 10000 | sed -e 's/./export var&=ZZZZZZZZZZZZZZZZ/'`"
bash$ du
bash: /usr/bin/du: Argument list too long
```

Note: this "error" has been fixed, as of kernel version 2.6.23.

(Thank you, Stéphane Chazelas for the clarification, and for providing the above example.)

If a script sets environmental variables, they need to be "exported," that is, reported to the *environment* local to the script. This is the function of the [export](#) command.

-  A script can **export** variables only to child [processes](#), that is, only to commands or processes which that particular script initiates. A script invoked from the command-line *cannot* export variables back to the command-line environment. [Child processes](#) cannot export variables back to the parent processes that spawned them.

Definition: A *child process* is a subprocess launched by another process, its [parent](#).

Positional parameters

Arguments passed to the script from the command line [\[1\]](#): \$0, \$1, \$2, \$3 ...

\$0 is the name of the script itself, \$1 is the first argument, \$2 the second, \$3 the third, and so forth. [\[2\]](#) After \$9, the arguments must be enclosed in brackets, for example, \${10}, \${11}, \${12}.

The special variables [\\$*](#) and [\\$@](#) denote *all* the positional parameters.

Example 4-5. Positional Parameters

```
1 #!/bin/bash
2
3 # Call this script with at least 10 parameters, for example
4 # ./scriptname 1 2 3 4 5 6 7 8 9 10
```

```

5 MINPARAMS=10
6
7 echo
8
9 echo "The name of this script is \"\$0\"."
10 # Adds ./ for current directory
11 echo "The name of this script is \"`basename $0`\"."
12 # Strips out path name info (see 'basename')
13
14 echo
15
16 if [ -n "$1" ]           # Tested variable is quoted.
17 then
18   echo "Parameter #1 is $1" # Need quotes to escape #
19 fi
20
21 if [ -n "$2" ]
22 then
23   echo "Parameter #2 is $2"
24 fi
25
26 if [ -n "$3" ]
27 then
28   echo "Parameter #3 is $3"
29 fi
30
31 # ...
32
33
34 if [ -n "${10}" ] # Parameters > $9 must be enclosed in {brackets}.
35 then
36   echo "Parameter #10 is ${10}"
37 fi
38
39 echo "-----"
40 echo "All the command-line parameters are: \"$*"
41
42 if [ $# -lt "$MINPARAMS" ]
43 then
44   echo
45   echo "This script needs at least $MINPARAMS command-line arguments!"
46 fi
47
48 echo
49
50 exit 0

```

Bracket notation for positional parameters leads to a fairly simple way of referencing the *last* argument passed to a script on the command-line. This also requires [indirect referencing](#).

```

1 args=$#           # Number of args passed.
2 lastarg=${!args}
3 # Note: This is an *indirect reference* to $args ...
4
5
6 # Or:           lastarg=${!#}           (Thanks, Chris Monson.)
7 # This is an *indirect reference* to the $# variable.
8 # Note that lastarg=${!$#} doesn't work.

```

Some scripts can perform different operations, depending on which name they are invoked with. For this to work, the script needs to check \$0, the name it was invoked by. [3] There must also exist symbolic links to all the alternate names of the script. See [Example 16-2](#).

i If a script expects a command-line parameter but is invoked without one, this may cause a *null variable assignment*, generally an undesirable result. One way to prevent this is to append an extra character to both sides of the assignment statement using the expected positional parameter.

```
1 variable1_=$1_ # Rather than variable1=$1
2 # This will prevent an error, even if positional parameter is absent.
3
4 critical_argument01=$variable1_
5
6 # The extra character can be stripped off later, like so.
7 variable1=${variable1_/_/}
8 # Side effects only if $variable1_ begins with an underscore.
9 # This uses one of the parameter substitution templates discussed later.
10 # (Leaving out the replacement pattern results in a deletion.)
11
12 # A more straightforward way of dealing with this is
13 #+ to simply test whether expected positional parameters have been passed.
14 if [ -z $1 ]
15 then
16     exit $E_MISSING_POS_PARAM
17 fi
18
19
20 # However, as Fabian Kreutz points out,
21 #+ the above method may have unexpected side-effects.
22 # A better method is parameter substitution:
23 #     ${1:-$DefaultVal}
24 # See the "Parameter Substitution" section
25 #+ in the "Variables Revisited" chapter.
```

Example 4-6. *wh*, *whois* domain name lookup

```
1 #!/bin/bash
2 # ex18.sh
3
4 # Does a 'whois domain-name' lookup on any of 3 alternate servers:
5 #     ripe.net, cw.net, radb.net
6
7 # Place this script -- renamed 'wh' -- in /usr/local/bin
8
9 # Requires symbolic links:
10 # ln -s /usr/local/bin/wh /usr/local/bin/wh-ripe
11 # ln -s /usr/local/bin/wh /usr/local/bin/wh-apnic
12 # ln -s /usr/local/bin/wh /usr/local/bin/wh-tucows
13
14 E_NOARGS=75
15
16
17 if [ -z "$1" ]
18 then
19     echo "Usage: `basename $0` [domain-name]"
20     exit $E_NOARGS
21 fi
22
23 # Check script name and call proper server.
24 case `basename $0` in # Or: case ${0##*/} in
25     "wh"           ) whois $1@whois.tucows.com;;
26     "wh-ripe"      ) whois $1@whois.ripe.net;;
27     "wh-apnic"     ) whois $1@whois.apnic.net;;
28     "wh-cw"        ) whois $1@whois.cw.net;;
29     *               ) echo "Usage: `basename $0` [domain-name]";;
```

```
30 esac
31
32 exit $?
```

The **shift** command reassigns the positional parameters, in effect shifting them to the left one notch.

\$1 <--- \$2, \$2 <--- \$3, \$3 <--- \$4, etc.

The old \$1 disappears, but \$0 (*the script name*) *does not change*. If you use a large number of positional parameters to a script, **shift** lets you access those past 10, although [{bracket} notation](#) also permits this.

Example 4-7. Using *shift*

```
1 #!/bin/bash
2 # shft.sh: Using 'shift' to step through all the positional parameters.
3
4 # Name this script something like shft.sh,
5 #+ and invoke it with some parameters.
6 #+ For example:
7 #           sh shft.sh a b c def 83 barndoor
8
9 until [ -z "$1" ] # Until all parameters used up . . .
10 do
11     echo -n "$1 "
12     shift
13 done
14
15 echo           # Extra linefeed.
16
17 # But, what happens to the "used-up" parameters?
18 echo "$2"
19 # Nothing echoes!
20 # When $2 shifts into $1 (and there is no $3 to shift into $2)
21 #+ then $2 remains empty.
22 # So, it is not a parameter *copy*, but a *move*.
23
24 exit
25
26 # See also the echo-params.sh script for a "shiftless"
27 #+ alternative method of stepping through the positional params.
```

The **shift** command can take a numerical parameter indicating how many positions to shift.

```
1 #!/bin/bash
2 # shift-past.sh
3
4 shift 3      # Shift 3 positions.
5 # n=3; shift $n
6 # Has the same effect.
7
8 echo "$1"
9
10 exit 0
11
12 # ===== #
13
```

```

14
15 $ sh shift-past.sh 1 2 3 4 5
16 4
17
18 # However, as Eleni Fragkiadaki, points out,
19 #+ attempting a 'shift' past the number of
20 #+ positional parameters ($#) returns an exit status of 1,
21 #+ and the positional parameters themselves do not change.
22 # This means possibly getting stuck in an endless loop. . . .
23 # For example:
24 #     until [ -z "$1" ]
25 #     do
26 #         echo -n "$1 "
27 #         shift 20      # If less than 20 pos params,
28 #         done          #+ then loop never ends!
29 #
30 # When in doubt, add a sanity check. . . .
31 #         shift 20 || break
32 #             ^^^^^^^^

```



The **shift** command works in a similar fashion on parameters passed to a [function](#). See [Example 36-18](#).

Notes

- [1] Note that [functions also take positional parameters](#).
- [2] The process calling the script sets the \$0 parameter. By convention, this parameter is the name of the script. See the [manpage](#) (manual page) for **execv**.

From the *command-line*, however, \$0 is the name of the shell.

```

bash$ echo $0
bash

tcsh% echo $0
tcsh

```

- [3] If the the script is [sourced](#) or [symlinked](#), then this will not work. It is safer to check [\\$BASH_SOURCE](#).

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Chapter 5. Quoting

Quoting means just that, bracketing a string in quotes. This has the effect of protecting [special characters](#) in the string from reinterpretation or expansion by the shell or shell script. (A character is "special" if it has an interpretation other than its literal meaning. For example, the [asterisk](#) `*` represents a *wild card* character in [globbing](#) and [Regular Expressions](#)).

```
bash$ ls -l [Vv]*
-rw-rw-r-- 1 bozo bozo 324 Apr 2 15:05 VIEWDATA.BAT
-rw-rw-r-- 1 bozo bozo 507 May 4 14:25 vartrace.sh
-rw-rw-r-- 1 bozo bozo 539 Apr 14 17:11 viewdata.sh

bash$ ls -l '[Vv]*'
ls: [Vv]*: No such file or directory
```

In everyday speech or writing, when we "quote" a phrase, we set it apart and give it special meaning. In a Bash script, when we *quote* a string, we set it apart and protect its *literal* meaning.

Certain programs and utilities reinterpret or expand special characters in a quoted string. An important use of quoting is protecting a command-line parameter from the shell, but still letting the calling program expand it.

```
bash$ grep '[Ff]irst' *.txt
file1.txt:This is the first line of file1.txt.
file2.txt:This is the First line of file2.txt.
```

Note that the unquoted `grep [Ff]irst *.txt` works under the Bash shell. [\[1\]](#)

Quoting can also suppress [echo's](#) "appetite" for newlines.

```
bash$ echo $(ls -l)
total 8 -rw-rw-r-- 1 bo bo 13 Aug 21 12:57 t.sh -rw-rw-r-- 1 bo bo 78 Aug 21 12:57 u.sh

bash$ echo "$(ls -l)"
total 8
-rw-rw-r-- 1 bo bo 13 Aug 21 12:57 t.sh
-rw-rw-r-- 1 bo bo 78 Aug 21 12:57 u.sh
```


5.1. Quoting Variables


When referencing a variable, it is generally advisable to enclose its name in double quotes. This prevents reinterpretation of all special characters within the quoted string -- except \$, ` (backquote), and \ (escape). [2] Keeping \$ as a special character within double quotes permits referencing a quoted variable ("*\$variable*"), that is, replacing the variable with its value (see [Example 4-1](#), above).

Use double quotes to prevent word splitting. [3] An argument enclosed in double quotes presents itself as a single word, even if it contains [whitespace](#) separators.

```
1 List="one two three"
2
3 for a in $List      # Splits the variable in parts at whitespace.
4 do
5   echo "$a"
6 done
7 # one
8 # two
9 # three
10
11 echo "---"
12
13 for a in "$List"   # Preserves whitespace in a single variable.
14 do #           ^   ^
15   echo "$a"
16 done
17 # one two three
```

A more elaborate example:

```
1 variable1="a variable containing five words"
2 COMMAND This is $variable1      # Executes COMMAND with 7 arguments:
3 # "This" "is" "a" "variable" "containing" "five" "words"
4
5 COMMAND "This is $variable1"    # Executes COMMAND with 1 argument:
6 # "This is a variable containing five words"
7
8
9 variable2=""                   # Empty.
10
11 COMMAND $variable2 $variable2 $variable2
12 # Executes COMMAND with no arguments.
13 COMMAND "$variable2" "$variable2" "$variable2"
14 # Executes COMMAND with 3 empty arguments.
15 COMMAND "$variable2 $variable2 $variable2"
16 # Executes COMMAND with 1 argument (2 spaces).
17
18 # Thanks, Stéphane Chazelas.
```

 Enclosing the arguments to an **echo** statement in double quotes is necessary only when word splitting or preservation of [whitespace](#) is an issue.

Example 5-1. Echoing Weird Variables


```
1 #!/bin/bash
2 # weirdvars.sh: Echoing weird variables.
3
4 echo
5
```

```

6 var="([\]\{\}\$\"
7 echo $var      # '([\]\{\}$"
8 echo "$var"    # '([\]\{\}$"    Doesn't make a difference.
9
10 echo
11
12 IFS='\ '
13 echo $var      # '([\ ]{\}$"    \ converted to space. Why?
14 echo "$var"    # '([\]\{\}$"
15
16 # Examples above supplied by Stephane Chazelas.
17
18 echo
19
20 var2="\\\\\\\"
21 echo $var2     # "
22 echo "$var2"   # \\
23 echo
24 # But ... var2="\\\\\\\" is illegal. Why?
25 var3='\\\\\\'
26 echo "$var3"   # \\\\
27 # Strong quoting works, though.
28
29
30 # ***** #
31 # As the first example above shows, nesting quotes is permitted.
32
33 echo "$(echo '')" # "
34 #   ^           ^
35
36
37 # At times this comes in useful.
38
39 var1="Two bits"
40 echo "\$var1 = \"$var1\"" # $var1 = Two bits
41 #   ^                 ^
42
43 # Or, as Chris Hiestand points out ...
44
45 if [[ "$(du "$My_File1")" -gt "$(du "$My_File2")" ]]
46 #   ^         ^         ^ ^         ^         ^         ^ ^
47 then
48   ...
49 fi
50 # ***** #

```

Single quotes (') operate similarly to double quotes, but do not permit referencing variables, since the special meaning of \$ is turned off. Within single quotes, *every* special character except ' gets interpreted literally. Consider single quotes ("full quoting") to be a stricter method of quoting than double quotes ("partial quoting").

 Since even the escape character (\) gets a literal interpretation within single quotes, trying to enclose a single quote within single quotes will not yield the expected result.

```

1 echo "Why can't I write 's between single quotes"
2
3 echo
4
5 # The roundabout method.
6 echo 'Why can\'\'t I write \''\'s between single quotes'
7 # |-----| |-----| |-----|
8 # Three single-quoted strings, with escaped and quoted single quotes between.
9

```

Notes

[1] Unless there is a file named `first` in the current working directory. Yet another reason to *quote*. (Thank you, Harald Koenig, for pointing this out.)

[2] Encapsulating `!"` within double quotes gives an error when used *from the command line*. This is interpreted as a [history command](#). Within a script, though, this problem does not occur, since the Bash history mechanism is disabled then.

Of more concern is the *apparently* inconsistent behavior of `\` within double quotes, and especially following an `echo -e` command.

```
bash$ echo hello\!
hello!
bash$ echo "hello\!"
hello\!

bash$ echo \
>
bash$ echo "\
>
bash$ echo \a
a
bash$ echo "\a"
\a

bash$ echo x\ty
xty
bash$ echo "x\ty"
x\ty

bash$ echo -e x\ty
xty
bash$ echo -e "x\ty"
x      y
```

Double quotes following an *echo* sometimes escape `\`. Moreover, the `-e` option to *echo* causes the `"\t"` to be interpreted as a *tab*.

(Thank you, Wayne Pollock, for pointing this out, and Geoff Lee and Daniel Barclay for explaining it.)

[3] "Word splitting," in this context, means dividing a character string into separate and discrete arguments.

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5.2. Escaping

Escaping is a method of quoting single characters. The escape (`\`) preceding a character tells the shell to interpret that character literally.

 With certain commands and utilities, such as [echo](#) and [sed](#), escaping a character may have the opposite effect - it can toggle on a special meaning for that character.

Special meanings of certain escaped characters

used with **echo** and **sed**

`\n`

means newline

`\r`

means return

`\t`

means tab

`\v`

means vertical tab

`\b`

means backspace

`\a`

means *alert* (beep or flash)

`\0xx`

translates to the octal [ASCII](#) equivalent of `0nn`, where `nn` is a string of digits



The `$' . . . '` [quoted](#) string-expansion construct is a mechanism that uses escaped octal or hex values to assign ASCII characters to variables, e.g., `quote=$'\042'`.

Example 5-2. Escaped Characters

```
1 #!/bin/bash
2 # escaped.sh: escaped characters
3
4 #####
5 ### First, let's show some basic escaped-character usage. ###
6 #####
7
8 # Escaping a newline.
9 # -----
10
11 echo ""
12
13 echo "This will print
14 as two lines."
15 # This will print
16 # as two lines.
17
18 echo "This will print \
19 as one line."
20 # This will print as one line.
21
22 echo; echo
23
24 echo "======"
25
```

```

26
27 echo "\v\v\v\v"      # Prints \v\v\v\v literally.
28 # Use the -e option with 'echo' to print escaped characters.
29 echo "======"
30 echo "VERTICAL TABS"
31 echo -e "\v\v\v\v"   # Prints 4 vertical tabs.
32 echo "======"
33
34 echo "QUOTATION MARK"
35 echo -e "\042"       # Prints " (quote, octal ASCII character 42).
36 echo "======"
37
38
39
40 # The '$\X' construct makes the -e option unnecessary.
41
42 echo; echo "NEWLINE and (maybe) BEEP"
43 echo $\n'           # Newline.
44 echo $\a'           # Alert (beep).
45                     # May only flash, not beep, depending on terminal.
46
47 # We have seen $\nnn" string expansion, and now . . .
48
49 # ===== #
50 # Version 2 of Bash introduced the $\nnn' string expansion construct.
51 # ===== #
52
53 echo "Introducing the $\' ... \' string-expansion construct . . ."
54 echo ". . . featuring more quotation marks."
55
56 echo $\t \042 \t'   # Quote (") framed by tabs.
57 # Note that '\nnn' is an octal value.
58
59 # It also works with hexadecimal values, in an $\xhhh' construct.
60 echo $\t \x22 \t'   # Quote (") framed by tabs.
61 # Thank you, Greg Keraunen, for pointing this out.
62 # Earlier Bash versions allowed '\x022'.
63
64 echo
65
66
67 # Assigning ASCII characters to a variable.
68 # -----
69 quote=$'\042'       # " assigned to a variable.
70 echo "$quote Quoted string $quote and this lies outside the quotes."
71
72 echo
73
74 # Concatenating ASCII chars in a variable.
75 triple_underline=$'\137\137\137' # 137 is octal ASCII code for '_'.
76 echo "$triple_underline UNDERLINE $triple_underline"
77
78 echo
79
80 ABC=$'\101\102\103\010'          # 101, 102, 103 are octal A, B, C.
81 echo $ABC
82
83 echo
84
85 escape=$'\033'                 # 033 is octal for escape.
86 echo "\"escape\" echoes as $escape"
87 #                               no visible output.
88
89 echo
90
91 exit 0

```

A more elaborate example:

Example 5-3. Detecting key-presses

```
1 #!/bin/bash
2 # Author: Sigurd Solaas, 20 Apr 2011
3 # Used in ABS Guide with permission.
4 # Requires version 4.2+ of Bash.
5
6 key="no value yet"
7 while true; do
8     clear
9     echo "Bash Extra Keys Demo. Keys to try:"
10    echo
11    echo "* Insert, Delete, Home, End, Page_Up and Page_Down"
12    echo "* The four arrow keys"
13    echo "* Tab, enter, escape, and space key"
14    echo "* The letter and number keys, etc."
15    echo
16    echo "    d = show date/time"
17    echo "    q = quit"
18    echo "===== "
19    echo
20
21    # Convert the separate home-key to home-key_num_7:
22    if [ "$key" = $'\x1b\x4f\x48' ]; then
23        key=$'\x1b\x5b\x31\x7e'
24        # Quoted string-expansion construct.
25    fi
26
27    # Convert the separate end-key to end-key_num_1.
28    if [ "$key" = $'\x1b\x4f\x46' ]; then
29        key=$'\x1b\x5b\x34\x7e'
30    fi
31
32    case "$key" in
33        $'\x1b\x5b\x32\x7e') # Insert
34            echo Insert Key
35            ;;
36        $'\x1b\x5b\x33\x7e') # Delete
37            echo Delete Key
38            ;;
39        $'\x1b\x5b\x31\x7e') # Home_key_num_7
40            echo Home Key
41            ;;
42        $'\x1b\x5b\x34\x7e') # End_key_num_1
43            echo End Key
44            ;;
45        $'\x1b\x5b\x35\x7e') # Page_Up
46            echo Page_Up
47            ;;
48        $'\x1b\x5b\x36\x7e') # Page_Down
49            echo Page_Down
50            ;;
51        $'\x1b\x5b\x41') # Up_arrow
52            echo Up arrow
53            ;;
54        $'\x1b\x5b\x42') # Down_arrow
55            echo Down arrow
56            ;;
57        $'\x1b\x5b\x43') # Right_arrow
58            echo Right arrow
```

```

59 ;;
60 $'\x1b\x5b\x44') # Left_arrow
61     echo Left arrow
62 ;;
63 $'\x09') # Tab
64     echo Tab Key
65 ;;
66 $'\x0a') # Enter
67     echo Enter Key
68 ;;
69 $'\x1b') # Escape
70     echo Escape Key
71 ;;
72 $'\x20') # Space
73     echo Space Key
74 ;;
75 d)
76     date
77 ;;
78 q)
79     echo Time to quit...
80     echo
81     exit 0
82 ;;
83 *)
84     echo You pressed: \"$key\"
85 ;;
86 esac
87
88 echo
89 echo "====="
90
91 unset K1 K2 K3
92 read -s -N1 -p "Press a key: "
93 K1="$REPLY"
94 read -s -N2 -t 0.001
95 K2="$REPLY"
96 read -s -N1 -t 0.001
97 K3="$REPLY"
98 key="$K1$K2$K3"
99
100 done
101
102 exit $?

```

See also [Example 37-1](#).

"

gives the quote its literal meaning

```

1 echo "Hello" # Hello
2 echo "\"Hello\" ... he said." # "Hello" ... he said.

```

\\$

gives the dollar sign its literal meaning (variable name following \\$ will not be referenced)

```

1 echo "\$variable01" # $variable01
2 echo "The book cost \$7.98." # The book cost $7.98.

```

\\

gives the backslash its literal meaning

```

1 echo "\\\" # Results in \
2
3 # Whereas . . .
4

```



```

5 echo "\" # Invokes secondary prompt from the command-line.
6           # In a script, gives an error message.
7
8 # However . . .
9
10 echo '\\' # Results in \

```



The behavior of `\` depends on whether it is escaped, [strong-quoted](#), [weak-quoted](#), or appearing within [command substitution](#) or a [here document](#).

```

1           # Simple escaping and quoting
2 echo \z           # z
3 echo \\z          # \z
4 echo '\z'         # \z
5 echo '\\z'        # \\z
6 echo "\"z"        # \z
7 echo "\\z"        # \z
8
9           # Command substitution
10 echo `echo \z`    # z
11 echo `echo \\z`  # z
12 echo `echo \\z`  # \z
13 echo `echo \\z`  # \z
14 echo `echo \\z`  # \z
15 echo `echo \\z`  # \z
16 echo `echo "\z"` # \z
17 echo `echo "\\z"` # \z
18
19           # Here document
20 cat <<EOF
21 \z
22 EOF              # \z
23
24 cat <<EOF
25 \\z
26 EOF              # \z
27
28 # These examples supplied by Stéphane Chazelas.

```

Elements of a string assigned to a variable may be escaped, but the escape character alone may not be assigned to a variable.

```

1 variable=\
2 echo "$variable"
3 # Will not work - gives an error message:
4 # test.sh: : command not found
5 # A "naked" escape cannot safely be assigned to a variable.
6 #
7 # What actually happens here is that the "\" escapes the newline and
8 #+ the effect is          variable=echo "$variable"
9 #+                          invalid variable assignment
10
11 variable=\
12 23skidoo
13 echo "$variable"          # 23skidoo
14                           # This works, since the second line
15                           #+ is a valid variable assignment.
16
17 variable=\
18 #          \^  escape followed by space
19 echo "$variable"          # space
20
21 variable=\\
22 echo "$variable"          # \
23

```

```

24 variable=\\
25 echo "$variable"
26 # Will not work - gives an error message:
27 # test.sh: \: command not found
28 #
29 # First escape escapes second one, but the third one is left "naked",
30 #+ with same result as first instance, above.
31
32 variable=\\\
33 echo "$variable"          # \
34                          # Second and fourth escapes escaped.
35                          # This is o.k.

```

Escaping a space can prevent word splitting in a command's argument list.

```

1 file_list="/bin/cat /bin/gzip /bin/more /usr/bin/less /usr/bin/emacs-20.7"
2 # List of files as argument(s) to a command.
3
4 # Add two files to the list, and list all.
5 ls -l /usr/X11R6/bin/xsetroot /sbin/dump $file_list
6
7 echo "-----"
8
9 # What happens if we escape a couple of spaces?
10 ls -l /usr/X11R6/bin/xsetroot\ /sbin/dump\ $file_list
11 # Error: the first three files concatenated into a single argument to 'ls -l'
12 # because the two escaped spaces prevent argument (word) splitting.

```

The escape also provides a means of writing a multi-line command. Normally, each separate line constitutes a different command, but an escape at the end of a line *escapes the newline character*, and the command sequence continues on to the next line.

```

1 (cd /source/directory && tar cf - . ) | \
2 (cd /dest/directory && tar xpvf -)
3 # Repeating Alan Cox's directory tree copy command,
4 # but split into two lines for increased legibility.
5
6 # As an alternative:
7 tar cf - -C /source/directory . |
8 tar xpvf - -C /dest/directory
9 # See note below.
10 # (Thanks, Stéphane Chazelas.)

```



If a script line ends with a |, a pipe character, then a \, an escape, is not strictly necessary. It is, however, good programming practice to always escape the end of a line of code that continues to the following line.

```

1 echo "foo
2 bar"
3 #foo
4 #bar
5
6 echo
7
8 echo 'foo
9 bar'      # No difference yet.
10 #foo
11 #bar
12
13 echo
14
15 echo foo\
16 bar      # Newline escaped.
17 #foobar

```

```
18
19 echo
20
21 echo "foo\
22 bar"      # Same here, as \ still interpreted as escape within weak quotes.
23 #foobar
24
25 echo
26
27 echo 'foo\
28 bar'      # Escape character \ taken literally because of strong quoting.
29 #foo\
30 #bar
31
32 # Examples suggested by Stéphane Chazelas.
```

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Chapter 6. Exit and Exit Status


... there are dark corners in the Bourne shell, and people use all of them.

--Chet Ramey

The **exit** command terminates a script, just as in a C program. It can also return a value, which is available to the script's parent process.

Every command returns an *exit status* (sometimes referred to as a *return status* or *exit code*). A successful command returns a 0, while an unsuccessful one returns a non-zero value that usually can be interpreted as an *error code*. Well-behaved UNIX commands, programs, and utilities return a 0 exit code upon successful completion, though there are some exceptions.

Likewise, [functions](#) within a script and the script itself return an exit status. The last command executed in the function or script determines the exit status. Within a script, an **exit nnn** command may be used to deliver an *nnn* exit status to the shell (*nnn* must be an integer in the 0 - 255 range).

 When a script ends with an **exit** that has no parameter, the exit status of the script is the exit status of the last command executed in the script (previous to the **exit**).

```
1 #!/bin/bash
2
3 COMMAND_1
4
5 . . .
6
7 COMMAND_LAST
8
9 # Will exit with status of last command.
10
11 exit
```

The equivalent of a bare **exit** is **exit \$?** or even just omitting the **exit**.

```
1 #!/bin/bash
2
3 COMMAND_1
4
5 . . .
6
7 COMMAND_LAST
8
9 # Will exit with status of last command.
10
11 exit $?
```

```
1 #!/bin/bash
2
3 COMMAND1
4
5 . . .
6
7 COMMAND_LAST
8
9 # Will exit with status of last command.
```

`$?` reads the exit status of the last command executed. After a function returns, `$?` gives the exit status of the last command executed in the function. This is Bash's way of giving functions a "return value." [\[1\]](#)

Following the execution of a [pipe](#), a `$?` gives the exit status of the last command executed.

After a script terminates, a `$?` from the command-line gives the exit status of the script, that is, the last command executed in the script, which is, by convention, `0` on success or an integer in the range `1 - 255` on error.

Example 6-1. exit / exit status

```
1 #!/bin/bash
2
3 echo hello
4 echo $?      # Exit status 0 returned because command executed successfully.
5
6 lskdf       # Unrecognized command.
7 echo $?     # Non-zero exit status returned -- command failed to execute.
8
9 echo
10
11 exit 113    # Will return 113 to shell.
12            # To verify this, type "echo $?" after script terminates.
13
14 # By convention, an 'exit 0' indicates success,
15 #+ while a non-zero exit value means an error or anomalous condition.
16 # See the "Exit Codes With Special Meanings" appendix.
```

[\\$?](#) is especially useful for testing the result of a command in a script (see [Example 16-35](#) and [Example 16-20](#)).



The `!`, the *logical not* qualifier, reverses the outcome of a test or command, and this affects its [exit status](#).

Example 6-2. Negating a condition using !

```
1 true      # The "true" builtin.
2 echo "exit status of \"true\" = $?"      # 0
3
4 ! true
5 echo "exit status of \"! true\" = $?"      # 1
6 # Note that the "!" needs a space between it and the command.
7 # !true leads to a "command not found" error
8 #
9 # The "!!" operator prefixing a command invokes the Bash history mechanism.
10
11 true
12 !true
13 # No error this time, but no negation either.
14 # It just repeats the previous command (true).
15
16
17 # ===== #
18 # Preceding a _pipe_ with ! inverts the exit status returned.
19 ls | bogus_command      # bash: bogus_command: command not found
20 echo $?                # 127
21
22 ! ls | bogus_command    # bash: bogus_command: command not found
23 echo $?                # 0
24 # Note that the ! does not change the execution of the pipe.
25 # Only the exit status changes.
```

```
26 # ===== #
27
28 # Thanks, Stéphane Chazelas and Kristopher Newsome.
```

 Certain exit status codes have [reserved meanings](#) and should not be user-specified in a script.

Notes

[1] In those instances when there is no [return](#) terminating the function.

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Chapter 7. Tests

Every reasonably complete programming language can test for a condition, then act according to the result of the test. Bash has the [test](#) command, various [bracket](#) and [parenthesis](#) operators, and the **if/then** construct.


7.1. Test Constructs

- An **if/then** construct tests whether the [exit status](#) of a list of commands is 0 (since 0 means "success" by UNIX convention), and if so, executes one or more commands.
- There exists a dedicated command called `[` ([left bracket](#) special character). It is a synonym for **test**, and a [builtin](#) for efficiency reasons. This command considers its arguments as comparison expressions or file tests and returns an exit status corresponding to the result of the comparison (0 for true, 1 for false).
- With version 2.02, Bash introduced the `[[...]]` *extended test command*, which performs comparisons in a manner more familiar to programmers from other languages. Note that `[[` is a [keyword](#), not a command.

Bash sees `[[$a -lt $b]]` as a single element, which returns an exit status.

- The `((...))` and `let...` constructs return an [exit status](#), according to whether the arithmetic expressions they evaluate expand to a non-zero value. These [arithmetic-expansion](#) constructs may therefore be used to perform [arithmetic comparisons](#).

```
1 (( 0 && 1 ))          # Logical AND
2 echo $?              # 1      ***
3 # And so ...
4 let "num = (( 0 && 1 ))"
5 echo $num            # 0
6 # But ...
7 let "num = (( 0 && 1 ))"
8 echo $?              # 1      ***
9
10
11 (( 200 || 11 ))     # Logical OR
12 echo $?              # 0      ***
13 # ...
14 let "num = (( 200 || 11 ))"
15 echo $num            # 1
16 let "num = (( 200 || 11 ))"
17 echo $?              # 0      ***
18
19
20 (( 200 | 11 ))      # Bitwise OR
21 echo $?              # 0      ***
22 # ...
23 let "num = (( 200 | 11 ))"
24 echo $num            # 203
25 let "num = (( 200 | 11 ))"
26 echo $?              # 0      ***
27
28 # The "let" construct returns the same exit status
29 #+ as the double-parentheses arithmetic expansion.
```

 Again, note that the *exit status* of an arithmetic expression is *not* an error value.

```
1 var=-2 && (( var+=2 ))
2 echo $?              # 1
3
4 var=-2 && (( var+=2 )) && echo $var
5                      # Will not echo $var!
```

- An **if** can test any command, not just conditions enclosed within brackets.

```
1 if cmp a b &> /dev/null # Suppress output.
```

```

2 then echo "Files a and b are identical."
3 else echo "Files a and b differ."
4 fi
5
6 # The very useful "if-grep" construct:
7 # -----
8 if grep -q Bash file
9 then echo "File contains at least one occurrence of Bash."
10 fi
11
12 word=Linux
13 letter_sequence=inu
14 if echo "$word" | grep -q "$letter_sequence"
15 # The "-q" option to grep suppresses output.
16 then
17     echo "$letter_sequence found in $word"
18 else
19     echo "$letter_sequence not found in $word"
20 fi
21
22
23 if COMMAND_WHOSE_EXIT_STATUS_IS_0_UNLESS_ERROR_OCCURRED
24 then echo "Command succeeded."
25 else echo "Command failed."
26 fi

```

• *These last two examples courtesy of Stéphane Chazelas.*

Example 7-1. What is truth?

```

1 #!/bin/bash
2
3 # Tip:
4 # If you're unsure how a certain condition might evaluate,
5 #+ test it in an if-test.
6
7 echo
8
9 echo "Testing \"0\""
10 if [ 0 ] # zero
11 then
12     echo "0 is true."
13 else # Or else ...
14     echo "0 is false."
15 fi # 0 is true.
16
17 echo
18
19 echo "Testing \"1\""
20 if [ 1 ] # one
21 then
22     echo "1 is true."
23 else
24     echo "1 is false."
25 fi # 1 is true.
26
27 echo
28
29 echo "Testing \"-1\""
30 if [ -1 ] # minus one
31 then
32     echo "-1 is true."
33 else
34     echo "-1 is false."
35 fi # -1 is true.

```

```
36
37 echo
38
39 echo "Testing \"NULL\""
40 if [ ]          # NULL (empty condition)
41 then
42   echo "NULL is true."
43 else
44   echo "NULL is false."
45 fi              # NULL is false.
46
47 echo
48
49 echo "Testing \"xyz\""
50 if [ xyz ]      # string
51 then
52   echo "Random string is true."
53 else
54   echo "Random string is false."
55 fi              # Random string is true.
56
57 echo
58
59 echo "Testing \"\$xyz\""
60 if [ $xyz ]     # Tests if $xyz is null, but...
61                 # it's only an uninitialized variable.
62 then
63   echo "Uninitialized variable is true."
64 else
65   echo "Uninitialized variable is false."
66 fi              # Uninitialized variable is false.
67
68 echo
69
70 echo "Testing \"-n \$xyz\""
71 if [ -n "$xyz" ] # More pedantically correct.
72 then
73   echo "Uninitialized variable is true."
74 else
75   echo "Uninitialized variable is false."
76 fi              # Uninitialized variable is false.
77
78 echo
79
80
81 xyz=            # Initialized, but set to null value.
82
83 echo "Testing \"-n \$xyz\""
84 if [ -n "$xyz" ]
85 then
86   echo "Null variable is true."
87 else
88   echo "Null variable is false."
89 fi              # Null variable is false.
90
91
92 echo
93
94
95 # When is "false" true?
96
97 echo "Testing \"false\""
98 if [ "false" ]  # It seems that "false" is just a string ...
99 then
100  echo "\"false\" is true." #+ and it tests true.
101 else
```

```

102 echo "\"false\" is false."
103 fi          # "false" is true.
104
105 echo
106
107 echo "Testing \"\$false\"" # Again, uninitialized variable.
108 if [ "$false" ]
109 then
110     echo "\"\$false\" is true."
111 else
112     echo "\"\$false\" is false."
113 fi          # "$false" is false.
114            # Now, we get the expected result.
115
116 # What would happen if we tested the uninitialized variable "$true"?
117
118 echo
119
120 exit 0


```

Exercise. Explain the behavior of [Example 7-1](#), above.

```

1 if [ condition-true ]
2 then
3     command 1
4     command 2
5     ...
6 else # Or else ...
7     # Adds default code block executing if original condition tests false.
8     command 3
9     command 4
10    ...
11 fi

```

 When *if* and *then* are on same line in a condition test, a semicolon must terminate the *if* statement. Both *if* and *then* are [keywords](#). Keywords (or commands) begin statements, and before a new statement on the same line begins, the old one must terminate.

```
1 if [ -x "$filename" ]; then
```

Else if and elif

elif

elif is a contraction for *else if*. The effect is to nest an inner if/then construct within an outer one.

```

1 if [ condition1 ]
2 then
3     command1
4     command2
5     command3
6 elif [ condition2 ]
7 # Same as else if
8 then
9     command4
10    command5
11 else
12    default-command
13 fi

```

The **if test condition-true** construct is the exact equivalent of **if [condition-true]**. As it happens, the left bracket, **[**, is a [token \[1\]](#) which invokes the **test** command. The closing right bracket, **]**, in an if/test should not therefore be strictly necessary, however newer versions of Bash require it.



The `test` command is a Bash [builtin](#) which tests file types and compares strings. Therefore, in a Bash script, `test` does *not* call the external `/usr/bin/test` binary, which is part of the `sh-utils` package. Likewise, `[` does not call `/usr/bin/[`, which is linked to `/usr/bin/test`.

```
bash$ type test
test is a shell builtin
bash$ type '['
[ is a shell builtin
bash$ type '['
[[ is a shell keyword
bash$ type ']'
]] is a shell keyword
bash$ type ']'
bash: type: ]: not found
```

If, for some reason, you wish to use `/usr/bin/test` in a Bash script, then specify it by full pathname.

Example 7-2. Equivalence of `test`, `/usr/bin/test`, `[]`, and `/usr/bin/[`

```
1 #!/bin/bash
2
3 echo
4
5 if test -z "$1"
6 then
7     echo "No command-line arguments."
8 else
9     echo "First command-line argument is $1."
10 fi
11
12 echo
13
14 if /usr/bin/test -z "$1"           # Equivalent to "test" builtin.
15 # ^^^^^^^^^^^^^^^^^             # Specifying full pathname.
16 then
17     echo "No command-line arguments."
18 else
19     echo "First command-line argument is $1."
20 fi
21
22 echo
23
24 if [ -z "$1" ]                   # Functionally identical to above code blocks.
25 #   if [ -z "$1"                 # should work, but...
26 #+ Bash responds to a missing close-bracket with an error message.
27 then
28     echo "No command-line arguments."
29 else
30     echo "First command-line argument is $1."
31 fi
32
33 echo
34
35
36 if /usr/bin/[ -z "$1" ]          # Again, functionally identical to above.
37 # if /usr/bin/[ -z "$1"         # Works, but gives an error message.
38 #                               # Note:
39 #                               # This has been fixed in Bash, version 3.x.
40 then
41     echo "No command-line arguments."
```

```

42 else
43     echo "First command-line argument is $1."
44 fi
45
46 echo
47
48 exit 0

```

The `[[]]` construct is the more versatile Bash version of `[]`. This is the *extended test command*, adopted from *ksh88*.

No filename expansion or word splitting takes place between `[[` and `]]`, but there is parameter expansion and command substitution.

```

1 file=/etc/passwd
2
3 if [[ -e $file ]]
4 then
5     echo "Password file exists."
6 fi

```

Using the `[[...]]` test construct, rather than `[...]` can prevent many logic errors in scripts. For example, the `&&`, `||`, `<`, and `>` operators work within a `[[]]` test, despite giving an error within a `[]` construct.

Arithmetic evaluation of octal / hexadecimal constants takes place automatically within a `[[...]]` construct.

```

1 # [[ Octal and hexadecimal evaluation ]]
2 # Thank you, Moritz Gronbach, for pointing this out.
3
4
5 decimal=15
6 octal=017    # = 15 (decimal)
7 hex=0x0f    # = 15 (decimal)
8
9 if [ "$decimal" -eq "$octal" ]
10 then
11     echo "$decimal equals $octal"
12 else
13     echo "$decimal is not equal to $octal"          # 15 is not equal to 017
14 fi          # Doesn't evaluate within [ single brackets ]!
15
16
17 if [[ "$decimal" -eq "$octal" ]]
18 then
19     echo "$decimal equals $octal"                  # 15 equals 017
20 else
21     echo "$decimal is not equal to $octal"
22 fi          # Evaluates within [[ double brackets ]]!
23
24 if [[ "$decimal" -eq "$hex" ]]
25 then
26     echo "$decimal equals $hex"                    # 15 equals 0x0f
27 else
28     echo "$decimal is not equal to $hex"
29 fi          # [[ $hexadecimal ]] also evaluates!

```



Following an **if**, neither the **test** command nor the test brackets (`[]` or `[[]]`) are strictly necessary.


```

1 dir=/home/bozo
2
3 if cd "$dir" 2>/dev/null; then # "2>/dev/null" hides error message.
4   echo "Now in $dir."
5 else
6   echo "Can't change to $dir."
7 fi

```

The "if COMMAND" construct returns the exit status of COMMAND.

Similarly, a condition within test brackets may stand alone without an **if**, when used in combination with a [list construct](#).

```

1 var1=20
2 var2=22
3 [ "$var1" -ne "$var2" ] && echo "$var1 is not equal to $var2"
4
5 home=/home/bozo
6 [ -d "$home" ] || echo "$home directory does not exist."

```

The [\(\(\)\) construct](#) expands and evaluates an arithmetic expression. If the expression evaluates as zero, it returns an [exit status](#) of 1, or "false". A non-zero expression returns an exit status of 0, or "true". This is in marked contrast to using the **test** and **[]** constructs previously discussed.

Example 7-3. Arithmetic Tests using (())

```

1 #!/bin/bash
2 # arith-tests.sh
3 # Arithmetic tests.
4
5 # The (( ... )) construct evaluates and tests numerical expressions.
6 # Exit status opposite from [ ... ] construct!
7
8 (( 0 ))
9 echo "Exit status of \"(( 0 ))\" is $?." # 1
10
11 (( 1 ))
12 echo "Exit status of \"(( 1 ))\" is $?." # 0
13
14 (( 5 > 4 )) # true
15 echo "Exit status of \"(( 5 > 4 ))\" is $?." # 0
16
17 (( 5 > 9 )) # false
18 echo "Exit status of \"(( 5 > 9 ))\" is $?." # 1
19
20 (( 5 == 5 )) # true
21 echo "Exit status of \"(( 5 == 5 ))\" is $?." # 0
22 # (( 5 = 5 )) gives an error message.
23
24 (( 5 - 5 )) # 0
25 echo "Exit status of \"(( 5 - 5 ))\" is $?." # 1
26
27 (( 5 / 4 )) # Division o.k.
28 echo "Exit status of \"(( 5 / 4 ))\" is $?." # 0
29
30 (( 1 / 2 )) # Division result < 1.
31 echo "Exit status of \"(( 1 / 2 ))\" is $?." # Rounded off to 0.
32 # 1
33
34 (( 1 / 0 )) 2>/dev/null # Illegal division by 0.
35 # ^^^^^^^^^^^
36 echo "Exit status of \"(( 1 / 0 ))\" is $?." # 1
37

```

```
38 # What effect does the ">/dev/null" have?
39 # What would happen if it were removed?
40 # Try removing it, then rerunning the script.
41
42 # ===== #
43
44 # (( ... )) also useful in an if-then test.
45
46 var1=5
47 var2=4
48
49 if (( var1 > var2 ))
50 then #^      ^      Note: Not $var1, $var2. Why?
51   echo "$var1 is greater than $var2"
52 fi      # 5 is greater than 4
53
54 exit 0
```

Notes

[1] A *token* is a symbol or short string with a special meaning attached to it (a [meta-meaning](#)). In Bash, certain tokens, such as `[` and `.(dot-command)`, may expand to *keywords* and commands.

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7.2. File test operators

Returns true if...

-e
file exists

-a
file exists

This is identical in effect to -e. It has been "deprecated," [\[1\]](#) and its use is discouraged.

-f
file is a *regular* file (not a directory or [device file](#))

-s
file is not zero size

-d
file is a directory

-b
file is a [block device](#)

-c
file is a [character device](#)

```
1 device0="/dev/sda2"    # /    (root directory)
2 if [ -b "$device0" ]
3 then
4     echo "$device0 is a block device."
5 fi
6
7 # /dev/sda2 is a block device.
8
9
10
11 device1="/dev/ttyS1"  # PCMCIA modem card.
12 if [ -c "$device1" ]
13 then
14     echo "$device1 is a character device."
15 fi
16
17 # /dev/ttyS1 is a character device.
```

-p
file is a [pipe](#)

```
1 function show_input_type()
2 {
3     [ -p /dev/fd/0 ] && echo PIPE || echo STDIN
4 }
5
6 show_input_type "Input"           # STDIN
7 echo "Input" | show_input_type    # PIPE
8
9 # This example courtesy of Carl Anderson.
```

-h
file is a [symbolic link](#)

-L
file is a symbolic link

-S
file is a [socket](#)

-t

file ([descriptor](#)) is associated with a terminal device

This test option [may be used to check](#) whether the `stdin [-t 0]` or `stdout [-t 1]` in a given script is a terminal.

- r file has read permission (*for the user running the test*)
- w file has write permission (for the user running the test)
- x file has execute permission (for the user running the test)
- g set-group-id (sgid) flag set on file or directory

If a directory has the `sgid` flag set, then a file created within that directory belongs to the group that owns the directory, not necessarily to the group of the user who created the file. This may be useful for a directory shared by a workgroup.

- u set-user-id (suid) flag set on file

A binary owned by `root` with `set-user-id` flag set runs with `root` privileges, even when an ordinary user invokes it. [2] This is useful for executables (such as `pppd` and `cdrecord`) that need to access system hardware. Lacking the `suid` flag, these binaries could not be invoked by a *non-root* user.

```
-rwsr-xr-t 1 root 178236 Oct 2 2000 /usr/sbin/pppd
```

A file with the `suid` flag set shows an `s` in its permissions.

- k *sticky bit* set

Commonly known as the *sticky bit*, the `save-text-mode` flag is a special type of file permission. If a file has this flag set, that file will be kept in cache memory, for quicker access. [3] If set on a directory, it restricts write permission. Setting the sticky bit adds a `t` to the permissions on the file or directory listing. This restricts altering or deleting specific files in that directory to the owner of those files.

```
drwxrwxrwt 7 root 1024 May 19 21:26 tmp/
```

If a user does not own a directory that has the sticky bit set, but has write permission in that directory, she can only delete those files that she owns in it. This keeps users from inadvertently overwriting or deleting each other's files in a publicly accessible directory, such as `/tmp`. (The *owner* of the directory or `root` can, of course, delete or rename files there.)

- O you are owner of file
- G group-id of file same as yours
- N file modified since it was last read
- f1 -nt f2 file *f1* is newer than *f2*
- f1 -ot f2 file *f1* is older than *f2*
- f1 -ef f2

files *f1* and *f2* are hard links to the same file

!

"not" -- reverses the sense of the tests above (returns true if condition absent).

Example 7-4. Testing for broken links

```
1 #!/bin/bash
2 # broken-link.sh
3 # Written by Lee bigelow <ligelowbee@yahoo.com>
4 # Used in ABS Guide with permission.
5
6 # A pure shell script to find dead symlinks and output them quoted
7 #+ so they can be fed to xargs and dealt with :)
8 #+ eg. sh broken-link.sh /somedir /someotherdir|xargs rm
9 #
10 # This, however, is a better method:
11 #
12 # find "somedir" -type l -print0|\
13 # xargs -r0 file|\
14 # grep "broken symbolic"|
15 # sed -e 's/^\ |: *broken symbolic.*$/"/g'
16 #
17 #+ but that wouldn't be pure Bash, now would it.
18 # Caution: beware the /proc file system and any circular links!
19 #####
20
21
22 # If no args are passed to the script set directories-to-search
23 #+ to current directory. Otherwise set the directories-to-search
24 #+ to the args passed.
25 #####
26
27 [ $# -eq 0 ] && directories=`pwd` || directories=$@
28
29
30 # Setup the function linkchk to check the directory it is passed
31 #+ for files that are links and don't exist, then print them quoted.
32 # If one of the elements in the directory is a subdirectory then
33 #+ send that subdirectory to the linkcheck function.
34 #####
35
36 linkchk () {
37     for element in $1/*; do
38         [ -h "$element" -a ! -e "$element" ] && echo "\"$element\""
39         [ -d "$element" ] && linkchk $element
40         # Of course, '-h' tests for symbolic link, '-d' for directory.
41     done
42 }
43
44 # Send each arg that was passed to the script to the linkchk() function
45 #+ if it is a valid directory. If not, then print the error message
46 #+ and usage info.
47 #####
48 for directory in $directories; do
49     if [ -d $directory ]
50     then linkchk $directory
51     else
52         echo "$directory is not a directory"
53         echo "Usage: $0 dir1 dir2 ..."
54     fi
55 done
56
57 exit $?
```

[Example 31-1](#), [Example 11-8](#), [Example 11-3](#), [Example 31-3](#), and [Example A-1](#) also illustrate uses of the file test operators.

Notes

[1] Per the 1913 edition of *Webster's Dictionary*:

```
1 Deprecate
2 ...
3
4 To pray against, as an evil;
5 to seek to avert by prayer;
6 to desire the removal of;
7 to seek deliverance from;
8 to express deep regret for;
9 to disapprove of strongly.
```

[2] Be aware that *suid* binaries may open security holes. The *suid* flag has no effect on shell scripts.

[3] On Linux systems, the sticky bit is no longer used for files, only on directories.

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7.3. Other Comparison Operators

A *binary* comparison operator compares two variables or quantities. *Note that integer and string comparison use a different set of operators.*

integer comparison

-eq

is equal to

```
if [ "$a" -eq "$b" ]
```

-ne

is not equal to

```
if [ "$a" -ne "$b" ]
```

-gt

is greater than

```
if [ "$a" -gt "$b" ]
```

-ge

is greater than or equal to

```
if [ "$a" -ge "$b" ]
```

-lt

is less than

```
if [ "$a" -lt "$b" ]
```

-le

is less than or equal to

```
if [ "$a" -le "$b" ]
```

<

is less than (within [double parentheses](#))

```
(( "$a" < "$b" ))
```

<=

is less than or equal to (within double parentheses)

```
(( "$a" <= "$b" ))
```

>

is greater than (within double parentheses)

```
(( "$a" > "$b" ))
```

>=

is greater than or equal to (within double parentheses)

```
(( "$a" >= "$b" ))
```

string comparison

=

is equal to

```
if [ "$a" = "$b" ]
```

 Note the [whitespace](#) framing the =.

```
if [ "$a"="$b" ] is not equivalent to the above.
```

==

is equal to

```
if [ "$a" == "$b" ]
```

This is a synonym for =.



The == comparison operator behaves differently within a [double-brackets](#) test than within single brackets.

```
1 [[ $a == z* ]] # True if $a starts with an "z" (pattern matching).
2 [[ $a == "z*" ]] # True if $a is equal to z* (literal matching).
3
4 [ $a == z* ] # File globbing and word splitting take place.
5 [ "$a" == "z*" ] # True if $a is equal to z* (literal matching).
6
7 # Thanks, Stéphane Chazelas
```

!=

is not equal to

```
if [ "$a" != "$b" ]
```

This operator uses pattern matching within a [\[\[...\]\]](#) construct.

<

is less than, in [ASCII](#) alphabetical order

```
if [[ "$a" < "$b" ]]
```

```
if [ "$a" \< "$b" ]
```

Note that the "<" needs to be [escaped](#) within a [] construct.

>

is greater than, in ASCII alphabetical order

```
if [[ "$a" > "$b" ]]
```

```
if [ "$a" \> "$b" ]
```

Note that the ">" needs to be escaped within a [] construct.

See [Example 27-11](#) for an application of this comparison operator.

-z

string is *null*, that is, has zero length

```
1 String='' # Zero-length ("null") string variable.
2
3 if [ -z "$String" ]
4 then
5   echo "\$String is null."
6 else
7   echo "\$String is NOT null."
```



```
8 fi      # $String is null.
```

-n

string is not *null*.



The `-n` test requires that the string be quoted within the test brackets. Using an unquoted string with `! -z`, or even just the unquoted string alone within test brackets (see [Example 7-6](#)) normally works, however, this is an unsafe practice. *Always* quote a tested string. [1]

Example 7-5. Arithmetic and string comparisons

```
1 #!/bin/bash
2
3 a=4
4 b=5
5
6 # Here "a" and "b" can be treated either as integers or strings.
7 # There is some blurring between the arithmetic and string comparisons,
8 #+ since Bash variables are not strongly typed.
9
10 # Bash permits integer operations and comparisons on variables
11 #+ whose value consists of all-integer characters.
12 # Caution advised, however.
13
14 echo
15
16 if [ "$a" -ne "$b" ]
17 then
18     echo "$a is not equal to $b"
19     echo "(arithmetic comparison)"
20 fi
21
22 echo
23
24 if [ "$a" != "$b" ]
25 then
26     echo "$a is not equal to $b."
27     echo "(string comparison)"
28     #     "4" != "5"
29     # ASCII 52 != ASCII 53
30 fi
31
32 # In this particular instance, both "-ne" and "!=" work.
33
34 echo
35
36 exit 0
```

Example 7-6. Testing whether a string is *null*

```
1 #!/bin/bash
2 # str-test.sh: Testing null strings and unquoted strings,
3 #+ but not strings and sealing wax, not to mention cabbages and kings . . .
4
5 # Using if [ ... ]
6
7 # If a string has not been initialized, it has no defined value.
8 # This state is called "null" (not the same as zero!).
```

```

9
10 if [ -n $string1 ]      # string1 has not been declared or initialized.
11 then
12   echo "String \"string1\" is not null."
13 else
14   echo "String \"string1\" is null."
15 fi                      # Wrong result.
16 # Shows $string1 as not null, although it was not initialized.
17
18 echo
19
20 # Let's try it again.
21
22 if [ -n "$string1" ]    # This time, $string1 is quoted.
23 then
24   echo "String \"string1\" is not null."
25 else
26   echo "String \"string1\" is null."
27 fi                      # Quote strings within test brackets!
28
29 echo
30
31 if [ $string1 ]         # This time, $string1 stands naked.
32 then
33   echo "String \"string1\" is not null."
34 else
35   echo "String \"string1\" is null."
36 fi                      # This works fine.
37 # The [ ... ] test operator alone detects whether the string is null.
38 # However it is good practice to quote it (if [ "$string1" ]).
39 #
40 # As Stephane Chazelas points out,
41 #   if [ $string1 ]     has one argument, "]"
42 #   if [ "$string1" ]  has two arguments, the empty "$string1" and "]"
43
44
45 echo
46
47
48 string1=initialized
49
50 if [ $string1 ]         # Again, $string1 stands unquoted.
51 then
52   echo "String \"string1\" is not null."
53 else
54   echo "String \"string1\" is null."
55 fi                      # Again, gives correct result.
56 # Still, it is better to quote it ("string1"), because . . .
57
58
59 string1="a = b"
60
61 if [ $string1 ]         # Again, $string1 stands unquoted.
62 then
63   echo "String \"string1\" is not null."
64 else
65   echo "String \"string1\" is null."
66 fi                      # Not quoting "$string1" now gives wrong result!
67
68 exit 0      # Thank you, also, Florian Wisser, for the "heads-up".

```

Example 7-7. *zmore*

```

1 #!/bin/bash
2 # zmore
3
4 # View gzipped files with 'more' filter.
5
6 E_NOARGS=85
7 E_NOTFOUND=86
8 E_NOTGZIP=87
9
10 if [ $# -eq 0 ] # same effect as: if [ -z "$1" ]
11 # $1 can exist, but be empty: zmore "" arg2 arg3
12 then
13     echo "Usage: `basename $0` filename" >&2
14     # Error message to stderr.
15     exit $E_NOARGS
16     # Returns 85 as exit status of script (error code).
17 fi
18
19 filename=$1
20
21 if [ ! -f "$filename" ] # Quoting $filename allows for possible spaces.
22 then
23     echo "File $filename not found!" >&2 # Error message to stderr.
24     exit $E_NOTFOUND
25 fi
26
27 if [ ${filename##*.} != "gz" ]
28 # Using bracket in variable substitution.
29 then
30     echo "File $1 is not a gzipped file!"
31     exit $E_NOTGZIP
32 fi
33
34 zcat $1 | more
35
36 # Uses the 'more' filter.
37 # May substitute 'less' if desired.
38
39 exit $? # Script returns exit status of pipe.
40 # Actually "exit $?" is unnecessary, as the script will, in any case,
41 #+ return the exit status of the last command executed.

```

compound comparison

-a

logical and

exp1 -a exp2 returns true if *both* *exp1* and *exp2* are true.

-o

logical or

exp1 -o exp2 returns true if either *exp1* *or* *exp2* is true.

These are similar to the Bash comparison operators **&&** and **||**, used within [double brackets](#).

```
1 [[ condition1 && condition2 ]]
```


The **-o** and **-a** operators work with the [test](#) command or occur within single test brackets.

```

1 if [ "$expr1" -a "$expr2" ]
2 then
3     echo "Both expr1 and expr2 are true."
4 else

```

```
5 echo "Either expr1 or expr2 is false."
6 fi
```

 But, as *rihad* points out:

```
1 [ 1 -eq 1 ] && [ -n "`echo true 1>&2`" ] # true
2 [ 1 -eq 2 ] && [ -n "`echo true 1>&2`" ] # (no output)
3 # ^^^^^^^ False condition. So far, everything as expected.
4
5 # However ...
6 [ 1 -eq 2 -a -n "`echo true 1>&2`" ] # true
7 # ^^^^^^^ False condition. So, why "true" output?
8
9 # Is it because both condition clauses within brackets evaluate?
10 [[ 1 -eq 2 && -n "`echo true 1>&2`" ]] # (no output)
11 # No, that's not it.
12
13 # Apparently && and || "short-circuit" while -a and -o do not.
```

Refer to [Example 8-3](#), [Example 27-17](#), and [Example A-29](#) to see compound comparison operators in action.

Notes

- [1] As S.C. points out, in a compound test, even quoting the string variable might not suffice. [`-n "$string" -o "$a" = "$b"]` may cause an error with some versions of Bash if `$string` is empty. The safe way is to append an extra character to possibly empty variables, [`"x$string" != x -o "x$a" = "x$b"]` (the "x's" cancel out).

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7.4. Nested *if/then* Condition Tests

Condition tests using the *if/then* construct may be nested. The net result is equivalent to using the [&&](#) compound comparison operator.

```
1 a=3
2
3 if [ "$a" -gt 0 ]
4 then
5     if [ "$a" -lt 5 ]
6     then
7         echo "The value of \"a\" lies somewhere between 0 and 5."
8     fi
9 fi
10
11 # Same result as:
12
13 if [ "$a" -gt 0 ] && [ "$a" -lt 5 ]
14 then
15     echo "The value of \"a\" lies somewhere between 0 and 5."
16 fi
```

[Example 37-4](#) and [Example 17-11](#) demonstrate nested *if/then* condition tests.

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7.5. Testing Your Knowledge of Tests

The systemwide `xinitrc` file can be used to launch the X server. This file contains quite a number of *if/then* tests. The following is excerpted from an "ancient" version of `xinitrc` (*Red Hat 7.1*, or thereabouts).

```
1 if [ -f $HOME/.Xclients ]; then
2   exec $HOME/.Xclients
3 elif [ -f /etc/X11/xinit/Xclients ]; then
4   exec /etc/X11/xinit/Xclients
5 else
6   # failsafe settings.  Although we should never get here
7   # (we provide fallbacks in Xclients as well) it can't hurt.
8   xclock -geometry 100x100-5+5 &
9   xterm -geometry 80x50-50+150 &
10  if [ -f /usr/bin/netcape -a -f /usr/share/doc/HTML/index.html ]; then
11    netcape /usr/share/doc/HTML/index.html &
12  fi
13 fi
```

Explain the *test* constructs in the above snippet, then examine an updated version of the file, `/etc/X11/xinit/xinitrc`, and analyze the *if/then* test constructs there. You may need to refer ahead to the discussions of [grep](#), [sed](#), and [regular expressions](#).

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Chapter 8. Operations and Related Topics

8.1. Operators

assignment

variable assignment

Initializing or changing the value of a variable

=

All-purpose assignment operator, which works for both arithmetic and string assignments.

```
1 var=27
2 category=minerals # No spaces allowed after the "=".
```



Do not confuse the "=" assignment operator with the [= test operator](#).

```
1 # = as a test operator
2
3 if [ "$string1" = "$string2" ]
4 then
5     command
6 fi
7
8 # if [ "X$string1" = "X$string2" ] is safer,
9 #+ to prevent an error message should one of the variables be empty.
10 # (The prepended "X" characters cancel out.)
```

arithmetic operators

+

plus

-

minus

*

multiplication

/

division

**

exponentiation

```
1 # Bash, version 2.02, introduced the "**" exponentiation operator.
2
3 let "z=5**3" # 5 * 5 * 5
4 echo "z = $z" # z = 125
```

%

modulo, or mod (returns the *remainder* of an integer division operation)

```
bash$ expr 5 % 3
2
```

$5/3 = 1$, with remainder 2

This operator finds use in, among other things, generating numbers within a specific range (see [Example 9-11](#) and [Example 9-15](#)) and formatting program output (see [Example 27-16](#) and [Example A-6](#)). It can even be used to generate prime numbers, (see [Example A-15](#)). Modulo turns up surprisingly often in numerical recipes.

Example 8-1. Greatest common divisor

```
1 #!/bin/bash
2 # gcd.sh: greatest common divisor
3 #     Uses Euclid's algorithm
4
5 # The "greatest common divisor" (gcd) of two integers
6 #+ is the largest integer that will divide both, leaving no remainder.
7
8 # Euclid's algorithm uses successive division.
9 #     In each pass,
10 #+     dividend <--- divisor
11 #+     divisor <--- remainder
12 #+     until remainder = 0.
13 #     The gcd = dividend, on the final pass.
14 #
15 # For an excellent discussion of Euclid's algorithm, see
16 #+ Jim Loy's site, http://www.jimloy.com/number/euclids.htm.
17
18
19 # -----
20 # Argument check
21 ARGS=2
22 E_BADARGS=85
23
24 if [ $# -ne "$ARGS" ]
25 then
26     echo "Usage: `basename $0` first-number second-number"
27     exit $E_BADARGS
28 fi
29 # -----
30
31
32 gcd ()
33 {
34
35     dividend=$1           # Arbitrary assignment.
36     divisor=$2           #! It doesn't matter which of the two is larger.
37                         # Why not?
38
39     remainder=1          # If an uninitialized variable is used inside
40                         #+ test brackets, an error message results.
41
42     until [ "$remainder" -eq 0 ]
43     do # ^^^^^^^^^ Must be previously initialized!
44         let "remainder = $dividend % $divisor"
45         dividend=$divisor # Now repeat with 2 smallest numbers.
46         divisor=$remainder
47     done # Euclid's algorithm
48
49 } # Last $dividend is the gcd.
50
51
52 gcd $1 $2
53
54 echo; echo "GCD of $1 and $2 = $dividend"; echo
55
56
57 # Exercises :
58 # -----
59 # 1) Check command-line arguments to make sure they are integers,
60 #+ and exit the script with an appropriate error message if not.
61 # 2) Rewrite the gcd () function to use local variables.
62
63 exit 0
```

`+=`

plus-equal (increment variable by a constant) [\[1\]](#)

let "var += 5" results in *var* being incremented by 5.

`-=`

minus-equal (decrement variable by a constant)

`*=`

times-equal (multiply variable by a constant)

let "var *= 4" results in *var* being multiplied by 4.

`/=`

slash-equal (divide variable by a constant)

`%=`

mod-equal (remainder of dividing variable by a constant)

Arithmetic operators often occur in an [expr](#) or [let](#) expression.


Example 8-2. Using Arithmetic Operations

```
1 #!/bin/bash
2 # Counting to 11 in 10 different ways.
3
4 n=1; echo -n "$n "
5
6 let "n = $n + 1"    # let "n = n + 1" also works.
7 echo -n "$n "
8
9
10 : ${n = $n + 1}
11 # ":" necessary because otherwise Bash attempts
12 #+ to interpret "${n = $n + 1}" as a command.
13 echo -n "$n "
14
15 (( n = n + 1 ))
16 # A simpler alternative to the method above.
17 # Thanks, David Lombard, for pointing this out.
18 echo -n "$n "
19
20 n=$(( $n + 1 ))
21 echo -n "$n "
22
23 : ${ n = $n + 1 }
24 # ":" necessary because otherwise Bash attempts
25 #+ to interpret "${ n = $n + 1 }" as a command.
26 # Works even if "n" was initialized as a string.
27 echo -n "$n "
28
29 n=${ n = $n + 1 }
30 # Works even if "n" was initialized as a string.
31 #* Avoid this type of construct, since it is obsolete and nonportable.
32 # Thanks, Stephane Chazelas.
33 echo -n "$n "
34
35 # Now for C-style increment operators.
36 # Thanks, Frank Wang, for pointing this out.
37
38 let "n++"          # let "++n" also works.
39 echo -n "$n "
40
```

```

41 (( n++ ))          # (( ++n )) also works.
42 echo -n "$n "
43
44 : $(( n++ ))      # : $(( ++n )) also works.
45 echo -n "$n "
46
47 : ${ n++ }        # : ${ ++n } also works
48 echo -n "$n "
49
50 echo
51
52 exit 0

```

 Integer variables in older versions of Bash were signed *long* (32-bit) integers, in the range of -2147483648 to 2147483647. An operation that took a variable outside these limits gave an erroneous result.

```

1 echo $BASH_VERSION # 1.14
2
3 a=2147483646
4 echo "a = $a"      # a = 2147483646
5 let "a+=1"         # Increment "a".
6 echo "a = $a"      # a = 2147483647
7 let "a+=1"         # increment "a" again, past the limit.
8 echo "a = $a"      # a = -2147483648
9                   # ERROR: out of range,
10                  # + and the leftmost bit, the sign bit,
11                  # + has been set, making the result negative.

```

As of version $\geq 2.05b$, Bash supports 64-bit integers.



Bash does not understand floating point arithmetic. It treats numbers containing a decimal point as strings.

```

1 a=1.5
2
3 let "b = $a + 1.3" # Error.
4 # t2.sh: let: b = 1.5 + 1.3: syntax error in expression
5 # (error token is ".5 + 1.3")
6
7 echo "b = $b"      # b=1

```

Use [bc](#) in scripts that need floating point calculations or math library functions.

bitwise operators. The bitwise operators seldom make an appearance in shell scripts. Their chief use seems to be manipulating and testing values read from ports or [sockets](#). "Bit flipping" is more relevant to compiled languages, such as C and C++, which provide direct access to system hardware. However, see *vladz's* ingenious use of bitwise operators in his *base64.sh* ([Example A-54](#)) script.

bitwise operators

<<

bitwise left shift (multiplies by 2 for each shift position)

<<=

left-shift-equal

let "var <<= 2" results in *var* left-shifted 2 bits (multiplied by 4)

>>

bitwise right shift (divides by 2 for each shift position)

>>= *right-shift-equal* (inverse of <<=)
& bitwise AND
&= bitwise *AND-equal*
| bitwise OR
|= bitwise *OR-equal*
~ bitwise NOT
^ bitwise XOR
^= bitwise *XOR-equal*

logical (boolean) operators

!
NOT

```
1 if [ ! -f $FILENAME ]
2 then
3   ...
```

&&
AND

```
1 if [ $condition1 ] && [ $condition2 ]
2 # Same as: if [ $condition1 -a $condition2 ]
3 # Returns true if both condition1 and condition2 hold true...
4
5 if [[ $condition1 && $condition2 ]] # Also works.
6 # Note that && operator not permitted inside brackets
7 #+ of [ ... ] construct.
```

 && may also be used, depending on context, in an [and list](#) to concatenate commands.

||
OR

```
1 if [ $condition1 ] || [ $condition2 ]
2 # Same as: if [ $condition1 -o $condition2 ]
3 # Returns true if either condition1 or condition2 holds true...
4
5 if [[ $condition1 || $condition2 ]] # Also works.
6 # Note that || operator not permitted inside brackets
7 #+ of a [ ... ] construct.
```

 Bash tests the [exit status](#) of each statement linked with a logical operator.

Example 8-3. Compound Condition Tests Using && and ||

```
1 #!/bin/bash
2
3 a=24
4 b=47
5
```

```

6 if [ "$a" -eq 24 ] && [ "$b" -eq 47 ]
7 then
8     echo "Test #1 succeeds."
9 else
10    echo "Test #1 fails."
11 fi
12
13 # ERROR:   if [ "$a" -eq 24 && "$b" -eq 47 ]
14 #+        attempts to execute ' [ "$a" -eq 24 '
15 #+        and fails to finding matching ']'.
16 #
17 # Note:   if [[ $a -eq 24 && $b -eq 24 ]] works.
18 # The double-bracket if-test is more flexible
19 #+ than the single-bracket version.
20 # (The "&&" has a different meaning in line 17 than in line 6.)
21 # Thanks, Stephane Chazelas, for pointing this out.
22
23
24 if [ "$a" -eq 98 ] || [ "$b" -eq 47 ]
25 then
26     echo "Test #2 succeeds."
27 else
28     echo "Test #2 fails."
29 fi
30
31
32 # The -a and -o options provide
33 #+ an alternative compound condition test.
34 # Thanks to Patrick Callahan for pointing this out.
35
36
37 if [ "$a" -eq 24 -a "$b" -eq 47 ]
38 then
39     echo "Test #3 succeeds."
40 else
41     echo "Test #3 fails."
42 fi
43
44
45 if [ "$a" -eq 98 -o "$b" -eq 47 ]
46 then
47     echo "Test #4 succeeds."
48 else
49     echo "Test #4 fails."
50 fi
51
52
53 a=rhino
54 b=crocodile
55 if [ "$a" = rhino ] && [ "$b" = crocodile ]
56 then
57     echo "Test #5 succeeds."
58 else
59     echo "Test #5 fails."
60 fi
61
62 exit 0

```

The && and || operators also find use in an arithmetic context.

```

bash$ echo $(( 1 && 2 )) $((3 && 0)) $((4 || 0)) $((0 || 0))
1 0 1 0

```


miscellaneous operators

Comma operator

The **comma operator** chains together two or more arithmetic operations. All the operations are evaluated (with possible *side effects*). [2]

```
1 let "t1 = ((5 + 3, 7 - 1, 15 - 4))"
2 echo "t1 = $t1"           ^^^^^^ # t1 = 11
3 # Here t1 is set to the result of the last operation. Why?
4
5 let "t2 = ((a = 9, 15 / 3))" # Set "a" and calculate "t2".
6 echo "t2 = $t2   a = $a"   # t2 = 5   a = 9
```

The comma operator finds use mainly in [for loops](#). See [Example 11-13](#).

Notes

- [1] In a different context, += can serve as a *string concatenation* operator. This can be useful for [modifying environmental variables](#).
- [2] *Side effects* are, of course, unintended -- and usually undesirable -- consequences.

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8.2. Numerical Constants

A shell script interprets a number as decimal (base 10), unless that number has a special prefix or notation. A number preceded by a *0* is *octal* (base 8). A number preceded by *0x* is *hexadecimal* (base 16). A number with an embedded *#* evaluates as *BASE#NUMBER* (with range and notational restrictions).

Example 8-4. Representation of numerical constants

```
1 #!/bin/bash
2 # numbers.sh: Representation of numbers in different bases.
3
4 # Decimal: the default
5 let "dec = 32"
6 echo "decimal number = $dec"           # 32
7 # Nothing out of the ordinary here.
8
9
10 # Octal: numbers preceded by '0' (zero)
11 let "oct = 032"
12 echo "octal number = $oct"           # 26
13 # Expresses result in decimal.
14 # -----
15
16
17 # Hexadecimal: numbers preceded by '0x' or '0X'
18 let "hex = 0x32"
19 echo "hexadecimal number = $hex"     # 50
20
21 echo $((0x9abc))                     # 39612
22 #   ^^   ^^   double-parentheses arithmetic expansion/evaluation
23 # Expresses result in decimal.
24
25
26
27 # Other bases: BASE#NUMBER
28 # BASE between 2 and 64.
29 # NUMBER must use symbols within the BASE range, see below.
30
31
32 let "bin = 2#111100111001101"
33 echo "binary number = $bin"         # 31181
34
35 let "b32 = 32#77"
36 echo "base-32 number = $b32"       # 231
37
38 let "b64 = 64#@_"
39 echo "base-64 number = $b64"       # 4031
40 # This notation only works for a limited range (2 - 64) of ASCII characters.
41 # 10 digits + 26 lowercase characters + 26 uppercase characters + @ + _
42
43
44 echo
45
46 echo $((36#zz)) $((2#10101010)) $((16#AF16)) $((53#1aA))
47                                     # 1295 170 44822 3375
48
49
50 # Important note:
51 # -----
52 # Using a digit out of range of the specified base notation
53 #+ gives an error message.
54
```

```
55 let "bad_oct = 081"
56 # (Partial) error message output:
57 # bad_oct = 081: value too great for base (error token is "081")
58 #           Octal numbers use only digits in the range 0 - 7.
59
60 exit $? # Exit value = 1 (error)
61
62 # Thanks, Rich Bartell and Stephane Chazelas, for clarification.
```

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8.3. The Double-Parentheses Construct

Similar to the [let](#) command, the `((...))` construct permits arithmetic expansion and evaluation. In its simplest form, `a=$((5 + 3))` would set `a` to `5 + 3`, or `8`. However, this double-parentheses construct is also a mechanism for allowing C-style manipulation of variables in Bash, for example, `((var++))`.

Example 8-5. C-style manipulation of variables

```
1 #!/bin/bash
2 # c-vars.sh
3 # Manipulating a variable, C-style, using the (( ... )) construct.
4
5
6 echo
7
8 (( a = 23 )) # Setting a value, C-style,
9             #+ with spaces on both sides of the "=".
10 echo "a (initial value) = $a" # 23
11
12 (( a++ )) # Post-increment 'a', C-style.
13 echo "a (after a++) = $a" # 24
14
15 (( a-- )) # Post-decrement 'a', C-style.
16 echo "a (after a--) = $a" # 23
17
18
19 (( ++a )) # Pre-increment 'a', C-style.
20 echo "a (after ++a) = $a" # 24
21
22 (( --a )) # Pre-decrement 'a', C-style.
23 echo "a (after --a) = $a" # 23
24
25 echo
26
27 #####
28 # Note that, as in C, pre- and post-decrement operators
29 #+ have different side-effects.
30
31 n=1; let --n && echo "True" || echo "False" # False
32 n=1; let n-- && echo "True" || echo "False" # True
33
34 # Thanks, Jeroen Domburg.
35 #####
36
37 echo
38
39 (( t = a<45?7:11 )) # C-style trinary operator.
40 #               ^ ^ ^
41 echo "If a < 45, then t = 7, else t = 11." # a = 23
42 echo "t = $t " # t = 7
43
44 echo
45
46
47 # -----
48 # Easter Egg alert!
49 # -----
50 # Chet Ramey seems to have snuck a bunch of undocumented C-style
51 #+ constructs into Bash (actually adapted from ksh, pretty much).
```

```
52 # In the Bash docs, Ramey calls (( ... )) shell arithmetic,
53 #+ but it goes far beyond that.
54 # Sorry, Chet, the secret is out.
55
56 # See also "for" and "while" loops using the (( ... )) construct.
57
58 # These work only with version 2.04 or later of Bash.
59
60 exit
```

See also [Example 11-13](#) and [Example 8-4](#).

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8.4. Operator Precedence

In a script, operations execute in order of *precedence*: the higher precedence operations execute *before* the lower precedence ones. [1]

Table 8-1. Operator Precedence

Operator	Meaning	Comments
		HIGHEST PRECEDENCE
var++ var--	post-increment, post-decrement	C-style operators
++var --var	pre-increment, pre-decrement	
! ~	negation	logical / bitwise, inverts sense of following operator
**	exponentiation	arithmetic operation
* / %	multiplication, division, modulo	arithmetic operation
+ -	addition, subtraction	arithmetic operation
<< >>	left, right shift	bitwise
-z -n	<i>unary</i> comparison	string is/is-not null
-e -f -t -x, etc.	<i>unary</i> comparison	file-test
< -lt > -gt <= -le >= -ge	<i>compound</i> comparison	string and integer
-nt -ot -ef	<i>compound</i> comparison	file-test
== -eq != -ne	equality / inequality	test operators, string and integer
&	AND	bitwise
^	XOR	<i>exclusive</i> OR, bitwise
	OR	bitwise
&& -a	AND	logical , <i>compound</i> comparison
-o	OR	logical, <i>compound</i> comparison
?:	trinary operator	C-style
=	assignment	(do not confuse with equality <i>test</i>)
*= /= %= += -= <<= >>=	combination assignment	times-equal, divide-equal, mod-equal, etc.
&=		
,	comma	links a sequence of operations

In practice, all you really need to remember is the following:

- The "My Dear Aunt Sally" mantra (*multiply, divide, add, subtract*) for the familiar [arithmetic operations](#).
- The *compound* logical operators, **&&**, **||**, **-a**, and **-o** have low precedence.
- The order of evaluation of equal-precedence operators is usually *left-to-right*.

Now, let's utilize our knowledge of operator precedence to analyze a couple of lines from the `/etc/init.d/functions` file, as found in the *Fedora Core* Linux distro.

```

1 while [ -n "$remaining" -a "$retry" -gt 0 ]; do
2
3 # This looks rather daunting at first glance.
4
5
6 # Separate the conditions:
7 while [ -n "$remaining" -a "$retry" -gt 0 ]; do
8 #     --condition 1-- ^^ --condition 2-
9
10 # If variable "$remaining" is not zero length
11 #+     AND (-a)
12 #+ variable "$retry" is greater-than zero
13 #+ then
14 #+ the [ expression-within-condition-brackets ] returns success (0)
15 #+ and the while-loop executes an iteration.
16 # =====
17 # Evaluate "condition 1" and "condition 2" ***before***
18 #+ ANDing them. Why? Because the AND (-a) has a lower precedence
19 #+ than the -n and -gt operators,
20 #+ and therefore gets evaluated *last*.
21
22 #####
23
24 if [ -f /etc/sysconfig/il8n -a -z "${NOLOCALE:-}" ] ; then
25
26
27 # Again, separate the conditions:
28 if [ -f /etc/sysconfig/il8n -a -z "${NOLOCALE:-}" ] ; then
29 #     --condition 1----- ^^ --condition 2-----
30
31 # If file "/etc/sysconfig/il8n" exists
32 #+     AND (-a)
33 #+ variable $NOLOCALE is zero length
34 #+ then
35 #+ the [ test-expression-within-condition-brackets ] returns success (0)
36 #+ and the commands following execute.
37 #
38 # As before, the AND (-a) gets evaluated *last*
39 #+ because it has the lowest precedence of the operators within
40 #+ the test brackets.
41 # =====
42 # Note:
43 # ${NOLOCALE:-} is a parameter expansion that seems redundant.
44 # But, if $NOLOCALE has not been declared, it gets set to *null*,
45 #+ in effect declaring it.
46 # This makes a difference in some contexts.

```



To avoid confusion or error in a complex sequence of test operators, break up the sequence into bracketed sections.


```
1 if [ "$v1" -gt "$v2" -o "$v1" -lt "$v2" -a -e "$filename" ]
2 # Unclear what's going on here...
3
4 if [[ "$v1" -gt "$v2" ]] || [[ "$v1" -lt "$v2" ]] && [[ -e "$filename" ]]
5 # Much better -- the condition tests are grouped in logical sections.
```

Notes

[1] *Precedence*, in this context, has approximately the same meaning as *priority*

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Chapter 9. Another Look at Variables

Used properly, variables can add power and flexibility to scripts. This requires learning their subtleties and nuances.

9.1. Internal Variables

Builtin variables:

variables affecting bash script behavior

`$BASH`

The path to the *Bash* binary itself

```
bash$ echo $BASH
/bin/bash
```

`$BASH_ENV`

An [environmental variable](#) pointing to a Bash startup file to be read when a script is invoked

`$BASH_SUBSHELL`

A variable indicating the [subshell](#) level. This is a new addition to Bash, [version 3](#).

See [Example 21-1](#) for usage.

`$BASHPID`

Process ID of the current instance of Bash. This is not the same as the `$$` variable, but it often gives the same result.

```
bash4$ echo $$
11015

bash4$ echo $BASHPID
11015

bash4$ ps ax | grep bash4
11015 pts/2    R      0:00 bash4
```

But ...

```
1 #!/bin/bash4
2
3 echo "\$\$ outside of subshell = $$" # 9602
4 echo "\$BASH_SUBSHELL outside of subshell = $BASH_SUBSHELL" # 0
5 echo "\$BASHPID outside of subshell = $BASHPID" # 9602
6
7 echo
8
9 ( echo "\$\$ inside of subshell = $$" # 9602
10  echo "\$BASH_SUBSHELL inside of subshell = $BASH_SUBSHELL" # 1
11  echo "\$BASHPID inside of subshell = $BASHPID" ) # 9603
12 # Note that $$ returns PID of parent process.
```

`$BASH_VERSINFO[n]`

A 6-element [array](#) containing version information about the installed release of Bash. This is similar to `$BASH_VERSION`, below, but a bit more detailed.

```
1 # Bash version info:
2
3 for n in 0 1 2 3 4 5
4 do
5   echo "BASH_VERSINFO[$n] = ${BASH_VERSINFO[$n]}"
6 done
7
8 # BASH_VERSINFO[0] = 3 # Major version no.
9 # BASH_VERSINFO[1] = 00 # Minor version no.
10 # BASH_VERSINFO[2] = 14 # Patch level.
11 # BASH_VERSINFO[3] = 1 # Build version.
```

```

12 # BASH_VERSINFO[4] = release           # Release status.
13 # BASH_VERSINFO[5] = i386-redhat-linux-gnu # Architecture
14                                         # (same as $MACHTYPE).

```

\$BASH_VERSION

The version of Bash installed on the system

```

bash$ echo $BASH_VERSION
3.2.25(1)-release

```

```

tcsh% echo $BASH_VERSION
BASH_VERSION: Undefined variable.

```

Checking \$BASH_VERSION is a good method of determining which shell is running. [\\$SHELL](#) does not necessarily give the correct answer.

\$CDPATH

A colon-separated list of search paths available to the `cd` command, similar in function to the [\\$PATH](#) variable for binaries. The \$CDPATH variable may be set in the local `~/.bashrc` file.

```

bash$ cd bash-doc
bash: cd: bash-doc: No such file or directory

bash$ CDPATH=/usr/share/doc
bash$ cd bash-doc
/usr/share/doc/bash-doc

bash$ echo $PWD
/usr/share/doc/bash-doc

```

\$DIRSTACK

The top value in the directory stack [\[1\]](#) (affected by [pushd](#) and [popd](#))

This builtin variable corresponds to the [dirs](#) command, however `dirs` shows the entire contents of the directory stack.

\$EDITOR

The default editor invoked by a script, usually `vi` or `emacs`.

\$EUID

"effective" user ID number

Identification number of whatever identity the current user has assumed, perhaps by means of [su](#).



The \$EUID is not necessarily the same as the [\\$UID](#).

\$FUNCNAME

Name of the current function

```

1 xyz23 ()
2 {
3     echo "$FUNCNAME now executing." # xyz23 now executing.
4 }
5
6 xyz23
7
8 echo "FUNCNAME = $FUNCNAME"       # FUNCNAME =
9                                     # Null value outside a function.

```

See also [Example A-50](#).

\$GLOBIGNORE

A list of filename patterns to be excluded from matching in [globbing](#).

`$GROUPS`

Groups current user belongs to

This is a listing (array) of the group id numbers for current user, as recorded in [/etc/passwd](#) and [/etc/group](#).

```
root# echo $GROUPS
0

root# echo ${GROUPS[1]}
1

root# echo ${GROUPS[5]}
6
```

`$HOME`

Home directory of the user, usually `/home/username` (see [Example 10-7](#))

`$HOSTNAME`

The [hostname](#) command assigns the system host name at bootup in an init script. However, the `gethostname()` function sets the Bash internal variable `$HOSTNAME`. See also [Example 10-7](#).

`$HOSTTYPE`

host type

Like [\\$MACHTYPE](#), identifies the system hardware.

```
bash$ echo $HOSTTYPE
i686
```

`$IFS`

internal field separator

This variable determines how Bash recognizes [fields](#), or word boundaries, when it interprets character strings.

`$IFS` defaults to [whitespace](#) (space, tab, and newline), but may be changed, for example, to parse a comma-separated data file. Note that `$*` uses the first character held in `$IFS`. See [Example 5-1](#).

```
bash$ echo "$IFS"

(With $IFS set to default, a blank line displays.)

bash$ echo "$IFS" | cat -vte
^I$
$
(Show whitespace: here a single space, ^I [horizontal tab],
 and newline, and display "$" at end-of-line.)

bash$ bash -c 'set w x y z; IFS=":-;"; echo "$*"'
w:x:y:z
(Read commands from string and assign any arguments to pos params.)
```

Set `$IFS` to eliminate whitespace in [pathnames](#).



\$IFS does not handle whitespace the same as it does other characters.

Example 9-1. \$IFS and whitespace

```
1 #!/bin/bash
2 # ifs.sh
3
4
5 var1="a+b+c"
6 var2="d-e-f"
7 var3="g,h,i"
8
9 IFS=+
10 # The plus sign will be interpreted as a separator.
11 echo $var1 # a b c
12 echo $var2 # d-e-f
13 echo $var3 # g,h,i
14
15 echo
16
17 IFS="-"
18 # The plus sign reverts to default interpretation.
19 # The minus sign will be interpreted as a separator.
20 echo $var1 # a+b+c
21 echo $var2 # d e f
22 echo $var3 # g,h,i
23
24 echo
25
26 IFS=", "
27 # The comma will be interpreted as a separator.
28 # The minus sign reverts to default interpretation.
29 echo $var1 # a+b+c
30 echo $var2 # d-e-f
31 echo $var3 # g h i
32
33 echo
34
35 IFS=" "
36 # The space character will be interpreted as a separator.
37 # The comma reverts to default interpretation.
38 echo $var1 # a+b+c
39 echo $var2 # d-e-f
40 echo $var3 # g,h,i
41
42 # ===== #
43
44 # However ...
45 # $IFS treats whitespace differently than other characters.
46
47 output_args_one_per_line()
48 {
49     for arg
50     do
51         echo "[$arg]"
52     done # ^ ^ Embed within brackets, for your viewing pleasure.
53 }
54
55 echo; echo "IFS=\" \" \" \""
56 echo "-----"
57
58 IFS=" "
```

```

59 var=" a b c  "
60 #   ^  ^ ^  ^ ^ ^
61 output_args_one_per_line $var # output_args_one_per_line `echo " a b c  "`
62 # [a]
63 # [b]
64 # [c]
65
66
67 echo; echo "IFS=:"
68 echo "-----"
69
70 IFS=:
71 var=":a::b:c:::" # Same pattern as above,
72 #   ^  ^ ^  ^ ^ ^ #+ but substituting ":" for " " ...
73 output_args_one_per_line $var
74 # []
75 # [a]
76 # []
77 # [b]
78 # [c]
79 # []
80 # []
81
82 # Note "empty" brackets.
83 # The same thing happens with the "FS" field separator in awk.
84
85
86 echo
87
88 exit

```

(Many thanks, Stéphane Chazelas, for clarification and above examples.)

See also [Example 16-41](#), [Example 11-8](#), and [Example 19-14](#) for instructive examples of using \$IFS.

\$IGNOREEOF

Ignore EOF: how many end-of-files (control-D) the shell will ignore before logging out.

\$LC_COLLATE

Often set in the [.bashrc](#) or `/etc/profile` files, this variable controls collation order in filename expansion and pattern matching. If mishandled, LC_COLLATE can cause unexpected results in [filename globbing](#).



As of version 2.05 of Bash, filename globbing no longer distinguishes between lowercase and uppercase letters in a character range between brackets. For example, `ls [A-M]*` would match both `File1.txt` and `file1.txt`. To revert to the customary behavior of bracket matching, set LC_COLLATE to C by an **export LC_COLLATE=C** in `/etc/profile` and/or `~/.bashrc`.

\$LC_CTYPE

This internal variable controls character interpretation in [globbing](#) and pattern matching.

\$LINENO

This variable is the line number of the shell script in which this variable appears. It has significance only within the script in which it appears, and is chiefly useful for debugging purposes.

```

1 # *** BEGIN DEBUG BLOCK ***
2 last_cmd_arg=$_ # Save it.
3
4 echo "At line number $LINENO, variable \"v1\" = $v1"
5 echo "Last command argument processed = $last_cmd_arg"
6 # *** END DEBUG BLOCK ***

```

\$MACHTYPE

machine type

Identifies the system hardware.

```
bash$ echo $MACHINE
i686
```

\$OLDPWD

Old working directory ("OLD-Print-Working-Directory", previous directory you were in).

\$OSTYPE

operating system type

```
bash$ echo $OSTYPE
linux
```

\$PATH

Path to binaries, usually `/usr/bin/`, `/usr/X11R6/bin/`, `/usr/local/bin`, etc.

When given a command, the shell automatically does a hash table search on the directories listed in the *path* for the executable. The path is stored in the [environmental variable](#), `$PATH`, a list of directories, separated by colons. Normally, the system stores the `$PATH` definition in `/etc/profile` and/or `~/.bashrc` (see [Appendix H](#)).

```
bash$ echo $PATH
/bin:/usr/bin:/usr/local/bin:/usr/X11R6/bin:/sbin:/usr/sbin
```

`PATH=${PATH}:/opt/bin` appends the `/opt/bin` directory to the current path. In a script, it may be expedient to temporarily add a directory to the path in this way. When the script exits, this restores the original `$PATH` (a child process, such as a script, may not change the environment of the parent process, the shell).



The current "working directory", `./`, is usually omitted from the `$PATH` as a security measure.

\$PIPESTATUS

[Array](#) variable holding [exit status\(es\)](#) of last executed *foreground pipe*.

```
bash$ echo $PIPESTATUS
0

bash$ ls -al | bogus_command
bash: bogus_command: command not found
bash$ echo ${PIPESTATUS[1]}
127

bash$ ls -al | bogus_command
bash: bogus_command: command not found
bash$ echo $?
127
```

The members of the `$PIPESTATUS` array hold the exit status of each respective command executed in a pipe. `$PIPESTATUS[0]` holds the exit status of the first command in the pipe, `$PIPESTATUS[1]` the exit status of the second command, and so on.



The `$PIPESTATUS` variable may contain an erroneous 0 value in a login shell (in releases prior to 3.0 of Bash).

```
tosh% bash

bash$ who | grep nobody | sort
```

```
bash$ echo ${PIPESTATUS[*]}
0
```

The above lines contained in a script would produce the expected 0 1 0 output.

Thank you, Wayne Pollock for pointing this out and supplying the above example.



The `$PIPESTATUS` variable gives unexpected results in some contexts.

```
bash$ echo $BASH_VERSION
3.00.14(1)-release

bash$ $ ls | bogus_command | wc
bash: bogus_command: command not found
0      0      0

bash$ echo ${PIPESTATUS[@]}
141 127 0
```

Chet Ramey attributes the above output to the behavior of `ls`. If `ls` writes to a *pipe* whose output is not read, then `SIGPIPE` kills it, and its [exit status](#) is 141. Otherwise its exit status is 0, as expected. This likewise is the case for `tr`.



`$PIPESTATUS` is a "volatile" variable. It needs to be captured immediately after the pipe in question, before any other command intervenes.

```
bash$ $ ls | bogus_command | wc
bash: bogus_command: command not found
0      0      0

bash$ echo ${PIPESTATUS[@]}
0 127 0

bash$ echo ${PIPESTATUS[@]}
0
```



The [pipefail option](#) may be useful in cases where `$PIPESTATUS` does not give the desired information.

`$PPID`

The `$PPID` of a process is the process ID (`pid`) of its parent process. [\[2\]](#)

Compare this with the [pidof](#) command.

`$PROMPT_COMMAND`

A variable holding a command to be executed just before the primary prompt, `$PS1` is to be displayed.

`$PS1`

This is the main prompt, seen at the command-line.

`$PS2`

The secondary prompt, seen when additional input is expected. It displays as ">".

`$PS3`

The tertiary prompt, displayed in a [select](#) loop (see [Example 11-30](#)).

`$PS4`

The quaternary prompt, shown at the beginning of each line of output when invoking a script with the `-x [verbose trace] option`. It displays as "+".

As a debugging aid, it may be useful to embed diagnostic information in `$PS4`.

```
1 P4='$(read time junk < /proc/$$/schedstat; echo "@@@ $time @@@ " )'
2 # Per suggestion by Erik Brandsberg.
3 set -x
4 # Various commands follow ...
```

\$PWD

Working directory (directory you are in at the time)

This is the analog to the [pwd](#) builtin command.

```
1 #!/bin/bash
2
3 E_WRONG_DIRECTORY=85
4
5 clear # Clear the screen.
6
7 TargetDirectory=/home/bozo/projects/GreatAmericanNovel
8
9 cd $TargetDirectory
10 echo "Deleting stale files in $TargetDirectory."
11
12 if [ "$PWD" != "$TargetDirectory" ]
13 then # Keep from wiping out wrong directory by accident.
14     echo "Wrong directory!"
15     echo "In $PWD, rather than $TargetDirectory!"
16     echo "Bailing out!"
17     exit $E_WRONG_DIRECTORY
18 fi
19
20 rm -rf *
21 rm .[A-Za-z0-9]* # Delete dotfiles.
22 # rm -f .[^.]* ..?* to remove filenames beginning with multiple dots.
23 # (shopt -s dotglob; rm -f *) will also work.
24 # Thanks, S.C. for pointing this out.
25
26 # A filename (`basename`) may contain all characters in the 0 - 255 range,
27 #+ except "/".
28 # Deleting files beginning with weird characters, such as -
29 #+ is left as an exercise. (Hint: rm ./-weirdname or rm -- -weirdname)
30 result=$? # Result of delete operations. If successful = 0.
31
32 echo
33 ls -al # Any files left?
34 echo "Done."
35 echo "Old files deleted in $TargetDirectory."
36 echo
37
38 # Various other operations here, as necessary.
39
40 exit $result
```

\$REPLY

The default value when a variable is not supplied to [read](#). Also applicable to [select](#) menus, but only supplies the item number of the variable chosen, not the value of the variable itself.

```
1 #!/bin/bash
2 # reply.sh
3
4 # REPLY is the default value for a 'read' command.
5
6 echo
7 echo -n "What is your favorite vegetable? "
8 read
9
10 echo "Your favorite vegetable is $REPLY."
11 # REPLY holds the value of last "read" if and only if
```

```

12 #+ no variable supplied.
13
14 echo
15 echo -n "What is your favorite fruit? "
16 read fruit
17 echo "Your favorite fruit is $fruit."
18 echo "but..."
19 echo "Value of \$REPLY is still $REPLY."
20 # $REPLY is still set to its previous value because
21 #+ the variable $fruit absorbed the new "read" value.
22
23 echo
24
25 exit 0

```

\$SECONDS

The number of seconds the script has been running.

```

1 #!/bin/bash
2
3 TIME_LIMIT=10
4 INTERVAL=1
5
6 echo
7 echo "Hit Control-C to exit before $TIME_LIMIT seconds."
8 echo
9
10 while [ "$SECONDS" -le "$TIME_LIMIT" ]
11 do # $SECONDS is an internal shell variable.
12   if [ "$SECONDS" -eq 1 ]
13   then
14     units=second
15   else
16     units=seconds
17   fi
18
19   echo "This script has been running $SECONDS $units."
20   # On a slow or overburdened machine, the script may skip a count
21   #+ every once in a while.
22   sleep $INTERVAL
23 done
24
25 echo -e "\a" # Beep!
26
27 exit 0

```

\$SHELLOPTS

The list of enabled shell [options](#), a readonly variable.

```

bash$ echo $SHELLOPTS
braceexpand:hashall:histexpand:monitor:history:interactive-comments:emacs

```

\$SHLVL

Shell level, how deeply Bash is nested. [\[3\]](#) If, at the command-line, \$SHLVL is 1, then in a script it will increment to 2.



This variable is *not affected by subshells*. Use [\\$BASH_SUBSHELL](#) when you need an indication of subshell nesting.

\$TMOUT

If the `$TMOUT` environmental variable is set to a non-zero value `time`, then the shell prompt will time out after `$time` seconds. This will cause a logout.

As of version 2.05b of Bash, it is now possible to use `$TMOUT` in a script in combination with [read](#).

```

1 # Works in scripts for Bash, versions 2.05b and later.
2
3 TMOU=3      # Prompt times out at three seconds.
4
5 echo "What is your favorite song?"
6 echo "Quickly now, you only have $TMOU seconds to answer!"
7 read song
8
9 if [ -z "$song" ]
10 then
11     song="(no answer)"
12     # Default response.
13 fi
14
15 echo "Your favorite song is $song."

```

There are other, more complex, ways of implementing timed input in a script. One alternative is to set up a timing loop to signal the script when it times out. This also requires a signal handling routine to [trap](#) (see [Example 32-5](#)) the interrupt generated by the timing loop (whew!).

Example 9-2. Timed Input

```

1 #!/bin/bash
2 # timed-input.sh
3
4 # TMOU=3      Also works, as of newer versions of Bash.
5
6 TIMER_INTERRUPT=14
7 TIMELIMIT=3  # Three seconds in this instance.
8              # May be set to different value.
9
10 PrintAnswer()
11 {
12     if [ "$answer" = TIMEOUT ]
13     then
14         echo $answer
15     else
16         # Don't want to mix up the two instances.
17         echo "Your favorite veggie is $answer"
18         kill $! # Kills no-longer-needed TimerOn function
19                 #+ running in background.
20                 # $! is PID of last job running in background.
21     fi
22 }
23
24
25 TimerOn()
26 {
27     sleep $TIMELIMIT && kill -s 14 $$ &
28     # Waits 3 seconds, then sends sigalarm to script.
29 }
30
31
32 Int14Vector()
33 {
34     answer="TIMEOUT"
35     PrintAnswer
36     exit $TIMER_INTERRUPT
37 }
38
39 trap Int14Vector $TIMER_INTERRUPT
40 # Timer interrupt (14) subverted for our purposes.
41

```



```

42 echo "What is your favorite vegetable "
43 TimerOn
44 read answer
45 PrintAnswer
46
47
48 # Admittedly, this is a kludgy implementation of timed input.
49 # However, the "-t" option to "read" simplifies this task.
50 # See the "t-out.sh" script.
51 # However, what about timing not just single user input,
52 #+ but an entire script?
53
54 # If you need something really elegant ...
55 #+ consider writing the application in C or C++,
56 #+ using appropriate library functions, such as 'alarm' and 'setitimer.'
57
58 exit 0

```

An alternative is using [stty](#).

Example 9-3. Once more, timed input

```

1 #!/bin/bash
2 # timeout.sh
3
4 # Written by Stephane Chazelas,
5 #+ and modified by the document author.
6
7 INTERVAL=5          # timeout interval
8
9 timedout_read() {
10  timeout=$1
11  varname=$2
12  old_tty_settings=`stty -g`
13  stty -icanon min 0 time ${timeout}0
14  eval read $varname # or just read $varname
15  stty "$old_tty_settings"
16  # See man page for "stty."
17 }
18
19 echo; echo -n "What's your name? Quick! "
20 timedout_read $INTERVAL your_name
21
22 # This may not work on every terminal type.
23 # The maximum timeout depends on the terminal.
24 #+ (it is often 25.5 seconds).
25
26 echo
27
28 if [ ! -z "$your_name" ] # If name input before timeout ...
29 then
30  echo "Your name is $your_name."
31 else
32  echo "Timed out."
33 fi
34
35 echo
36
37 # The behavior of this script differs somewhat from "timed-input.sh."
38 # At each keystroke, the counter resets.
39
40 exit 0

```

Perhaps the simplest method is using the `-t` option to [read](#).

Example 9-4. Timed read

```
1 #!/bin/bash
2 # t-out.sh [time-out]
3 # Inspired by a suggestion from "syngin seven" (thanks).
4
5
6 TIMELIMIT=4          # 4 seconds
7
8 read -t $TIMELIMIT variable <&1
9 #                   ^^^
10 # In this instance, "<&1" is needed for Bash 1.x and 2.x,
11 # but unnecessary for Bash 3+.
12
13 echo
14
15 if [ -z "$variable" ] # Is null?
16 then
17     echo "Timed out, variable still unset."
18 else
19     echo "variable = $variable"
20 fi
21
22 exit 0
```

\$UID

User ID number

Current user's user identification number, as recorded in [/etc/passwd](#)

This is the current user's real id, even if she has temporarily assumed another identity through [su](#). \$UID is a readonly variable, not subject to change from the command line or within a script, and is the counterpart to the [id](#) builtin.

Example 9-5. Am I root?


```
1 #!/bin/bash
2 # am-i-root.sh:  Am I root or not?
3
4 ROOT_UID=0      # Root has $UID 0.
5
6 if [ "$UID" -eq "$ROOT_UID" ] # Will the real "root" please stand up?
7 then
8     echo "You are root."
9 else
10    echo "You are just an ordinary user (but mom loves you just the same)."
```

```

21 ROOTUSER_NAME=root
22
23 username=`id -nu`           # Or...   username=`whoami`
24 if [ "$username" = "$ROOTUSER_NAME" ]
25 then
26     echo "Rooty, toot, toot. You are root."
27 else
28     echo "You are just a regular fella."
29 fi

```

See also [Example 2-3](#).

 The variables \$ENV, \$LOGNAME, \$MAIL, \$TERM, \$USER, and \$USERNAME are *not* Bash [builtins](#). These are, however, often set as [environmental variables](#) in one of the [Bash](#) or *login* startup files. \$SHELL, the name of the user's login shell, may be set from /etc/passwd or in an "init" script, and it is likewise not a Bash builtin.

```

tcsh% echo $LOGNAME
bozo
tcsh% echo $SHELL
/bin/tcsh
tcsh% echo $TERM
rxvt

bash$ echo $LOGNAME
bozo
bash$ echo $SHELL
/bin/tcsh
bash$ echo $TERM
rxvt

```

Positional Parameters

\$0, \$1, \$2, etc.


Positional parameters, passed from command line to script, passed to a function, or [set](#) to a variable (see [Example 4-5](#) and [Example 15-16](#))

\$#

Number of command-line arguments [\[4\]](#) or positional parameters (see [Example 36-2](#))


\$*

All of the positional parameters, seen as a single word

 "\$*" must be quoted.

\$@

Same as \$*, but each parameter is a quoted string, that is, the parameters are passed on intact, without interpretation or expansion. This means, among other things, that each parameter in the argument list is seen as a separate word.

 Of course, "\$@" should be quoted.

Example 9-6. *arglist*: Listing arguments with \$* and \$@

```

1 #!/bin/bash
2 # arglist.sh
3 # Invoke this script with several arguments, such as "one two three" ...
4

```

```

5 E_BADARGS=85
6
7 if [ ! -n "$1" ]
8 then
9   echo "Usage: `basename $0` argument1 argument2 etc."
10  exit $E_BADARGS
11 fi
12
13 echo
14
15 index=1          # Initialize count.
16
17 echo "Listing args with \"\$*\":"
18 for arg in "$*" # Doesn't work properly if "$*" isn't quoted.
19 do
20   echo "Arg #$index = $arg"
21   let "index+=1"
22 done            # $* sees all arguments as single word.
23 echo "Entire arg list seen as single word."
24
25 echo
26
27 index=1          # Reset count.
28                  # What happens if you forget to do this?
29
30 echo "Listing args with \"\$@\":"
31 for arg in "$@"
32 do
33   echo "Arg #$index = $arg"
34   let "index+=1"
35 done            # $@ sees arguments as separate words.
36 echo "Arg list seen as separate words."
37
38 echo
39
40 index=1          # Reset count.
41
42 echo "Listing args with \$* (unquoted):"
43 for arg in $*
44 do
45   echo "Arg #$index = $arg"
46   let "index+=1"
47 done            # Unquoted $* sees arguments as separate words.
48 echo "Arg list seen as separate words."
49
50 exit 0

```


Following a **shift**, the `$@` holds the remaining command-line parameters, lacking the previous `$1`, which was lost.

```

1 #!/bin/bash
2 # Invoke with ./scriptname 1 2 3 4 5
3
4 echo "$@"      # 1 2 3 4 5
5 shift
6 echo "$@"      # 2 3 4 5
7 shift
8 echo "$@"      # 3 4 5
9
10 # Each "shift" loses parameter $1.
11 # "$@" then contains the remaining parameters.

```

The `$@` special parameter finds use as a tool for filtering input into shell scripts. The **cat "\$@"** construction accepts input to a script either from `stdin` or from files given as parameters to the script. See [Example 16-24](#) and [Example 16-25](#).

 The `$*` and `$@` parameters sometimes display inconsistent and puzzling behavior, depending on the setting of `IIFS`.

Example 9-7. Inconsistent `$*` and `$@` behavior

```
1 #!/bin/bash
2
3 # Erratic behavior of the "$*" and "$@" internal Bash variables,
4 #+ depending on whether or not they are quoted.
5 # Demonstrates inconsistent handling of word splitting and linefeeds.
6
7
8 set -- "First one" "second" "third:one" "" "Fifth: :one"
9 # Setting the script arguments, $1, $2, $3, etc.
10
11 echo
12
13 echo 'IFS unchanged, using "$*"'
14 c=0
15 for i in "$*" # quoted
16 do echo "$((c+=1)): [$i]" # This line remains the same in every instance.
17 # Echo args.
18 done
19 echo ---
20
21 echo 'IFS unchanged, using $*'
22 c=0
23 for i in $* # unquoted
24 do echo "$((c+=1)): [$i]"
25 done
26 echo ---
27
28 echo 'IFS unchanged, using "$@"'
29 c=0
30 for i in "$@"
31 do echo "$((c+=1)): [$i]"
32 done
33 echo ---
34
35 echo 'IFS unchanged, using $@'
36 c=0
37 for i in $@
38 do echo "$((c+=1)): [$i]"
39 done
40 echo ---
41
42 IFS=:
43 echo 'IFS=":", using "$*"'
44 c=0
45 for i in "$*"
46 do echo "$((c+=1)): [$i]"
47 done
48 echo ---
49
50 echo 'IFS=":", using $*'
51 c=0
52 for i in $*
53 do echo "$((c+=1)): [$i]"
54 done
55 echo ---
56
57 var=$*
58 echo 'IFS=":", using "$var" (var=$*)'
```

```
59 c=0
60 for i in "$var"
61 do echo "$((c+=1)): [$i]"
62 done
63 echo ---
64
65 echo 'IFS=":", using $var (var=$*)'
66 c=0
67 for i in $var
68 do echo "$((c+=1)): [$i]"
69 done
70 echo ---
71
72 var="$*"
73 echo 'IFS=":", using $var (var="$*")'
74 c=0
75 for i in $var
76 do echo "$((c+=1)): [$i]"
77 done
78 echo ---
79
80 echo 'IFS=":", using "$var" (var="$*")'
81 c=0
82 for i in "$var"
83 do echo "$((c+=1)): [$i]"
84 done
85 echo ---
86
87 echo 'IFS=":", using "$@"'
88 c=0
89 for i in "$@"
90 do echo "$((c+=1)): [$i]"
91 done
92 echo ---
93
94 echo 'IFS=":", using $@'
95 c=0
96 for i in $@
97 do echo "$((c+=1)): [$i]"
98 done
99 echo ---
100
101 var=$@
102 echo 'IFS=":", using $var (var=$@)'
103 c=0
104 for i in $var
105 do echo "$((c+=1)): [$i]"
106 done
107 echo ---
108
109 echo 'IFS=":", using "$var" (var=$@)'
110 c=0
111 for i in "$var"
112 do echo "$((c+=1)): [$i]"
113 done
114 echo ---
115
116 var="$@"
117 echo 'IFS=":", using "$var" (var="$@")'
118 c=0
119 for i in "$var"
120 do echo "$((c+=1)): [$i]"
121 done
122 echo ---
123
124 echo 'IFS=":", using $var (var="$@")'
```

```

125 c=0
126 for i in $var
127 do echo "$((c+=1)): [$i]"
128 done
129
130 echo
131
132 # Try this script with ksh or zsh -y.
133
134 exit 0
135
136 # This example script written by Stephane Chazelas,
137 #+ and slightly modified by the document author.

```



The `$@` and `$*` parameters differ only when between double quotes.

Example 9-8. `$*` and `$@` when `$IFS` is empty

```

1 #!/bin/bash
2
3 # If $IFS set, but empty,
4 #+ then "$*" and "$@" do not echo positional params as expected.
5
6 mecho ()          # Echo positional parameters.
7 {
8 echo "$1,$2,$3";
9 }
10
11
12 IFS=""           # Set, but empty.
13 set a b c        # Positional parameters.
14
15 mecho "$*"       # abc,,
16 #               ^^
17 mecho $*         # a,b,c
18
19 mecho $@         # a,b,c
20 mecho "$@"       # a,b,c
21
22 # The behavior of $* and $@ when $IFS is empty depends
23 #+ on which Bash or sh version being run.
24 # It is therefore inadvisable to depend on this "feature" in a script.
25
26
27 # Thanks, Stephane Chazelas.
28
29 exit

```

Other Special Parameters

`$-`

Flags passed to script (using [set](#)). See [Example 15-16](#).



This was originally a *ksh* construct adopted into Bash, and unfortunately it does not seem to work reliably in Bash scripts. One possible use for it is to have a script [self-test whether it is interactive](#).

`$!`

[PID](#) (process ID) of last job run in background

```

1 LOG=$0.log
2
3 COMMAND1="sleep 100"
4
5 echo "Logging PIDs background commands for script: $0" >> "$LOG"
6 # So they can be monitored, and killed as necessary.
7 echo >> "$LOG"
8
9 # Logging commands.
10
11 echo -n "PID of \"\$COMMAND1\":  " >> "$LOG"
12 ${COMMAND1} &
13 echo $! >> "$LOG"
14 # PID of "sleep 100":  1506
15
16 # Thank you, Jacques Lederer, for suggesting this.

```

Using \$! for job control:

```

1 possibly_hanging_job & { sleep ${TIMEOUT}; eval 'kill -9 $!' &> /dev/null; }
2 # Forces completion of an ill-behaved program.
3 # Useful, for example, in init scripts.
4
5 # Thank you, Sylvain Fourmanoit, for this creative use of the "!" variable.

```

Or, alternately:

```

1 # This example by Matthew Sage.
2 # Used with permission.
3
4 TIMEOUT=30    # Timeout value in seconds
5 count=0
6
7 possibly_hanging_job & {
8     while ((count < TIMEOUT)); do
9         eval '[ ! -d "/proc/$!" ] && ((count = TIMEOUT))'
10        # /proc is where information about running processes is found.
11        # "-d" tests whether it exists (whether directory exists).
12        # So, we're waiting for the job in question to show up.
13        ((count++))
14        sleep 1
15    done
16    eval '[ -d "/proc/$!" ] && kill -15 $!'
17    # If the hanging job is running, kill it.
18 }
19
20 # ----- #
21
22 # However, this may not work as specified if another process
23 #+ begins to run after the "hanging_job" . . .
24 # In such a case, the wrong job may be killed.
25 # Ariel Meragelman suggests the following fix.
26
27 TIMEOUT=30
28 count=0
29 # Timeout value in seconds
30 possibly_hanging_job & {
31
32 while ((count < TIMEOUT)); do
33     eval '[ ! -d "/proc/$lastjob" ] && ((count = TIMEOUT))'
34     lastjob=$!
35     ((count++))
36     sleep 1
37 done
38 eval '[ -d "/proc/$lastjob" ] && kill -15 $lastjob'
39
40 }

```



```
41
42 exit
```

\$_

Special variable set to final argument of previous command executed.

Example 9-9. Underscore variable

```
1 #!/bin/bash
2
3 echo $_           # /bin/bash
4                   # Just called /bin/bash to run the script.
5                   # Note that this will vary according to
6                   #+ how the script is invoked.
7
8 du >/dev/null    # So no output from command.
9 echo $_          # du
10
11 ls -al >/dev/null # So no output from command.
12 echo $_         # -al (last argument)
13
14 :
15 echo $_         # :
```

\$?

[Exit status](#) of a command, [function](#), or the script itself (see [Example 24-7](#))

\$\$

Process ID (*PID*) of the script itself. [5] The \$\$ variable often finds use in scripts to construct "unique" temp file names (see [Example 32-6](#), [Example 16-31](#), and [Example 15-27](#)). This is usually simpler than invoking [mktemp](#).

Notes

- [1] A *stack register* is a set of consecutive memory locations, such that the values stored (*pushed*) are retrieved (*popped*) in *reverse* order. The last value stored is the first retrieved. This is sometimes called a *LIFO (last-in-first-out)* or *pushdown stack*.
- [2] The PID of the currently running script is \$\$, of course.
- [3] Somewhat analogous to [recursion](#), in this context *nesting* refers to a pattern embedded within a larger pattern. One of the definitions of *nest*, according to the 1913 edition of *Webster's Dictionary*, illustrates this beautifully: "A collection of boxes, cases, or the like, of graduated size, each put within the one next larger."
- [4] The words "argument" and "parameter" are often used interchangeably. In the context of this document, they have the same precise meaning: *a variable passed to a script or function*.
- [5] Within a script, inside a subshell, \$\$ [returns the PID of the script](#), not the subshell.

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9.2. Typing variables: declare or typeset

The *declare* or *typeset* [builtins](#), which are exact synonyms, permit modifying the properties of variables. This is a very weak form of the *typing* [\[1\]](#) available in certain programming languages. The *declare* command is specific to version 2 or later of Bash. The *typeset* command also works in ksh scripts.

declare/typeset options

-r readonly

(**declare -r var1** works the same as **readonly var1**)

This is the rough equivalent of the C *const* type qualifier. An attempt to change the value of a *readonly* variable fails with an error message.

```
1 declare -r var1=1
2 echo "var1 = $var1" # var1 = 1
3
4 (( var1++ )) # x.sh: line 4: var1: readonly variable
```

-i integer

```
1 declare -i number
2 # The script will treat subsequent occurrences of "number" as an integer.
3
4 number=3
5 echo "Number = $number" # Number = 3
6
7 number=three
8 echo "Number = $number" # Number = 0
9 # Tries to evaluate the string "three" as an integer.
```

Certain arithmetic operations are permitted for declared integer variables without the need for [expr](#) or [let](#).

```
1 n=6/3
2 echo "n = $n" # n = 6/3
3
4 declare -i n
5 n=6/3
6 echo "n = $n" # n = 2
```

-a array

```
1 declare -a indices
```

The variable *indices* will be treated as an [array](#).

-f function(s)

```
1 declare -f
```

A **declare -f** line with no arguments in a script causes a listing of all the [functions](#) previously defined in that script.

```
1 declare -f function_name
```

A **declare -f function_name** in a script lists just the function named.

-x export

```
1 declare -x var3
```

This declares a variable as available for exporting outside the environment of the script itself.


-x var=\$value

```
1 declare -x var3=373
```

The **declare** command permits assigning a value to a variable in the same statement as setting its properties.

Example 9-10. Using *declare* to type variables

```
1 #!/bin/bash
2
3 func1 ()
4 {
5     echo This is a function.
6 }
7
8 declare -f          # Lists the function above.
9
10 echo
11
12 declare -i var1    # var1 is an integer.
13 var1=2367
14 echo "var1 declared as $var1"
15 var1=var1+1       # Integer declaration eliminates the need for 'let'.
16 echo "var1 incremented by 1 is $var1."
17 # Attempt to change variable declared as integer.
18 echo "Attempting to change var1 to floating point value, 2367.1."
19 var1=2367.1       # Results in error message, with no change to variable.
20 echo "var1 is still $var1"
21
22 echo
23
24 declare -r var2=13.36    # 'declare' permits setting a variable property
25                          #+ and simultaneously assigning it a value.
26 echo "var2 declared as $var2" # Attempt to change readonly variable.
27 var2=13.37                # Generates error message, and exit from script.
28
29 echo "var2 is still $var2" # This line will not execute.
30
31 exit 0                    # Script will not exit here.
```

 Using the *declare* builtin restricts the [scope](#) of a variable.

```
1 foo ()
2 {
3     FOO="bar"
4 }
5
6 bar ()
7 {
8     foo
9     echo $FOO
10 }
11
12 bar    # Prints bar.
```

However ...

```
1 foo (){
2     declare FOO="bar"
3 }
4
5 bar ()
6 {
7     foo
```

```
8 echo $FOO
9 }
10
11 bar # Prints nothing.
12
13
14 # Thank you, Michael Iatrou, for pointing this out.
```

9.2.1. Another use for *declare*

The *declare* command can be helpful in identifying variables, [environmental](#) or otherwise. This can be especially useful with [arrays](#).

```
bash$ declare | grep HOME
HOME=/home/bozo

bash$ zzy=68
bash$ declare | grep zzy
zzy=68

bash$ Colors=([0]="purple" [1]="reddish-orange" [2]="light green")
bash$ echo ${Colors[@]}
purple reddish-orange light green
bash$ declare | grep Colors
Colors=([0]="purple" [1]="reddish-orange" [2]="light green")
```

Notes

- [1] In this context, *typing* a variable means to classify it and restrict its properties. For example, a variable *declared* or *typed* as an integer is no longer available for [string operations](#).

```
1 declare -i intvar
2
3 intvar=23
4 echo "$intvar" # 23
5 intvar=stringval
6 echo "$intvar" # 0
```

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9.3. \$RANDOM: generate random integer

Anyone who attempts to generate random numbers by deterministic means is, of course, living in a state of sin.

--John von Neumann

\$RANDOM is an internal Bash [function](#) (not a constant) that returns a *pseudorandom* [\[1\]](#) integer in the range 0 - 32767. It should *not* be used to generate an encryption key.

Example 9-11. Generating random numbers

```
1 #!/bin/bash
2
3 # $RANDOM returns a different random integer at each invocation.
4 # Nominal range: 0 - 32767 (signed 16-bit integer).
5
6 MAXCOUNT=10
7 count=1
8
9 echo
10 echo "$MAXCOUNT random numbers:"
11 echo "-----"
12 while [ "$count" -le $MAXCOUNT ]      # Generate 10 ($MAXCOUNT) random integers.
13 do
14     number=$RANDOM
15     echo $number
16     let "count += 1" # Increment count.
17 done
18 echo "-----"
19
20 # If you need a random int within a certain range, use the 'modulo' operator.
21 # This returns the remainder of a division operation.
22
23 RANGE=500
24
25 echo
26
27 number=$RANDOM
28 let "number %= $RANGE"
29 #           ^^
30 echo "Random number less than $RANGE --- $number"
31
32 echo
33
34
35
36 # If you need a random integer greater than a lower bound,
37 #+ then set up a test to discard all numbers below that.
38
39 FLOOR=200
40
41 number=0 #initialize
42 while [ "$number" -le $FLOOR ]
43 do
44     number=$RANDOM
45 done
46 echo "Random number greater than $FLOOR --- $number"
47 echo
48
```

```

49 # Let's examine a simple alternative to the above loop, namely
50 #     let "number = $RANDOM + $FLOOR"
51 # That would eliminate the while-loop and run faster.
52 # But, there might be a problem with that. What is it?
53
54
55
56 # Combine above two techniques to retrieve random number between two limits.
57 number=0 #initialize
58 while [ "$number" -le $FLOOR ]
59 do
60     number=$RANDOM
61     let "number %= $RANGE" # Scales $number down within $RANGE.
62 done
63 echo "Random number between $FLOOR and $RANGE --- $number"
64 echo
65
66
67
68 # Generate binary choice, that is, "true" or "false" value.
69 BINARY=2
70 T=1
71 number=$RANDOM
72
73 let "number %= $BINARY"
74 # Note that     let "number >= 14"     gives a better random distribution
75 #+ (right shifts out everything except last binary digit).
76 if [ "$number" -eq $T ]
77 then
78     echo "TRUE"
79 else
80     echo "FALSE"
81 fi
82
83 echo
84
85
86 # Generate a toss of the dice.
87 SPOTS=6 # Modulo 6 gives range 0 - 5.
88         # Incrementing by 1 gives desired range of 1 - 6.
89         # Thanks, Paulo Marcel Coelho Aragao, for the simplification.
90 die1=0
91 die2=0
92 # Would it be better to just set SPOTS=7 and not add 1? Why or why not?
93
94 # Tosses each die separately, and so gives correct odds.
95
96     let "die1 = $RANDOM % $SPOTS +1" # Roll first one.
97     let "die2 = $RANDOM % $SPOTS +1" # Roll second one.
98     # Which arithmetic operation, above, has greater precedence --
99     #+ modulo (%) or addition (+)?
100
101
102 let "throw = $die1 + $die2"
103 echo "Throw of the dice = $throw"
104 echo
105
106
107 exit 0

```

Example 9-12. Picking a random card from a deck

```

1 #!/bin/bash
2 # pick-card.sh
3
4 # This is an example of choosing random elements of an array.
5
6
7 # Pick a card, any card.
8
9 Suites="Clubs
10 Diamonds
11 Hearts
12 Spades"
13
14 Denominations="2
15 3
16 4
17 5
18 6
19 7
20 8
21 9
22 10
23 Jack
24 Queen
25 King
26 Ace"
27
28 # Note variables spread over multiple lines.
29
30
31 suite=($Suites)           # Read into array variable.
32 denomination=($Denominations)
33
34 num_suites=${#suite[*]}   # Count how many elements.
35 num_denominations=${#denomination[*]}
36
37 echo -n "${denomination[$((RANDOM%num_denominations))]} of "
38 echo ${suite[$((RANDOM%num_suites))]}
39
40
41 # $bozo sh pick-cards.sh
42 # Jack of Clubs
43
44
45 # Thank you, "jipe," for pointing out this use of $RANDOM.
46 exit 0

```

Example 9-13. Brownian Motion Simulation

```

1 #!/bin/bash
2 # brownian.sh
3 # Author: Mendel Cooper
4 # ReIdate: 10/26/07
5 # License: GPL3
6
7 # -----
8 # This script models Brownian motion:
9 #+ the random wanderings of tiny particles in a fluid,
10 #+ as they are buffeted by random currents and collisions.
11 #+ This is colloquially known as the "Drunkard's Walk."
12
13 # It can also be considered as a stripped-down simulation of a

```

```

14 #+ Galton Board, a slanted board with a pattern of pegs,
15 #+ down which rolls a succession of marbles, one at a time.
16 #+ At the bottom is a row of slots or catch basins in which
17 #+ the marbles come to rest at the end of their journey.
18 # Think of it as a kind of bare-bones Pachinko game.
19 # As you see by running the script,
20 #+ most of the marbles cluster around the center slot.
21 #+ This is consistent with the expected binomial distribution.
22 # As a Galton Board simulation, the script
23 #+ disregards such parameters as
24 #+ board tilt-angle, rolling friction of the marbles,
25 #+ angles of impact, and elasticity of the pegs.
26 # To what extent does this affect the accuracy of the simulation?
27 # -----
28
29 PASSES=500           # Number of particle interactions / marbles.
30 ROWS=10             # Number of "collisions" (or horiz. peg rows).
31 RANGE=3             # 0 - 2 output range from $RANDOM.
32 POS=0              # Left/right position.
33 RANDOM=$$          # Seeds the random number generator from PID
34                   #+ of script.
35
36 declare -a Slots    # Array holding cumulative results of passes.
37 NUMSLOTS=21        # Number of slots at bottom of board.
38
39
40 Initialize_Slots () { # Zero out all elements of the array.
41 for i in $( seq $NUMSLOTS )
42 do
43   Slots[$i]=0
44 done
45
46 echo                # Blank line at beginning of run.
47 }
48
49
50 Show_Slots () {
51 echo; echo
52 echo -n " "
53 for i in $( seq $NUMSLOTS ) # Pretty-print array elements.
54 do
55   printf "%3d" ${Slots[$i]} # Allot three spaces per result.
56 done
57
58 echo # Row of slots:
59 echo " |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|"
60 echo "                                     ||"
61 echo # Note that if the count within any particular slot exceeds 99,
62 #+ it messes up the display.
63 # Running only(!) 500 passes usually avoids this.
64 }
65
66
67 Move () {           # Move one unit right / left, or stay put.
68   Move=$RANDOM       # How random is $RANDOM? Well, let's see ...
69   let "Move %= RANGE" # Normalize into range of 0 - 2.
70   case "$Move" in
71     0 ) ;;          # Do nothing, i.e., stay in place.
72     1 ) ((POS--)); # Left.
73     2 ) ((POS++)); # Right.
74     * ) echo -n "Error ";; # Anomaly! (Should never occur.)
75   esac
76 }
77
78
79 Play () {          # Single pass (inner loop).

```

```

80 i=0
81 while [ "$i" -lt "$ROWS" ] # One event per row.
82 do
83     Move
84     ((i++));
85 done
86
87 SHIFT=11 # Why 11, and not 10?
88 let "POS += $SHIFT" # Shift "zero position" to center.
89 (( Slots[$POS]++ )) # DEBUG: echo $POS
90
91 # echo -n "$POS "
92
93 }
94
95
96 Run () { # Outer loop.
97 p=0
98 while [ "$p" -lt "$PASSES" ]
99 do
100     Play
101     (( p++ ))
102     POS=0 # Reset to zero. Why?
103 done
104 }
105
106
107 # -----
108 # main ()
109 Initialize_Slots
110 Run
111 Show_Slots
112 # -----
113
114 exit $?
115
116 # Exercises:
117 # -----
118 # 1) Show the results in a vertical bar graph, or as an alternative,
119 #+ a scattergram.
120 # 2) Alter the script to use /dev/urandom instead of $RANDOM.
121 # Will this make the results more random?
122 # 3) Provide some sort of "animation" or graphic output
123 # for each marble played.

```

Jipe points out a set of techniques for generating random numbers within a range.

```

1 # Generate random number between 6 and 30.
2 rnumber=$((RANDOM%25+6))
3
4 # Generate random number in the same 6 - 30 range,
5 #+ but the number must be evenly divisible by 3.
6 rnumber=$(( (RANDOM%30/3+1)*3 ))
7
8 # Note that this will not work all the time.
9 # It fails if $RANDOM%30 returns 0.
10
11 # Frank Wang suggests the following alternative:
12 rnumber=$(( RANDOM%27/3*3+6 ))

```

Bill Gradwohl came up with an improved formula that works for positive numbers.

```

1 rnumber=$(( (RANDOM%(max-min+divisibleBy))/divisibleBy*divisibleBy+min ))

```

Here Bill presents a versatile function that returns a random number between two specified values.

Example 9-14. Random between values

```
1 #!/bin/bash
2 # random-between.sh
3 # Random number between two specified values.
4 # Script by Bill Gradwohl, with minor modifications by the document author.
5 # Corrections in lines 187 and 189 by Anthony Le Clezio.
6 # Used with permission.
7
8
9 randomBetween() {
10  # Generates a positive or negative random number
11  #+ between $min and $max
12  #+ and divisible by $divisibleBy.
13  # Gives a "reasonably random" distribution of return values.
14  #
15  # Bill Gradwohl - Oct 1, 2003
16
17  syntax() {
18  # Function embedded within function.
19  echo
20  echo "Syntax: randomBetween [min] [max] [multiple]"
21  echo
22  echo -n "Expects up to 3 passed parameters, "
23  echo "but all are completely optional."
24  echo "min is the minimum value"
25  echo "max is the maximum value"
26  echo -n "multiple specifies that the answer must be "
27  echo "a multiple of this value."
28  echo "    i.e. answer must be evenly divisible by this number."
29  echo
30  echo "If any value is missing, defaults area supplied as: 0 32767 1"
31  echo -n "Successful completion returns 0, "
32  echo "unsuccessful completion returns"
33  echo "function syntax and 1."
34  echo -n "The answer is returned in the global variable "
35  echo "randomBetweenAnswer"
36  echo -n "Negative values for any passed parameter are "
37  echo "handled correctly."
38  }
39
40  local min=${1:-0}
41  local max=${2:-32767}
42  local divisibleBy=${3:-1}
43  # Default values assigned, in case parameters not passed to function.
44
45  local x
46  local spread
47
48  # Let's make sure the divisibleBy value is positive.
49  [ ${divisibleBy} -lt 0 ] && divisibleBy=$((0-divisibleBy))
50
51  # Sanity check.
52  if [ $# -gt 3 -o ${divisibleBy} -eq 0 -o ${min} -eq ${max} ]; then
53  syntax
54  return 1
55  fi
56
57  # See if the min and max are reversed.
58  if [ ${min} -gt ${max} ]; then
59  # Swap them.
60  x=${min}
61  min=${max}
```

```

62     max=${x}
63     fi
64
65     # If min is itself not evenly divisible by $divisibleBy,
66     #+ then fix the min to be within range.
67     if [  $$(\{min\}/divisibleBy * divisibleBy) -ne \{min\}$  ]; then
68         if [  $\{min\} -lt 0$  ]; then
69             min= $$(\{min\}/divisibleBy * divisibleBy)$ 
70         else
71             min= $$(\{((\{min\}/divisibleBy)+1) * divisibleBy\})$ 
72         fi
73     fi
74
75     # If max is itself not evenly divisible by $divisibleBy,
76     #+ then fix the max to be within range.
77     if [  $$(\{max\}/divisibleBy * divisibleBy) -ne \{max\}$  ]; then
78         if [  $\{max\} -lt 0$  ]; then
79             max= $$(\{((\{max\}/divisibleBy)-1) * divisibleBy\})$ 
80         else
81             max= $$(\{(\{max\}/divisibleBy * divisibleBy)\})$ 
82         fi
83     fi
84
85     # -----
86     # Now, to do the real work.
87
88     # Note that to get a proper distribution for the end points,
89     #+ the range of random values has to be allowed to go between
90     #+ 0 and  $\text{abs}(\text{max}-\text{min})+\text{divisibleBy}$ , not just  $\text{abs}(\text{max}-\text{min})+1$ .
91
92     # The slight increase will produce the proper distribution for the
93     #+ end points.
94
95     # Changing the formula to use  $\text{abs}(\text{max}-\text{min})+1$  will still produce
96     #+ correct answers, but the randomness of those answers is faulty in
97     #+ that the number of times the end points ( $\{min\}$  and  $\{max\}$ ) are returned
98     #+ is considerably lower than when the correct formula is used.
99     # -----
100
101     spread= $$(\{max\}-\{min\})$ 
102     # Omair Eshkenazi points out that this test is unnecessary,
103     #+ since max and min have already been switched around.
104     [  $\{spread\} -lt 0$  ] && spread= $$(\{0\}-spread)$ 
105     let spread+=divisibleBy
106     randomBetweenAnswer= $$(\{(\{RANDOM\}%spread)/divisibleBy * divisibleBy + min\})$ 
107
108     return 0
109
110     # However, Paulo Marcel Coelho Aragao points out that
111     #+ when  $\{max\}$  and  $\{min\}$  are not divisible by $divisibleBy,
112     #+ the formula fails.
113     #
114     # He suggests instead the following formula:
115     #     rnumber =  $$(\{(\{RANDOM\} * (\{max\} - \{min\} + 1) + \{min\}) / divisibleBy * divisibleBy\})$ 
116
117 }
118
119 # Let's test the function.
120 min=-14
121 max=20
122 divisibleBy=3
123
124
125 # Generate an array of expected answers and check to make sure we get
126 #+ at least one of each answer if we loop long enough.
127

```

```

128 declare -a answer
129 minimum=${min}
130 maximum=${max}
131   if [  $$(($minimum/divisibleBy*divisibleBy)) -ne ${minimum}$  ]; then
132     if [  $${minimum} -lt 0$  ]; then
133       minimum= $$(($minimum/divisibleBy*divisibleBy))$ 
134     else
135       minimum= $$(($minimum/divisibleBy+1)*divisibleBy)$ 
136     fi
137   fi
138
139
140   # If max is itself not evenly divisible by $divisibleBy,
141   #+ then fix the max to be within range.
142
143   if [  $$(($maximum/divisibleBy*divisibleBy)) -ne ${maximum}$  ]; then
144     if [  $${maximum} -lt 0$  ]; then
145       maximum= $$(($maximum/divisibleBy-1)*divisibleBy)$ 
146     else
147       maximum= $$(($maximum/divisibleBy*divisibleBy))$ 
148     fi
149   fi
150
151
152   # We need to generate only positive array subscripts,
153   #+ so we need a displacement that that will guarantee
154   #+ positive results.
155
156   disp= $$(0-$minimum)$ 
157   for ((i=${minimum}; i<=${maximum}; i+=divisibleBy)); do
158     answer[i+disp]=0
159   done
160
161
162   # Now loop a large number of times to see what we get.
163   loopIt=1000   # The script author suggests 100000,
164               #+ but that takes a good long while.
165
166   for ((i=0; i<${loopIt}; ++i)); do
167
168     # Note that we are specifying min and max in reversed order here to
169     #+ make the function correct for this case.
170
171     randomBetween  $${max} ${min} ${divisibleBy}$ 
172
173     # Report an error if an answer is unexpected.
174     [  $${randomBetweenAnswer} -lt ${min} -o ${randomBetweenAnswer} -gt ${max}$  ] \
175     && echo MIN or MAX error -  $${randomBetweenAnswer}!$ 
176     [  $$(($randomBetweenAnswer%$divisibleBy)) -ne 0$  ] \
177     && echo DIVISIBLE BY error -  $${randomBetweenAnswer}!$ 
178
179     # Store the answer away statistically.
180     answer[randomBetweenAnswer+disp]= $$(($answer[randomBetweenAnswer+disp]+1))$ 
181   done
182
183
184
185   # Let's check the results
186
187   for ((i=${minimum}; i<=${maximum}; i+=divisibleBy)); do
188     [  $${answer[i+disp]} -eq 0$  ] \
189     && echo "We never got an answer of $i." \
190     || echo " $${i}$  occurred  $${answer[i+disp]}$  times."
191   done
192
193

```

Just how random is \$RANDOM? The best way to test this is to write a script that tracks the distribution of "random" numbers generated by \$RANDOM. Let's roll a \$RANDOM die a few times . . .

Example 9-15. Rolling a single die with RANDOM

```
1 #!/bin/bash
2 # How random is RANDOM?
3
4 RANDOM=$$      # Reseed the random number generator using script process ID.
5
6 PIPS=6         # A die has 6 pips.
7 MAXTHROWS=600 # Increase this if you have nothing better to do with your time.
8 throw=0       # Number of times the dice have been cast.
9
10 ones=0        # Must initialize counts to zero,
11 twos=0        #+ since an uninitialized variable is null, NOT zero.
12 threes=0
13 fours=0
14 fives=0
15 sixes=0
16
17 print_result ()
18 {
19 echo
20 echo "ones =  $ones"
21 echo "twos =  $twos"
22 echo "threes = $threes"
23 echo "fours = $fours"
24 echo "fives = $fives"
25 echo "sixes = $sixes"
26 echo
27 }
28
29 update_count ()
30 {
31 case "$1" in
32 0) ((ones++)); # Since a die has no "zero", this corresponds to 1.
33 1) ((twos++)); # And this to 2.
34 2) ((threes++)); # And so forth.
35 3) ((fours++));
36 4) ((fives++));
37 5) ((sixes++));
38 esac
39 }
40
41 echo
42
43
44 while [ "$throw" -lt "$MAXTHROWS" ]
45 do
46   let "die1 = RANDOM % $PIPS"
47   update_count $die1
48   let "throw += 1"
49 done
50
51 print_result
52
53 exit $?
54
55 # The scores should distribute evenly, assuming RANDOM is random.
56 # With $MAXTHROWS at 600, all should cluster around 100,
```

```

57 #+ plus-or-minus 20 or so.
58 #
59 # Keep in mind that RANDOM is a ***pseudorandom*** generator,
60 #+ and not a spectacularly good one at that.
61
62 # Randomness is a deep and complex subject.
63 # Sufficiently long "random" sequences may exhibit
64 #+ chaotic and other "non-random" behavior.
65
66 # Exercise (easy):
67 # -----
68 # Rewrite this script to flip a coin 1000 times.
69 # Choices are "HEADS" and "TAILS."

```

As we have seen in the last example, it is best to *reseed* the *RANDOM* generator each time it is invoked. Using the same seed for *RANDOM* repeats the same series of numbers. [\[2\]](#) (This mirrors the behavior of the *random()* function in C.)

Example 9-16. Reseeding RANDOM

```

1 #!/bin/bash
2 # seeding-random.sh: Seeding the RANDOM variable.
3 # v 1.1, reldate 09 Feb 2013
4
5 MAXCOUNT=25      # How many numbers to generate.
6 SEED=
7
8 random_numbers ()
9 {
10 local count=0
11 local number
12
13 while [ "$count" -lt "$MAXCOUNT" ]
14 do
15     number=$RANDOM
16     echo -n "$number "
17     let "count++"
18 done
19 }
20
21 echo; echo
22
23 SEED=1
24 RANDOM=$SEED      # Setting RANDOM seeds the random number generator.
25 echo "Random seed = $SEED"
26 random_numbers
27
28
29 RANDOM=$SEED      # Same seed for RANDOM . . .
30 echo; echo "Again, with same random seed ..."
31 echo "Random seed = $SEED"
32 random_numbers   # . . . reproduces the exact same number series.
33                 #
34                 # When is it useful to duplicate a "random" series?
35
36 echo; echo
37
38 SEED=2
39 RANDOM=$SEED      # Trying again, but with a different seed . . .
40 echo "Random seed = $SEED"
41 random_numbers   # . . . gives a different number series.
42
43 echo; echo

```



```

44
45 # RANDOM=$$ seeds RANDOM from process id of script.
46 # It is also possible to seed RANDOM from 'time' or 'date' commands.
47
48 # Getting fancy...
49 SEED=$(head -1 /dev/urandom | od -N 1 | awk '{ print $2 }'| sed s/^0*//)
50 # Pseudo-random output fetched
51 #+ from /dev/urandom (system pseudo-random device-file),
52 #+ then converted to line of printable (octal) numbers by "od",
53 #+ then "awk" retrieves just one number for SEED,
54 #+ finally "sed" removes any leading zeros.
55 RANDOM=$SEED
56 echo "Random seed = $SEED"
57 random_numbers
58
59 echo; echo
60
61 exit 0

```



The `/dev/urandom` pseudo-device file provides a method of generating much more "random" pseudorandom numbers than the `$RANDOM` variable. **`dd if=/dev/urandom of=targetfile bs=1 count=XX`** creates a file of well-scattered pseudorandom numbers. However, assigning these numbers to a variable in a script requires a workaround, such as filtering through `od` (as in above example, [Example 16-14](#), and [Example A-36](#)), or even piping to `md5sum` (see [Example 36-16](#)).

There are also other ways to generate pseudorandom numbers in a script. **Awk** provides a convenient means of doing this.

Example 9-17. Pseudorandom numbers, using [awk](#)

```

1 #!/bin/bash
2 # random2.sh: Returns a pseudorandom number in the range 0 - 1,
3 #+ to 6 decimal places. For example: 0.822725
4 # Uses the awk rand() function.
5
6 AWKSCRIPT=' { srand(); print rand() } '
7 #           Command(s)/parameters passed to awk
8 # Note that srand() reseeds awk's random number generator.
9
10
11 echo -n "Random number between 0 and 1 = "
12
13 echo | awk "$AWKSCRIPT"
14 # What happens if you leave out the 'echo'?
15
16 exit 0
17
18
19 # Exercises:
20 # -----
21
22 # 1) Using a loop construct, print out 10 different random numbers.
23 #     (Hint: you must reseed the srand() function with a different seed
24 #+     in each pass through the loop. What happens if you omit this?)
25
26 # 2) Using an integer multiplier as a scaling factor, generate random numbers
27 #+     in the range of 10 to 100.
28
29 # 3) Same as exercise #2, above, but generate random integers this time.

```

The [date](#) command also lends itself to [generating pseudorandom integer sequences](#).

Notes

- [1] True "randomness," insofar as it exists at all, can only be found in certain incompletely understood natural phenomena, such as radioactive decay. Computers only *simulate* randomness, and computer-generated sequences of "random" numbers are therefore referred to as *pseudorandom*.
- [2] The *seed* of a computer-generated pseudorandom number series can be considered an identification label. For example, think of the pseudorandom series with a seed of 23 as *Series #23*.

A property of a pseudorandom number series is the length of the cycle before it starts repeating itself. A good pseudorandom generator will produce series with very long cycles.

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Chapter 10. Manipulating Variables

10.1. Manipulating Strings

Bash supports a surprising number of string manipulation operations. Unfortunately, these tools lack a unified focus. Some are a subset of [parameter substitution](#), and others fall under the functionality of the UNIX [expr](#) command. This results in inconsistent command syntax and overlap of functionality, not to mention confusion.

String Length

```
 ${#string}  
 expr length $string
```

These are the equivalent of *strlen()* in C.

```
 expr "$string" : '.*'
```

```
1 stringZ=abcABC123ABCabc  
2  
3 echo ${#stringZ}           # 15  
4 echo `expr length $stringZ` # 15  
5 echo `expr "$stringZ" : '.*'` # 15
```

Example 10-1. Inserting a blank line between paragraphs in a text file

```
1 #!/bin/bash  
2 # paragraph-space.sh  
3 # Ver. 2.1, Reldate 29Jul12 [fixup]  
4  
5 # Inserts a blank line between paragraphs of a single-spaced text file.  
6 # Usage: $0 <FILENAME  
7  
8 MINLEN=60          # Change this value? It's a judgment call.  
9 # Assume lines shorter than $MINLEN characters ending in a period  
10 #+ terminate a paragraph. See exercises below.  
11  
12 while read line # For as many lines as the input file has ...  
13 do  
14     echo "$line" # Output the line itself.  
15  
16     len=${#line}  
17     if [[ "$len" -lt "$MINLEN" && "$line" =~ [*\.\.}$ ]]  
18 # if [[ "$len" -lt "$MINLEN" && "$line" =~ \[*\.\.\\ ] ]  
19 # An update to Bash broke the previous version of this script. Ouch!  
20 # Thank you, Halim Srama, for pointing this out and suggesting a fix.  
21     then echo # Add a blank line immediately  
22     fi #+ after a short line terminated by a period.  
23 done  
24  
25 exit  
26  
27 # Exercises:  
28 # -----  
29 # 1) The script usually inserts a blank line at the end  
30 #+ of the target file. Fix this.  
31 # 2) Line 17 only considers periods as sentence terminators.  
32 # Modify this to include other common end-of-sentence characters,  
33 #+ such as ?, !, and ".
```

Length of Matching Substring at Beginning of String

```
expr match "$string" '$substring'
    $substring is a regular expression.
expr "$string" : '$substring'
    $substring is a regular expression.
```

```
1 stringZ=abcABC123ABCabc
2 #      |-----|
3 #      12345678
4
5 echo `expr match "$stringZ" 'abc[A-Z]*.2'` # 8
6 echo `expr "$stringZ" : 'abc[A-Z]*.2'` # 8
```

Index

```
expr index $string $substring
```

Numerical position in \$string of first character in \$substring that matches.

```
1 stringZ=abcABC123ABCabc
2 #      123456 ...
3 echo `expr index "$stringZ" C12` # 6
4 # C position.
5
6 echo `expr index "$stringZ" 1c` # 3
7 # 'c' (in #3 position) matches before '1'.
```

This is the near equivalent of *strchr()* in C.

Substring Extraction

```
${string:position}
```

Extracts substring from *\$string* at *\$position*.

If the *\$string* parameter is "*" or "@", then this extracts the [positional parameters](#), [1] starting at *\$position*.

```
${string:position:length}
```

Extracts *\$length* characters of substring from *\$string* at *\$position*.

```
1 stringZ=abcABC123ABCabc
2 #      0123456789.....
3 #      0-based indexing.
4
5 echo ${stringZ:0} # abcABC123ABCabc
6 echo ${stringZ:1} # bcABC123ABCabc
7 echo ${stringZ:7} # 23ABCabc
8
9 echo ${stringZ:7:3} # 23A
10 # Three characters of substring.
11
12
13
14 # Is it possible to index from the right end of the string?
15
16 echo ${stringZ:-4} # abcABC123ABCabc
17 # Defaults to full string, as in ${parameter:-default}.
18 # However . . .
19
20 echo ${stringZ:(-4)} # Cabc
21 echo ${stringZ: -4} # Cabc
22 # Now, it works.
```

```

23 # Parentheses or added space "escape" the position parameter.
24
25 # Thank you, Dan Jacobson, for pointing this out.

```

The *position* and *length* arguments can be "parameterized," that is, represented as a variable, rather than as a numerical constant.

Example 10-2. Generating an 8-character "random" string

```

1 #!/bin/bash
2 # rand-string.sh
3 # Generating an 8-character "random" string.
4
5 if [ -n "$1" ] # If command-line argument present,
6 then          #+ then set start-string to it.
7   str0="$1"
8 else          # Else use PID of script as start-string.
9   str0="$ $"
10 fi
11
12 POS=2 # Starting from position 2 in the string.
13 LEN=8 # Extract eight characters.
14
15 str1=$( echo "$str0" | md5sum | md5sum )
16 # Doubly scramble          ^^^^^^  ^^^^^^
17 #+ by piping and repiping to md5sum.
18
19 randstring="${str1:$POS:$LEN}"
20 # Can parameterize ^^^^ ^^^^
21
22 echo "$randstring"
23
24 exit $?
25
26 # bozo$ ./rand-string.sh my-password
27 # lbdd88c4
28
29 # No, this is is not recommended
30 #+ as a method of generating hack-proof passwords.

```

If the `$string` parameter is "*" or "@", then this extracts a maximum of `$length` positional parameters, starting at `$position`.

```

1 echo ${*:2}          # Echoes second and following positional parameters.
2 echo {@:2}          # Same as above.
3
4 echo ${*:2:3}        # Echoes three positional parameters, starting at second.

```

`expr substr $string $position $length`

Extracts `$length` characters from `$string` starting at `$position`.

```

1 stringZ=abcABC123ABCabc
2 #      123456789.....
3 #      1-based indexing.
4
5 echo `expr substr $stringZ 1 2`          # ab
6 echo `expr substr $stringZ 4 3`          # ABC

```

`expr match "$string" "\($substring\)"`

Extracts `$substring` at beginning of `$string`, where `$substring` is a [regular expression](#).

`expr "$string" : "\($substring\)"`

Extracts *\$substring* at beginning of *\$string*, where *\$substring* is a regular expression.

```
1 stringZ=abcABC123ABCabc
2 #          =====
3
4 echo `expr match "$stringZ" '\([b-c]*[A-Z]..[0-9]\)` # abcABC1
5 echo `expr "$stringZ" : '\([b-c]*[A-Z]..[0-9]\)` # abcABC1
6 echo `expr "$stringZ" : '\(.....\) ` # abcABC1
7 # All of the above forms give an identical result.
```

`expr match "$string" '.*\($substring\)`

Extracts *\$substring* at end of *\$string*, where *\$substring* is a regular expression.

`expr "$string" : '.*\($substring\)`

Extracts *\$substring* at end of *\$string*, where *\$substring* is a regular expression.

```
1 stringZ=abcABC123ABCabc
2 #          =====
3
4 echo `expr match "$stringZ" '.*\([A-C][A-C][A-C][a-c]*\) ` # ABCabc
5 echo `expr "$stringZ" : '.*\([A-C][A-C][A-C][a-c]*\) ` # ABCabc
```

Substring Removal

`${string#substring}`

Deletes shortest match of *\$substring* from front of *\$string*.

`${string##substring}`

Deletes longest match of *\$substring* from front of *\$string*.

```
1 stringZ=abcABC123ABCabc
2 #          |----|          shortest
3 #          |-----|       longest
4
5 echo ${stringZ#a*C} # 123ABCabc
6 # Strip out shortest match between 'a' and 'C'.
7
8 echo ${stringZ##a*C} # abc
9 # Strip out longest match between 'a' and 'C'.
10
11
12
13 # You can parameterize the substrings.
14
15 X='a*C'
16
17 echo ${stringZ#$X} # 123ABCabc
18 echo ${stringZ##$X} # abc
19 # As above.
```

`${string%substring}`

Deletes shortest match of *\$substring* from back of *\$string*.

For example:

```
1 # Rename all filenames in $PWD with "TXT" suffix to a "txt" suffix.
2 # For example, "file1.TXT" becomes "file1.txt" . . .
3
4 SUFF=TXT
5 suff=txt
6
7 for i in $(ls *.$SUFF)
8 do
9     mv -f $i ${i%.$SUFF}.$suff
10 # Leave unchanged everything *except* the shortest pattern match
```



```

11  #+ starting from the right-hand-side of the variable $i . . .
12 done ### This could be condensed into a "one-liner" if desired.
13
14 # Thank you, Rory Winston.

```

`${string%%substring}`

Deletes longest match of *\$substring* from *back* of *\$string*.

```

1 stringZ=abcABC123ABCabc
2 #                               ||      shortest
3 #          |-----|          longest
4
5 echo ${stringZ%b*c}           # abcABC123ABCa
6 # Strip out shortest match between 'b' and 'c', from back of $stringZ.
7
8 echo ${stringZ%%b*c}         # a
9 # Strip out longest match between 'b' and 'c', from back of $stringZ.

```

This operator is useful for generating filenames.

Example 10-3. Converting graphic file formats, with filename change

```

1 #!/bin/bash
2 #  cvt.sh:
3 #  Converts all the MacPaint image files in a directory to "pbm" format.
4
5 #  Uses the "macptopbm" binary from the "netpbm" package,
6 #+ which is maintained by Brian Henderson (bryanh@giraffe-data.com).
7 #  Netpbm is a standard part of most Linux distros.
8
9 OPERATION=macptopbm
10 SUFFIX=pbm           # New filename suffix.
11
12 if [ -n "$1" ]
13 then
14     directory=$1     # If directory name given as a script argument...
15 else
16     directory=$PWD   # Otherwise use current working directory.
17 fi
18
19 #  Assumes all files in the target directory are MacPaint image files,
20 #+ with a ".mac" filename suffix.
21
22 for file in $directory/*      # Filename globbing.
23 do
24     filename=${file%.*c}      # Strip ".mac" suffix off filename
25                               #+ ('.*c' matches everything
26                               #+ between '.' and 'c', inclusive).
27     $OPERATION $file > "$filename.$SUFFIX"
28                               # Redirect conversion to new filename.
29     rm -f $file              # Delete original files after converting.
30     echo "$filename.$SUFFIX" # Log what is happening to stdout.
31 done
32
33 exit 0
34
35 # Exercise:
36 # -----
37 #  As it stands, this script converts *all* the files in the current
38 #+ working directory.
39 #  Modify it to work *only* on files with a ".mac" suffix.
40
41
42
43 # *** And here's another way to do it. *** #

```

```

44
45 #!/bin/bash
46 # Batch convert into different graphic formats.
47 # Assumes imagemagick installed (standard in most Linux distros).
48
49 INFMT=png # Can be tif, jpg, gif, etc.
50 OUTFMT=pdf # Can be tif, jpg, gif, pdf, etc.
51
52 for pic in *"$INFMT"
53 do
54     p2=$(ls "$pic" | sed -e s/\.${INFMT}/)
55     # echo $p2
56     convert "$pic" $p2.$OUTFMT
57     done
58
59 exit $?

```

Example 10-4. Converting streaming audio files to ogg

```

1 #!/bin/bash
2 # ra2ogg.sh: Convert streaming audio files (*.ra) to ogg.
3
4 # Uses the "mplayer" media player program:
5 #     http://www.mplayerhq.hu/homepage
6 # Uses the "ogg" library and "oggenc":
7 #     http://www.xiph.org/
8 #
9 # This script may need appropriate codecs installed, such as sipr.so ...
10 # Possibly also the compat-libstdc++ package.
11
12
13 OFILEPREF=${1%$ra} # Strip off the "ra" suffix.
14 OFILESUFF=wav # Suffix for wav file.
15 OUTFILE="$OFILEPREF"$OFILESUFF"
16 E_NOARGS=85
17
18 if [ -z "$1" ] # Must specify a filename to convert.
19 then
20     echo "Usage: `basename $0` [filename]"
21     exit $E_NOARGS
22 fi
23
24
25 #####
26 mplayer "$1" -ao pcm:file=$OUTFILE
27 oggenc "$OUTFILE" # Correct file extension automatically added by oggenc.
28 #####
29
30 rm "$OUTFILE" # Delete intermediate *.wav file.
31 # If you want to keep it, comment out above line.
32
33 exit $?
34
35 # Note:
36 # ----
37 # On a Website, simply clicking on a *.ram streaming audio file
38 #+ usually only downloads the URL of the actual *.ra audio file.
39 # You can then use "wget" or something similar
40 #+ to download the *.ra file itself.
41
42
43 # Exercises:

```

```
44 # -----
45 # As is, this script converts only *.ra filenames.
46 # Add flexibility by permitting use of *.ram and other filenames.
47 #
48 # If you're really ambitious, expand the script
49 #+ to do automatic downloads and conversions of streaming audio files.
50 # Given a URL, batch download streaming audio files (using "wget")
51 #+ and convert them on the fly.
```

A simple emulation of [getopt](#) using substring-extraction constructs.

Example 10-5. Emulating *getopt*

```
1 #!/bin/bash
2 # getopt-simple.sh
3 # Author: Chris Morgan
4 # Used in the ABS Guide with permission.
5
6
7 getopt_simple()
8 {
9     echo "getopt_simple()"
10    echo "Parameters are '$*'"
11    until [ -z "$1" ]
12    do
13        echo "Processing parameter of: '$1'"
14        if [ ${1:0:1} = '/' ]
15        then
16            tmp=${1:1}           # Strip off leading '/' . . .
17            parameter=${tmp%*=} # Extract name.
18            value=${tmp##*=}    # Extract value.
19            echo "Parameter: '$parameter', value: '$value'"
20            eval $parameter=$value
21        fi
22        shift
23    done
24 }
25
26 # Pass all options to getopt_simple().
27 getopt_simple $*
28
29 echo "test is '$test'"
30 echo "test2 is '$test2'"
31
32 exit 0 # See also, UseGetOpt.sh, a modified version of this script.
33
34 ---
35
36 sh getopt_example.sh /test=value1 /test2=value2
37
38 Parameters are '/test=value1 /test2=value2'
39 Processing parameter of: '/test=value1'
40 Parameter: 'test', value: 'value1'
41 Processing parameter of: '/test2=value2'
42 Parameter: 'test2', value: 'value2'
43 test is 'value1'
44 test2 is 'value2'
45
```

`${string/substring/replacement}`

Replace first *match* of *\$substring* with *\$replacement*. [2]

`${string//substring/replacement}`

Replace all matches of *\$substring* with *\$replacement*.

```
1 stringZ=abcABC123ABCabc
2
3 echo ${stringZ/abc/xyz}      # xyzABC123ABCabc
4                               # Replaces first match of 'abc' with 'xyz'.
5
6 echo ${stringZ//abc/xyz}    # xyzABC123ABCxyz
7                               # Replaces all matches of 'abc' with # 'xyz'.
8
9 echo -----
10 echo "$stringZ"            # abcABC123ABCabc
11 echo -----
12                               # The string itself is not altered!
13
14 # Can the match and replacement strings be parameterized?
15 match=abc
16 repl=000
17 echo ${stringZ/$match/$repl} # 000ABC123ABCabc
18 #           ^           ^           ^^^
19 echo ${stringZ//$match/$repl} # 000ABC123ABC000
20 # Yes!           ^           ^           ^^^           ^^^
21
22 echo
23
24 # What happens if no $replacement string is supplied?
25 echo ${stringZ/abc}        # ABC123ABCabc
26 echo ${stringZ//abc}       # ABC123ABC
27 # A simple deletion takes place.
```

`${string/#substring/replacement}`

If *\$substring* matches *front end* of *\$string*, substitute *\$replacement* for *\$substring*.

`${string/%substring/replacement}`

If *\$substring* matches *back end* of *\$string*, substitute *\$replacement* for *\$substring*.

```
1 stringZ=abcABC123ABCabc
2
3 echo ${stringZ/#abc/XYZ}    # XYZABC123ABCabc
4                               # Replaces front-end match of 'abc' with 'XYZ'.
5
6 echo ${stringZ/%abc/XYZ}   # abcABC123ABCXYZ
7                               # Replaces back-end match of 'abc' with 'XYZ'.
```

10.1.1. Manipulating strings using awk

A Bash script may invoke the string manipulation facilities of [awk](#) as an alternative to using its built-in operations.

Example 10-6. Alternate ways of extracting and locating substrings

```
1 #!/bin/bash
2 # substring-extraction.sh
3
4 String=23skidool
5 #           012345678      Bash
6 #           123456789      awk
```

```

7 # Note different string indexing system:
8 # Bash numbers first character of string as 0.
9 # Awk numbers first character of string as 1.
10
11 echo ${String:2:4} # position 3 (0-1-2), 4 characters long
12                     # skid
13
14 # The awk equivalent of ${string:pos:length} is substr(string,pos,length).
15 echo | awk '
16 { print substr("'"${String}"'",3,4)      # skid
17 }
18 '
19 # Piping an empty "echo" to awk gives it dummy input,
20 #+ and thus makes it unnecessary to supply a filename.
21
22 echo "----"
23
24 # And likewise:
25
26 echo | awk '
27 { print index("'"${String}"'", "skid")    # 3
28 }                                           # (skid starts at position 3)
29 ' # The awk equivalent of "expr index" ...
30
31 exit 0

```

10.1.2. Further Reference

For more on string manipulation in scripts, refer to [Section 10.2](#) and the [relevant section](#) of the [expr](#) command listing.

Script examples:

1. [Example 16-9](#)
2. [Example 10-9](#)
3. [Example 10-10](#)
4. [Example 10-11](#)
5. [Example 10-13](#)
6. [Example A-36](#)
7. [Example A-41](#)

Notes

- [1] This applies to either command-line arguments or parameters passed to a [function](#).
- [2] Note that *\$substring* and *\$replacement* may refer to either *literal strings* or *variables*, depending on context. See the first usage example.

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10.2. Parameter Substitution

Manipulating and/or expanding variables

`${parameter}`

Same as `$parameter`, i.e., value of the variable `parameter`. In certain contexts, only the less ambiguous `${parameter}` form works.

May be used for concatenating variables with strings.

```
1 your_id=${USER}-on-${HOSTNAME}
2 echo "$your_id"
3 #
4 echo "Old \SPATH = $PATH"
5 PATH=${PATH}:/opt/bin # Add /opt/bin to $PATH for duration of script.
6 echo "New \SPATH = $PATH"
```

`${parameter-default}`, `${parameter:-default}`

If parameter not set, use default.

```
1 var1=1
2 var2=2
3 # var3 is unset.
4
5 echo ${var1-$var2} # 1
6 echo ${var3-$var2} # 2
7 #           ^           Note the $ prefix.
8
9
10
11 echo ${username-`whoami`}
12 # Echoes the result of `whoami`, if variable $username is still unset.
```



`${parameter-default}` and `${parameter:-default}` are almost equivalent. The extra `:` makes a difference only when `parameter` has been declared, but is null.

```
1 #!/bin/bash
2 # param-sub.sh
3
4 # Whether a variable has been declared
5 #+ affects triggering of the default option
6 #+ even if the variable is null.
7
8 username0=
9 echo "username0 has been declared, but is set to null."
10 echo "username0 = ${username0-`whoami`}"
11 # Will not echo.
12
13 echo
14
15 echo username1 has not been declared.
16 echo "username1 = ${username1-`whoami`}"
17 # Will echo.
18
19 username2=
20 echo "username2 has been declared, but is set to null."
21 echo "username2 = ${username2:-`whoami`}"
22 #           ^
23 # Will echo because of :- rather than just - in condition test.
24 # Compare to first instance, above.
```

```

25
26
27 #
28
29 # Once again:
30
31 variable=
32 # variable has been declared, but is set to null.
33
34 echo "${variable-0}"      # (no output)
35 echo "${variable:-1}"    # 1
36 #           ^
37
38 unset variable
39
40 echo "${variable-2}"      # 2
41 echo "${variable:-3}"    # 3
42
43 exit 0

```

The *default parameter* construct finds use in providing "missing" command-line arguments in scripts.

```

1 DEFAULT_FILENAME=generic.data
2 filename=${1:-$DEFAULT_FILENAME}
3 # If not otherwise specified, the following command block operates
4 #+ on the file "generic.data".
5 # Begin-Command-Block
6 # ...
7 # ...
8 # ...
9 # End-Command-Block
10
11
12
13 # From "hanoi2.bash" example:
14 DISKS=${1:-E_NOPARAM} # Must specify how many disks.
15 # Set $DISKS to $1 command-line-parameter,
16 #+ or to $E_NOPARAM if that is unset.

```

See also [Example 3-4](#), [Example 31-2](#), and [Example A-6](#).

Compare this method with [using an and list to supply a default command-line argument](#).

`${parameter=default}`, **`${parameter:=default}`**

If parameter not set, set it to *default*.

Both forms nearly equivalent. The `:` makes a difference only when `$parameter` has been declared and is null, [\[1\]](#) as above.

```

1 echo ${var=abc} # abc
2 echo ${var=xyz} # abc
3 # $var had already been set to abc, so it did not change.

```

`${parameter+alt_value}`, **`${parameter:+alt_value}`**

If parameter set, use **`alt_value`**, else use null string.

Both forms nearly equivalent. The `:` makes a difference only when *parameter* has been declared and is null, see below.

```

1 echo "##### \${parameter+alt_value} #####"
2 echo
3
4 a=${param1+xyz}
5 echo "a = $a" # a =

```



```

6
7 param2=
8 a=${param2+xyz}
9 echo "a = $a"      # a = xyz
10
11 param3=123
12 a=${param3+xyz}
13 echo "a = $a"      # a = xyz
14
15 echo
16 echo "##### \${parameter:+alt_value} #####"
17 echo
18
19 a=${param4:+xyz}
20 echo "a = $a"      # a =
21
22 param5=
23 a=${param5:+xyz}
24 echo "a = $a"      # a =
25 # Different result from a=${param5+xyz}
26
27 param6=123
28 a=${param6:+xyz}
29 echo "a = $a"      # a = xyz

```

`${parameter?err_msg}`, `${parameter:?err_msg}`

If parameter set, use it, else print *err_msg* and *abort the script* with an [exit status](#) of 1.

Both forms nearly equivalent. The `:` makes a difference only when *parameter* has been declared and is null, as above.

Example 10-7. Using parameter substitution and error messages

```

1 #!/bin/bash
2
3 # Check some of the system's environmental variables.
4 # This is good preventative maintenance.
5 # If, for example, $USER, the name of the person at the console, is not set,
6 #+ the machine will not recognize you.
7
8 : ${HOSTNAME?} ${USER?} ${HOME?} ${MAIL?}
9 echo
10 echo "Name of the machine is $HOSTNAME."
11 echo "You are $USER."
12 echo "Your home directory is $HOME."
13 echo "Your mail INBOX is located in $MAIL."
14 echo
15 echo "If you are reading this message,"
16 echo "critical environmental variables have been set."
17 echo
18 echo
19
20 # -----
21
22 # The ${variablename?} construction can also check
23 #+ for variables set within the script.
24
25 ThisVariable=Value-of-ThisVariable
26 # Note, by the way, that string variables may be set
27 #+ to characters disallowed in their names.
28 : ${ThisVariable?}
29 echo "Value of ThisVariable is $ThisVariable".
30
31 echo; echo

```

```

32
33
34 : ${ZZXy23AB?"ZZXy23AB has not been set."}
35 # Since ZZXy23AB has not been set,
36 #+ then the script terminates with an error message.
37
38 # You can specify the error message.
39 # : ${variablename?"ERROR MESSAGE"}
40
41
42 # Same result with: dummy_variable=${ZZXy23AB?}
43 # dummy_variable=${ZZXy23AB?"ZXY23AB has not been set."}
44 #
45 # echo ${ZZXy23AB?} >/dev/null
46
47 # Compare these methods of checking whether a variable has been set
48 #+ with "set -u" . . .
49
50
51
52 echo "You will not see this message, because script already terminated."
53
54 HERE=0
55 exit $HERE # Will NOT exit here.
56
57 # In fact, this script will return an exit status (echo $?) of 1.

```

Example 10-8. Parameter substitution and "usage" messages

```

1 #!/bin/bash
2 # usage-message.sh
3
4 : ${1?"Usage: $0 ARGUMENT"}
5 # Script exits here if command-line parameter absent,
6 #+ with following error message.
7 # usage-message.sh: 1: Usage: usage-message.sh ARGUMENT
8
9 echo "These two lines echo only if command-line parameter given."
10 echo "command-line parameter = \"$1\""
11
12 exit 0 # Will exit here only if command-line parameter present.
13
14 # Check the exit status, both with and without command-line parameter.
15 # If command-line parameter present, then "$?" is 0.
16 # If not, then "$?" is 1.


```

Parameter substitution and/or expansion. The following expressions are the complement to the **match** *in* **expr** string operations (see [Example 16-9](#)). These particular ones are used mostly in parsing file path names.

Variable length / Substring removal

`#{#var}`

String length (number of characters in `$var`). For an [array](#), `#{#array}` is the length of the first element in the array.

 Exceptions:

◇

`#{#*}` and `#{#@}` give the *number of positional parameters*.

◇ For an array, `${#array[*]}` and `${#array[@]}` give the number of elements in the array.

Example 10-9. Length of a variable

```
1 #!/bin/bash
2 # length.sh
3
4 E_NO_ARGS=65
5
6 if [ $# -eq 0 ] # Must have command-line args to demo script.
7 then
8     echo "Please invoke this script with one or more command-line arguments."
9     exit $E_NO_ARGS
10 fi
11
12 var01=abcdEFGH28ij
13 echo "var01 = ${var01}"
14 echo "Length of var01 = ${#var01}"
15 # Now, let's try embedding a space.
16 var02="abcd EFGH28ij"
17 echo "var02 = ${var02}"
18 echo "Length of var02 = ${#var02}"
19
20 echo "Number of command-line arguments passed to script = ${#@}"
21 echo "Number of command-line arguments passed to script = ${#*}"
22
23 exit 0
```

`${var#Pattern}`, `${var##Pattern}`

`${var#Pattern}` Remove from `$var` the *shortest* part of `$Pattern` that matches the *front end* of `$var`.

`${var##Pattern}` Remove from `$var` the *longest* part of `$Pattern` that matches the *front end* of `$var`.

A usage illustration from [Example A-7](#):

```
1 # Function from "days-between.sh" example.
2 # Strips leading zero(s) from argument passed.
3
4 strip_leading_zero () # Strip possible leading zero(s)
5 {                    #+ from argument passed.
6     return=${1#0}    # The "1" refers to "$1" -- passed arg.
7 }                   # The "0" is what to remove from "$1" -- strips zeros.
```

Manfred Schwarz's more elaborate variation of the above:

```
1 strip_leading_zero2 () # Strip possible leading zero(s), since otherwise
2 {                      # Bash will interpret such numbers as octal values.
3     shopt -s extglob    # Turn on extended globbing.
4     local val=${1##+(0)} # Use local variable, longest matching series of 0's.
5     shopt -u extglob    # Turn off extended globbing.
6     _strip_leading_zero2=${val:-0}
7                         # If input was 0, return 0 instead of "".
8 }
```

Another usage illustration:

```

1 echo `basename $PWD`           # Basename of current working directory.
2 echo "${PWD##*/}"              # Basename of current working directory.
3 echo
4 echo `basename $0`             # Name of script.
5 echo $0                        # Name of script.
6 echo "${0##*/}"                # Name of script.
7 echo
8 filename=test.data
9 echo "${filename##*.}"         # data
10                               # Extension of filename.

```

`${var%Pattern}`, `${var%%Pattern}`

`${var%Pattern}` Remove from `$var` the *shortest* part of `$Pattern` that matches the *back end* of `$var`.

`${var%%Pattern}` Remove from `$var` the *longest* part of `$Pattern` that matches the *back end* of `$var`.

[Version 2](#) of Bash added additional options.

Example 10-10. Pattern matching in parameter substitution

```

1 #!/bin/bash
2 # patt-matching.sh
3
4 # Pattern matching using the # ## % %% parameter substitution operators.
5
6 var1=abcd12345abc6789
7 pattern1=a*c # * (wild card) matches everything between a - c.
8
9 echo
10 echo "var1 = $var1"           # abcd12345abc6789
11 echo "var1 = ${var1}"        # abcd12345abc6789
12                               # (alternate form)
13 echo "Number of characters in ${var1} = ${#var1}"
14 echo
15
16 echo "pattern1 = $pattern1"   # a*c (everything between 'a' and 'c')
17 echo "-----"
18 echo "${var1#$pattern1} =" "${var1#$pattern1}" #           d12345abc6789
19 # Shortest possible match, strips out first 3 characters  abcd12345abc6789
20 #                               ^^^^^          | - |
21 echo "${var1##$pattern1} =" "${var1##$pattern1}" #           6789
22 # Longest possible match, strips out first 12 characters  abcd12345abc6789
23 #                               ^^^^^          |-----|
24
25 echo; echo; echo
26
27 pattern2=b*9                 # everything between 'b' and '9'
28 echo "var1 = $var1"         # Still abcd12345abc6789
29 echo
30 echo "pattern2 = $pattern2"
31 echo "-----"
32 echo "${var1%$pattern2} =" "${var1%$pattern2}" #           abcd12345a
33 # Shortest possible match, strips out last 6 characters  abcd12345abc6789
34 #                               ^^^^^          |----|
35 echo "${var1%%$pattern2} =" "${var1%%$pattern2}" #           a
36 # Longest possible match, strips out last 12 characters  abcd12345abc6789
37 #                               ^^^^^          |-----|
38
39 # Remember, # and ## work from the left end (beginning) of string,

```

```
40 #           % and %% work from the right end.
41
42 echo
43
44 exit 0
```

Example 10-11. Renaming file extensions:

```
1 #!/bin/bash
2 # rfe.sh: Renaming file extensions.
3 #
4 #           rfe old_extension new_extension
5 #
6 # Example:
7 # To rename all *.gif files in working directory to *.jpg,
8 #           rfe gif jpg
9
10
11 E_BADARGS=65
12
13 case $# in
14   0|1)           # The vertical bar means "or" in this context.
15     echo "Usage: `basename $0` old_file_suffix new_file_suffix"
16     exit $E_BADARGS # If 0 or 1 arg, then bail out.
17   ;;
18 esac
19
20
21 for filename in *.$1
22 # Traverse list of files ending with 1st argument.
23 do
24   mv $filename ${filename%$1}$2
25   # Strip off part of filename matching 1st argument,
26   #+ then append 2nd argument.
27 done
28
29 exit 0
```

Variable expansion / Substring replacement

These constructs have been adopted from *ksh*.

`${var:pos}`

Variable *var* expanded, starting from offset *pos*.

`${var:pos:len}`

Expansion to a max of *len* characters of variable *var*, from offset *pos*. See [Example A-13](#) for an example of the creative use of this operator.

`${var/Pattern/Replacement}`

First match of *Pattern*, within *var* replaced with *Replacement*.

If *Replacement* is omitted, then the first match of *Pattern* is replaced by *nothing*, that is, deleted.

`${var//Pattern/Replacement}`

Global replacement. All matches of *Pattern*, within *var* replaced with *Replacement*.

As above, if *Replacement* is omitted, then all occurrences of *Pattern* are replaced by *nothing*, that is, deleted.

Example 10-12. Using pattern matching to parse arbitrary strings

```
1 #!/bin/bash
2
3 var1=abcd-1234-defg
4 echo "var1 = $var1"
5
6 t=${var1#*-}
7 echo "var1 (with everything, up to and including first - stripped out) = $t"
8 # t=${var1#*-} works just the same,
9 #+ since # matches the shortest string,
10 #+ and * matches everything preceding, including an empty string.
11 # (Thanks, Stephane Chazelas, for pointing this out.)
12
13 t=${var1##*-}
14 echo "If var1 contains a \"-\", returns empty string... var1 = $t"
15
16
17 t=${var1%*-}
18 echo "var1 (with everything from the last - on stripped out) = $t"
19
20 echo
21
22 # -----
23 path_name=/home/bozo/ideas/thoughts.for.today
24 # -----
25 echo "path_name = $path_name"
26 t=${path_name##*/}
27 echo "path_name, stripped of prefixes = $t"
28 # Same effect as t=`basename $path_name` in this particular case.
29 # t=${path_name%/*}; t=${t##*/} is a more general solution,
30 #+ but still fails sometimes.
31 # If $path_name ends with a newline, then `basename $path_name` will not work,
32 #+ but the above expression will.
33 # (Thanks, S.C.)
34
35 t=${path_name%/*.*}
36 # Same effect as t=`dirname $path_name`
37 echo "path_name, stripped of suffixes = $t"
38 # These will fail in some cases, such as "../", "/foo////", # "foo/", "/".
39 # Removing suffixes, especially when the basename has no suffix,
40 #+ but the dirname does, also complicates matters.
41 # (Thanks, S.C.)
42
43 echo
44
45 t=${path_name:11}
46 echo "$path_name, with first 11 chars stripped off = $t"
47 t=${path_name:11:5}
48 echo "$path_name, with first 11 chars stripped off, length 5 = $t"
49
50 echo
51
52 t=${path_name/bozo/clown}
53 echo "$path_name with \"bozo\" replaced by \"clown\" = $t"
54 t=${path_name/today/}
55 echo "$path_name with \"today\" deleted = $t"
56 t=${path_name//o/O}
57 echo "$path_name with all o's capitalized = $t"
58 t=${path_name//o/}
59 echo "$path_name with all o's deleted = $t"
60
61 exit 0
```

`${var/#Pattern/Replacement}`

If *prefix* of *var* matches *Pattern*, then substitute *Replacement* for *Pattern*.
`${var/%Pattern/Replacement}`
If *suffix* of *var* matches *Pattern*, then substitute *Replacement* for *Pattern*.

Example 10-13. Matching patterns at prefix or suffix of string

```
1 #!/bin/bash
2 # var-match.sh:
3 # Demo of pattern replacement at prefix / suffix of string.
4
5 v0=abc1234zip1234abc      # Original variable.
6 echo "v0 = $v0"          # abc1234zip1234abc
7 echo
8
9 # Match at prefix (beginning) of string.
10 v1=${v0/#abc/ABCDEF}     # abc1234zip1234abc
11                          # |-|
12 echo "v1 = $v1"         # ABCDEF1234zip1234abc
13                          # |----|
14
15 # Match at suffix (end) of string.
16 v2=${v0/%abc/ABCDEF}     # abc1234zip123abc
17                          #                |-|
18 echo "v2 = $v2"         # abc1234zip1234ABCDEF
19                          #                |----|
20
21 echo
22
23 # -----
24 # Must match at beginning / end of string,
25 #+ otherwise no replacement results.
26 # -----
27 v3=${v0/#123/000}        # Matches, but not at beginning.
28 echo "v3 = $v3"         # abc1234zip1234abc
29                          # NO REPLACEMENT.
30 v4=${v0/%123/000}        # Matches, but not at end.
31 echo "v4 = $v4"         # abc1234zip1234abc
32                          # NO REPLACEMENT.
33
34 exit 0
```

`${!varprefix*}`, **`${!varprefix@}`**

Matches *names* of all previously declared variables beginning with *varprefix*.

```
1 # This is a variation on indirect reference, but with a * or @.
2 # Bash, version 2.04, adds this feature.
3
4 xyz23=whatever
5 xyz24=
6
7 a=${!xyz*}                # Expands to *names* of declared variables
8 # ^ ^ ^                  + beginning with "xyz".
9 echo "a = $a"            # a = xyz23 xyz24
10 a=${!xyz@}              # Same as above.
11 echo "a = $a"          # a = xyz23 xyz24
12
13 echo "---"
14
15 abc23=something_else
16 b=${!abc*}
17 echo "b = $b"          # b = abc23
18 c=${!b}                # Now, the more familiar type of indirect reference.
```

Notes

[1] If \$parameter is null in a non-interactive script, it will terminate with a [127 exit status](#) (the Bash error code for "command not found").

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Chapter 11. Loops and Branches

What needs this iteration, woman?

--Shakespeare, Othello

Operations on code blocks are the key to structured and organized shell scripts. Looping and branching constructs provide the tools for accomplishing this.

11.1. Loops

A *loop* is a block of code that *iterates* [1] a list of commands as long as the *loop control condition* is true.

for loops

for *arg* in [*list*]

This is the basic looping construct. It differs significantly from its *C* counterpart.

```
for arg in [list]  
do  
    command(s)...  
done
```



During each pass through the loop, *arg* takes on the value of each successive variable in the *list*.

```
1 for arg in "$var1" "$var2" "$var3" ... "$varN"  
2 # In pass 1 of the loop, arg = $var1  
3 # In pass 2 of the loop, arg = $var2  
4 # In pass 3 of the loop, arg = $var3  
5 # ...  
6 # In pass N of the loop, arg = $varN  
7  
8 # Arguments in [list] quoted to prevent possible word splitting.
```

The argument *list* may contain [wild cards](#).

If *do* is on same line as *for*, there needs to be a semicolon after *list*.

```
for arg in [list]; do
```

Example 11-1. Simple *for* loops

```
1 #!/bin/bash  
2 # Listing the planets.  
3  
4 for planet in Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto  
5 do  
6     echo $planet # Each planet on a separate line.  
7 done  
8  
9 echo; echo  
10  
11 for planet in "Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto"  
12     # All planets on same line.  
13     # Entire 'list' enclosed in quotes creates a single variable.  
14     # Why? Whitespace incorporated into the variable.  
15 do  
16     echo $planet  
17 done  
18  
19 echo; echo "Whoops! Pluto is no longer a planet!"  
20  
21 exit 0
```

Each **[list]** element may contain multiple parameters. This is useful when processing parameters in groups. In such cases, use the [set](#) command (see [Example 15-16](#)) to force parsing of each **[list]** element and assignment of each component to the positional parameters.

Example 11-2. *for* loop with two parameters in each **[list]** element

```
1 #!/bin/bash
2 # Planets revisited.
3
4 # Associate the name of each planet with its distance from the sun.
5
6 for planet in "Mercury 36" "Venus 67" "Earth 93" "Mars 142" "Jupiter 483"
7 do
8     set -- $planet # Parses variable "planet"
9                   #+ and sets positional parameters.
10    # The "--" prevents nasty surprises if $planet is null or
11    #+ begins with a dash.
12
13    # May need to save original positional parameters,
14    #+ since they get overwritten.
15    # One way of doing this is to use an array,
16    #     original_params=("$@")
17
18    echo "$1          $2,000,000 miles from the sun"
19    #-----two tabs---concatenate zeroes onto parameter $2
20 done
21
22 # (Thanks, S.C., for additional clarification.)
23
24 exit 0
```

A variable may supply the **[list]** in a *for* loop.

Example 11-3. *Fileinfo*: operating on a file list contained in a variable

```
1 #!/bin/bash
2 # fileinfo.sh
3
4 FILES="/usr/sbin/accept
5 /usr/sbin/pwck
6 /usr/sbin/chroot
7 /usr/bin/fakefile
8 /sbin/badblocks
9 /sbin/ypbind" # List of files you are curious about.
10              # Threw in a dummy file, /usr/bin/fakefile.
11
12 echo
13
14 for file in $FILES
15 do
16
17     if [ ! -e "$file" ] # Check if file exists.
18     then
19         echo "$file does not exist."; echo
20         continue # On to next.
21     fi
22
23     ls -l $file | awk '{ print $8 "          file size: " $5 }' # Print 2 fields.
24     whatis `basename $file` # File info.
```

```
25 # Note that the whatis database needs to have been set up for this to work.
26 # To do this, as root run /usr/bin/makewhatis.
27 echo
28 done
29
30 exit 0
```

The **[list]** in a *for loop* may be parameterized.

Example 11-4. Operating on a parameterized file list

```
1 #!/bin/bash
2
3 filename="*txt"
4
5 for file in $filename
6 do
7   echo "Contents of $file"
8   echo "---"
9   cat "$file"
10  echo
11 done
```

If the **[list]** in a *for loop* contains wild cards (* and ?) used in filename expansion, then [globbing](#) takes place.

Example 11-5. Operating on files with a *for loop*

```
1 #!/bin/bash
2 # list-glob.sh: Generating [list] in a for-loop, using "globbing" ...
3 # Globbing = filename expansion.
4
5 echo
6
7 for file in *
8 #           ^ Bash performs filename expansion
9 #+         on expressions that globbing recognizes.
10 do
11   ls -l "$file" # Lists all files in $PWD (current directory).
12   # Recall that the wild card character "*" matches every filename,
13   #+ however, in "globbing," it doesn't match dot-files.
14
15   # If the pattern matches no file, it is expanded to itself.
16   # To prevent this, set the nullglob option
17   #+ (shopt -s nullglob).
18   # Thanks, S.C.
19 done
20
21 echo; echo
22
23 for file in [jx]*
24 do
25   rm -f $file # Removes only files beginning with "j" or "x" in $PWD.
26   echo "Removed file \"$file\"".
27 done
28
29 echo
```

```
30
31 exit 0
```

Omitting the `in [list]` part of a *for loop* causes the loop to operate on `$@` -- the [positional parameters](#). A particularly clever illustration of this is [Example A-15](#). See also [Example 15-17](#).

Example 11-6. Missing `in [list]` in a *for loop*

```
1 #!/bin/bash
2
3 # Invoke this script both with and without arguments,
4 #+ and see what happens.
5
6 for a
7 do
8   echo -n "$a "
9 done
10
11 # The 'in list' missing, therefore the loop operates on '$@'
12 #+ (command-line argument list, including whitespace).
13
14 echo
15
16 exit 0
```

It is possible to use [command substitution](#) to generate the `[list]` in a *for loop*. See also [Example 16-54](#), [Example 11-11](#) and [Example 16-48](#).

Example 11-7. Generating the `[list]` in a *for loop* with command substitution

```
1 #!/bin/bash
2 # for-loopcmd.sh: for-loop with [list]
3 #+ generated by command substitution.
4
5 NUMBERS="9 7 3 8 37.53"
6
7 for number in `echo $NUMBERS` # for number in 9 7 3 8 37.53
8 do
9   echo -n "$number "
10 done
11
12 echo
13 exit 0
```

Here is a somewhat more complex example of using command substitution to create the `[list]`.

Example 11-8. A *grep* replacement for binary files

```
1 #!/bin/bash
2 # bin-grep.sh: Locates matching strings in a binary file.
3
4 # A "grep" replacement for binary files.
5 # Similar effect to "grep -a"
6
```

```

7 E_BADARGS=65
8 E_NOFILE=66
9
10 if [ $# -ne 2 ]
11 then
12     echo "Usage: `basename $0` search_string filename"
13     exit $E_BADARGS
14 fi
15
16 if [ ! -f "$2" ]
17 then
18     echo "File \"$2\" does not exist."
19     exit $E_NOFILE
20 fi
21
22
23 IFS=$'\012'          # Per suggestion of Anton Filippov.
24                     # was: IFS="\n"
25 for word in $( strings "$2" | grep "$1" )
26 # The "strings" command lists strings in binary files.
27 # Output then piped to "grep", which tests for desired string.
28 do
29     echo $word
30 done
31
32 # As S.C. points out, lines 23 - 30 could be replaced with the simpler
33 # strings "$2" | grep "$1" | tr -s "$IFS" '[\n*]'
34
35
36 # Try something like ".bin-grep.sh mem /bin/ls"
37 #+ to exercise this script.
38
39 exit 0

```

More of the same.

Example 11-9. Listing all users on the system

```

1 #!/bin/bash
2 # userlist.sh
3
4 PASSWORD_FILE=/etc/passwd
5 n=1          # User number
6
7 for name in $(awk 'BEGIN{FS=":"}{print $1}' < "$PASSWORD_FILE" )
8 # Field separator = :      ^^^^^^
9 # Print first field          ^^^^^^^
10 # Get input from password file /etc/passwd ^^^^^^^^^^^^^^^^^^^
11 do
12     echo "USER #n = $name"
13     let "n += 1"
14 done
15
16
17 # USER #1 = root
18 # USER #2 = bin
19 # USER #3 = daemon
20 # ...
21 # USER #33 = bozo
22
23 exit $?
24
25 # Discussion:

```

```
26 # -----
27 # How is it that an ordinary user, or a script run by same,
28 #+ can read /etc/passwd? (Hint: Check the /etc/passwd file permissions.)
29 # Is this a security hole? Why or why not?
```

Yet another example of the **[list]** resulting from command substitution.

Example 11-10. Checking all the binaries in a directory for authorship

```
1 #!/bin/bash
2 # findstring.sh:
3 # Find a particular string in the binaries in a specified directory.
4
5 directory=/usr/bin/
6 fstring="Free Software Foundation" # See which files come from the FSF.
7
8 for file in $( find $directory -type f -name '*' | sort )
9 do
10  strings -f $file | grep "$fstring" | sed -e "s%$directory%"
11  # In the "sed" expression,
12  #+ it is necessary to substitute for the normal "/" delimiter
13  #+ because "/" happens to be one of the characters filtered out.
14  # Failure to do so gives an error message. (Try it.)
15 done
16
17 exit $?
18
19 # Exercise (easy):
20 # -----
21 # Convert this script to take command-line parameters
22 #+ for $directory and $fstring.
```

A final example of **[list]** / command substitution, but this time the "command" is a [function](#).

```
1 generate_list ()
2 {
3  echo "one two three"
4 }
5
6 for word in $(generate_list) # Let "word" grab output of function.
7 do
8  echo "$word"
9 done
10
11 # one
12 # two
13 # three
```

The output of a *for loop* may be piped to a command or commands.

Example 11-11. Listing the *symbolic links* in a directory

```
1 #!/bin/bash
2 # symlinks.sh: Lists symbolic links in a directory.
3
4
5 directory=${1-`pwd`}
6 # Defaults to current working directory,
7 #+ if not otherwise specified.
```



```

8 # Equivalent to code block below.
9 # -----
10 # ARGS=1 # Expect one command-line argument.
11 #
12 # if [ $# -ne "$ARGS" ] # If not 1 arg...
13 # then
14 #     directory=`pwd` # current working directory
15 # else
16 #     directory=$1
17 # fi
18 # -----
19
20 echo "symbolic links in directory \"${directory}\""
21
22 for file in "$( find $directory -type l )" # -type l = symbolic links
23 do
24     echo "$file"
25 done | sort # Otherwise file list is unsorted.
26 # Strictly speaking, a loop isn't really necessary here,
27 #+ since the output of the "find" command is expanded into a single word.
28 # However, it's easy to understand and illustrative this way.
29
30 # As Dominik 'Aeneas' Schnitzer points out,
31 #+ failing to quote $( find $directory -type l )
32 #+ will choke on filenames with embedded whitespace.
33 # containing whitespace.
34
35 exit 0
36
37
38 # -----
39 # Jean Helou proposes the following alternative:
40
41 echo "symbolic links in directory \"${directory}\""
42 # Backup of the current IFS. One can never be too cautious.
43 OLDIFS=$IFS
44 IFS=:
45
46 for file in $(find $directory -type l -printf "%p$IFS")
47 do # ^^^^^^^^^^^^^^^^^^^^^^^
48     echo "$file"
49     done|sort
50
51 # And, James "Mike" Conley suggests modifying Helou's code thusly:
52
53 OLDIFS=$IFS
54 IFS='' # Null IFS means no word breaks
55 for file in $( find $directory -type l )
56 do
57     echo $file
58     done | sort
59
60 # This works in the "pathological" case of a directory name having
61 #+ an embedded colon.
62 # "This also fixes the pathological case of the directory name having
63 #+ a colon (or space in earlier example) as well."
64

```

The stdout of a loop may be [redirected](#) to a file, as this slight modification to the previous example shows.

Example 11-12. Symbolic links in a directory, saved to a file

```

1 #!/bin/bash
2 # symlinks.sh: Lists symbolic links in a directory.
3
4 OUTFILE=symlinks.list          # save-file
5
6 directory=${1-`pwd`}
7 # Defaults to current working directory,
8 #+ if not otherwise specified.
9
10
11 echo "symbolic links in directory \"${directory}\" > \"$OUTFILE"
12 echo "-----" >> "$OUTFILE"
13
14 for file in "$( find $directory -type l )"    # -type l = symbolic links
15 do
16     echo "$file"
17 done | sort >> "$OUTFILE"                  # stdout of loop
18 #             ^^^^^^^^^^^^^^^^^         redirected to save file.
19
20 # echo "Output file = $OUTFILE"
21
22 exit $?

```

There is an alternative syntax to a *for loop* that will look very familiar to C programmers. This requires [double parentheses](#).

Example 11-13. A C-style *for* loop

```

1 #!/bin/bash
2 # Multiple ways to count up to 10.
3
4 echo
5
6 # Standard syntax.
7 for a in 1 2 3 4 5 6 7 8 9 10
8 do
9     echo -n "$a "
10 done
11
12 echo; echo
13
14 # +-----+
15
16 # Using "seq" ...
17 for a in `seq 10`
18 do
19     echo -n "$a "
20 done
21
22 echo; echo
23
24 # +-----+
25
26 # Using brace expansion ...
27 # Bash, version 3+.
28 for a in {1..10}
29 do
30     echo -n "$a "
31 done
32
33 echo; echo
34

```

```

35 # +=====+
36
37 # Now, let's do the same, using C-like syntax.
38
39 LIMIT=10
40
41 for ((a=1; a <= LIMIT ; a++)) # Double parentheses, and naked "LIMIT"
42 do
43     echo -n "$a "
44 done # A construct borrowed from ksh93.
45
46 echo; echo
47
48 # +=====+
49
50 # Let's use the C "comma operator" to increment two variables simultaneously.
51
52 for ((a=1, b=1; a <= LIMIT ; a++, b++))
53 do # The comma concatenates operations.
54     echo -n "$a-$b "
55 done
56
57 echo; echo
58
59 exit 0

```

See also [Example 27-16](#), [Example 27-17](#), and [Example A-6](#).

Now, a *for loop* used in a "real-life" context.

Example 11-14. Using *efax* in batch mode

```


1 #!/bin/bash
2 # Faxing (must have 'efax' package installed).
3
4 EXPECTED_ARGS=2
5 E_BADARGS=85
6 MODEM_PORT="/dev/ttyS2" # May be different on your machine.
7 #             ^^^^^ PCMCIA modem card default port.
8
9 if [ $# -ne $EXPECTED_ARGS ]
10 # Check for proper number of command-line args.
11 then
12     echo "Usage: `basename $0` phone# text-file"
13     exit $E_BADARGS
14 fi
15
16
17 if [ ! -f "$2" ]
18 then
19     echo "File $2 is not a text file."
20     # File is not a regular file, or does not exist.
21     exit $E_BADARGS
22 fi
23
24
25 fax make $2 # Create fax-formatted files from text files.
26
27 for file in $(ls $2.0*) # Concatenate the converted files.
28 # Uses wild card (filename "globbing")

```

```

29             #+ in variable list.
30 do
31   fil="$fil $file"
32 done
33
34 efax -d "$MODEM_PORT" -t "T$1" $fil # Finally, do the work.
35 # Trying adding -o1 if above line fails.
36
37
38 # As S.C. points out, the for-loop can be eliminated with
39 #   efax -d /dev/ttyS2 -o1 -t "T$1" $2.0*
40 #+ but it's not quite as instructive [grin].
41
42 exit $? # Also, efax sends diagnostic messages to stdout.

```

 The **keywords** `do` and `done` delineate the *for-loop* command block. However, these may, in certain contexts, be omitted by framing the command block within [curly brackets](#)

```

1 for((n=1; n<=10; n++))
2 # No do!
3 {
4   echo -n "* $n *"
5 }
6 # No done!
7
8
9 # Outputs:
10 # * 1 ** 2 ** 3 ** 4 ** 5 ** 6 ** 7 ** 8 ** 9 ** 10 *
11 # And, echo $? returns 0, so Bash does not register an error.
12
13
14 echo
15
16
17 # But, note that in a classic for-loop:   for n in [list] ...
18 #+ a terminal semicolon is required.
19
20 for n in 1 2 3
21 { echo -n "$n "; }
22 #           ^
23
24
25 # Thank you, YongYe, for pointing this out.

```

while

This construct tests for a condition at the top of a loop, and keeps looping as long as that condition is true (returns a 0 [exit status](#)). In contrast to a [for loop](#), a *while loop* finds use in situations where the number of loop repetitions is not known beforehand.

```

while [ condition ]
do
  command(s)...
done

```

The bracket construct in a *while loop* is nothing more than our old friend, the [test brackets](#) used in an *if/then* test. In fact, a *while loop* can legally use the more versatile [double-brackets construct](#) (while [[*condition*]]).

[As is the case with for loops](#), placing the *do* on the same line as the condition test requires a

semicolon.

```
while [ condition ]; do
```

Note that the *test brackets* [are not mandatory](#) in a *while* loop. See, for example, the [getopts construct](#).

Example 11-15. Simple *while* loop

```
1 #!/bin/bash
2
3 var0=0
4 LIMIT=10
5
6 while [ "$var0" -lt "$LIMIT" ]
7 #      ^           ^
8 # Spaces, because these are "test-brackets" . . .
9 do
10 echo -n "$var0 "      # -n suppresses newline.
11 #                    ^           Space, to separate printed out numbers.
12
13 var0=`expr $var0 + 1` # var0=$((var0+1)) also works.
14                       # var0=$((var0 + 1)) also works.
15                       # let "var0 += 1" also works.
16 done                 # Various other methods also work.
17
18 echo
19
20 exit 0
```

Example 11-16. Another *while* loop

```
1 #!/bin/bash
2
3 echo
4
5 while [ "$var1" != "end" ] # Equivalent to:
6 do                       # while test "$var1" != "end"
7   echo "Input variable #1 (end to exit) "
8   read var1              # Not 'read $var1' (why?).
9   echo "variable #1= $var1" # Need quotes because of "#" . . .
10  # If input is 'end', echoes it here.
11  # Does not test for termination condition until top of loop.
12  echo
13 done
14
15 exit 0
```

A *while* loop may have multiple conditions. Only the final condition determines when the loop terminates. This necessitates a slightly different loop syntax, however.

Example 11-17. *while* loop with multiple conditions

```
1 #!/bin/bash
2
3 var1=unset
```

```

4 previous=$var1
5
6 while echo "previous-variable = $previous"
7     echo
8     previous=$var1
9     [ "$var1" != end ] # Keeps track of what $var1 was previously.
10    # Four conditions on *while*, but only the final one controls loop.
11    # The *last* exit status is the one that counts.
12 do
13 echo "Input variable #1 (end to exit) "
14     read var1
15     echo "variable #1 = $var1"
16 done
17
18 # Try to figure out how this all works.
19 # It's a wee bit tricky.
20
21 exit 0

```

As with a *for loop*, a *while loop* may employ C-style syntax by using the double-parentheses construct (see also [Example 8-5](#)).

Example 11-18. C-style syntax in a *while* loop

```

1 #!/bin/bash
2 # wh-loopc.sh: Count to 10 in a "while" loop.
3
4 LIMIT=10                # 10 iterations.
5 a=1
6
7 while [ "$a" -le $LIMIT ]
8 do
9     echo -n "$a "
10    let "a+=1"
11 done                    # No surprises, so far.
12
13 echo; echo
14
15 # +=====+
16
17 # Now, we'll repeat with C-like syntax.
18
19 ((a = 1))              # a=1
20 # Double parentheses permit space when setting a variable, as in C.
21
22 while (( a <= LIMIT )) # Double parentheses,
23 do                    #+ and no "$" preceding variables.
24     echo -n "$a "
25     ((a += 1))        # let "a+=1"
26     # Yes, indeed.
27     # Double parentheses permit incrementing a variable with C-like syntax.
28 done
29
30 echo
31
32 # C and Java programmers can feel right at home in Bash.
33
34 exit 0

```

Inside its test brackets, a *while loop* can call a [function](#).

```

1 t=0
2
3 condition ()
4 {
5     ((t++))
6
7     if [ $t -lt 5 ]
8     then
9         return 0 # true
10    else
11        return 1 # false
12    fi
13 }
14
15 while condition
16 #     ^^^^^^^^^
17 #     Function call -- four loop iterations.
18 do
19     echo "Still going: t = $t"
20 done
21
22 # Still going: t = 1
23 # Still going: t = 2
24 # Still going: t = 3
25 # Still going: t = 4

```

Similar to the [if-test](#) construct, a *while* loop can omit the test brackets.

```

1 while condition
2 do
3     command(s) ...
4 done


```

By coupling the power of the [read](#) command with a *while loop*, we get the handy [while read](#) construct, useful for reading and parsing files.

```

1 cat $filename | # Supply input from a file.
2 while read line # As long as there is another line to read ...
3 do
4     ...
5 done
6
7 # ===== Snippet from "sd.sh" example script ===== #
8
9 while read value # Read one data point at a time.
10 do
11     rt=$(echo "scale=$SC; $rt + $value" | bc)
12     (( ct++ ))
13 done
14
15 am=$(echo "scale=$SC; $rt / $ct" | bc)
16
17 echo $am; return $ct # This function "returns" TWO values!
18 # Caution: This little trick will not work if $ct > 255!
19 # To handle a larger number of data points,
20 #+ simply comment out the "return $ct" above.
21 } <"$datafile" # Feed in data file.

```

 A *while loop* may have its `stdin` [redirected to a file](#) by a `<` at its end.

A *while loop* may have its `stdin` [supplied by a pipe](#).

until

This construct tests for a condition at the top of a loop, and keeps looping as long as that condition is *false* (opposite of *while loop*).

```
until [ condition-is-true ]
do
  command(s)...
done
```

Note that an *until loop* tests for the terminating condition at the *top* of the loop, differing from a similar construct in some programming languages.

As is the case with *for loops*, placing the *do* on the same line as the condition test requires a semicolon.

```
until [ condition-is-true ];do
```

Example 11-19. *until* loop

```
1 #!/bin/bash
2
3 END_CONDITION=end
4
5 until [ "$var1" = "$END_CONDITION" ]
6 # Tests condition here, at top of loop.
7 do
8   echo "Input variable #1 "
9   echo "($END_CONDITION to exit)"
10  read var1
11  echo "variable #1 = $var1"
12  echo
13 done
14
15 #           ---           #
16
17 # As with "for" and "while" loops,
18 #+ an "until" loop permits C-like test constructs.
19
20 LIMIT=10
21 var=0
22
23 until (( var > LIMIT ))
24 do # ^^ ^      ^      ^^   No brackets, no $ prefixing variables.
25   echo -n "$var "
26   (( var++ ))
27 done # 0 1 2 3 4 5 6 7 8 9 10
28
29
30 exit 0
```

How to choose between a *for* loop or a *while* loop or *until* loop? In **C**, you would typically use a *for* loop when the number of loop iterations is known beforehand. With *Bash*, however, the situation is fuzzier. The *Bash for* loop is more loosely structured and more flexible than its equivalent in other languages. Therefore, feel free to use whatever type of loop gets the job done in the simplest way.

Notes

[1] *Iteration*: Repeated execution of a command or group of commands, usually -- but not always, *while* a given condition holds, or *until* a given condition is met.

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11.2. Nested Loops

A *nested loop* is a loop within a loop, an inner loop within the body of an outer one. How this works is that the first pass of the outer loop triggers the inner loop, which executes to completion. Then the second pass of the outer loop triggers the inner loop again. This repeats until the outer loop finishes. Of course, a *break* within either the inner or outer loop would interrupt this process.

Example 11-20. Nested Loop

```
1 #!/bin/bash
2 # nested-loop.sh: Nested "for" loops.
3
4 outer=1          # Set outer loop counter.
5
6 # Beginning of outer loop.
7 for a in 1 2 3 4 5
8 do
9     echo "Pass $outer in outer loop."
10    echo "-----"
11    inner=1       # Reset inner loop counter.
12
13    # =====
14    # Beginning of inner loop.
15    for b in 1 2 3 4 5
16    do
17        echo "Pass $inner in inner loop."
18        let "inner+=1" # Increment inner loop counter.
19    done
20    # End of inner loop.
21    # =====
22
23    let "outer+=1" # Increment outer loop counter.
24    echo          # Space between output blocks in pass of outer loop.
25 done
26 # End of outer loop.
27
28 exit 0
```

See [Example 27-11](#) for an illustration of nested [while loops](#), and [Example 27-13](#) to see a while loop nested inside an [until loop](#).

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11.3. Loop Control

Tournez cent tours, tournez mille tours,

Tournez souvent et tournez toujours . . .

--Verlaine, "Chevaux de bois"

Commands affecting loop behavior

break, continue

The **break** and **continue** loop control commands [1] correspond exactly to their counterparts in other programming languages. The **break** command terminates the loop (*breaks* out of it), while **continue** causes a jump to the next [iteration](#) of the loop, skipping all the remaining commands in that particular loop cycle.

Example 11-21. Effects of *break* and *continue* in a loop

```
1 #!/bin/bash
2
3 LIMIT=19 # Upper limit
4
5 echo
6 echo "Printing Numbers 1 through 20 (but not 3 and 11)."
```

```
44 echo -n "$a "  
45 done  
46  
47 echo; echo; echo  
48  
49 exit 0
```

The **break** command may optionally take a parameter. A plain **break** terminates only the innermost loop in which it is embedded, but a **break N** breaks out of *N* levels of loop.

Example 11-22. Breaking out of multiple loop levels

```
1 #!/bin/bash  
2 # break-levels.sh: Breaking out of loops.  
3  
4 # "break N" breaks out of N level loops.  
5  
6 for outerloop in 1 2 3 4 5  
7 do  
8   echo -n "Group $outerloop: "  
9  
10  # -----  
11  for innerloop in 1 2 3 4 5  
12  do  
13    echo -n "$innerloop "  
14  
15    if [ "$innerloop" -eq 3 ]  
16    then  
17      break # Try break 2 to see what happens.  
18            # ("Breaks" out of both inner and outer loops.)  
19    fi  
20  done  
21  # -----  
22  
23  echo  
24 done  
25  
26 echo  
27  
28 exit 0
```

The **continue** command, similar to **break**, optionally takes a parameter. A plain **continue** cuts short the current iteration within its loop and begins the next. A **continue N** terminates all remaining iterations at its loop level and continues with the next iteration at the loop, *N* levels above.

Example 11-23. Continuing at a higher loop level

```
1 #!/bin/bash  
2 # The "continue N" command, continuing at the Nth level loop.  
3  
4 for outer in I II III IV V # outer loop  
5 do  
6   echo; echo -n "Group $outer: "  
7  
8   # -----  
9   for inner in 1 2 3 4 5 6 7 8 9 10 # inner loop  
10  do  
11
```

```

12     if [[ "$sinner" -eq 7 && "$outer" = "III" ]]
13     then
14         continue 2 # Continue at loop on 2nd level, that is "outer loop".
15                 # Replace above line with a simple "continue"
16                 # to see normal loop behavior.
17     fi
18
19     echo -n "$sinner " # 7 8 9 10 will not echo on "Group III."
20 done
21 # -----
22
23 done
24
25 echo; echo
26
27 # Exercise:
28 # Come up with a meaningful use for "continue N" in a script.
29
30 exit 0

```

Example 11-24. Using *continue N* in an actual task

```

1 # Albert Reiner gives an example of how to use "continue N":
2 # -----
3
4 # Suppose I have a large number of jobs that need to be run, with
5 #+ any data that is to be treated in files of a given name pattern
6 #+ in a directory. There are several machines that access
7 #+ this directory, and I want to distribute the work over these
8 #+ different boxes.
9 # Then I usually nohup something like the following on every box:
10
11 while true
12 do
13     for n in .iso.*
14     do
15         [ "$n" = ".iso.opts" ] && continue
16         beta=${n#.iso.}
17         [ -r .Iso.$beta ] && continue
18         [ -r .lock.$beta ] && sleep 10 && continue
19         lockfile -r0 .lock.$beta || continue
20         echo -n "$beta: " `date`
21         run-isotherm $beta
22         date
23         ls -alF .Iso.$beta
24         [ -r .Iso.$beta ] && rm -f .lock.$beta
25         continue 2
26     done
27     break
28 done
29
30 exit 0
31
32 # The details, in particular the sleep N, are particular to my
33 #+ application, but the general pattern is:
34
35 while true
36 do
37     for job in {pattern}
38     do
39         {job already done or running} && continue
40         {mark job as running, do job, mark job as done}

```

```
41     continue 2
42     done
43     break          # Or something like `sleep 600' to avoid termination.
44 done
45
46 # This way the script will stop only when there are no more jobs to do
47 #+ (including jobs that were added during runtime). Through the use
48 #+ of appropriate lockfiles it can be run on several machines
49 #+ concurrently without duplication of calculations [which run a couple
50 #+ of hours in my case, so I really want to avoid this]. Also, as search
51 #+ always starts again from the beginning, one can encode priorities in
52 #+ the file names. Of course, one could also do this without `continue 2',
53 #+ but then one would have to actually check whether or not some job
54 #+ was done (so that we should immediately look for the next job) or not
55 #+ (in which case we terminate or sleep for a long time before checking
56 #+ for a new job).
```



The **continue N** construct is difficult to understand and tricky to use in any meaningful context. It is probably best avoided.

Notes

[1] These are shell [builtins](#), whereas other loop commands, such as [while](#) and [case](#), are [keywords](#).

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11.4. Testing and Branching

The **case** and **select** constructs are technically not loops, since they do not iterate the execution of a code block. Like loops, however, they direct program flow according to conditions at the top or bottom of the block.

Controlling program flow in a code block

case (in) / esac

The **case** construct is the shell scripting analog to *switch* in **C/C++**. It permits branching to one of a number of code blocks, depending on condition tests. It serves as a kind of shorthand for multiple **if/then/else** statements and is an appropriate tool for creating menus.

```
case "$variable" in
    "$condition1" )
        command...
        ;;
    "$condition2" )
        command...
        ;;

```

esac



- ◇ Quoting the variables is not mandatory, since word splitting does not take place.
- ◇ Each test line ends with a right paren). [\[1\]](#)
- ◇ Each condition block ends with a *double* semicolon ;;.
- ◇ If a condition tests *true*, then the associated commands execute and the **case** block terminates.
- ◇ The entire **case** block ends with an **esac** (*case* spelled backwards).

Example 11-25. Using *case*

```
1 #!/bin/bash
2 # Testing ranges of characters.
3
4 echo; echo "Hit a key, then hit return."
5 read Keypress
6
7 case "$Keypress" in
8     [[:lower:]] ) echo "Lowercase letter";;
9     [[:upper:]] ) echo "Uppercase letter";;
10    [0-9]       ) echo "Digit";;
11    *           ) echo "Punctuation, whitespace, or other";;
12 esac          # Allows ranges of characters in [square brackets],
13              #+ or POSIX ranges in [[double square brackets.
14
15 # In the first version of this example,
16 #+ the tests for lowercase and uppercase characters were
17 #+ [a-z] and [A-Z].
18 # This no longer works in certain locales and/or Linux distros.
```

```
19 # POSIX is more portable.
20 # Thanks to Frank Wang for pointing this out.
21
22 # Exercise:
23 # -----
24 # As the script stands, it accepts a single keystroke, then terminates.
25 # Change the script so it accepts repeated input,
26 #+ reports on each keystroke, and terminates only when "X" is hit.
27 # Hint: enclose everything in a "while" loop.
28
29 exit 0
```

Example 11-26. Creating menus using *case*

```
1 #!/bin/bash
2
3 # Crude address database
4
5 clear # Clear the screen.
6
7 echo "          Contact List"
8 echo "          -----"
9 echo "Choose one of the following persons:"
10 echo
11 echo "[E]vans, Roland"
12 echo "[J]ones, Mildred"
13 echo "[S]mith, Julie"
14 echo "[Z]ane, Morris"
15 echo
16
17 read person
18
19 case "$person" in
20 # Note variable is quoted.
21
22   "E" | "e" )
23   # Accept upper or lowercase input.
24   echo
25   echo "Roland Evans"
26   echo "4321 Flash Dr."
27   echo "Hardscrabble, CO 80753"
28   echo "(303) 734-9874"
29   echo "(303) 734-9892 fax"
30   echo "revans@zzy.net"
31   echo "Business partner & old friend"
32   ;;
33 # Note double semicolon to terminate each option.
34
35   "J" | "j" )
36   echo
37   echo "Mildred Jones"
38   echo "249 E. 7th St., Apt. 19"
39   echo "New York, NY 10009"
40   echo "(212) 533-2814"
41   echo "(212) 533-9972 fax"
42   echo "milliej@loisaida.com"
43   echo "Ex-girlfriend"
44   echo "Birthday: Feb. 11"
45   ;;
46
47 # Add info for Smith & Zane later.
48
```

```

49         * )
50     # Default option.
51     # Empty input (hitting RETURN) fits here, too.
52     echo
53     echo "Not yet in database."
54     ;;
55
56 esac
57
58 echo
59
60 # Exercise:
61 # -----
62 # Change the script so it accepts multiple inputs,
63 #+ instead of terminating after displaying just one address.
64
65 exit 0

```

An exceptionally clever use of **case** involves testing for command-line parameters.

```

1  #! /bin/bash
2
3  case "$1" in
4      "") echo "Usage: ${0##*/} <filename>"; exit $E_PARAM;;
5          # No command-line parameters,
6          # or first parameter empty.
7  # Note that ${0##*/} is ${var##pattern} param substitution.
8          # Net result is $0.
9
10     -*) FILENAME=./$1;;    # If filename passed as argument ($1)
11         #+ starts with a dash,
12         #+ replace it with ./$1
13         #+ so further commands don't interpret it
14         #+ as an option.
15
16     * ) FILENAME=$1;;    # Otherwise, $1.
17 esac

```

Here is a more straightforward example of command-line parameter handling:

```

1  #! /bin/bash
2
3
4  while [ $# -gt 0 ]; do    # Until you run out of parameters . . .
5      case "$1" in
6          -d|--debug)
7              # "-d" or "--debug" parameter?
8              DEBUG=1
9              ;;
10         -c|--conf)
11             CONFFILE="$2"
12             shift
13             if [ ! -f $CONFFILE ]; then
14                 echo "Error: Supplied file doesn't exist!"
15                 exit $E_CONFFILE    # File not found error.
16             fi
17             ;;
18         esac
19         shift    # Check next set of parameters.
20     done
21
22 # From Stefano Falsetto's "Log2Rot" script,
23 #+ part of his "rottlog" package.
24 # Used with permission.

```

Example 11-27. Using *command substitution* to generate the *case* variable

```
1 #!/bin/bash
2 # case-cmd.sh: Using command substitution to generate a "case" variable.
3
4 case $( arch ) in # $( arch ) returns machine architecture.
5                 # Equivalent to 'uname -m' ...
6     i386 ) echo "80386-based machine";;
7     i486 ) echo "80486-based machine";;
8     i586 ) echo "Pentium-based machine";;
9     i686 ) echo "Pentium2+-based machine";;
10    *    ) echo "Other type of machine";;
11 esac
12
13 exit 0
```

A **case** construct can filter strings for [globbing](#) patterns.

Example 11-28. Simple string matching

```
1 #!/bin/bash
2 # match-string.sh: Simple string matching
3 #                       using a 'case' construct.
4
5 match_string ()
6 { # Exact string match.
7     MATCH=0
8     E_NOMATCH=90
9     PARAMS=2 # Function requires 2 arguments.
10    E_BAD_PARAMS=91
11
12    [ $# -eq $PARAMS ] || return $E_BAD_PARAMS
13
14    case "$1" in
15        "$2") return $MATCH;;
16        *    ) return $E_NOMATCH;;
17    esac
18
19 }
20
21
22 a=one
23 b=two
24 c=three
25 d=two
26
27
28 match_string $a # wrong number of parameters
29 echo $? # 91
30
31 match_string $a $b # no match
32 echo $? # 90
33
34 match_string $b $d # match
35 echo $? # 0
36
37
38 exit 0
```

Example 11-29. Checking for alphabetic input

```
1 #!/bin/bash
2 # isalpha.sh: Using a "case" structure to filter a string.
3
4 SUCCESS=0
5 FAILURE=1 # Was FAILURE=-1,
6           #+ but Bash no longer allows negative return value.
7
8 isalpha () # Tests whether *first character* of input string is alphabetic.
9 {
10 if [ -z "$1" ] # No argument passed?
11 then
12     return $FAILURE
13 fi
14
15 case "$1" in
16     [a-zA-Z]*) return $SUCCESS;; # Begins with a letter?
17     *          ) return $FAILURE;;
18 esac
19 } # Compare this with "isalpha ()" function in C.
20
21
22 isalpha2 () # Tests whether *entire string* is alphabetic.
23 {
24     [ $# -eq 1 ] || return $FAILURE
25
26     case $1 in
27         *[^a-zA-Z]*|") return $FAILURE;;
28         *) return $SUCCESS;;
29     esac
30 }
31
32 isdigit () # Tests whether *entire string* is numerical.
33 { # In other words, tests for integer variable.
34     [ $# -eq 1 ] || return $FAILURE
35
36     case $1 in
37         *[^0-9]*|") return $FAILURE;;
38         *) return $SUCCESS;;
39     esac
40 }
41
42
43
44 check_var () # Front-end to isalpha ().
45 {
46 if isalpha "$@"
47 then
48     echo "\"$*\\" begins with an alpha character."
49     if isalpha2 "$@"
50     then # No point in testing if first char is non-alpha.
51         echo "\"$*\\" contains only alpha characters."
52     else
53         echo "\"$*\\" contains at least one non-alpha character."
54     fi
55 else
56     echo "\"$*\\" begins with a non-alpha character."
57     # Also "non-alpha" if no argument passed.
58 fi
59
60 echo
```

```

61
62 }
63
64 digit_check () # Front-end to isdigit ().
65 {
66 if isdigit "$@"
67 then
68     echo "\"$*\\" contains only digits [0 - 9].\"
69 else
70     echo "\"$*\\" has at least one non-digit character.\"
71 fi
72
73 echo
74
75 }
76
77 a=23skidoo
78 b=H3llo
79 c=-What?
80 d=What?
81 e=$(echo $b) # Command substitution.
82 f=AbcDef
83 g=27234
84 h=27a34
85 i=27.34
86
87 check_var $a
88 check_var $b
89 check_var $c
90 check_var $d
91 check_var $e
92 check_var $f
93 check_var # No argument passed, so what happens?
94 #
95 digit_check $g
96 digit_check $h
97 digit_check $i
98
99
100 exit 0 # Script improved by S.C.
101
102 # Exercise:
103 # -----
104 # Write an 'isfloat ()' function that tests for floating point numbers.
105 # Hint: The function duplicates 'isdigit ()',
106 #+ but adds a test for a mandatory decimal point.

```

select

The **select** construct, adopted from the Korn Shell, is yet another tool for building menus.

```

select variable [in list]
do
    command...
break
done

```

This prompts the user to enter one of the choices presented in the variable list. Note that **select** uses the \$PS3 prompt (# ?) by default, but this may be changed.

Example 11-30. Creating menus using *select*

```

1 #!/bin/bash
2
3 PS3='Choose your favorite vegetable: ' # Sets the prompt string.
4                                     # Otherwise it defaults to #? .
5
6 echo
7
8 select vegetable in "beans" "carrots" "potatoes" "onions" "rutabagas"
9 do
10  echo
11  echo "Your favorite veggie is $vegetable."
12  echo "Yuck!"
13  echo
14  break # What happens if there is no 'break' here?
15 done
16
17 exit
18
19 # Exercise:
20 # -----
21 # Fix this script to accept user input not specified in
22 #+ the "select" statement.
23 # For example, if the user inputs "peas,"
24 #+ the script would respond "Sorry. That is not on the menu."

```

If **in *list*** is omitted, then **select** uses the list of command line arguments ($\$@$) passed to the script or the function containing the **select** construct.

Compare this to the behavior of a

for *variable* [in *list*]

construct with the **in *list*** omitted.

Example 11-31. Creating menus using *select* in a function

```

1 #!/bin/bash
2
3 PS3='Choose your favorite vegetable: '
4
5 echo
6
7 choice_of()
8 {
9  select vegetable
10 # [in list] omitted, so 'select' uses arguments passed to function.
11 do
12  echo
13  echo "Your favorite veggie is $vegetable."
14  echo "Yuck!"
15  echo
16  break
17 done
18 }
19
20 choice_of beans rice carrots radishes rutabaga spinach
21 #          $1   $2   $3       $4         $5         $6
22 #          passed to choice_of() function
23
24 exit 0

```

See also [Example 37-3](#).

Notes

[1] Pattern-match lines may also *start* with a (left paren to give the layout a more structured appearance.

```
1 case $( arch ) in # $( arch ) returns machine architecture.
2   ( i386 ) echo "80386-based machine";;
3 # ^         ^
4   ( i486 ) echo "80486-based machine";;
5   ( i586 ) echo "Pentium-based machine";;
6   ( i686 ) echo "Pentium2+-based machine";;
7   ( * ) echo "Other type of machine";;
8 esac
```

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Chapter 12. Command Substitution

Command substitution reassigns the output of a command [1] or even multiple commands; it literally plugs the command output into another context. [2]

The classic form of command substitution uses *backquotes* (``...``). Commands within backquotes (backticks) generate command-line text.

```
1 script_name=`basename $0`
2 echo "The name of this script is $script_name."
```

The output of commands can be used as arguments to another command, to set a variable, and even for generating the argument list in a [for](#) loop.

```
1 rm `cat filename` # "filename" contains a list of files to delete.
2 #
3 # S. C. points out that "arg list too long" error might result.
4 # Better is          xargs rm -- < filename
5 # ( -- covers those cases where "filename" begins with a "-" )
6
7 textfile_listing=`ls *.txt`
8 # Variable contains names of all *.txt files in current working directory.
9 echo $textfile_listing
10
11 textfile_listing2=$(ls *.txt) # The alternative form of command substitution.
12 echo $textfile_listing2
13 # Same result.
14
15 # A possible problem with putting a list of files into a single string
16 # is that a newline may creep in.
17 #
18 # A safer way to assign a list of files to a parameter is with an array.
19 #     shopt -s nullglob # If no match, filename expands to nothing.
20 #     textfile_listing=( *.txt )
21 #
22 # Thanks, S.C.
```



Command substitution invokes a [subshell](#).



Command substitution may result in [word splitting](#).

```
1 COMMAND `echo a b` # 2 args: a and b
2
3 COMMAND "`echo a b`" # 1 arg: "a b"
4
5 COMMAND `echo` # no arg
6
7 COMMAND "`echo`" # one empty arg
8
9
10 # Thanks, S.C.
```


Even when there is no word splitting, command substitution can remove trailing newlines.

```
1 # cd "`pwd`" # This should always work.
2 # However...
3
4 mkdir 'dir with trailing newline
5 '
6
7 cd 'dir with trailing newline
8 '
9
```

```

10 cd "`pwd`" # Error message:
11 # bash: cd: /tmp/file with trailing newline: No such file or directory
12
13 cd "$PWD" # Works fine.
14
15
16
17
18
19 old_tty_setting=$(stty -g) # Save old terminal setting.
20 echo "Hit a key "
21 stty -icanon -echo # Disable "canonical" mode for terminal.
22 # Also, disable *local* echo.
23 key=$(dd bs=1 count=1 2> /dev/null) # Using 'dd' to get a keypress.
24 stty "$old_tty_setting" # Restore old setting.
25 echo "You hit ${#key} key." # ${#variable} = number of characters in $variable
26 #
27 # Hit any key except RETURN, and the output is "You hit 1 key."
28 # Hit RETURN, and it's "You hit 0 key."
29 # The newline gets eaten in the command substitution.
30
31 #Code snippet by Stéphane Chazelas.

```

 Using **echo** to output an *unquoted* variable set with command substitution removes trailing newlines characters from the output of the reassigned command(s). This can cause unpleasant surprises.

```

1 dir_listing=`ls -l`
2 echo $dir_listing # unquoted
3
4 # Expecting a nicely ordered directory listing.
5
6 # However, what you get is:
7 # total 3 -rw-rw-r-- 1 bozo bozo 30 May 13 17:15 1.txt -rw-rw-r-- 1 bozo
8 # bozo 51 May 15 20:57 t2.sh -rwxr-xr-x 1 bozo bozo 217 Mar 5 21:13 wi.sh
9
10 # The newlines disappeared.
11
12
13 echo "$dir_listing" # quoted
14 # -rw-rw-r-- 1 bozo 30 May 13 17:15 1.txt
15 # -rw-rw-r-- 1 bozo 51 May 15 20:57 t2.sh
16 # -rwxr-xr-x 1 bozo 217 Mar 5 21:13 wi.sh

```

Command substitution even permits setting a variable to the contents of a file, using either [redirection](#) or the [cat](#) command.

```

1 variable1=`<file1` # Set "variable1" to contents of "file1".
2 variable2=`cat file2` # Set "variable2" to contents of "file2".
3 # This, however, forks a new process,
4 #+ so the line of code executes slower than the above version.
5
6 # Note that the variables may contain embedded whitespace,
7 #+ or even (horrors), control characters.
8
9 # It is not necessary to explicitly assign a variable.
10 echo "`<$0`" # Echoes the script itself to stdout.

```

```


1 # Excerpts from system file, /etc/rc.d/rc.sysinit
2 #+ (on a Red Hat Linux installation)
3
4
5 if [ -f /fsckoptions ]; then
6     fsckoptions=`cat /fsckoptions`
7 ...
8 fi

```

```

9 #
10 #
11 if [ -e "/proc/ide/${disk[$device]}/media" ] ; then
12     hdmedia=`cat /proc/ide/${disk[$device]}/media`
13 ...
14 fi
15 #
16 #
17 if [ ! -n "`uname -r | grep -- "-`" ] ; then
18     ktag=`cat /proc/version`
19 ...
20 fi
21 #
22 #
23 if [ $usb = "1" ] ; then
24     sleep 5
25     mouseoutput=`cat /proc/bus/usb/devices 2>/dev/null|grep -E "^I.*Cls=03.*Prot=02"`
26     kbdoutput=`cat /proc/bus/usb/devices 2>/dev/null|grep -E "^I.*Cls=03.*Prot=01"`
27 ...
28 fi

```

 Do not set a variable to the contents of a *long* text file unless you have a very good reason for doing so. Do not set a variable to the contents of a *binary* file, even as a joke.

Example 12-1. Stupid script tricks

```

1 #!/bin/bash
2 # stupid-script-tricks.sh: Don't try this at home, folks.
3 # From "Stupid Script Tricks," Volume I.
4
5 exit 99  ### Comment out this line if you dare.
6
7 dangerous_variable=`cat /boot/vmlinuz`  # The compressed Linux kernel itself.
8
9 echo "string-length of `${dangerous_variable} = ${#dangerous_variable}"
10 # string-length of $dangerous_variable = 794151
11 # (Newer kernels are bigger.)
12 # Does not give same count as 'wc -c /boot/vmlinuz'.
13
14 # echo "$dangerous_variable"
15 # Don't try this! It would hang the script.
16
17
18 # The document author is aware of no useful applications for
19 #+ setting a variable to the contents of a binary file.
20
21 exit 0

```

Notice that a *buffer overrun* does not occur. This is one instance where an interpreted language, such as Bash, provides more protection from programmer mistakes than a compiled language.

Command substitution permits setting a variable to the output of a [loop](#). The key to this is grabbing the output of an [echo](#) command within the loop.

Example 12-2. Generating a variable from a loop

```

1 #!/bin/bash
2 # csubloop.sh: Setting a variable to the output of a loop.
3
4 variable1=`for i in 1 2 3 4 5

```

```

5 do
6   echo -n "$i"           # The 'echo' command is critical
7 done`                   #+ to command substitution here.
8
9 echo "variable1 = $variable1" # variable1 = 12345
10
11
12 i=0
13 variable2=`while [ "$i" -lt 10 ]
14 do
15   echo -n "$i"           # Again, the necessary 'echo'.
16   let "i += 1"           # Increment.
17 done`
18
19 echo "variable2 = $variable2" # variable2 = 0123456789
20
21 # Demonstrates that it's possible to embed a loop
22 #+ inside a variable declaration.
23
24 exit 0

```

Command substitution makes it possible to extend the toolset available to Bash. It is simply a matter of writing a program or script that outputs to `stdout` (like a well-behaved UNIX tool should) and assigning that output to a variable.

```

1 #include <stdio.h>
2
3 /* "Hello, world." C program */
4
5 int main()
6 {
7   printf( "Hello, world.\n" );
8   return (0);
9 }

```


bash\$ **gcc -o hello hello.c**

```

1 #!/bin/bash
2 # hello.sh
3
4 greeting=`./hello`
5 echo $greeting

```

bash\$ **sh hello.sh**
Hello, world.

 The `$(...)` form has superseded backticks for command substitution.

```

1 output=$(sed -n /"$1"/p $file) # From "grp.sh" example.
2
3 # Setting a variable to the contents of a text file.
4 File_contents1=$(cat $file1)
5 File_contents2=$(<$file2) # Bash permits this also.

```

The `$(...)` form of command substitution treats a double backslash in a different way than ``...``.

```

bash$ echo `echo \\\`
\

bash$ echo $(echo \\\)
\

```

The `$(...)` form of command substitution permits nesting. [\[3\]](#)

```
1 word_count=$( wc -w $(echo * | awk '{print $8}') )
```

Or, for something a bit more elaborate . . .

Example 12-3. Finding anagrams

```
1 #!/bin/bash
2 # agram2.sh
3 # Example of nested command substitution.
4
5 # Uses "anagram" utility
6 #+ that is part of the author's "yawl" word list package.
7 # http://ibiblio.org/pub/Linux/libs/yawl-0.3.2.tar.gz
8 # http://bash.deta.in/yawl-0.3.2.tar.gz
9
10 E_NOARGS=86
11 E_BADARG=87
12 MINLEN=7
13
14 if [ -z "$1" ]
15 then
16     echo "Usage $0 LETTERSET"
17     exit $E_NOARGS          # Script needs a command-line argument.
18 elif [ ${#1} -lt $MINLEN ]
19 then
20     echo "Argument must have at least $MINLEN letters."
21     exit $E_BADARG
22 fi
23
24
25
26 FILTER='.....'          # Must have at least 7 letters.
27 #     1234567
28 Anagrams=( $(echo $(anagram $1 | grep $FILTER) ) )
29 #     $( $( nested command sub. ) )
30 #     (         array assignment         )
31
32 echo
33 echo "${#Anagrams[*]} 7+ letter anagrams found"
34 echo
35 echo ${Anagrams[0]}      # First anagram.
36 echo ${Anagrams[1]}      # Second anagram.
37                          # Etc.
38
39 # echo "${Anagrams[*]}" # To list all the anagrams in a single line . . .
40
41 # Look ahead to the Arrays chapter for enlightenment on
42 #+ what's going on here.
43
44 # See also the agram.sh script for an exercise in anagram finding.
45
46 exit $?
```

Examples of command substitution in shell scripts:

1. [Example 11-8](#)
2. [Example 11-27](#)
3. [Example 9-16](#)

4. [Example 16-3](#)
5. [Example 16-22](#)
6. [Example 16-17](#)
7. [Example 16-54](#)
8. [Example 11-14](#)
9. [Example 11-11](#)
10. [Example 16-32](#)
11. [Example 20-8](#)
12. [Example A-16](#)
13. [Example 29-3](#)
14. [Example 16-47](#)
15. [Example 16-48](#)
16. [Example 16-49](#)

Notes

- [1] For purposes of *command substitution*, a **command** may be an external system command, an internal scripting [builtin](#), or even [a script function](#).
- [2] In a more technically correct sense, *command substitution* extracts the `stdout` of a command, then assigns it to a variable using the `=` operator.
- [3] In fact, nesting with backticks is also possible, but only by escaping the inner backticks, as John Defaul points out.

```
1 word_count=` wc -w `echo * | awk '{print $8}'` ` `
```

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Arithmetic Expansion

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Chapter 13. Arithmetic Expansion

Arithmetic expansion provides a powerful tool for performing (integer) arithmetic operations in scripts. Translating a string into a numerical expression is relatively straightforward using *backticks*, *double parentheses*, or *let*.

Variations

Arithmetic expansion with [backticks](#) (often used in conjunction with [expr](#))

```
1 z=`expr $z + 3`          # The 'expr' command performs the expansion.
```

Arithmetic expansion with [double parentheses](#), and using [let](#)

The use of *backticks* (*backquotes*) in arithmetic expansion has been superseded by *double parentheses* -- `((...))` and `$(...)` -- and also by the very convenient [let](#) construction.

```
1 z=$((z+3))
2 z=$((z+3))              # Also correct.
3                          # Within double parentheses,
4                          #+ parameter dereferencing
5                          #+ is optional.
6
7 # $((EXPRESSION)) is arithmetic expansion. # Not to be confused with
8                                          #+ command substitution.
9
10
11
12 # You may also use operations within double parentheses without assignment.
13
14 n=0
15 echo "n = $n"          # n = 0
16
17 (( n += 1 ))           # Increment.
18 # (( $n += 1 )) is incorrect!
19 echo "n = $n"          # n = 1
20
21
22 let z=z+3
23 let "z += 3"           # Quotes permit the use of spaces in variable assignment.
24                          # The 'let' operator actually performs arithmetic evaluation,
25                          #+ rather than expansion.
```

Examples of arithmetic expansion in scripts:

1. [Example 16-9](#)
2. [Example 11-15](#)
3. [Example 27-1](#)
4. [Example 27-11](#)
5. [Example A-16](#)

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Recess Time

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Chapter 14. Recess Time

This bizarre little intermission gives the reader a chance to relax and maybe laugh a bit.

Fellow Linux user, greetings! You are reading something which will bring you luck and good fortune. Just e-mail a copy of this document to 10 of your friends. Before making the copies, send a 100-line Bash script to the first person on the list at the bottom of this letter. Then delete their name and add yours to the bottom of the list.

Don't break the chain! Make the copies within 48 hours. Wilfred P. of Brooklyn failed to send out his ten copies and woke the next morning to find his job description changed to "COBOL programmer." Howard L. of Newport News sent out his ten copies and within a month had enough hardware to build a 100-node Beowulf cluster dedicated to playing *Tuxracer*. Amelia V. of Chicago laughed at this letter and broke the chain. Shortly thereafter, a fire broke out in her terminal and she now spends her days writing documentation for MS Windows.

Don't break the chain! Send out your ten copies today!

Courtesy 'NIX "fortune cookies", with some alterations and many apologies

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Part 4. Commands

Mastering the commands on your Linux machine is an indispensable prelude to writing effective shell scripts.

This section covers the following commands:

- [.](#) (See also [source](#))
- [ac](#)
- [adduser](#)
- [agetty](#)
- [agrep](#)
- [ar](#)
- [arch](#)
- [at](#)
- [autoload](#)
- [awk](#) (See also [Using awk for math operations](#))
- [badblocks](#)
- [banner](#)
- [basename](#)
- [batch](#)
- [bc](#)
- [bg](#)
- [bind](#)
- [bison](#)
- [builtin](#)
- [bzgrep](#)
- [bzip2](#)
- [cal](#)
- [caller](#)
- [cat](#)
- [cd](#)
- [chattr](#)
- [chfn](#)
- [chgrp](#)
- [chkconfig](#)
- [chmod](#)
- [chown](#)
- [chroot](#)
- [cksum](#)
- [clear](#)
- [clock](#)
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- [dd](#)
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- [declare](#)
- [depmod](#)
- [df](#)
- [dialog](#)
- [diff](#)
- [diff3](#)
- [diffstat](#)
- [dig](#)
- [dirname](#)
- [dirs](#)
- [disown](#)
- [dmesg](#)
- [doexec](#)
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- [eval](#)
- [exec](#)
- [exit](#) (Related topic: [exit status](#))
- [expand](#)
- [export](#)
- [expr](#)
- [factor](#)
- [false](#)
- [fdformat](#)
- [fdisk](#)
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- [flex](#)
- [flock](#)
- [fmt](#)
- [fold](#)

- [free](#)
- [fsck](#)
- [ftp](#)
- [fuser](#)
- [getfacl](#)
- [getopt](#)
- [getopts](#)
- [gettext](#)
- [getty](#)
- [gnome-mount](#)
- [grep](#)
- [groff](#)
- [groupmod](#)
- [groups](#) (Related topic: the [\\$GROUPS](#) variable)
- [gs](#)
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Internal Commands and Builtins

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Chapter 15. Internal Commands and Builtins

A *builtin* is a **command** contained within the Bash tool set, literally *built in*. This is either for performance reasons -- builtins execute faster than external commands, which usually require *forking off* [\[1\]](#) a separate process -- or because a particular builtin needs direct access to the shell internals.

When a command or the shell itself initiates (or *spawns*) a new subprocess to carry out a task, this is called *forking*. This new process is the *child*, and the process that *forked* it off is the *parent*. While the *child process* is doing its work, the *parent process* is still executing.

Note that while a *parent process* gets the *process ID* of the *child process*, and can thus pass arguments to it, *the reverse is not true*. [This can create problems that are subtle and hard to track down](#).

Example 15-1. A script that spawns multiple instances of itself

```
1 #!/bin/bash
2 # spawn.sh
3
4
5 PIDS=$(pidof sh $0) # Process IDs of the various instances of this script.
6 P_array=( $PIDS ) # Put them in an array (why?).
7 echo $PIDS # Show process IDs of parent and child processes.
8 let "instances = ${#P_array[*]} - 1" # Count elements, less 1.
9 # Why subtract 1?
10 echo "$instances instance(s) of this script running."
11 echo "[Hit Ctl-C to exit.]"; echo
12
13
14 sleep 1 # Wait.
15 sh $0 # Play it again, Sam.
16
17 exit 0 # Not necessary; script will never get to here.
18 # Why not?
19
20 # After exiting with a Ctl-C,
21 #+ do all the spawned instances of the script die?
22 # If so, why?
23
24 # Note:
25 # ----
26 # Be careful not to run this script too long.
27 # It will eventually eat up too many system resources.
28
29 # Is having a script spawn multiple instances of itself
30 #+ an advisable scripting technique.
31 # Why or why not?
```

Generally, a Bash *builtin* does not fork a subprocess when it executes within a script. An external system command or filter in a script usually *will* fork a subprocess.

A builtin may be a synonym to a system command of the same name, but Bash reimplements it internally. For example, the Bash **echo** command is not the same as `/bin/echo`, although their behavior is almost identical.

```

1 #!/bin/bash
2
3 echo "This line uses the \"echo\" builtin."
4 /bin/echo "This line uses the /bin/echo system command."

```

A *keyword* is a *reserved* word, token or operator. Keywords have a special meaning to the shell, and indeed are the building blocks of the shell's syntax. As examples, *for*, *while*, *do*, and *!* are keywords. Similar to a [builtin](#), a keyword is hard-coded into Bash, but unlike a *builtin*, a keyword is not in itself a command, but a *subunit of a command construct*. [\[2\]](#)

I/O

echo

prints (to stdout) an expression or variable (see [Example 4-1](#)).

```

1 echo Hello
2 echo $a

```

An **echo** requires the `-e` option to print escaped characters. See [Example 5-2](#).

Normally, each **echo** command prints a terminal newline, but the `-n` option suppresses this.



An **echo** can be used to feed a sequence of commands down a pipe.

```

1 if echo "$VAR" | grep -q txt    # if [[ $VAR = *txt* ]]
2 then
3     echo "$VAR contains the substring sequence \"txt\""
4 fi

```



An **echo**, in combination with [command substitution](#) can set a variable.

```
a=`echo "HELLO" | tr A-Z a-z`
```

See also [Example 16-22](#), [Example 16-3](#), [Example 16-47](#), and [Example 16-48](#).

Be aware that **echo `command`** deletes any linefeeds that the output of *command* generates.

The [IFS](#) (internal field separator) variable normally contains `\n` (linefeed) as one of its set of [whitespace](#) characters. Bash therefore splits the output of *command* at linefeeds into arguments to **echo**. Then **echo** outputs these arguments, separated by spaces.

```

bash$ ls -l /usr/share/apps/kjezz/sounds
-rw-r--r--  1 root   root           1407 Nov  7  2000 reflect.au
-rw-r--r--  1 root   root           362 Nov  7  2000 seconds.au

bash$ echo `ls -l /usr/share/apps/kjezz/sounds`
total 40 -rw-r--r-- 1 root root 716 Nov 7 2000 reflect.au -rw-r--r-- 1 root root ...

```

So, how can we embed a linefeed within an [echoed](#) character string?

```


1 # Embedding a linefeed?
2 echo "Why doesn't this string \n split on two lines?"
3 # Doesn't split.
4
5 # Let's try something else.
6
7 echo

```

```

8
9 echo $"A line of text containing
10 a linefeed."
11 # Prints as two distinct lines (embedded linefeed).
12 # But, is the "$" variable prefix really necessary?
13
14 echo
15
16 echo "This string splits
17 on two lines."
18 # No, the "$" is not needed.
19
20 echo
21 echo "-----"
22 echo
23
24 echo -n $"Another line of text containing
25 a linefeed."
26 # Prints as two distinct lines (embedded linefeed).
27 # Even the -n option fails to suppress the linefeed here.
28
29 echo
30 echo
31 echo "-----"
32 echo
33 echo
34
35 # However, the following doesn't work as expected.
36 # Why not? Hint: Assignment to a variable.
37 string1=$"Yet another line of text containing
38 a linefeed (maybe)."
39
40 echo $string1
41 # Yet another line of text containing a linefeed (maybe).
42 #                                     ^
43 # Linefeed becomes a space.
44
45 # Thanks, Steve Parker, for pointing this out.

```

 This command is a shell builtin, and not the same as `/bin/echo`, although its behavior is similar.

```

bash$ type -a echo
echo is a shell builtin
echo is /bin/echo


```

printf

The **printf**, formatted print, command is an enhanced **echo**. It is a limited variant of the C language `printf()` library function, and its syntax is somewhat different.

printf *format-string... parameter...*

This is the Bash *builtin* version of the `/bin/printf` or `/usr/bin/printf` command. See the **printf** [manpage](#) (of the system command) for in-depth coverage.

 Older versions of Bash may not support **printf**.

Example 15-2. *printf* in action

```

1 #!/bin/bash
2 # printf demo
3
4 declare -r PI=3.14159265358979      # Read-only variable, i.e., a constant.
5 declare -r DecimalConstant=31373
6
7 Message1="Greetings,"
8 Message2="Earthling."
9
10 echo
11
12 printf "Pi to 2 decimal places = %1.2f" $PI
13 echo
14 printf "Pi to 9 decimal places = %1.9f" $PI # It even rounds off correctly.
15
16 printf "\n"                          # Prints a line feed,
17                                       # Equivalent to 'echo' . . .
18
19 printf "Constant = \t%d\n" $DecimalConstant # Inserts tab (\t).
20
21 printf "%s %s \n" $Message1 $Message2
22
23 echo
24
25 # =====#
26 # Simulation of C function, sprintf().
27 # Loading a variable with a formatted string.
28
29 echo
30
31 Pi12=$(printf "%1.12f" $PI)
32 echo "Pi to 12 decimal places = $Pi12"      # Roundoff error!
33
34 Msg=`printf "%s %s \n" $Message1 $Message2`
35 echo $Msg; echo $Msg
36
37 # As it happens, the 'sprintf' function can now be accessed
38 #+ as a loadable module to Bash,
39 #+ but this is not portable.
40
41 exit 0

```

Formatting error messages is a useful application of **printf**

```

1 E_BADDIR=85
2
3 var=nonexistent_directory
4
5 error()
6 {
7     printf "$@" >&2
8     # Formats positional params passed, and sends them to stderr.
9     echo
10    exit $E_BADDIR
11 }
12
13 cd $var || error $"Can't cd to %s." "$var"
14
15 # Thanks, S.C.

```

See also [Example 36-17](#).

read

"Reads" the value of a variable from `stdin`, that is, interactively fetches input from the keyboard. The `-a` option lets **read** get array variables (see [Example 27-6](#)).

Example 15-3. Variable assignment, using *read*

```
1 #!/bin/bash
2 # "Reading" variables.
3
4 echo -n "Enter the value of variable 'var1': "
5 # The -n option to echo suppresses newline.
6
7 read var1
8 # Note no '$' in front of var1, since it is being set.
9
10 echo "var1 = $var1"
11
12
13 echo
14
15 # A single 'read' statement can set multiple variables.
16 echo -n "Enter the values of variables 'var2' and 'var3' "
17 echo -n "(separated by a space or tab): "
18 read var2 var3
19 echo "var2 = $var2      var3 = $var3"
20 # If you input only one value,
21 #+ the other variable(s) will remain unset (null).
22
23 exit 0
```

A **read** without an associated variable assigns its input to the dedicated variable [\\$REPLY](#).

Example 15-4. What happens when *read* has no variable

```
1 #!/bin/bash
2 # read-novar.sh
3
4 echo
5
6 # ----- #
7 echo -n "Enter a value: "
8 read var
9 echo "\"var\" = \"$var\""
10 # Everything as expected here.
11 # ----- #
12
13 echo
14
15 # ----- #
16 echo -n "Enter another value: "
17 read          # No variable supplied for 'read', therefore...
18              #+ Input to 'read' assigned to default variable, $REPLY.
19 var="$REPLY"
20 echo "\"var\" = \"$var\""
21 # This is equivalent to the first code block.
22 # ----- #
23
24 echo
25 echo "===== "
26 echo
27
28
29 # This example is similar to the "reply.sh" script.
30 # However, this one shows that $REPLY is available
```

```

31 #+ even after a 'read' to a variable in the conventional way.
32
33
34 # ===== #
35
36 # In some instances, you might wish to discard the first value read.
37 # In such cases, simply ignore the $REPLY variable.
38
39 { # Code block.
40 read          # Line 1, to be discarded.
41 read line2    # Line 2, saved in variable.
42 } <$0
43 echo "Line 2 of this script is:"
44 echo "$line2" # # read-novar.sh
45 echo          # #!/bin/bash line discarded.
46
47 # See also the soundcard-on.sh script.
48
49 exit 0

```

Normally, inputting a `\` suppresses a newline during input to a **read**. The `-r` option causes an inputted `\` to be interpreted literally.

Example 15-5. Multi-line input to *read*

```

1 #!/bin/bash
2
3 echo
4
5 echo "Enter a string terminated by a \\, then press <ENTER>."
6 echo "Then, enter a second string (no \\ this time), and again press <ENTER>."
7
8 read var1      # The "\" suppresses the newline, when reading $var1.
9                # first line \
10               # second line
11
12 echo "var1 = $var1"
13 # var1 = first line second line
14
15 # For each line terminated by a "\"
16 #+ you get a prompt on the next line to continue feeding characters into var1.
17
18 echo; echo
19
20 echo "Enter another string terminated by a \\ , then press <ENTER>."
21 read -r var2  # The -r option causes the "\" to be read literally.
22               # first line \
23
24 echo "var2 = $var2"
25 # var2 = first line \
26
27 # Data entry terminates with the first <ENTER>.
28
29 echo
30
31 exit 0

```

The **read** command has some interesting options that permit echoing a prompt and even reading keystrokes without hitting **ENTER**.

```

1 # Read a keypress without hitting ENTER.
2
3 read -s -n1 -p "Hit a key " keypress
4 echo; echo "Keypress was \"$keypress\"."
5
6 # -s option means do not echo input.
7 # -n N option means accept only N characters of input.
8 # -p option means echo the following prompt before reading input.
9
10 # Using these options is tricky, since they need to be in the correct order.

```

The `-n` option to `read` also allows detection of the **arrow keys** and certain of the other unusual keys.

Example 15-6. Detecting the arrow keys

```

1 #!/bin/bash
2 # arrow-detect.sh: Detects the arrow keys, and a few more.
3 # Thank you, Sandro Magi, for showing me how.
4
5 # -----
6 # Character codes generated by the keypresses.
7 arrowup='\[A'
8 arrowdown='\[B'
9 arrowrt='\[C'
10 arrowleft='\[D'
11 insert='\[2'
12 delete='\[3'
13 # -----
14
15 SUCCESS=0
16 OTHER=65
17
18 echo -n "Press a key... "
19 # May need to also press ENTER if a key not listed above pressed.
20 read -n3 key # Read 3 characters.
21
22 echo -n "$key" | grep "$arrowup" #Check if character code detected.
23 if [ "$?" -eq $SUCCESS ]
24 then
25     echo "Up-arrow key pressed."
26     exit $SUCCESS
27 fi
28
29 echo -n "$key" | grep "$arrowdown"
30 if [ "$?" -eq $SUCCESS ]
31 then
32     echo "Down-arrow key pressed."
33     exit $SUCCESS
34 fi
35
36 echo -n "$key" | grep "$arrowrt"
37 if [ "$?" -eq $SUCCESS ]
38 then
39     echo "Right-arrow key pressed."
40     exit $SUCCESS
41 fi
42
43 echo -n "$key" | grep "$arrowleft"
44 if [ "$?" -eq $SUCCESS ]
45 then
46     echo "Left-arrow key pressed."
47     exit $SUCCESS
48 fi

```

```


49
50 echo -n "$key" | grep "$insert"
51 if [ "$?" -eq $SUCCESS ]
52 then
53     echo "\"Insert\" key pressed."
54     exit $SUCCESS
55 fi
56
57 echo -n "$key" | grep "$delete"
58 if [ "$?" -eq $SUCCESS ]
59 then
60     echo "\"Delete\" key pressed."
61     exit $SUCCESS
62 fi
63
64
65 echo " Some other key pressed."
66
67 exit $OTHER
68
69 # ===== #
70
71 # Mark Alexander came up with a simplified
72 #+ version of the above script (Thank you!).
73 # It eliminates the need for grep.
74
75 #!/bin/bash
76
77 uparrow=$'\x1b[A'
78 downarrow=$'\x1b[B'
79 leftarrow=$'\x1b[D'
80 rightarrow=$'\x1b[C'
81
82 read -s -n3 -p "Hit an arrow key: " x
83
84 case "$x" in
85     $uparrow)
86         echo "You pressed up-arrow"
87         ;;
88     $downarrow)
89         echo "You pressed down-arrow"
90         ;;
91     $leftarrow)
92         echo "You pressed left-arrow"
93         ;;
94     $rightarrow)
95         echo "You pressed right-arrow"
96         ;;
97     esac
98
99 exit $?
100
101 # ===== #
102
103 # Antonio Macchi has a simpler alternative.
104
105 #!/bin/bash
106
107 while true
108 do
109     read -sn1 a
110     test "$a" == `echo -en "\e"` || continue
111     read -sn1 a
112     test "$a" == "[" || continue
113     read -sn1 a
114     case "$a" in

```

```

115     A)  echo "up";;
116     B)  echo "down";;
117     C)  echo "right";;
118     D)  echo "left";;
119  esac
120 done
121
122 # ===== #
123
124 # Exercise:
125 # -----
126 # 1) Add detection of the "Home," "End," "PgUp," and "PgDn" keys.

```

 The `-n` option to **read** will not detect the **ENTER** (newline) key.

The `-t` option to **read** permits timed input (see [Example 9-4](#) and [Example A-41](#)).

The `-u` option takes the [file descriptor](#) of the target file.

The **read** command may also "read" its variable value from a file [redirected](#) to `stdin`. If the file contains more than one line, only the first line is assigned to the variable. If **read** has more than one parameter, then each of these variables gets assigned a successive [whitespace-delineated](#) string. Caution!

Example 15-7. Using *read* with [file redirection](#)

```

1  #!/bin/bash
2
3  read var1 <data-file
4  echo "var1 = $var1"
5  # var1 set to the entire first line of the input file "data-file"
6
7  read var2 var3 <data-file
8  echo "var2 = $var2   var3 = $var3"
9  # Note non-intuitive behavior of "read" here.
10 # 1) Rewinds back to the beginning of input file.
11 # 2) Each variable is now set to a corresponding string,
12 #    separated by whitespace, rather than to an entire line of text.
13 # 3) The final variable gets the remainder of the line.
14 # 4) If there are more variables to be set than whitespace-terminated strings
15 #    on the first line of the file, then the excess variables remain empty.
16
17 echo "-----"
18
19 # How to resolve the above problem with a loop:
20 while read line
21 do
22     echo "$line"
23 done <data-file
24 # Thanks, Heiner Steven for pointing this out.
25
26 echo "-----"
27
28 # Use $IFS (Internal Field Separator variable) to split a line of input to
29 # "read", if you do not want the default to be whitespace.
30
31 echo "List of all users:"
32 OIFS=$IFS; IFS=:      # /etc/passwd uses ":" for field separator.
33 while read name passwd uid gid fullname ignore

```

```

34 do
35   echo "$name ($fullname)"
36 done </etc/passwd # I/O redirection.
37 IFS=$OIFS          # Restore original $IFS.
38 # This code snippet also by Heiner Steven.
39
40
41
42 # Setting the $IFS variable within the loop itself
43 #+ eliminates the need for storing the original $IFS
44 #+ in a temporary variable.
45 # Thanks, Dim Segebart, for pointing this out.
46 echo "-----"
47 echo "List of all users:"
48
49 while IFS=: read name passwd uid gid fullname ignore
50 do
51   echo "$name ($fullname)"
52 done </etc/passwd # I/O redirection.
53
54 echo
55 echo "\$IFS still $IFS"
56
57 exit 0

```



Piping output to a *read*, using [echo](#) to set variables [will fail](#).

Yet, piping the output of [cat](#) *seems* to work.

```

1 cat file1 file2 |
2 while read line
3 do
4   echo $line
5 done

```

However, as Bjön Eriksson shows:

Example 15-8. Problems reading from a pipe

```

1 #!/bin/sh
2 # readpipe.sh
3 # This example contributed by Bjön Eriksson.
4
5 ### shopt -s lastpipe
6
7 last="(null)"
8 cat $0 |
9 while read line
10 do
11   echo "${line}"
12   last=$line
13 done
14
15 echo
16 echo "+++++"
17 printf "\nAll done, last: $last\n" # The output of this line
18                                     #+ changes if you uncomment line 5.
19                                     # (Bash, version -ge 4.2 required.)
20
21 exit 0 # End of code.

```

```

22      # (Partial) output of script follows.
23      # The 'echo' supplies extra brackets.
24
25 #####
26
27 ./readpipe.sh
28
29 {#!/bin/sh}
30 {last="(null)"}
31 {cat $0 |}
32 {while read line}
33 {do}
34 {echo "${line}"}
35 {last=$line}
36 {done}
37 {printf "\nAll done, last: $lastn"}
38
39
40 All done, last: (null)
41
42 The variable (last) is set within the loop/subshell
43 but its value does not persist outside the loop.


```

The *gendiff* script, usually found in `/usr/bin` on many Linux distros, pipes the output of [find](#) to a *while read* construct.

```

1 find $1 \( -name "$2" -o -name ".$2" \) -print |
2 while read f; do
3 . . .

```

 It is possible to *paste* text into the input field of a *read* (but *not* multiple lines!). See [Example A-38](#).

Filesystem

cd


The familiar **cd** change directory command finds use in scripts where execution of a command requires being in a specified directory.

```
1 (cd /source/directory && tar cf - .) | (cd /dest/directory && tar xpvf -)
```

[from the [previously cited](#) example by Alan Cox]

The `-P` (physical) option to **cd** causes it to ignore symbolic links.

cd - changes to [\\$OLDPWD](#), the previous working directory.

 The **cd** command does not function as expected when presented with two forward slashes.

```
bash$ cd //
bash$ pwd
//
```

The output should, of course, be `/`. This is a problem both from the command-line and in a script.

pwd

Print Working Directory. This gives the user's (or script's) current directory (see [Example 15-9](#)). The effect is identical to reading the value of the builtin variable [\\$PWD](#).

pushd, popd, dirs

This command set is a mechanism for bookmarking working directories, a means of moving back and forth through directories in an orderly manner. A pushdown [stack](#) is used to keep track of directory names. Options allow various manipulations of the directory stack.

pushd *dir-name* pushes the path *dir-name* onto the directory stack (to the *top* of the stack) and simultaneously changes the current working directory to *dir-name*

popd removes (pops) the top directory path name off the directory stack and simultaneously changes the current working directory to the directory now at the *top* of the stack.

dirs lists the contents of the directory stack (compare this with the [\\$DIRSTACK](#) variable). A successful **pushd** or **popd** will automatically invoke **dirs**.

Scripts that require various changes to the current working directory without hard-coding the directory name changes can make good use of these commands. Note that the implicit `$DIRSTACK` array variable, accessible from within a script, holds the contents of the directory stack.

Example 15-9. Changing the current working directory

```
1 #!/bin/bash
2
3 dir1=/usr/local
4 dir2=/var/spool
5
6 pushd $dir1
7 # Will do an automatic 'dirs' (list directory stack to stdout).
8 echo "Now in directory `pwd`." # Uses back-quoted 'pwd'.
9
10 # Now, do some stuff in directory 'dir1'.
11 pushd $dir2
12 echo "Now in directory `pwd`."
13
14 # Now, do some stuff in directory 'dir2'.
15 echo "The top entry in the DIRSTACK array is $DIRSTACK."
16 popd
17 echo "Now back in directory `pwd`."
18
19 # Now, do some more stuff in directory 'dir1'.
20 popd
21 echo "Now back in original working directory `pwd`."
22
23 exit 0
24
25 # What happens if you don't 'popd' -- then exit the script?
26 # Which directory do you end up in? Why?
```

Variables

let


The **let** command carries out *arithmetic* operations on variables. [\[3\]](#) In many cases, it functions as a less complex version of [expr](#).

Example 15-10. Letting *let* do arithmetic.

```

1 #!/bin/bash
2
3 echo
4
5 let a=11          # Same as 'a=11'
6 let a=a+5        # Equivalent to let "a = a + 5"
7                  # (Double quotes and spaces make it more readable.)
8 echo "11 + 5 = $a" # 16
9
10 let "a <= 3"     # Equivalent to let "a = a <= 3"
11 echo "\"\$a\" (=16) left-shifted 3 places = $a"
12                  # 128
13
14 let "a /= 4"     # Equivalent to let "a = a / 4"
15 echo "128 / 4 = $a" # 32
16
17 let "a -= 5"     # Equivalent to let "a = a - 5"
18 echo "32 - 5 = $a" # 27
19
20 let "a *= 10"    # Equivalent to let "a = a * 10"
21 echo "27 * 10 = $a" # 270
22
23 let "a %= 8"     # Equivalent to let "a = a % 8"
24 echo "270 modulo 8 = $a (270 / 8 = 33, remainder $a)"
25                  # 6
26
27
28 # Does "let" permit C-style operators?
29 # Yes, just as the (( ... )) double-parentheses construct does.
30
31 let a++          # C-style (post) increment.
32 echo "6++ = $a" # 6++ = 7
33 let a--          # C-style decrement.
34 echo "7-- = $a" # 7-- = 6
35 # Of course, ++a, etc., also allowed . . .
36 echo
37
38
39 # Trinary operator.
40
41 # Note that $a is 6, see above.
42 let "t = a<7?7:11" # True
43 echo $t # 7
44
45 let a++
46 let "t = a<7?7:11" # False
47 echo $t # 11
48
49 exit

```

 The `let` command can, in certain contexts, return a surprising [exit status](#).

```

1 # Evgeniy Ivanov points out:
2
3 var=0
4 echo $? # 0
5          # As expected.
6
7 let var++
8 echo $? # 1
9          # The command was successful, so why isn't $?=0 ???
10         # Anomaly!
11

```

```


12 let var++
13 echo $?      # 0
14             # As expected.
15
16
17 # Likewise . . .
18
19 let var=0
20 echo $?      # 1
21             # The command was successful, so why isn't $?=0 ???
22
23 # However, as Jeff Gorak points out,
24 #+ this is part of the design spec for 'let' . . .
25 # "If the last ARG evaluates to 0, let returns 1;
26 # let returns 0 otherwise." ['help let']

```

eval

eval *arg1* [*arg2*] ... [*argN*]

Combines the arguments in an expression or list of expressions and *evaluates* them. Any variables within the expression are expanded. The net result is to **convert a string into a command**.

 The **eval** command can be used for code generation from the command-line or within a script.

```

bash$ command_string="ps ax"
bash$ process="ps ax"
bash$ eval "$command_string" | grep "$process"
26973 pts/3      R+      0:00 grep --color ps ax
26974 pts/3      R+      0:00 ps ax

```

Each invocation of *eval* forces a re-evaluation of its arguments.

```

1 a='$b'
2 b='$c'
3 c=d
4
5 echo $a      # $b
6             # First level.
7 eval echo $a # $c
8             # Second level.
9 eval eval echo $a # d
10            # Third level.
11
12 # Thank you, E. Choroba.

```

Example 15-11. Showing the effect of *eval*

```

1 #!/bin/bash
2 # Exercising "eval" ...
3
4 y=`eval ls -l` # Similar to y=`ls -l`
5 echo $y      #+ but linefeeds removed because "echoed" variable is unquoted.
6 echo
7 echo "$y"    # Linefeeds preserved when variable is quoted.
8
9 echo; echo
10
11 y=`eval df` # Similar to y=`df`
12 echo $y     #+ but linefeeds removed.

```



```

13
14 # When LF's not preserved, it may make it easier to parse output,
15 #+ using utilities such as "awk".
16
17 echo
18 echo "=====
19 echo
20
21 eval "`seq 3 | sed -e 's/.*/echo var&=ABCDEFGHJIJ/'`"
22 # var1=ABCDEFGHJIJ
23 # var2=ABCDEFGHJIJ
24 # var3=ABCDEFGHJIJ
25
26 echo
27 echo "=====
28 echo
29
30
31 # Now, showing how to do something useful with "eval" . . .
32 # (Thank you, E. Choroba!)
33
34 version=3.4      # Can we split the version into major and minor
35                  #+ part in one command?
36 echo "version = $version"
37 eval major=${version/./;minor=}      # Replaces '.' in version by ';minor='
38                                     # The substitution yields '3; minor=4'
39                                     #+ so eval does minor=4, major=3
40 echo Major: $major, minor: $minor    # Major: 3, minor: 4

```

Example 15-12. Using *eval* to select among variables

```

1 #!/bin/bash
2 # arr-choice.sh
3
4 # Passing arguments to a function to select
5 #+ one particular variable out of a group.
6
7 arr0=( 10 11 12 13 14 15 )
8 arr1=( 20 21 22 23 24 25 )
9 arr2=( 30 31 32 33 34 35 )
10 #      0  1  2  3  4  5      Element number (zero-indexed)
11
12
13 choose_array ()
14 {
15     eval array_member=\${arr${array_number}[element_number]}
16     #           ^           ^^^^^^^^^^^^^^^
17     # Using eval to construct the name of a variable,
18     #+ in this particular case, an array name.
19
20     echo "Element $element_number of array $array_number is $array_member"
21 } # Function can be rewritten to take parameters.
22
23 array_number=0      # First array.
24 element_number=3
25 choose_array      # 13
26
27 array_number=2      # Third array.
28 element_number=4
29 choose_array      # 34
30
31 array_number=3      # Null array (arr3 not allocated).

```

```
32 element_number=4
33 choose_array      # (null)
34
35 # Thank you, Antonio Macchi, for pointing this out.
```

Example 15-13. *Echoing the command-line parameters*

```
1 #!/bin/bash
2 # echo-params.sh
3
4 # Call this script with a few command-line parameters.
5 # For example:
6 #     sh echo-params.sh first second third fourth fifth
7
8 params=$#           # Number of command-line parameters.
9 param=1            # Start at first command-line param.
10
11 while [ "$param" -le "$params" ]
12 do
13     echo -n "Command-line parameter "
14     echo -n \$$param # Gives only the *name* of variable.
15 #     ^^^          # $1, $2, $3, etc.
16 #                 # Why?
17 #                 # \$ escapes the first "$"
18 #                 #+ so it echoes literally,
19 #                 #+ and $param dereferences "$param" . . .
20 #                 #+ . . . as expected.
21     echo -n " = "
22     eval echo \$$param # Gives the *value* of variable.
23 #     ^^^^          # The "eval" forces the *evaluation*
24 #                 #+ of \$$
25 #                 #+ as an indirect variable reference.
26
27 (( param ++ ))      # On to the next.
28 done
29
30 exit $?
31
32 # =====
33
34 $ sh echo-params.sh first second third fourth fifth
35 Command-line parameter $1 = first
36 Command-line parameter $2 = second
37 Command-line parameter $3 = third
38 Command-line parameter $4 = fourth
39 Command-line parameter $5 = fifth
```

Example 15-14. *Forcing a log-off*

```
1 #!/bin/bash
2 # Killing ppp to force a log-off.
3 # For dialup connection, of course.
4
5 # Script should be run as root user.
6
7 SERPORT=ttyS3
8 # Depending on the hardware and even the kernel version,
9 #+ the modem port on your machine may be different --
10 #+ /dev/ttyS1 or /dev/ttyS2.
```

```

11
12
13 killppp="eval kill -9 `ps ax | awk '/ppp/ { print $1 }`"
14 # ----- process ID of ppp -----
15
16 $killppp # This variable is now a command.
17
18
19 # The following operations must be done as root user.
20
21 chmod 666 /dev/$SERPORT # Restore r+w permissions, or else what?
22 # Since doing a SIGKILL on ppp changed the permissions on the serial port,
23 #+ we restore permissions to previous state.
24
25 rm /var/lock/LCK..$SERPORT # Remove the serial port lock file. Why?
26
27 exit $?
28
29 # Exercises:
30 # -----
31 # 1) Have script check whether root user is invoking it.
32 # 2) Do a check on whether the process to be killed
33 #+ is actually running before attempting to kill it.
34 # 3) Write an alternate version of this script based on 'fuser':
35 #+ if [ fuser -s /dev/modem ]; then . . .

```

Example 15-15. A version of *rot13*

```

1 #!/bin/bash
2 # A version of "rot13" using 'eval'.
3 # Compare to "rot13.sh" example.
4
5 setvar_rot_13() # "rot13" scrambling
6 {
7     local varname=$1 varvalue=$2
8     eval $varname='$(echo "$varvalue" | tr a-z n-za-m)'
9 }
10
11
12 setvar_rot_13 var "foobar" # Run "foobar" through rot13.
13 echo $var # sbbone
14
15 setvar_rot_13 var "$var" # Run "sbbone" through rot13.
16 # Back to original variable.
17 echo $var # foobar
18
19 # This example by Stephane Chazelas.
20 # Modified by document author.
21
22 exit 0

```

Here is another example of using *eval* to *evaluate* a complex expression, this one from an earlier version of YongYe's [Tetris game script](#).


```
1 eval ${1}+=\ "${x} ${y} \"
```

[Example A-53](#) uses *eval* to convert [array](#) elements into a command list.

The *eval* command occurs in the older version of [indirect referencing](#).

```
1 eval var=\$$var
```

 The `eval` command can be used to [parameterize brace expansion](#).

 The `eval` command can be risky, and normally should be avoided when there exists a reasonable alternative. An `eval $COMMANDS` executes the contents of `COMMANDS`, which may contain such unpleasant surprises as `rm -rf *`. Running an `eval` on unfamiliar code written by persons unknown is living dangerously.

set

The `set` command changes the value of internal script variables/options. One use for this is to toggle [option flags](#) which help determine the behavior of the script. Another application for it is to reset the [positional parameters](#) that a script sees as the result of a command (`set `command``). The script can then parse the [fields](#) of the command output.

Example 15-16. Using `set` with positional parameters

```
1 #!/bin/bash
2 # ex34.sh
3 # Script "set-test"
4
5 # Invoke this script with three command-line parameters,
6 # for example, "sh ex34.sh one two three".
7
8 echo
9 echo "Positional parameters before set `uname -a` :"
10 echo "Command-line argument #1 = $1"
11 echo "Command-line argument #2 = $2"
12 echo "Command-line argument #3 = $3"
13
14
15 set `uname -a` # Sets the positional parameters to the output
16                # of the command `uname -a`
17
18 echo
19 echo +++++
20 echo $_        # +++++
21 # Flags set in script.
22 echo $-        # hB
23 #                Anomalous behavior?
24 echo
25
26 echo "Positional parameters after set `uname -a` :"
27 # $1, $2, $3, etc. reinitialized to result of `uname -a`
28 echo "Field #1 of 'uname -a' = $1"
29 echo "Field #2 of 'uname -a' = $2"
30 echo "Field #3 of 'uname -a' = $3"
31 echo `#`#`#`#
32 echo $_        # ###
33 echo
34
35 exit 0
```

More fun with positional parameters.

Example 15-17. Reversing the positional parameters

```
1 #!/bin/bash
2 # revposparams.sh: Reverse positional parameters.
```

```

3 # Script by Dan Jacobson, with stylistic revisions by document author.
4
5
6 set a\ b c d\ e;
7 #      ^      ^      Spaces escaped
8 #      ^ ^      Spaces not escaped
9 OIFS=$IFS; IFS=:;
10 #      ^      Saving old IFS and setting new one.
11
12 echo
13
14 until [ $# -eq 0 ]
15 do      #      Step through positional parameters.
16     echo "### k0 = "$k"      # Before
17     k=$1:$k; #      Append each pos param to loop variable.
18 #      ^
19     echo "### k = "$k"      # After
20     echo
21     shift;
22 done
23
24 set $k # Set new positional parameters.
25 echo -
26 echo $# # Count of positional parameters.
27 echo -
28 echo
29
30 for i # Omitting the "in list" sets the variable -- i --
31     #+ to the positional parameters.
32 do
33     echo $i # Display new positional parameters.
34 done
35
36 IFS=$OIFS # Restore IFS.
37
38 # Question:
39 # Is it necessary to set an new IFS, internal field separator,
40 #+ in order for this script to work properly?
41 # What happens if you don't? Try it.
42 # And, why use the new IFS -- a colon -- in line 17,
43 #+ to append to the loop variable?
44 # What is the purpose of this?
45
46 exit 0
47
48 $ ./revposparams.sh
49
50 ### k0 =
51 ### k = a b
52
53 ### k0 = a b
54 ### k = c a b
55
56 ### k0 = c a b
57 ### k = d e c a b
58
59 -
60 3
61 -
62
63 d e
64 c
65 a b

```

Invoking **set** without any options or arguments simply lists all the [environmental](#) and other variables that have been initialized.

```
bash$ set
AUTHORCOPY=/home/bozo/posts
BASH=/bin/bash
BASH_VERSION=$'2.05.8 (1)-release'
...
XAUTHORITY=/home/bozo/.Xauthority
_=/etc/bashrc
variable22=abc
variable23=xzy
```

Using **set** with the **--** option explicitly assigns the contents of a variable to the positional parameters. If no variable follows the **--** it *unsets* the positional parameters.

Example 15-18. Reassigning the positional parameters

```
1 #!/bin/bash
2
3 variable="one two three four five"
4
5 set -- $variable
6 # Sets positional parameters to the contents of "$variable".
7
8 first_param=$1
9 second_param=$2
10 shift; shift      # Shift past first two positional params.
11 # shift 2         also works.
12 remaining_params="$*"
13
14 echo
15 echo "first parameter = $first_param"           # one
16 echo "second parameter = $second_param"        # two
17 echo "remaining parameters = $remaining_params" # three four five
18
19 echo; echo
20
21 # Again.
22 set -- $variable
23 first_param=$1
24 second_param=$2
25 echo "first parameter = $first_param"           # one
26 echo "second parameter = $second_param"        # two
27
28 # =====
29
30 set --
31 # Unsets positional parameters if no variable specified.
32
33 first_param=$1
34 second_param=$2
35 echo "first parameter = $first_param"           # (null value)
36 echo "second parameter = $second_param"        # (null value)
37
38 exit 0
```

See also [Example 11-2](#) and [Example 16-56](#).

unset

The **unset** command deletes a shell variable, effectively setting it to *null*. Note that this command does not affect positional parameters.

```
bash$ unset PATH

bash$ echo $PATH

bash$
```

Example 15-19. "Unsetting" a variable

```
1 #!/bin/bash
2 # unset.sh: Unsetting a variable.
3
4 variable=hello                    # Initialized.
5 echo "variable = $variable"
6
7 unset variable                    # Unset.
8                                  # In this particular context,
9                                  #+ same effect as: variable=
10 echo "(unset) variable = $variable" # $variable is null.
11
12 if [ -z "$variable" ]            # Try a string-length test.
13 then
14     echo "\$variable has zero length."
15 fi
16
17 exit 0
```



In most contexts, an *undeclared* variable and one that has been *unset* are equivalent. However, the `_${parameter:-default}` parameter substitution construct can distinguish between the two.

export

The **export** [4] command makes available variables to all child processes of the running script or shell. One important use of the **export** command is in [startup files](#), to initialize and make accessible [environmental variables](#) to subsequent user processes.



Unfortunately, [there is no way to export variables back to the parent process](#), to the process that called or invoked the script or shell.


Example 15-20. Using *export* to pass a variable to an embedded *awk* script

```
1 #!/bin/bash
2
3 # Yet another version of the "column totaler" script (col-totaler.sh)
4 #+ that adds up a specified column (of numbers) in the target file.
5 # This uses the environment to pass a script variable to 'awk' . . .
6 #+ and places the awk script in a variable.
7
8
9 ARGS=2
10 E_WRONGARGS=85
11
12 if [ $# -ne "$ARGS" ] # Check for proper number of command-line args.
13 then
14     echo "Usage: `basename $0` filename column-number"
15     exit $E_WRONGARGS
16 fi
17
18 filename=$1
```

```

19 column_number=$2
20
21 #===== Same as original script, up to this point =====#
22
23 export column_number
24 # Export column number to environment, so it's available for retrieval.
25
26
27 # -----
28 awkscript='{ total += $ENVIRON["column_number"] }
29 END { print total }'
30 # Yes, a variable can hold an awk script.
31 # -----
32
33 # Now, run the awk script.
34 awk "$awkscript" "$filename"
35
36 # Thanks, Stephane Chazelas.
37
38 exit 0

```

 It is possible to initialize and export variables in the same operation, as in **export var1=xxx**.


However, as Greg Keraunen points out, in certain situations this may have a different effect than setting a variable, then exporting it.

```

bash$ export var=(a b); echo ${var[0]}
(a b)

bash$ var=(a b); export var; echo ${var[0]}
a

```

 A variable to be exported may require special treatment. See [Example M-2](#).

declare, typeset

The [declare](#) and [typeset](#) commands specify and/or restrict properties of variables.

readonly

Same as [declare -r](#), sets a variable as read-only, or, in effect, as a constant. Attempts to change the variable fail with an error message. This is the shell analog of the *C* language **const** type qualifier.

getopts

This powerful tool parses command-line arguments passed to the script. This is the Bash analog of the [getopt](#) external command and the *getopt* library function familiar to *C* programmers. It permits passing and concatenating multiple options [5] and associated arguments to a script (for example **scriptname -abc -e /usr/local**).

The **getopts** construct uses two implicit variables. `$OPTIND` is the argument pointer (*OPTion INDeX*) and `$OPTARG` (*OPTion ARGument*) the (optional) argument attached to an option. A colon following the option name in the declaration tags that option as having an associated argument.

A **getopts** construct usually comes packaged in a [while loop](#), which processes the options and arguments one at a time, then increments the implicit `$OPTIND` variable to point to the next.



1. The arguments passed from the command-line to the script must be preceded by a dash (-). It is the prefixed - that lets **getopts** recognize command-line

arguments as *options*. In fact, **getopts** will not process arguments without the prefixed `-`, and will terminate option processing at the first argument encountered lacking them.

2. The **getopts** template differs slightly from the standard [while loop](#), in that it lacks condition brackets.
3. The **getopts** construct is a highly functional replacement for the traditional [getopt](#) external command.

```
1 while getopts ":abcde:fg" Option
2 # Initial declaration.
3 # a, b, c, d, e, f, and g are the options (flags) expected.
4 # The : after option 'e' shows it will have an argument passed with it.
5 do
6     case $Option in
7         a ) # Do something with variable 'a'.
8         b ) # Do something with variable 'b'.
9             ...
10        e) # Do something with 'e', and also with $OPTARG,
11            # which is the associated argument passed with option 'e'.
12            ...
13        g ) # Do something with variable 'g'.
14    esac
15 done
16 shift $((OPTIND - 1))
17 # Move argument pointer to next.
18
19 # All this is not nearly as complicated as it looks <grin>.
```

Example 15-21. Using *getopts* to read the options/arguments passed to a script

```
1 #!/bin/bash
2 # ex33.sh: Exercising getopts and OPTIND
3 #           Script modified 10/09/03 at the suggestion of Bill Gradwohl.
4
5
6 # Here we observe how 'getopts' processes command-line arguments to script.
7 # The arguments are parsed as "options" (flags) and associated arguments.
8
9 # Try invoking this script with:
10 # 'scriptname -mn'
11 # 'scriptname -oq qOption' (qOption can be some arbitrary string.)
12 # 'scriptname -qXXX -r'
13 #
14 # 'scriptname -qr'
15 #+      - Unexpected result, takes "r" as the argument to option "q"
16 # 'scriptname -q -r'
17 #+      - Unexpected result, same as above
18 # 'scriptname -mnop -mnop' - Unexpected result
19 # (OPTIND is unreliable at stating where an option came from.)
20 #
21 # If an option expects an argument ("flag:"), then it will grab
22 #+ whatever is next on the command-line.
23
24 NO_ARGS=0
25 E_OPTERROR=85
26
27 if [ $# -eq "$NO_ARGS" ] # Script invoked with no command-line args?
28 then
29     echo "Usage: `basename $0` options (-mnopqrs)"
30     exit $E_OPTERROR # Exit and explain usage.
31 # Usage: scriptname -options
32 # Note: dash (-) necessary
```

```

33 fi
34
35
36 while getopts ":mnopq:rs" Option
37 do
38     case $Option in
39         m      ) echo "Scenario #1: option -m-      [OPTIND=${OPTIND}]";;
40         n | o ) echo "Scenario #2: option -$Option- [OPTIND=${OPTIND}]";;
41         p      ) echo "Scenario #3: option -p-      [OPTIND=${OPTIND}]";;
42         q      ) echo "Scenario #4: option -q-\
43                     with argument \"\$OPTARG\"     [OPTIND=${OPTIND}]";;
44         # Note that option 'q' must have an associated argument,
45         #+ otherwise it falls through to the default.
46         r | s ) echo "Scenario #5: option -$Option-";;
47         *      ) echo "Unimplemented option chosen.";; # Default.
48     esac
49 done
50
51 shift $(( ${OPTIND} - 1 ))
52 # Decrements the argument pointer so it points to next argument.
53 # $1 now references the first non-option item supplied on the command-line
54 #+ if one exists.
55
56 exit $?
57
58 # As Bill Gradwohl states,
59 # "The getopt mechanism allows one to specify: scriptname -mnop -mnop
60 #+ but there is no reliable way to differentiate what came
61 #+ from where by using OPTIND."
62 # There are, however, workarounds.

```

Script Behavior

source, . (dot command)

This command, when invoked from the command-line, executes a script. Within a script, a **source file-name** loads the file `file-name`. *Sourcing* a file (dot-command) *imports* code into the script, appending to the script (same effect as the **#include** directive in a C program). The net result is the same as if the "sourced" lines of code were physically present in the body of the script. This is useful in situations when multiple scripts use a common data file or function library.

Example 15-22. "Including" a data file

```

1 #!/bin/bash
2 # Note that this example must be invoked with bash, i.e., bash ex38.sh
3 #+ not sh ex38.sh !
4
5 . data-file # Load a data file.
6 # Same effect as "source data-file", but more portable.
7
8 # The file "data-file" must be present in current working directory,
9 #+ since it is referred to by its basename.
10
11 # Now, let's reference some data from that file.
12
13 echo "variable1 (from data-file) = $variable1"
14 echo "variable3 (from data-file) = $variable3"
15
16 let "sum = $variable2 + $variable4"
17 echo "Sum of variable2 + variable4 (from data-file) = $sum"
18 echo "message1 (from data-file) is \"\$message1\""

```

```

19 #                               Escaped quotes
20 echo "message2 (from data-file) is \"\$message2\""
21
22 print_message This is the message-print function in the data-file.
23
24
25 exit $?

```

File data-file for [Example 15-22](#), above. Must be present in same directory.

```

1 # This is a data file loaded by a script.
2 # Files of this type may contain variables, functions, etc.
3 # It loads with a 'source' or '.' command from a shell script.
4
5 # Let's initialize some variables.
6
7 variable1=23
8 variable2=474
9 variable3=5
10 variable4=97
11
12 message1="Greetings from *** line $LINENO *** of the data file!"
13 message2="Enough for now. Goodbye."
14
15 print_message ()
16 { # Echoes any message passed to it.
17
18     if [ -z "$1" ]
19     then
20         return 1 # Error, if argument missing.
21     fi
22
23     echo
24
25     until [ -z "$1" ]
26     do # Step through arguments passed to function.
27         echo -n "$1" # Echo args one at a time, suppressing line feeds.
28         echo -n " " # Insert spaces between words.
29         shift # Next one.
30     done
31
32     echo
33
34     return 0
35 }

```

If the *sourced* file is itself an executable script, then it will run, then return control to the script that called it. A *sourced* executable script may use a [return](#) for this purpose.

Arguments may be (optionally) passed to the *sourced* file as [positional parameters](#).

```
1 source $filename $arg1 arg2
```

It is even possible for a script to *source* itself, though this does not seem to have any practical applications.

Example 15-23. A (useless) script that sources itself

```

1 #!/bin/bash
2 # self-source.sh: a script sourcing itself "recursively."
3 # From "Stupid Script Tricks," Volume II.
4

```

```

5 MAXPASSCNT=100      # Maximum number of execution passes.
6
7 echo -n "$pass_count "
8 # At first execution pass, this just echoes two blank spaces,
9 #+ since $pass_count still uninitialized.
10
11 let "pass_count += 1"
12 # Assumes the uninitialized variable $pass_count
13 #+ can be incremented the first time around.
14 # This works with Bash and pdksh, but
15 #+ it relies on non-portable (and possibly dangerous) behavior.
16 # Better would be to initialize $pass_count to 0 before incrementing.
17
18 while [ "$pass_count" -le $MAXPASSCNT ]
19 do
20     . $0      # Script "sources" itself, rather than calling itself.
21             # ./ $0 (which would be true recursion) doesn't work here. Why?
22 done
23
24 # What occurs here is not actually recursion,
25 #+ since the script effectively "expands" itself, i.e.,
26 #+ generates a new section of code
27 #+ with each pass through the 'while' loop',
28 # with each 'source' in line 20.
29 #
30 # Of course, the script interprets each newly 'sourced' "#!" line
31 #+ as a comment, and not as the start of a new script.
32
33 echo
34
35 exit 0      # The net effect is counting from 1 to 100.
36             # Very impressive.
37
38 # Exercise:
39 # -----
40 # Write a script that uses this trick to actually do something useful.

```

exit

Unconditionally terminates a script. [6] The **exit** command may optionally take an integer argument, which is returned to the shell as the [exit status](#) of the script. It is good practice to end all but the simplest scripts with an **exit 0**, indicating a successful run.



If a script terminates with an **exit** lacking an argument, the exit status of the script is the exit status of the last command executed in the script, not counting the **exit**. This is equivalent to an **exit \$?**.



An **exit** command may also be used to terminate a [subshell](#).

exec

This shell builtin replaces the current process with a specified command. Normally, when the shell encounters a command, it [forks off](#) a child process to actually execute the command. Using the **exec** builtin, the shell does not fork, and the command *exec*'ed replaces the shell. When used in a script, therefore, it forces an exit from the script when the **exec**'ed command terminates. [7]

Example 15-24. Effects of *exec*

```

1 #!/bin/bash
2
3 exec echo "Exiting \"$0\" at line $LINENO." # Exit from script here.
4 # $LINENO is an internal Bash variable set to the line number it's on.
5

```

```

6 # -----
7 # The following lines never execute.
8
9 echo "This echo fails to echo."
10
11 exit 99                # This script will not exit here.
12                        # Check exit value after script terminates
13                        #+ with an 'echo $?'.
14                        # It will *not* be 99.

```

Example 15-25. A script that *exec*'s itself

```

1 #!/bin/bash
2 # self-exec.sh
3
4 # Note: Set permissions on this script to 555 or 755,
5 #       then call it with ./self-exec.sh or sh ./self-exec.sh.
6
7 echo
8
9 echo "This line appears ONCE in the script, yet it keeps echoing."
10 echo "The PID of this instance of the script is still $$."
11 #     Demonstrates that a subshell is not forked off.
12
13 echo "===== Hit Ctl-C to exit ====="
14
15 sleep 1
16
17 exec $0    # Spawns another instance of this same script
18           #+ that replaces the previous one.
19
20 echo "This line will never echo!" # Why not?
21
22 exit 99    # Will not exit here!
23           # Exit code will not be 99!

```

An **exec** also serves to [reassign file descriptors](#). For example, **exec <zxx-file** replaces stdin with the file zxx-file.



The **-exec** option to [find](#) is *not* the same as the **exec** shell builtin.

shopt

This command permits changing *shell options* on the fly (see [Example 25-1](#) and [Example 25-2](#)). It often appears in the Bash [startup files](#), but also has its uses in scripts. Needs [version 2](#) or later of Bash.

```

1 shopt -s cdspell
2 # Allows minor misspelling of directory names with 'cd'
3 # Option -s sets, -u unsets.
4
5 cd /hpme # Oops! Mistyped '/home'.
6 pwd     # /home
7         # The shell corrected the misspelling.

```

caller

Putting a **caller** command inside a [function](#) echoes to stdout information about the *caller* of that function.

```

1 #!/bin/bash
2
3 function1 ()

```

```

4 {
5   # Inside function1 ().
6   caller 0   # Tell me about it.
7 }
8
9 function1   # Line 9 of script.
10
11 # 9 main test.sh
12 # ^           Line number that the function was called from.
13 #   ^^^^      Invoked from "main" part of script.
14 #     ^^^^^^^ Name of calling script.
15
16 caller 0     # Has no effect because it's not inside a function.

```

A **caller** command can also return *caller* information from a script [sourced](#) within another script. Analogous to a function, this is a "subroutine call."

You may find this command useful in debugging.

Commands

true

A command that returns a successful (zero) [exit status](#), but does nothing else.

```

bash$ true
bash$ echo $?
0

```

```

1 # Endless loop
2 while true   # alias for ":"
3 do
4   operation-1
5   operation-2
6   ...
7   operation-n
8   # Need a way to break out of loop or script will hang.
9 done

```

false

A command that returns an unsuccessful [exit status](#), but does nothing else.

```

bash$ false
bash$ echo $?
1

```

```

1 # Testing "false"
2 if false
3 then
4   echo "false evaluates \"true\""
5 else
6   echo "false evaluates \"false\""
7 fi
8 # false evaluates "false"
9
10
11 # Looping while "false" (null loop)
12 while false
13 do
14   # The following code will not execute.
15   operation-1
16   operation-2
17   ...

```

```
18 operation-n
19 # Nothing happens!
20 done
```

type [cmd]

Similar to the [which](#) external command, **type cmd** identifies "cmd." Unlike **which**, **type** is a Bash builtin. The useful `-a` option to **type** identifies *keywords* and *builtins*, and also locates system commands with identical names.

```
bash$ type '['
[ is a shell builtin
bash$ type -a '['
[ is a shell builtin
[ is /usr/bin/[

bash$ type type
type is a shell builtin
```

The **type** command can be useful for [testing whether a certain command exists](#).

hash [cmds]

Records the *path* name of specified commands -- in the shell *hash table* [\[8\]](#) -- so the shell or script will not need to search the `$PATH` on subsequent calls to those commands. When **hash** is called with no arguments, it simply lists the commands that have been hashed. The `-r` option resets the hash table.

bind

The **bind** builtin displays or modifies *readline* [\[9\]](#) key bindings.

help

Gets a short usage summary of a shell builtin. This is the counterpart to [whatis](#), but for builtins. The display of *help* information got a much-needed update in the [version 4 release](#) of Bash.

```
bash$ help exit
exit: exit [n]
    Exit the shell with a status of N.  If N is omitted, the exit status
    is that of the last command executed.
```


15.1. Job Control Commands

Certain of the following job control commands take a *job identifier* as an argument. See the [table](#) at end of the chapter.

jobs

Lists the jobs running in the background, giving the *job number*. Not as useful as [ps](#).



It is all too easy to confuse *jobs* and *processes*. Certain [builtins](#), such as **kill**, **disown**, and **wait** accept either a job number or a process number as an argument. The [fg](#), [bg](#) and **jobs** commands accept only a job number.

```
bash$ sleep 100 &
[1] 1384

bash $ jobs
[1]+  Running                  sleep 100 &
```

"1" is the job number (jobs are maintained by the current shell). "1384" is the [PID](#) or *process ID number* (processes are maintained by the system). To kill this job/process, either a **kill %1** or a **kill 1384** works.

Thanks, S.C.

disown

Remove job(s) from the shell's table of active jobs.

fg, bg

The **fg** command switches a job running in the background into the foreground. The **bg** command restarts a suspended job, and runs it in the background. If no job number is specified, then the **fg** or **bg** command acts upon the currently running job.

wait

Suspend script execution until all jobs running in background have terminated, or until the job number or process ID specified as an option terminates. Returns the [exit status](#) of waited-for command.

You may use the **wait** command to prevent a script from exiting before a background job finishes executing (this would create a dreaded [orphan process](#)).

Example 15-26. Waiting for a process to finish before proceeding

```
1 #!/bin/bash
2
3 ROOT_UID=0    # Only users with $UID 0 have root privileges.
4 E_NOTROOT=65
5 E_NOPARAMS=66
6
7 if [ "$UID" -ne "$ROOT_UID" ]
8 then
9     echo "Must be root to run this script."
10    # "Run along kid, it's past your bedtime."
11    exit $E_NOTROOT
12 fi
13
14 if [ -z "$1" ]
15 then
16     echo "Usage: `basename $0` find-string"
17     exit $E_NOPARAMS
18 fi
19
```

```

20
21 echo "Updating 'locate' database..."
22 echo "This may take a while."
23 updatedb /usr &          # Must be run as root.
24
25 wait
26 # Don't run the rest of the script until 'updatedb' finished.
27 # You want the the database updated before looking up the file name.
28
29 locate $1
30
31 # Without the 'wait' command, in the worse case scenario,
32 #+ the script would exit while 'updatedb' was still running,
33 #+ leaving it as an orphan process.
34
35 exit 0

```

Optionally, **wait** can take a *job identifier* as an argument, for example, `wait%1` or `wait $PPID`.
[\[10\]](#) See the [job id table](#).

i Within a script, running a command in the background with an ampersand (&) may cause the script to hang until **ENTER** is hit. This seems to occur with commands that write to `stdout`. It can be a major annoyance.

```

1 #!/bin/bash
2 # test.sh
3
4 ls -l &
5 echo "Done."
bash$ ./test.sh
Done.
[bozo@localhost test-scripts]$ total 1
-rwxr-xr-x  1 bozo  bozo  34 Oct 11 15:09 test.sh
-

```

As Walter Brameld IV explains it:

As far as I can tell, such scripts don't actually hang. It just seems that they do because the background command writes text to the console after the prompt. The user gets the impression that the prompt was never displayed. Here's the sequence of events:

1. Script launches background command.
2. Script exits.
3. Shell displays the prompt.
4. Background command continues running and writing text to the console.
5. Background command finishes.
6. User doesn't see a prompt at the bottom of the output, thinks script is hanging.

Placing a **wait** after the background command seems to remedy this.

```

1 #!/bin/bash
2 # test.sh
3
4 ls -l &

```

```

5 echo "Done."
6 wait
bash$ ./test.sh
Done.
[bozo@localhost test-scripts]$ total 1
-rwxr-xr-x  1 bozo    bozo              34 Oct 11 15:09 test.sh

```

[Redirecting](#) the output of the command to a file or even to `/dev/null` also takes care of this problem.

suspend

This has a similar effect to **Control-Z**, but it suspends the shell (the shell's parent process should resume it at an appropriate time).

logout

Exit a login shell, optionally specifying an [exit status](#).

times

Gives statistics on the system time elapsed when executing commands, in the following form:

```
0m0.020s 0m0.020s
```

This capability is of relatively limited value, since it is not common to profile and benchmark shell scripts.

kill

Forcibly terminate a process by sending it an appropriate *terminate* signal (see [Example 17-6](#)).

Example 15-27. A script that kills itself

```

1 #!/bin/bash
2 # self-destruct.sh
3
4 kill $$ # Script kills its own process here.
5         # Recall that "$$" is the script's PID.
6
7 echo "This line will not echo."
8 # Instead, the shell sends a "Terminated" message to stdout.
9
10 exit 0 # Normal exit? No!
11
12 # After this script terminates prematurely,
13 #+ what exit status does it return?
14 #
15 # sh self-destruct.sh
16 # echo $?
17 # 143
18 #
19 # 143 = 128 + 15
20 #          TERM signal


```



kill -1 lists all the [signals](#) (as does the file `/usr/include/asm/signal.h`). A **kill -9** is a *sure kill*, which will usually terminate a process that stubbornly refuses to die with a plain **kill**. Sometimes, a **kill -15** works. A *zombie* process, that is, a child process that has terminated, but that the [parent process](#) has not (yet) killed, cannot be killed by a logged-on user -- you can't kill something that is already dead -- but **init** will generally clean it up sooner or later.

killall


The **killall** command kills a running process by *name*, rather than by [process ID](#). If there are multiple instances of a particular command running, then doing a *killall* on that command will terminate them *all*.

 This refers to the **killall** command in `/usr/bin`, *not* the [killall script](#) in `/etc/rc.d/init.d`.

command

The **command** directive disables aliases and functions for the command immediately following it.

```
bash$ command ls
```

 This is one of three shell directives that effect script command processing. The others are [builtin](#) and [enable](#).

builtin

Invoking **builtin BUILTIN_COMMAND** runs the command `BUILTIN_COMMAND` as a shell [builtin](#), temporarily disabling both functions and external system commands with the same name.

enable

This either enables or disables a shell builtin command. As an example, `enable -n kill` disables the shell builtin [kill](#), so that when Bash subsequently encounters `kill`, it invokes the external command `/bin/kill`.

The `-a` option to `enable` lists all the shell builtins, indicating whether or not they are enabled. The `-f filename` option lets `enable` load a [builtin](#) as a shared library (DLL) module from a properly compiled object file. [11].

autoload

This is a port to Bash of the `ksh` autoloader. With **autoload** in place, a function with an *autoload* declaration will load from an external file at its first invocation. [12] This saves system resources.

Note that *autoload* is not a part of the core Bash installation. It needs to be loaded in with `enable -f` (see above).

Table 15-1. Job identifiers

Notation	Meaning
<code>%N</code>	Job number [N]
<code>%S</code>	Invocation (command-line) of job begins with string <i>S</i>
<code>%?S</code>	Invocation (command-line) of job contains within it string <i>S</i>
<code>%%</code>	"current" job (last job stopped in foreground or started in background)
<code>%+</code>	"current" job (last job stopped in foreground or started in background)
<code>%-</code>	Last job
<code>#!</code>	Last background process

Notes

- [1] As Nathan Coulter points out, "while forking a process is a low-cost operation, executing a new program in the newly-forked child process adds more overhead."
- [2] An exception to this is the [time](#) command, listed in the official Bash documentation as a keyword ("reserved word").
- [3] Note that `let` [cannot be used for setting string variables](#).
- [4] To *Export* information is to make it available in a more general context. See also [scope](#).
- [5] An *option* is an argument that acts as a flag, switching script behaviors on or off. The argument associated with a particular option indicates the behavior that the option (flag) switches on or off.

[6] Technically, an **exit** only terminates the process (or shell) in which it is running, *not* the *parent process*.

[7] Unless the **exec** is used to [reassign file descriptors](#).

[8]

Hashing is a method of creating lookup keys for data stored in a table. The *data items themselves* are "scrambled" to create keys, using one of a number of simple mathematical *algorithms* (methods, or recipes).

An advantage of *hashing* is that it is fast. A disadvantage is that *collisions* -- where a single key maps to more than one data item -- are possible.

For examples of hashing see [Example A-20](#) and [Example A-21](#).

[9] The *readline* library is what Bash uses for reading input in an interactive shell.

[10] This only applies to *child processes*, of course.

[11] The C source for a number of loadable builtins is typically found in the `/usr/share/doc/bash-?.??.*/functions` directory.

Note that the `-f` option to **enable** is not [portable](#) to all systems.

[12] The same effect as **autoload** can be achieved with [typeset -fu](#).

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External Filters, Programs and
Commands

Advanced Bash-Scripting Guide: An in-depth exploration of the art of shell scripting

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Chapter 16. External Filters, Programs and Commands

Standard UNIX commands make shell scripts more versatile. The power of scripts comes from coupling system commands and shell directives with simple programming constructs.

16.1. Basic Commands

The first commands a novice learns

ls

The basic file "list" command. It is all too easy to underestimate the power of this humble command. For example, using the `-R`, recursive option, `ls` provides a tree-like listing of a directory structure. Other useful options are `-S`, sort listing by file size, `-t`, sort by file modification time, `-v`, sort by (numerical) version numbers embedded in the filenames, `[1]` `-b`, show escape characters, and `-i`, show file inodes (see [Example 16-4](#)).

```
bash$ ls -l
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter10.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter11.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter12.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter1.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter2.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter3.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:49 Chapter_headings.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:49 Preface.txt

bash$ ls -lv
total 0
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:49 Chapter_headings.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:49 Preface.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter1.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter2.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter3.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter10.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter11.txt
-rw-rw-r-- 1 bozo bozo 0 Sep 14 18:44 chapter12.txt
```

 The `ls` command returns a non-zero [exit status](#) when attempting to list a non-existent file.

```
bash$ ls abc
ls: abc: No such file or directory

bash$ echo $?
2
```

Example 16-1. Using `ls` to create a table of contents for burning a CDR disk

```
1 #!/bin/bash
2 # ex40.sh (burn-cd.sh)
3 # Script to automate burning a CDR.
4
5
6 SPEED=10          # May use higher speed if your hardware supports it.
7 IMAGEFILE=cddimage.iso
8 CONTENTSFILE=contents
9 # DEVICE=/dev/cdrom    For older versions of cddrecord
10 DEVICE="1,0,0"
11 DEFAULTDIR=/opt    # This is the directory containing the data to be burned.
12                   # Make sure it exists.
13                   # Exercise: Add a test for this.
14
15 # Uses Joerg Schilling's "cddrecord" package:
```

```

16 # http://www.fokus.fhg.de/usr/schilling/cdrecord.html
17
18 # If this script invoked as an ordinary user, may need to suid cdrecord
19 #+ chmod u+s /usr/bin/cdrecord, as root.
20 # Of course, this creates a security hole, though a relatively minor one.
21
22 if [ -z "$1" ]
23 then
24     IMAGE_DIRECTORY=$DEFAULTDIR
25     # Default directory, if not specified on command-line.
26 else
27     IMAGE_DIRECTORY=$1
28 fi
29
30 # Create a "table of contents" file.
31 ls -lRF $IMAGE_DIRECTORY > $IMAGE_DIRECTORY/$CONTENTSFIL
32 # The "l" option gives a "long" file listing.
33 # The "R" option makes the listing recursive.
34 # The "F" option marks the file types (directories get a trailing /).
35 echo "Creating table of contents."
36
37 # Create an image file preparatory to burning it onto the CDR.
38 mkisofs -r -o $IMAGEFILE $IMAGE_DIRECTORY
39 echo "Creating ISO9660 file system image ($IMAGEFILE)."
40
41 # Burn the CDR.
42 echo "Burning the disk."
43 echo "Please be patient, this will take a while."
44 wodim -v -isozsize dev=$DEVICE $IMAGEFILE
45 # In newer Linux distros, the "wodim" utility assumes the
46 #+ functionality of "cdrecord."
47 exitcode=$?
48 echo "Exit code = $exitcode"
49
50 exit $exitcode

```

cat, tac

cat, an acronym for *concatenate*, lists a file to `stdout`. When combined with redirection (`>` or `>>`), it is commonly used to concatenate files.

```

1 # Uses of 'cat'
2 cat filename                # Lists the file.
3
4 cat file.1 file.2 file.3 > file.123 # Combines three files into one.

```

The `-n` option to **cat** inserts consecutive numbers before all lines of the target file(s). The `-b` option numbers only the non-blank lines. The `-v` option echoes nonprintable characters, using `^` notation. The `-s` option squeezes multiple consecutive blank lines into a single blank line.

See also [Example 16-28](#) and [Example 16-24](#).



In a [pipe](#), it may be more efficient to [redirect](#) the `stdin` to a file, rather than to **cat** the file.

```

1 cat filename | tr a-z A-Z
2
3 tr a-z A-Z < filename    # Same effect, but starts one less process,
4                          #+ and also dispenses with the pipe.

```

tac, is the inverse of *cat*, listing a file backwards from its end.

rev

reverses each line of a file, and outputs to `stdout`. This does not have the same effect as **tac**, as it preserves the order of the lines, but flips each one around (mirror image).

```

bash$ cat file1.txt
This is line 1.
This is line 2.


bash$ tac file1.txt
This is line 2.
This is line 1.

bash$ rev file1.txt
.1 enil si sihT
.2 enil si sihT

```

cp

This is the file copy command. **cp file1 file2** copies file1 to file2, overwriting file2 if it already exists (see [Example 16-6](#)).

-  Particularly useful are the `-a` archive flag (for copying an entire directory tree), the `-u` update flag (which prevents overwriting identically-named newer files), and the `-r` and `-R` recursive flags.


```

1 cp -u source_dir/* dest_dir
2 # "Synchronize" dest_dir to source_dir
3 #+ by copying over all newer and not previously existing files.

```

mv

This is the file *move* command. It is equivalent to a combination of **cp** and **rm**. It may be used to move multiple files to a directory, or even to rename a directory. For some examples of using **mv** in a script, see [Example 10-11](#) and [Example A-2](#).

-  When used in a non-interactive script, **mv** takes the `-f` (*force*) option to bypass user input.

When a directory is moved to a preexisting directory, it becomes a subdirectory of the destination directory.

```


bash$ mv source_directory target_directory

bash$ ls -lF target_directory
total 1
drwxrwxr-x  2 bozo  bozo      1024 May 28 19:20 source_directory/

```

rm

Delete (remove) a file or files. The `-f` option forces removal of even readonly files, and is useful for bypassing user input in a script.

-  The **rm** command will, by itself, fail to remove filenames beginning with a dash. Why? Because **rm** sees a dash-prefixed filename as an *option*.

```

bash$ rm -badname
rm: invalid option -- b
Try `rm --help' for more information.

```

One clever workaround is to precede the filename with a "`--`" (the *end-of-options* flag).


```

bash$ rm -- -badname

```

Another method to is to preface the filename to be removed with a dot-slash .

```
bash$ rm ./-badname
```

 When used with the recursive flag `-r`, this command removes files all the way down the directory tree from the current directory. A careless `rm -rf *` can wipe out a big chunk of a directory structure.

rmdir

Remove directory. The directory must be empty of all files -- including "invisible" *dotfiles* [\[2\]](#) -- for this command to succeed.

mkdir

Make directory, creates a new directory. For example, `mkdir -p project/programs/December` creates the named directory. The `-p` option automatically creates any necessary parent directories.

chmod

Changes the attributes of an existing file or directory (see [Example 15-14](#)).

```
1 chmod +x filename
2 # Makes "filename" executable for all users.
3
4 chmod u+s filename
5 # Sets "suid" bit on "filename" permissions.
6 # An ordinary user may execute "filename" with same privileges as the file's owner.
7 # (This does not apply to shell scripts.)
```

```
1 chmod 644 filename
2 # Makes "filename" readable/writable to owner, readable to others
3 #+ (octal mode).
4
5 chmod 444 filename
6 # Makes "filename" read-only for all.
7 # Modifying the file (for example, with a text editor)
8 #+ not allowed for a user who does not own the file (except for root),
9 #+ and even the file owner must force a file-save
10 #+ if she modifies the file.
11 # Same restrictions apply for deleting the file.
```

```
1 chmod 1777 directory-name
2 # Gives everyone read, write, and execute permission in directory,
3 #+ however also sets the "sticky bit".
4 # This means that only the owner of the directory,
5 #+ owner of the file, and, of course, root
6 #+ can delete any particular file in that directory.
7
8 chmod 111 directory-name
9 # Gives everyone execute-only permission in a directory.
10 # This means that you can execute and READ the files in that directory
11 #+ (execute permission necessarily includes read permission
12 #+ because you can't execute a file without being able to read it).
13 # But you can't list the files or search for them with the "find" command.
14 # These restrictions do not apply to root.
15
16 chmod 000 directory-name
17 # No permissions at all for that directory.
18 # Can't read, write, or execute files in it.
19 # Can't even list files in it or "cd" to it.
20 # But, you can rename (mv) the directory
21 #+ or delete it (rmdir) if it is empty.
22 # You can even symlink to files in the directory,
23 #+ but you can't read, write, or execute the symlinks.
24 # These restrictions do not apply to root.
```

chattr

Change file **attributes**. This is analogous to **chmod** above, but with different options and a different invocation syntax, and it works only on *ext2/ext3* filesystems.

One particularly interesting **chattr** option is **i**. A **chattr +i filename** marks the file as immutable. The file cannot be modified, linked to, or deleted, *not even by root*. This file attribute can be set or removed only by *root*. In a similar fashion, the **a** option marks the file as append only.

```
root# chattr +i file1.txt

root# rm file1.txt

rm: remove write-protected regular file `file1.txt'? y
rm: cannot remove `file1.txt': Operation not permitted
```

If a file has the **s** (secure) attribute set, then when it is deleted its block is overwritten with binary zeroes. [3]

If a file has the **u** (undelete) attribute set, then when it is deleted, its contents can still be retrieved (undeleted).

If a file has the **c** (compress) attribute set, then it will automatically be compressed on writes to disk, and uncompressed on reads.



The file attributes set with **chattr** do not show in a file listing (**ls -l**).

ln

Creates links to pre-existing files. A "link" is a reference to a file, an alternate name for it. The **ln** command permits referencing the linked file by more than one name and is a superior alternative to aliasing (see [Example 4-6](#)).

The **ln** creates only a reference, a pointer to the file only a few bytes in size.

The **ln** command is most often used with the **-s**, symbolic or "soft" link flag. Advantages of using the **-s** flag are that it permits linking across file systems or to directories.

The syntax of the command is a bit tricky. For example: **ln -s oldfile newfile** links the previously existing *oldfile* to the newly created link, *newfile*.



If a file named *newfile* has previously existed, an error message will result.

Which type of link to use?

As John Macdonald explains it:

Both of these [types of links] provide a certain measure of dual reference -- if you edit the contents of the file using any name, your changes will affect both the original name and either a hard or soft new name. The differences between them occurs when you work at a higher level. The advantage of a hard link is that the new name is totally independent of the old name -- if you remove or rename the old name, that does not affect the hard link, which continues to point to the data while it would leave a soft link hanging pointing to the old name which is no longer there. The advantage of a soft link is that it can refer to a different file system (since it is just a reference to a file name, not to actual data). And, unlike a hard link, a symbolic link can refer to a directory.

Links give the ability to invoke a script (or any other type of executable) with multiple names, and having that script behave according to how it was invoked.

Example 16-2. Hello or Good-bye

```
1 #!/bin/bash
2 # hello.sh: Saying "hello" or "goodbye"
3 #+      depending on how script is invoked.
4
5 # Make a link in current working directory ($PWD) to this script:
6 #   ln -s hello.sh goodbye
7 # Now, try invoking this script both ways:
8 # ./hello.sh
9 # ./goodbye
10
11
12 HELLO_CALL=65
13 GOODBYE_CALL=66
14
15 if [ $0 = "./goodbye" ]
16 then
17     echo "Good-bye!"
18     # Some other goodbye-type commands, as appropriate.
19     exit $GOODBYE_CALL
20 fi
21
22 echo "Hello!"
23 # Some other hello-type commands, as appropriate.
24 exit $HELLO_CALL
```

man, info

These commands access the manual and information pages on system commands and installed utilities. When available, the *info* pages usually contain more detailed descriptions than do the *man* pages.

There have been various attempts at "automating" the writing of *man pages*. For a script that makes a tentative first step in that direction, see [Example A-39](#).

Notes

[1] The `-v` option also orders the sort by *upper- and lowercase prefixed* filenames.

[2] *Dotfiles* are files whose names begin with a *dot*, such as `~/ .Xdefaults`. Such filenames do not appear in a normal `ls` listing (although an `ls -a` will show them), and they cannot be deleted by an accidental `rm -rf *`. Dotfiles are generally used as setup and configuration files in a user's home directory.

[3] This particular feature may not yet be implemented in the version of the ext2/ext3 filesystem installed on your system. Check the documentation for your Linux distro.

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16.2. Complex Commands

Commands for more advanced users

find

`-exec COMMAND \;`

Carries out *COMMAND* on each file that **find** matches. The command sequence terminates with `;` (the `;` is [escaped](#) to make certain the shell passes it to **find** literally, without interpreting it as a special character).

```
bash$ find ~/ -name '*.txt'
/home/bozo/.kde/share/apps/karm/karmdata.txt
/home/bozo/misc/irmeyc.txt
/home/bozo/test-scripts/1.txt
```

If *COMMAND* contains `{}`, then **find** substitutes the full path name of the selected file for `"{}"`.

```
1 find ~/ -name 'core*' -exec rm {} \;
2 # Removes all core dump files from user's home directory.
```

```
1 find /home/bozo/projects -mtime -1
2 #
3 #           ^      Note minus sign!
4 # Lists all files in /home/bozo/projects directory tree
5 # that were modified within the last day (current_day - 1).
6 #
7 find /home/bozo/projects -mtime 1
8 # Same as above, but modified *exactly* one day ago.
9 #
10 # mtime = last modification time of the target file
11 # ctime = last status change time (via 'chmod' or otherwise)
12 # atime = last access time
13 #
14 DIR=/home/bozo/junk_files
15 find "$DIR" -type f -atime +5 -exec rm {} \;
16 #           ^           ^^
17 # Curly brackets are placeholder for the path name output by "find."
18 #
19 # Deletes all files in "/home/bozo/junk_files"
20 # that have not been accessed in *at least* 5 days (plus sign ... +5).
21 #
22 # "-type filetype", where
23 # f = regular file
24 # d = directory
25 # l = symbolic link, etc.
26 # (The 'find' manpage and info page have complete option listings.)
```

```
1 find /etc -exec grep '[0-9][0-9]*[.][0-9][0-9]*[.][0-9][0-9]*[.][0-9][0-9]*' {} \;
2
3 # Finds all IP addresses (xxx.xxx.xxx.xxx) in /etc directory files.
4 # There a few extraneous hits. Can they be filtered out?
5
6 # Possibly by:
7
8 find /etc -type f -exec cat '{}' \; | tr -c '[:digit:]' '\n' \
9 | grep '^^[^.]*\.^[^.]*\.^[^.]*\.^[^.]*$'
10 #
```

```
11 # [:digit:] is one of the character classes
12 #+ introduced with the POSIX 1003.2 standard.
13
14 # Thanks, Stéphane Chazelas.
```



The `-exec` option to **find** should not be confused with the [exec](#) shell builtin.

Example 16-3. *Badname*, eliminate file names in current directory containing bad characters and [whitespace](#).

```
1 #!/bin/bash
2 # badname.sh
3 # Delete filenames in current directory containing bad characters.
4
5 for filename in *
6 do
7     badname=`echo "$filename" | sed -n /[\+\{\;\;"\\=\?~\(\)\<\>\&\*\|\$]/p`
8     # badname=`echo "$filename" | sed -n '/[+{;"\=\?~()<>&*|$/p'` also works.
9     # Deletes files containing these nasties:      + { ; " \ = ? ~ ( ) < > & * | $
10    #
11    rm $badname 2>/dev/null
12    #             ^^^^^^^^^^^^^ Error messages deep-sixed.
13 done
14
15 # Now, take care of files containing all manner of whitespace.
16 find . -name "* *" -exec rm -f {} \;
17 # The path name of the file that _find_ finds replaces the "{}".
18 # The '\ ' ensures that the ';' is interpreted literally, as end of command.
19
20 exit 0
21
22 #-----
23 # Commands below this line will not execute because of _exit_ command.
24
25 # An alternative to the above script:
26 find . -name '*[+{;"\=\?~()<>&*|$ ]*' -maxdepth 0 \
27 -exec rm -f '{}' \;
28 # The "-maxdepth 0" option ensures that _find_ will not search
29 #+ subdirectories below $PWD.
30
31 # (Thanks, S.C.)
```

Example 16-4. Deleting a file by its *inode* number

```
1 #!/bin/bash
2 # idelete.sh: Deleting a file by its inode number.
3
4 # This is useful when a filename starts with an illegal character,
5 #+ such as ? or -.
6
7 ARGCOUNT=1 # Filename arg must be passed to script.
8 E_WRONGARGS=70
9 E_FILE_NOT_EXIST=71
10 E_CHANGED_MIND=72
11
12 if [ $# -ne "$ARGCOUNT" ]
13 then
14     echo "Usage: `basename $0` filename"
15     exit $E_WRONGARGS
16 fi
```



```

17
18 if [ ! -e "$1" ]
19 then
20     echo "File \"$1\" does not exist."
21     exit $E_FILE_NOT_EXIST
22 fi
23
24 inum=`ls -i | grep "$1" | awk '{print $1}'`
25 # inum = inode (index node) number of file
26 # -----
27 # Every file has an inode, a record that holds its physical address info.
28 # -----
29
30 echo; echo -n "Are you absolutely sure you want to delete \"$1\" (y/n)? "
31 # The '-v' option to 'rm' also asks this.
32 read answer
33 case "$answer" in
34 [nN]) echo "Changed your mind, huh?"
35       exit $E_CHANGED_MIND
36       ;;
37 *)    echo "Deleting file \"$1\".>";;
38 esac
39
40 find . -inum $inum -exec rm {} \;
41 #             ^^
42 #           Curly brackets are placeholder
43 #+         for text output by "find."
44 echo "File \"$1\" deleted!"
45
46 exit 0

```

The **find** command also works without the `-exec` option.

```

1 #!/bin/bash
2 # Find suid root files.
3 # A strange suid file might indicate a security hole,
4 #+ or even a system intrusion.
5
6 directory="/usr/sbin"
7 # Might also try /sbin, /bin, /usr/bin, /usr/local/bin, etc.
8 permissions="+4000" # suid root (dangerous!)
9
10
11 for file in $( find "$directory" -perm "$permissions" )
12 do
13     ls -ltF --author "$file"
14 done

```

See [Example 16-30](#), [Example 3-4](#), and [Example 11-10](#) for scripts using **find**. Its [manpage](#) provides more detail on this complex and powerful command.

xargs

A filter for feeding arguments to a command, and also a tool for assembling the commands themselves. It breaks a data stream into small enough chunks for filters and commands to process. Consider it as a powerful replacement for [backquotes](#). In situations where [command substitution](#) fails with a too many arguments error, substituting **xargs** often works. [1] Normally, **xargs** reads from `stdin` or from a pipe, but it can also be given the output of a file.

The default command for **xargs** is [echo](#). This means that input piped to **xargs** may have linefeeds and other whitespace characters stripped out.

```

bash$ ls -l
total 0
-rw-rw-r-- 1 bozo bozo 0 Jan 29 23:58 file1

```

```


-rw-rw-r--  1 bozo  bozo          0 Jan 29 23:58 file2

bash$ ls -l | xargs
total 0 -rw-rw-r-- 1 bozo bozo 0 Jan 29 23:58 file1 -rw-rw-r-- 1 bozo bozo 0 Jan...

bash$ find ~/mail -type f | xargs grep "Linux"
./misc:User-Agent: slrn/0.9.8.1 (Linux)
./sent-mail-jul-2005: hosted by the Linux Documentation Project.
./sent-mail-jul-2005: (Linux Documentation Project Site, rtf version)
./sent-mail-jul-2005: Subject: Criticism of Bozo's Windows/Linux article
./sent-mail-jul-2005: while mentioning that the Linux ext2/ext3 filesystem
. . .

```


`ls | xargs -p -l gzip gzips` every file in current directory, one at a time, prompting before each operation.

 Note that *xargs* processes the arguments passed to it sequentially, *one at a time*.


```

bash$ find /usr/bin | xargs file
/usr/bin:          directory
/usr/bin/foomatic-ppd-options:  perl script text executable
. . .

```

 An interesting *xargs* option is `-n NN`, which limits to *NN* the number of arguments passed.

`ls | xargs -n 8 echo` lists the files in the current directory in 8 columns.

 Another useful option is `-0`, in combination with `find -print0` or `grep -lZ`. This allows handling arguments containing whitespace or quotes.

```

find / -type f -print0 | xargs -0 grep -liwZ GUI | xargs
-0 rm -f

```

```

grep -rliwZ GUI / | xargs -0 rm -f

```


Either of the above will remove any file containing "GUI". (*Thanks, S.C.*)

Or:

```

1 cat /proc/"$pid"/"$OPTION" | xargs -0 echo
2 #   Formats output:          ^^^^^^^^^^^^^^^^^^^
3 #   From Han Holl's fixup of "get-commandline.sh"
4 #+ script in "/dev and /proc" chapter.

```

 The `-P` option to *xargs* permits running processes in parallel. This speeds up execution in a machine with a multicore CPU.

```

1 #!/bin/bash
2
3 ls *gif | xargs -t -n1 -P2 gif2png
4 # Converts all the gif images in current directory to png.

```

```
5
6 # Options:
7 # =====
8 # -t      Print command to stderr.
9 # -n1     At most 1 argument per command line.
10 # -P2    Run up to 2 processes simultaneously.
11
12 # Thank you, Roberto Polli, for the inspiration.
```

Example 16-5. Logfile: Using *xargs* to monitor system log

```
1 #!/bin/bash
2
3 # Generates a log file in current directory
4 # from the tail end of /var/log/messages.
5
6 # Note: /var/log/messages must be world readable
7 # if this script invoked by an ordinary user.
8 #      #root chmod 644 /var/log/messages
9
10 LINES=5
11
12 ( date; uname -a ) >>logfile
13 # Time and machine name
14 echo ----- >>logfile
15 tail -n $LINES /var/log/messages | xargs | fmt -s >>logfile
16 echo >>logfile
17 echo >>logfile
18
19 exit 0
20
21 # Note:
22 # ----
23 # As Frank Wang points out,
24 #+ unmatched quotes (either single or double quotes) in the source file
25 #+ may give xargs indigestion.
26 #
27 # He suggests the following substitution for line 15:
28 # tail -n $LINES /var/log/messages | tr -d "\"'" | xargs | fmt -s >>logfile
29
30
31
32 # Exercise:
33 # -----
34 # Modify this script to track changes in /var/log/messages at intervals
35 #+ of 20 minutes.
36 # Hint: Use the "watch" command.
```

[As in find](#), a curly bracket pair serves as a placeholder for replacement text.

Example 16-6. Copying files in current directory to another

```
1 #!/bin/bash
2 # copydir.sh
3
4 # Copy (verbose) all files in current directory ($PWD)
5 #+ to directory specified on command-line.
6
7 E_NOARGS=85
```

```

8
9 if [ -z "$1" ] # Exit if no argument given.
10 then
11     echo "Usage: `basename $0` directory-to-copy-to"
12     exit $E_NOARGS
13 fi
14
15 ls . | xargs -i -t cp ./{} $1
16 #      ^ ^ ^      ^ ^
17 # -t is "verbose" (output command-line to stderr) option.
18 # -i is "replace strings" option.
19 # {} is a placeholder for output text.
20 # This is similar to the use of a curly-bracket pair in "find."
21 #
22 # List the files in current directory (ls .),
23 #+ pass the output of "ls" as arguments to "xargs" (-i -t options),
24 #+ then copy (cp) these arguments ({} ) to new directory ($1).
25 #
26 # The net result is the exact equivalent of
27 #+ cp * $1
28 #+ unless any of the filenames has embedded "whitespace" characters.
29
30 exit 0

```

Example 16-7. Killing processes by name

```

1 #!/bin/bash
2 # kill-byname.sh: Killing processes by name.
3 # Compare this script with kill-process.sh.
4
5 # For instance,
6 #+ try "./kill-byname.sh xterm" --
7 #+ and watch all the xterms on your desktop disappear.
8
9 # Warning:
10 # -----
11 # This is a fairly dangerous script.
12 # Running it carelessly (especially as root)
13 #+ can cause data loss and other undesirable effects.
14
15 E_BADARGS=66
16
17 if test -z "$1" # No command-line arg supplied?
18 then
19     echo "Usage: `basename $0` Process(es)_to_kill"
20     exit $E_BADARGS
21 fi
22
23
24 PROCESS_NAME="$1"
25 ps ax | grep "$PROCESS_NAME" | awk '{print $1}' | xargs -i kill {} 2>/dev/null
26 #      ^ ^      ^ ^
27
28 # -----
29 # Notes:
30 # -i is the "replace strings" option to xargs.
31 # The curly brackets are the placeholder for the replacement.
32 # 2>/dev/null suppresses unwanted error messages.
33 #
34 # Can grep "$PROCESS_NAME" be replaced by pidof "$PROCESS_NAME"?
35 # -----
36

```

```
37 exit $?
38
39 # The "killall" command has the same effect as this script,
40 #+ but using it is not quite as educational.
```

Example 16-8. Word frequency analysis using *xargs*

```
1 #!/bin/bash
2 # wf2.sh: Crude word frequency analysis on a text file.
3
4 # Uses 'xargs' to decompose lines of text into single words.
5 # Compare this example to the "wf.sh" script later on.
6
7
8 # Check for input file on command-line.
9 ARGS=1
10 E_BADARGS=85
11 E_NOFILE=86
12
13 if [ $# -ne "$ARGS" ]
14 # Correct number of arguments passed to script?
15 then
16     echo "Usage: `basename $0` filename"
17     exit $E_BADARGS
18 fi
19
20 if [ ! -f "$1" ]          # Does file exist?
21 then
22     echo "File \"$1\" does not exist."
23     exit $E_NOFILE
24 fi
25
26
27
28 #####
29 cat "$1" | xargs -n1 | \
30 # List the file, one word per line.
31 tr A-Z a-z | \
32 # Shift characters to lowercase.
33 sed -e 's/\././g' -e 's/\,/./g' -e 's/ / \
34 /g' | \
35 # Filter out periods and commas, and
36 #+ change space between words to linefeed,
37 sort | uniq -c | sort -nr
38 # Finally remove duplicates, prefix occurrence count
39 #+ and sort numerically.
40 #####
41
42 # This does the same job as the "wf.sh" example,
43 #+ but a bit more ponderously, and it runs more slowly (why?).
44
45 exit $?
```

expr

All-purpose expression evaluator: Concatenates and evaluates the arguments according to the operation given (arguments must be separated by spaces). Operations may be arithmetic, comparison, string, or logical.

```
expr 3 + 5
returns 8
```

expr 5 % 3
returns 2

expr 1 / 0
returns the error message, expr: division by zero

Illegal arithmetic operations not allowed.

expr 5 * 3
returns 15

The multiplication operator must be escaped when used in an arithmetic expression with **expr**.

y=`expr \$y + 1`

Increment a variable, with the same effect as **let y=y+1** and **y=\$((y+1))**. This is an example of [arithmetic expansion](#).

z=`expr substr \$string \$position \$length`

Extract substring of \$length characters, starting at \$position.

Example 16-9. Using *expr*

```
1 #!/bin/bash
2
3 # Demonstrating some of the uses of 'expr'
4 # =====
5
6 echo
7
8 # Arithmetic Operators
9 # -----
10
11 echo "Arithmetic Operators"
12 echo
13 a=`expr 5 + 3`
14 echo "5 + 3 = $a"
15
16 a=`expr $a + 1`
17 echo
18 echo "a + 1 = $a"
19 echo "(incrementing a variable)"
20
21 a=`expr 5 % 3`
22 # modulo
23 echo
24 echo "5 mod 3 = $a"
25
26 echo
27 echo
28
29 # Logical Operators
30 # -----
31
32 # Returns 1 if true, 0 if false,
33 #+ opposite of normal Bash convention.
34
35 echo "Logical Operators"
36 echo
37
38 x=24
39 y=25
40 b=`expr $x = $y`           # Test equality.
41 echo "b = $b"             # 0 ( $x -ne $y )
```

```

42 echo
43
44 a=3
45 b=`expr $a \> 10`
46 echo 'b=`expr $a \> 10`, therefore...!'
47 echo "If a > 10, b = 0 (false)"
48 echo "b = $b"           # 0 ( 3 ! -gt 10 )
49 echo
50
51 b=`expr $a \< 10`
52 echo "If a < 10, b = 1 (true)"
53 echo "b = $b"           # 1 ( 3 -lt 10 )
54 echo
55 # Note escaping of operators.
56
57 b=`expr $a \<= 3`
58 echo "If a <= 3, b = 1 (true)"
59 echo "b = $b"           # 1 ( 3 -le 3 )
60 # There is also a "\>=" operator (greater than or equal to).
61
62
63 echo
64 echo
65
66
67
68 # String Operators
69 # -----
70
71 echo "String Operators"
72 echo
73
74 a=1234zipper43231
75 echo "The string being operated upon is \"$a\"."
76
77 # length: length of string
78 b=`expr length $a`
79 echo "Length of \"$a\" is $b."
80
81 # index: position of first character in substring
82 #         that matches a character in string
83 b=`expr index $a 23`
84 echo "Numerical position of first \"2\" in \"$a\" is \"$b\"."
85
86 # substr: extract substring, starting position & length specified
87 b=`expr substr $a 2 6`
88 echo "Substring of \"$a\", starting at position 2,\
89 and 6 chars long is \"$b\"."
90
91
92 # The default behavior of the 'match' operations is to
93 #+ search for the specified match at the BEGINNING of the string.
94 #
95 #     Using Regular Expressions ...
96 b=`expr match "$a" '[0-9]*'`           # Numerical count.
97 echo Number of digits at the beginning of \"$a\" is $b.
98 b=`expr match "$a" '\([0-9]*\) '`     # Note that escaped parentheses
99 #           ==           ==           #+ trigger substring match.
100 echo "The digits at the beginning of \"$a\" are \"$b\"."
101
102 echo
103
104 exit 0

```



The `:(null)` operator can substitute for `match`. For example, `b=`expr $a : [0-9]*`` is the exact equivalent of `b=`expr match $a [0-9]*`` in the above listing.

```

1 #!/bin/bash
2
3 echo
4 echo "String operations using \"expr \$string : \" construct"
5 echo "=====
6 echo
7
8 a=1234zipper5FLIPPER43231
9
10 echo "The string being operated upon is \"`expr \"$a\" : '\(.*\)'\`\"."
11 #      Escaped parentheses grouping operator.           == ==
12
13 #      *****
14 #+      Escaped parentheses
15 #+      match a substring
16 #      *****
17
18
19 # If no escaped parentheses ...
20 #+ then 'expr' converts the string operand to an integer.
21
22 echo "Length of \"$a\" is `expr \"$a\" : '.*'`.`" # Length of string
23
24 echo "Number of digits at the beginning of \"$a\" is `expr \"$a\" : '[0-9]*'`.`"
25
26 # ----- #
27
28 echo
29
30 echo "The digits at the beginning of \"$a\" are `expr \"$a\" : '\([0-9]*\)'\`\"."
31 #      == ==
32 echo "The first 7 characters of \"$a\" are `expr \"$a\" : '\(.....\)'\`\"."
33 #      == ==
34 # Again, escaped parentheses force a substring match.
35 #
36 echo "The last 7 characters of \"$a\" are `expr \"$a\" : '.*\(......\)`\"."
37 #      == end of string operator ^^
38 # (In fact, means skip over one or more of any characters until specified
39 #+ substring found.)
40
41 echo
42
43 exit 0

```

The above script illustrates how `expr` uses the *escaped parentheses* -- `(...)` -- grouping operator in tandem with [regular expression](#) parsing to match a substring. Here is another example, this time from "real life."

```

1 # Strip the whitespace from the beginning and end.
2 LRFDATE=`expr "$LRFDATE" : '[:space:]*\(...\)[:space:]*$`
3
4 # From Peter Knowles' "booklistgen.sh" script
5 #+ for converting files to Sony Librie/PRS-50X format.
6 # (http://booklistgensh.peterknowles.com)

```

[Perl](#), [sed](#), and [awk](#) have far superior string parsing facilities. A short `sed` or `awk` "subroutine" within a script (see [Section 36.2](#)) is an attractive alternative to `expr`.

See [Section 10.1](#) for more on using `expr` in string operations.

Notes

[1] And even when *xargs* is not strictly necessary, it can speed up execution of a command involving [batch-processing](#) of multiple files.

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16.3. Time / Date Commands

Time/date and timing

date

Simply invoked, **date** prints the date and time to `stdout`. Where this command gets interesting is in its formatting and parsing options.

Example 16-10. Using *date*

```
1 #!/bin/bash
2 # Exercising the 'date' command
3
4 echo "The number of days since the year's beginning is `date +%j`."
5 # Needs a leading '+' to invoke formatting.
6 # %j gives day of year.
7
8 echo "The number of seconds elapsed since 01/01/1970 is `date +%s`."
9 # %s yields number of seconds since "UNIX epoch" began,
10 #+ but how is this useful?
11
12 prefix=temp
13 suffix=$(date +%s) # The "+%s" option to 'date' is GNU-specific.
14 filename=$prefix.$suffix
15 echo "Temporary filename = $filename"
16 # It's great for creating "unique and random" temp filenames,
17 #+ even better than using $$
18
19 # Read the 'date' man page for more formatting options.
20
21 exit 0
```

The `-u` option gives the UTC (Universal Coordinated Time).

```
bash$ date
Fri Mar 29 21:07:39 MST 2002

bash$ date -u
Sat Mar 30 04:07:42 UTC 2002
```

This option facilitates calculating the time between different dates.

Example 16-11. *Date* calculations

```
1 #!/bin/bash
2 # date-calc.sh
3 # Author: Nathan Coulter
4 # Used in ABS Guide with permission (thanks!).
5
6 MPHR=60      # Minutes per hour.
7 HPD=24      # Hours per day.
8
9 diff () {
10     printf '%s' $(( $(date -u -d"$TARGET" +%s) -
11                    $(date -u -d"$CURRENT" +%s) ))
12 #           %d = day of month.
```

```

13 }
14
15
16 CURRENT=$(date -u -d '2007-09-01 17:30:24' '+%F %T.%N %Z')
17 TARGET=$(date -u -d '2007-12-25 12:30:00' '+%F %T.%N %Z')
18 # %F = full date, %T = %H:%M:%S, %N = nanoseconds, %Z = time zone.
19
20 printf '\nIn 2007, %s ' \
21     "$(date -d"$CURRENT" +
22     $(( $(diff) /$MPHR /$MPHR /$HPD / 2 )) days" '+%d %B')"
23 #     %B = name of month             ^ halfway
24 printf 'was halfway between %s ' "$(date -d"$CURRENT" '+%d %B')"
25 printf 'and %s\n' "$(date -d"$TARGET" '+%d %B')"
26
27 printf '\nOn %s at %s, there were\n' \
28     $(date -u -d"$CURRENT" +%F) $(date -u -d"$CURRENT" +%T)
29 DAYS=$(( $(diff) / $MPHR / $MPHR / $HPD ))
30 CURRENT=$(date -d"$CURRENT" +$DAYS days" '+%F %T.%N %Z')
31 HOURS=$(( $(diff) / $MPHR / $MPHR ))
32 CURRENT=$(date -d"$CURRENT" +$HOURS hours" '+%F %T.%N %Z')
33 MINUTES=$(( $(diff) / $MPHR ))
34 CURRENT=$(date -d"$CURRENT" +$MINUTES minutes" '+%F %T.%N %Z')
35 printf '%s days, %s hours, ' "$DAYS" "$HOURS"
36 printf '%s minutes, and %s seconds ' "$MINUTES" "$(diff)"
37 printf 'until Christmas Dinner!\n\n'
38
39 # Exercise:
40 # -----
41 # Rewrite the diff () function to accept passed parameters,
42 #+ rather than using global variables.

```

The *date* command has quite a number of *output* options. For example %N gives the nanosecond portion of the current time. One interesting use for this is to generate random integers.

```

1 date +%N | sed -e 's/000$//' -e 's/^0//'
2     ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
3 # Strip off leading and trailing zeroes, if present.
4 # Length of generated integer depends on
5 #+ how many zeroes stripped off.
6
7 # 115281032
8 # 63408725
9 # 394504284

```

There are many more options (try **man date**).

```

1 date +%j
2 # Echoes day of the year (days elapsed since January 1).
3
4 date +%k%M
5 # Echoes hour and minute in 24-hour format, as a single digit string.
6
7
8
9 # The 'TZ' parameter permits overriding the default time zone.
10 date           # Mon Mar 28 21:42:16 MST 2005
11 TZ=EST date    # Mon Mar 28 23:42:16 EST 2005
12 # Thanks, Frank Kannemann and Pete Sjoberg, for the tip.
13
14
15 SixDaysAgo=$(date --date='6 days ago')
16 OneMonthAgo=$(date --date='1 month ago') # Four weeks back (not a month!)
17 OneYearAgo=$(date --date='1 year ago')

```

See also [Example 3-4](#) and [Example A-43](#).

zdump

Time zone dump: echoes the time in a specified time zone.

```
bash$ zdump EST
EST Tue Sep 18 22:09:22 2001 EST
```

time

Outputs verbose timing statistics for executing a command.

time ls -l / gives something like this:

```
real    0m0.067s
user    0m0.004s
sys     0m0.005s
```

See also the very similar [times](#) command in the previous section.



As of [version 2.0](#) of Bash, **time** became a shell reserved word, with slightly altered behavior in a pipeline.

touch

Utility for updating access/modification times of a file to current system time or other specified time, but also useful for creating a new file. The command **touch zzz** will create a new file of zero length, named zzz, assuming that zzz did not previously exist. Time-stamping empty files in this way is useful for storing date information, for example in keeping track of modification times on a project.



The **touch** command is equivalent to `: >> newfile` or `>> newfile` (for ordinary files).



Before doing a [cp -u](#) (*copy/update*), use **touch** to update the time stamp of files you don't wish overwritten.

As an example, if the directory `/home/bozo/tax_audit` contains the files `spreadsheet-051606.data`, `spreadsheet-051706.data`, and `spreadsheet-051806.data`, then doing a **touch spreadsheet*.data** will protect these files from being overwritten by files with the same names during a **cp -u /home/bozo/financial_info/spreadsheet*.data /home/bozo/tax_audit**.

at

The **at** job control command executes a given set of commands at a specified time. Superficially, it resembles [cron](#), however, **at** is chiefly useful for one-time execution of a command set.

at 2pm January 15 prompts for a set of commands to execute at that time. These commands should be shell-script compatible, since, for all practical purposes, the user is typing in an executable shell script a line at a time. Input terminates with a [Ctl-D](#).

Using either the `-f` option or input redirection (`<`), **at** reads a command list from a file. This file is an executable shell script, though it should, of course, be non-interactive. Particularly clever is including the [run-parts](#) command in the file to execute a different set of scripts.

```
bash$ at 2:30 am Friday < at-jobs.list
job 2 at 2000-10-27 02:30
```

batch


The **batch** job control command is similar to **at**, but it runs a command list when the system load drops below `.8`. Like **at**, it can read commands from a file with the `-f` option.

The concept of *batch processing* dates back to the era of mainframe computers. It means running a set of commands without user intervention.


cal
Prints a neatly formatted monthly calendar to `stdout`. Will do current year or a large range of past and future years.

sleep
This is the shell equivalent of a *wait loop*. It pauses for a specified number of seconds, doing nothing. It can be useful for timing or in processes running in the background, checking for a specific event every so often (polling), as in [Example 32-6](#).

```
1 sleep 3      # Pauses 3 seconds.
```

 The **sleep** command defaults to seconds, but minute, hours, or days may also be specified.


```
1 sleep 3 h    # Pauses 3 hours!
```

 The [watch](#) command may be a better choice than **sleep** for running commands at timed intervals.

usleep
Microsleep (the *u* may be read as the Greek *mu*, or *micro-* prefix). This is the same as **sleep**, above, but "sleeps" in microsecond intervals. It can be used for fine-grained timing, or for polling an ongoing process at very frequent intervals.

```
1 usleep 30    # Pauses 30 microseconds.
```

This command is part of the Red Hat *initscripts* / *rc-scripts* package.

 The **usleep** command does not provide particularly accurate timing, and is therefore unsuitable for critical timing loops.

hwclock, clock
The **hwclock** command accesses or adjusts the machine's hardware clock. Some options require *root* privileges. The `/etc/rc.d/rc.sysinit` startup file uses **hwclock** to set the system time from the hardware clock at bootup.

The **clock** command is a synonym for **hwclock**.

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16.4. Text Processing Commands

Commands affecting text and text files

sort

File sort utility, often used as a filter in a pipe. This command sorts a *text stream* or file forwards or backwards, or according to various keys or character positions. Using the `-m` option, it merges presorted input files. The *info page* lists its many capabilities and options. See [Example 11-10](#), [Example 11-11](#), and [Example A-8](#).

tsort

Topological sort, reading in pairs of whitespace-separated strings and sorting according to input patterns. The original purpose of **tsort** was to sort a list of dependencies for an obsolete version of the *ld* linker in an "ancient" version of UNIX.

The results of a *tsort* will usually differ markedly from those of the standard **sort** command, above.

uniq

This filter removes duplicate lines from a sorted file. It is often seen in a pipe coupled with [sort](#).

```
1 cat list-1 list-2 list-3 | sort | uniq > final.list
2 # Concatenates the list files,
3 # sorts them,
4 # removes duplicate lines,
5 # and finally writes the result to an output file.
```

The useful `-c` option prefixes each line of the input file with its number of occurrences.

```
bash$ cat testfile
This line occurs only once.
This line occurs twice.
This line occurs twice.
This line occurs three times.
This line occurs three times.
This line occurs three times.

bash$ uniq -c testfile
 1 This line occurs only once.
 2 This line occurs twice.
 3 This line occurs three times.

bash$ sort testfile | uniq -c | sort -nr
 3 This line occurs three times.
 2 This line occurs twice.
 1 This line occurs only once.
```

The `sort INPUTFILE | uniq -c | sort -nr` command string produces a *frequency of occurrence* listing on the `INPUTFILE` file (the `-nr` options to **sort** cause a reverse numerical sort). This template finds use in analysis of log files and dictionary lists, and wherever the lexical structure of a document needs to be examined.

Example 16-12. Word Frequency Analysis

```
1 #!/bin/bash
2 # wf.sh: Crude word frequency analysis on a text file.
3 # This is a more efficient version of the "wf2.sh" script.
4
5
```

```

6 # Check for input file on command-line.
7 ARGS=1
8 E_BADARGS=85
9 E_NOFILE=86
10
11 if [ $# -ne "$ARGS" ] # Correct number of arguments passed to script?
12 then
13     echo "Usage: `basename $0` filename"
14     exit $E_BADARGS
15 fi
16
17 if [ ! -f "$1" ] # Check if file exists.
18 then
19     echo "File \"$1\" does not exist."
20     exit $E_NOFILE
21 fi
22
23
24
25 #####
26 # main ()
27 sed -e 's/\.//g' -e 's/\/,\/g' -e 's/ /\'
28 /g' "$1" | tr 'A-Z' 'a-z' | sort | uniq -c | sort -nr
29 # =====
30 # Frequency of occurrence
31
32 # Filter out periods and commas, and
33 #+ change space between words to linefeed,
34 #+ then shift characters to lowercase, and
35 #+ finally prefix occurrence count and sort numerically.
36
37 # Arun Giridhar suggests modifying the above to:
38 # . . . | sort | uniq -c | sort +1 [-f] | sort +0 -nr
39 # This adds a secondary sort key, so instances of
40 #+ equal occurrence are sorted alphabetically.
41 # As he explains it:
42 # "This is effectively a radix sort, first on the
43 #+ least significant column
44 #+ (word or string, optionally case-insensitive)
45 #+ and last on the most significant column (frequency)."
```

```

46 #
47 # As Frank Wang explains, the above is equivalent to
48 #+ . . . | sort | uniq -c | sort +0 -nr
49 #+ and the following also works:
50 #+ . . . | sort | uniq -c | sort -k1nr -k
51 #####
52
53 exit 0
54
55 # Exercises:
56 # -----
57 # 1) Add 'sed' commands to filter out other punctuation,
58 #+ such as semicolons.
59 # 2) Modify the script to also filter out multiple spaces and
60 #+ other whitespace.
```

```
bash$ cat testfile
```

```

This line occurs only once.
This line occurs twice.
This line occurs twice.
This line occurs three times.
This line occurs three times.
This line occurs three times.
```



```
bash$ ./wf.sh testfile
6 this
6 occurs
6 line
3 times
3 three
2 twice
1 only
1 once
```

expand, unexpand

The **expand** filter converts tabs to spaces. It is often used in a [pipe](#).

The **unexpand** filter converts spaces to tabs. This reverses the effect of **expand**.

cut

A tool for extracting [fields](#) from files. It is similar to the **print \$N** command set in [awk](#), but more limited. It may be simpler to use *cut* in a script than *awk*. Particularly important are the **-d** (delimiter) and **-f** (field specifier) options.

Using **cut** to obtain a listing of the mounted filesystems:

```
1 cut -d ' ' -f1,2 /etc/mtab
```

Using **cut** to list the OS and kernel version:

```
1 uname -a | cut -d" " -f1,3,11,12
```

Using **cut** to extract message headers from an e-mail folder:

```
bash$ grep '^Subject:' read-messages | cut -c10-80
Re: Linux suitable for mission-critical apps?
MAKE MILLIONS WORKING AT HOME!!!
Spam complaint
Re: Spam complaint
```

Using **cut** to parse a file:

```
1 # List all the users in /etc/passwd.
2
3 FILENAME=/etc/passwd
4
5 for user in $(cut -d: -f1 $FILENAME)
6 do
7   echo $user
8 done
9
10 # Thanks, Oleg Philon for suggesting this.
```

cut -d ' ' -f2,3 filename is equivalent to **awk -F'[]' '{ print \$2, \$3 }'**
filename



It is even possible to specify a linefeed as a delimiter. The trick is to actually embed a linefeed (**RETURN**) in the command sequence.

```
bash$ cut -d'
' -f3,7,19 testfile
This is line 3 of testfile.
This is line 7 of testfile.
This is line 19 of testfile.
```

Thank you, Jaka Kranjc, for pointing this out.

See also [Example 16-48](#).

paste

Tool for merging together different files into a single, multi-column file. In combination with [cut](#), useful for creating system log files.

```
bash$ cat items
alphabet blocks
building blocks
cables

bash$ cat prices
$1.00/dozen
$2.50 ea.
$3.75

bash$ paste items prices
alphabet blocks $1.00/dozen
building blocks $2.50 ea.
cables $3.75
```

join

Consider this a special-purpose cousin of **paste**. This powerful utility allows merging two files in a meaningful fashion, which essentially creates a simple version of a relational database.

The **join** command operates on exactly two files, but pastes together only those lines with a common tagged [field](#) (usually a numerical label), and writes the result to `stdout`. The files to be joined should be sorted according to the tagged field for the matchups to work properly.

```
1 File: 1.data
2
3 100 Shoes
4 200 Laces
5 300 Socks
```

```
1 File: 2.data
2
3 100 $40.00
4 200 $1.00
5 300 $2.00
```

```
bash$ join 1.data 2.data
File: 1.data 2.data

100 Shoes $40.00
200 Laces $1.00
300 Socks $2.00
```



The tagged field appears only once in the output.

head

lists the beginning of a file to `stdout`. The default is 10 lines, but a different number can be specified. The command has a number of interesting options.

Example 16-13. Which files are scripts?

```
1 #!/bin/bash
2 # script-detector.sh: Detects scripts within a directory.
3
4 TESTCHARS=2 # Test first 2 characters.
5 SHABANG='#!' # Scripts begin with a "sha-bang."
6
```

```

7 for file in * # Traverse all the files in current directory.
8 do
9   if [[ `head -c$TESTCHARS "$file"` = "$SHABANG" ]]
10  #       head -c2                               #!
11  # The '-c' option to "head" outputs a specified
12  #+ number of characters, rather than lines (the default).
13  then
14    echo "File \"$file\" is a script."
15  else
16    echo "File \"$file\" is *not* a script."
17  fi
18 done
19
20 exit 0
21
22 # Exercises:
23 # -----
24 # 1) Modify this script to take as an optional argument
25 #+ the directory to scan for scripts
26 #+ (rather than just the current working directory).
27 #
28 # 2) As it stands, this script gives "false positives" for
29 #+ Perl, awk, and other scripting language scripts.
30 # Correct this.

```

Example 16-14. Generating 10-digit random numbers

```

1 #!/bin/bash
2 # rnd.sh: Outputs a 10-digit random number
3
4 # Script by Stephane Chazelas.
5
6 head -c4 /dev/urandom | od -N4 -tu4 | sed -ne '1s/.*/p'
7
8
9 # ===== #
10
11 # Analysis
12 # -----
13
14 # head:
15 # -c4 option takes first 4 bytes.
16
17 # od:
18 # -N4 option limits output to 4 bytes.
19 # -tu4 option selects unsigned decimal format for output.
20
21 # sed:
22 # -n option, in combination with "p" flag to the "s" command,
23 # outputs only matched lines.
24
25
26
27 # The author of this script explains the action of 'sed', as follows.
28
29 # head -c4 /dev/urandom | od -N4 -tu4 | sed -ne '1s/.*/p'
30 # -----> |
31
32 # Assume output up to "sed" -----> |
33 # is 0000000 1198195154\n
34
35 # sed begins reading characters: 0000000 1198195154\n.

```

```

36 # Here it finds a newline character,
37 #+ so it is ready to process the first line (0000000 1198195154).
38 # It looks at its <range><action>s. The first and only one is
39
40 #   range      action
41 #   1          s/.*/ //p
42
43 # The line number is in the range, so it executes the action:
44 #+ tries to substitute the longest string ending with a space in the line
45 # ("0000000 ") with nothing (//), and if it succeeds, prints the result
46 # ("p" is a flag to the "s" command here, this is different
47 #+ from the "p" command).
48
49 # sed is now ready to continue reading its input. (Note that before
50 #+ continuing, if -n option had not been passed, sed would have printed
51 #+ the line once again).
52
53 # Now, sed reads the remainder of the characters, and finds the
54 #+ end of the file.
55 # It is now ready to process its 2nd line (which is also numbered '$' as
56 #+ it's the last one).
57 # It sees it is not matched by any <range>, so its job is done.
58
59 # In few word this sed commmand means:
60 # "On the first line only, remove any character up to the right-most space,
61 #+ then print it."
62
63 # A better way to do this would have been:
64 #       sed -e 's/.*/ //;q'
65
66 # Here, two <range><action>s (could have been written
67 #       sed -e 's/.*/ //' -e q):
68
69 #   range      action
70 #   nothing (matches line) s/.*/ //
71 #   nothing (matches line) q (quit)
72
73 # Here, sed only reads its first line of input.
74 # It performs both actions, and prints the line (substituted) before
75 #+ quitting (because of the "q" action) since the "-n" option is not passed.
76
77 # ===== #
78
79 # An even simpler altenative to the above one-line script would be:
80 #       head -c4 /dev/urandom| od -An -tu4
81
82 exit

```

See also [Example 16-39](#).

tail

lists the (tail) end of a file to `stdout`. The default is 10 lines, but this can be changed with the `-n` option. Commonly used to keep track of changes to a system logfile, using the `-f` option, which outputs lines appended to the file.

Example 16-15. Using *tail* to monitor the system log

```


1 #!/bin/bash
2
3 filename=sys.log
4
5 cat /dev/null > $filename; echo "Creating / cleaning out file."
6 # Creates the file if it does not already exist,

```

```

7 #+ and truncates it to zero length if it does.
8 # : > filename and > filename also work.
9
10 tail /var/log/messages > $filename
11 # /var/log/messages must have world read permission for this to work.
12
13 echo "$filename contains tail end of system log."
14
15 exit 0

```


 To list a specific line of a text file, [pipe](#) the output of **head** to **tail -n 1**. For example **head -n 8 database.txt | tail -n 1** lists the 8th line of the file `database.txt`.

To set a variable to a given block of a text file:

```

1 var=$(head -n $m $filename | tail -n $n)
2
3 # filename = name of file
4 # m = from beginning of file, number of lines to end of block
5 # n = number of lines to set variable to (trim from end of block)

```

 Newer implementations of **tail** deprecate the older **tail -\$LINES filename** usage. The standard **tail -n \$LINES filename** is correct.

See also [Example 16-5](#), [Example 16-39](#) and [Example 32-6](#).

grep

A multi-purpose file search tool that uses [Regular Expressions](#). It was originally a command/filter in the venerable **ed** line editor: **g/re/p** -- *global - regular expression - print*.

grep *pattern* [*file...*]

Search the target file(s) for occurrences of *pattern*, where *pattern* may be literal text or a Regular Expression.

```

bash$ grep '[rst]ystem.$' osinfo.txt
The GPL governs the distribution of the Linux operating system.

```

If no target file(s) specified, **grep** works as a filter on `stdout`, as in a [pipe](#).

```

bash$ ps ax | grep clock
765 tty1      S      0:00 xclock
901 pts/1    S      0:00 grep clock

```

The **-i** option causes a case-insensitive search.

The **-w** option matches only whole words.

The **-l** option lists only the files in which matches were found, but not the matching lines.

The **-r** (recursive) option searches files in the current working directory and all subdirectories below it.

The **-n** option lists the matching lines, together with line numbers.

```

bash$ grep -n Linux osinfo.txt
2:This is a file containing information about Linux.
6:The GPL governs the distribution of the Linux operating system.

```

The `-v` (or `--invert-match`) option *filters out* matches.

```
1 grep pattern1 *.txt | grep -v pattern2
2
3 # Matches all lines in "*.txt" files containing "pattern1",
4 # but ***not*** "pattern2".
```

The `-c` (`--count`) option gives a numerical count of matches, rather than actually listing the matches.

```
1 grep -c txt *.sgml # (number of occurrences of "txt" in "*.sgml" files)
2
3
4 # grep -cz .
5 # ^ dot
6 # means count (-c) zero-separated (-z) items matching "."
7 # that is, non-empty ones (containing at least 1 character).
8 #
9 printf 'a b\nc d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -cz . # 3
10 printf 'a b\nc d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -cz '$' # 5
11 printf 'a b\nc d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -cz '^' # 5
12 #
13 printf 'a b\nc d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -c '$' # 9
14 # By default, newline chars (\n) separate items to match.
15
16 # Note that the -z option is GNU "grep" specific.
17
18
19 # Thanks, S.C.
```

The `--color` (or `--colour`) option marks the matching string in color (on the console or in an *xterm* window). Since *grep* prints out each entire line containing the matching pattern, this lets you see exactly *what* is being matched. See also the `-o` option, which shows only the matching portion of the line(s).

Example 16-16. Printing out the *From* lines in stored e-mail messages

```
1 #!/bin/bash
2 # from.sh
3
4 # Emulates the useful 'from' utility in Solaris, BSD, etc.
5 # Echoes the "From" header line in all messages
6 #+ in your e-mail directory.
7
8
9 MAILDIR=~/mail/* # No quoting of variable. Why?
10 # Maybe check if-exists $MAILDIR: if [ -d $MAILDIR ] . . .
11 GREP_OPTS="-H -A 5 --color" # Show file, plus extra context lines
12 #+ and display "From" in color.
13 TARGETSTR="^From" # "From" at beginning of line.
14
15 for file in $MAILDIR # No quoting of variable.
16 do
17     grep $GREP_OPTS "$TARGETSTR" "$file"
18     # ^^^^^^^^^^^ # Again, do not quote this variable.
19     echo
20 done
21
22 exit $?
23
24 # You might wish to pipe the output of this script to 'more'
25 #+ or redirect it to a file . . .
```

When invoked with more than one target file given, **grep** specifies which file contains matches.

```
bash$ grep Linux osinfo.txt misc.txt
osinfo.txt:This is a file containing information about Linux.
osinfo.txt:The GPL governs the distribution of the Linux operating system.
misc.txt:The Linux operating system is steadily gaining in popularity.
```

i To force **grep** to show the filename when searching only one target file, simply give `/dev/null` as the second file.

```
bash$ grep Linux osinfo.txt /dev/null
osinfo.txt:This is a file containing information about Linux.
osinfo.txt:The GPL governs the distribution of the Linux operating system.
```

If there is a successful match, **grep** returns an [exit status](#) of 0, which makes it useful in a condition test in a script, especially in combination with the `-q` option to suppress output.

```
1 SUCCESS=0                # if grep lookup succeeds
2 word=Linux
3 filename=data.file
4
5 grep -q "$word" "$filename" # The "-q" option
6                             #+ causes nothing to echo to stdout.
7 if [ $? -eq $SUCCESS ]
8 # if grep -q "$word" "$filename" can replace lines 5 - 7.
9 then
10 echo "$word found in $filename"
11 else
12 echo "$word not found in $filename"
13 fi
```

[Example 32-6](#) demonstrates how to use **grep** to search for a word pattern in a system logfile.

Example 16-17. Emulating *grep* in a script

```
1 #!/bin/bash
2 # grp.sh: Rudimentary reimplementaion of grep.
3
4 E_BADARGS=85
5
6 if [ -z "$1" ] # Check for argument to script.
7 then
8 echo "Usage: `basename $0` pattern"
9 exit $E_BADARGS
10 fi
11
12 echo
13
14 for file in * # Traverse all files in $PWD.
15 do
16 output=$(sed -n /"$1"/p $file) # Command substitution.
17
18 if [ ! -z "$output" ] # What happens if "$output" is not quoted?
19 then
20 echo -n "$file: "
21 echo "$output"
22 fi # sed -ne "/$1/s|^|${file}: |p" is equivalent to above.
23
24 echo
25 done
26
27 echo
```

```
28
29 exit 0
30
31 # Exercises:
32 # -----
33 # 1) Add newlines to output, if more than one match in any given file.
34 # 2) Add features.
```

How can **grep** search for two (or more) separate patterns? What if you want **grep** to display all lines in a file or files that contain both "pattern1" *and* "pattern2"?

One method is to [pipe](#) the result of **grep pattern1** to **grep pattern2**.

For example, given the following file:

```
1 # Filename: tstfile
2
3 This is a sample file.
4 This is an ordinary text file.
5 This file does not contain any unusual text.
6 This file is not unusual.
7 Here is some text.
```

Now, let's search this file for lines containing *both* "file" and "text" ...

```
bash$ grep file tstfile
# Filename: tstfile
This is a sample file.
This is an ordinary text file.
This file does not contain any unusual text.
This file is not unusual.

bash$ grep file tstfile | grep text
This is an ordinary text file.
This file does not contain any unusual text.
```

Now, for an interesting recreational use of *grep* ...

Example 16-18. Crossword puzzle solver

```
1 #!/bin/bash
2 # cw-solver.sh
3 # This is actually a wrapper around a one-liner (line 46).
4
5 # Crossword puzzle and anagramming word game solver.
6 # You know *some* of the letters in the word you're looking for,
7 #+ so you need a list of all valid words
8 #+ with the known letters in given positions.
9 # For example: w...i....n
10 #          1???5????10
11 # w in position 1, 3 unknowns, i in the 5th, 4 unknowns, n at the end.
12 # (See comments at end of script.)
13
14
15 E_NOPATT=71
16 DICT=/usr/share/dict/word.lst
17 #          ^^^^^^^^ Looks for word list here.
18 # ASCII word list, one word per line.
19 # If you happen to need an appropriate list,
20 #+ download the author's "yaw1" word list package.
21 # http://ibiblio.org/pub/Linux/libs/yawl-0.3.2.tar.gz
22 # or
23 # http://bash.deta.in/yawl-0.3.2.tar.gz
```



```

24
25
26 if [ -z "$1" ] # If no word pattern specified
27 then          #+ as a command-line argument . . .
28   echo        #+ . . . then . . .
29   echo "Usage:" #+ Usage message.
30   echo
31   echo "$0" \ "pattern,\"
32   echo "where \"pattern\" is in the form"
33   echo "xxx..x.x..."
34   echo
35   echo "The x's represent known letters,"
36   echo "and the periods are unknown letters (blanks).\"
37   echo "Letters and periods can be in any position.\"
38   echo "For example, try:  sh cw-solver.sh w...i....n\"
39   echo
40   exit $E_NOPATT
41 fi
42
43 echo
44 # =====
45 # This is where all the work gets done.
46 grep ^"$1"$ "$DICT" # Yes, only one line!
47 # | |
48 # ^ is start-of-word regex anchor.
49 # $ is end-of-word regex anchor.
50
51 # From _Stupid Grep Tricks_, vol. 1,
52 #+ a book the ABS Guide author may yet get around
53 #+ to writing . . . one of these days . . .
54 # =====
55 echo
56
57
58 exit $? # Script terminates here.
59 # If there are too many words generated,
60 #+ redirect the output to a file.
61
62 $ sh cw-solver.sh w...i....n
63
64 wellington
65 workingman
66 workingmen

```

egrep -- *extended grep* -- is the same as **grep -E**. This uses a somewhat different, extended set of [Regular Expressions](#), which can make the search a bit more flexible. It also allows the boolean | (*or*) operator.

```

bash $ egrep 'matches|Matches' file.txt
Line 1 matches.
Line 3 Matches.
Line 4 contains matches, but also Matches

```

fgrep -- *fast grep* -- is the same as **grep -F**. It does a literal string search (no [Regular Expressions](#)), which generally speeds things up a bit.



On some Linux distros, **egrep** and **fgrep** are symbolic links to, or aliases for **grep**, but invoked with the **-E** and **-F** options, respectively.

Example 16-19. Looking up definitions in Webster's 1913 Dictionary

```


1 #!/bin/bash
2 # dict-lookup.sh
3
4 # This script looks up definitions in the 1913 Webster's Dictionary.
5 # This Public Domain dictionary is available for download
6 #+ from various sites, including
7 #+ Project Gutenberg (http://www.gutenberg.org/etext/247).
8 #
9 # Convert it from DOS to UNIX format (with only LF at end of line)
10 #+ before using it with this script.
11 # Store the file in plain, uncompressed ASCII text.
12 # Set DEFAULT_DICTFILE variable below to path/filename.
13
14
15 E_BADARGS=85
16 MAXCONTEXTLINES=50 # Maximum number of lines to show.
17 DEFAULT_DICTFILE="/usr/share/dict/webster1913-dict.txt"
18 # Default dictionary file pathname.
19 # Change this as necessary.
20 # Note:
21 # ----
22 # This particular edition of the 1913 Webster's
23 #+ begins each entry with an uppercase letter
24 #+ (lowercase for the remaining characters).
25 # Only the *very first line* of an entry begins this way,
26 #+ and that's why the search algorithm below works.
27
28
29
30 if [[ -z $(echo "$1" | sed -n '/^[A-Z]/p') ]]
31 # Must at least specify word to look up, and
32 #+ it must start with an uppercase letter.
33 then
34 echo "Usage: `basename $0` Word-to-define [dictionary-file]"
35 echo
36 echo "Note: Word to look up must start with capital letter,"
37 echo "with the rest of the word in lowercase."
38 echo "-----"
39 echo "Examples: Abandon, Dictionary, Marking, etc."
40 exit $E_BADARGS
41 fi
42
43
44 if [ -z "$2" ] # May specify different dictionary
45 #+ as an argument to this script.
46 then
47 dictfile=$DEFAULT_DICTFILE
48 else
49 dictfile="$2"
50 fi
51
52 # -----
53 Definition=$(fgrep -A $MAXCONTEXTLINES "$1 \\" "$dictfile")
54 # Definitions in form "Word \..."
55 #
56 # And, yes, "fgrep" is fast enough
57 #+ to search even a very large text file.
58
59
60 # Now, snip out just the definition block.
61
62 echo "$Definition" |
63 sed -n '1, /^[A-Z]/p' |
64 # Print from first line of output
65 #+ to the first line of the next entry.
66 sed '$d' | sed '$d'

```


```

67 # Delete last two lines of output
68 #+ (blank line and first line of next entry).
69 # -----
70
71 exit $?
72
73 # Exercises:
74 # -----
75 # 1) Modify the script to accept any type of alphabetic input
76 #   + (uppercase, lowercase, mixed case), and convert it
77 #   + to an acceptable format for processing.
78 #
79 # 2) Convert the script to a GUI application,
80 #   + using something like 'gdialog' or 'zenity' . . .
81 #   The script will then no longer take its argument(s)
82 #   + from the command-line.
83 #
84 # 3) Modify the script to parse one of the other available
85 #   + Public Domain Dictionaries, such as the U.S. Census Bureau Gazetteer.

```

 See also [Example A-41](#) for an example of speedy *fgrep* lookup on a large text file.

agrep (*approximate grep*) extends the capabilities of **grep** to approximate matching. The search string may differ by a specified number of characters from the resulting matches. This utility is not part of the core Linux distribution.

 To search compressed files, use **zgrep**, **zegrep**, or **zfgrep**. These also work on non-compressed files, though slower than plain **grep**, **egrep**, **fgrep**. They are handy for searching through a mixed set of files, some compressed, some not.

To search [bzipped](#) files, use **bzgrep**.

look

The command **look** works like **grep**, but does a lookup on a "dictionary," a sorted word list. By default, **look** searches for a match in `/usr/dict/words`, but a different dictionary file may be specified.

Example 16-20. Checking words in a list for validity

```

1 #!/bin/bash
2 # lookup: Does a dictionary lookup on each word in a data file.
3
4 file=words.data # Data file from which to read words to test.
5
6 echo
7 echo "Testing file $file"
8 echo
9
10 while [ "$word" != end ] # Last word in data file.
11 do
12     read word # From data file, because of redirection at end of loop.
13     look $word > /dev/null # Don't want to display lines in dictionary file.
14     # Searches for words in the file /usr/share/dict/words
15     #+ (usually a link to linux.words).
16     lookup=$? # Exit status of 'look' command.
17
18     if [ "$lookup" -eq 0 ]
19 then

```

```

20     echo "\"$word\" is valid."
21     else
22     echo "\"$word\" is invalid."
23     fi
24
25 done <"$file"      # Redirects stdin to $file, so "reads" come from there.
26
27 echo
28
29 exit 0
30
31 # -----
32 # Code below line will not execute because of "exit" command above.
33
34
35 # Stephane Chazelas proposes the following, more concise alternative:
36
37 while read word && [[ $word != end ]]
38 do if look "$word" > /dev/null
39     then echo "\"$word\" is valid."
40     else echo "\"$word\" is invalid."
41     fi
42 done <"$file"
43
44 exit 0

```

sed, awk

Scripting languages especially suited for parsing text files and command output. May be embedded singly or in combination in pipes and shell scripts.

sed

Non-interactive "stream editor", permits using many **ex** commands in [batch](#) mode. It finds many uses in shell scripts.

awk

Programmable file extractor and formatter, good for manipulating and/or extracting [fields](#) (columns) in structured text files. Its syntax is similar to C.

wc

wc gives a "word count" on a file or I/O stream:

```

bash $ wc /usr/share/doc/sed-4.1.2/README
13  70  447 README
[13 lines  70 words  447 characters]

```

wc -w gives only the word count.

wc -l gives only the line count.

wc -c gives only the byte count.

wc -m gives only the character count.

wc -L gives only the length of the longest line.

Using **wc** to count how many `.txt` files are in current working directory:

```

1 $ ls *.txt | wc -l
2 # Will work as long as none of the "*.txt" files
3 #+ have a linefeed embedded in their name.
4
5 # Alternative ways of doing this are:
6 #     find . -maxdepth 1 -name *.txt -print0 | grep -cz .
7 #     (shopt -s nullglob; set -- *.txt; echo $#)

```

```
8
9 # Thanks, S.C.
```

Using **wc** to total up the size of all the files whose names begin with letters in the range d - h

```
bash$ wc [d-h]* | grep total | awk '{print $3}'
71832
```

Using **wc** to count the instances of the word "Linux" in the main source file for this book.

```
bash$ grep Linux abs-book.sgml | wc -l
138
```


See also [Example 16-39](#) and [Example 20-8](#).

Certain commands include some of the functionality of **wc** as options.

```
1 ... | grep foo | wc -l
2 # This frequently used construct can be more concisely rendered.
3
4 ... | grep -c foo
5 # Just use the "-c" (or "--count") option of grep.
6
7 # Thanks, S.C.
```

tr

character translation filter.

 **Must use quoting and/or brackets**, as appropriate. Quotes prevent the shell from reinterpreting the special characters in **tr** command sequences. Brackets should be quoted to prevent expansion by the shell.

Either **tr "A-Z" "*" <filename** or **tr A-Z * <filename** changes all the uppercase letters in *filename* to asterisks (writes to `stdout`). On some systems this may not work, but **tr A-Z '[*]'** will.

The **-d** option deletes a range of characters.

```
1 echo "abcdef" # abcdef
2 echo "abcdef" | tr -d b-d # aef
3
4
5 tr -d 0-9 <filename
6 # Deletes all digits from the file "filename".
```

The **--squeeze-repeats** (or **-s**) option deletes all but the first instance of a string of consecutive characters. This option is useful for removing excess [whitespace](#).

```
bash$ echo "XXXXX" | tr --squeeze-repeats 'X'
X
```

The **-c** "complement" option *inverts* the character set to match. With this option, **tr** acts only upon those characters *not* matching the specified set.

```
bash$ echo "acfdeb123" | tr -c b-d +
+c+d+b++++
```

Note that **tr** recognizes [POSIX character classes](#). [1]

```
bash$ echo "abcd2ef1" | tr '[:alpha:]' -
----2--1
```

Example 16-21. *toupper*: Transforms a file to all uppercase.

```
1 #!/bin/bash
2 # Changes a file to all uppercase.
3
4 E_BADARGS=85
5
6 if [ -z "$1" ] # Standard check for command-line arg.
7 then
8     echo "Usage: `basename $0` filename"
9     exit $E_BADARGS
10 fi
11
12 tr a-z A-Z <"$1"
13
14 # Same effect as above, but using POSIX character set notation:
15 #     tr '[:lower:]' '[:upper:]' <"$1"
16 # Thanks, S.C.
17
18 #     Or even . . .
19 #     cat "$1" | tr a-z A-Z
20 #     Or dozens of other ways . . .
21
22 exit 0
23
24 # Exercise:
25 # Rewrite this script to give the option of changing a file
26 #+ to *either* upper or lowercase.
27 # Hint: Use either the "case" or "select" command.
```

Example 16-22. *lowercase*: Changes all filenames in working directory to lowercase.

```
1 #!/bin/bash
2 #
3 # Changes every filename in working directory to all lowercase.
4 #
5 # Inspired by a script of John Dubois,
6 #+ which was translated into Bash by Chet Ramey,
7 #+ and considerably simplified by the author of the ABS Guide.
8
9
10 for filename in * # Traverse all files in directory.
11 do
12     fname=`basename $filename`
13     n=`echo $fname | tr A-Z a-z` # Change name to lowercase.
14     if [ "$fname" != "$n" ] # Rename only files not already lowercase.
15     then
16         mv $fname $n
17     fi
18 done
19
20 exit $?
21
22
23 # Code below this line will not execute because of "exit".
24 #-----#
25 # To run it, delete script above line.
26
27 # The above script will not work on filenames containing blanks or newlines.
```

```

28 # Stephane Chazelas therefore suggests the following alternative:
29
30
31 for filename in *      # Not necessary to use basename,
32                       # since "*" won't return any file containing "/".
33 do n=`echo "$filename/" | tr '[:upper:]' '[:lower:]'`
34 #                       POSIX char set notation.
35 #                       Slash added so that trailing newlines are not
36 #                       removed by command substitution.
37 # Variable substitution:
38 n=${n%/}              # Removes trailing slash, added above, from filename.
39 [[ $filename == $n ]] || mv "$filename" "$n"
40                       # Checks if filename already lowercase.
41 done
42
43 exit $?

```

Example 16-23. *du*: DOS to UNIX text file conversion.

```

1 #!/bin/bash
2 # Du.sh: DOS to UNIX text file converter.
3
4 E_WRONGARGS=85
5
6 if [ -z "$1" ]
7 then
8     echo "Usage: `basename $0` filename-to-convert"
9     exit $E_WRONGARGS
10 fi
11
12 NEWFILENAME=$1.unx
13
14 CR='\015' # Carriage return.
15          # 015 is octal ASCII code for CR.
16          # Lines in a DOS text file end in CR-LF.
17          # Lines in a UNIX text file end in LF only.
18
19 tr -d $CR < $1 > $NEWFILENAME
20 # Delete CR's and write to new file.
21
22 echo "Original DOS text file is \"$1\"."
23 echo "Converted UNIX text file is \"$NEWFILENAME\"."
24
25 exit 0
26
27 # Exercise:
28 # -----
29 # Change the above script to convert from UNIX to DOS.

```

Example 16-24. *rot13*: ultra-weak encryption.

```

1 #!/bin/bash
2 # rot13.sh: Classic rot13 algorithm,
3 #           encryption that might fool a 3-year old
4 #           for about 10 minutes.
5
6 # Usage: ./rot13.sh filename
7 # or    ./rot13.sh <filename
8 # or    ./rot13.sh and supply keyboard input (stdin)

```

```

9
10 cat "$@" | tr 'a-zA-Z' 'n-za-mN-ZA-M' # "a" goes to "n", "b" to "o" ...
11 # The cat "$@" construct
12 #+ permits input either from stdin or from files.
13
14 exit 0

```

Example 16-25. Generating "Crypto-Quote" Puzzles

```

1 #!/bin/bash
2 # crypto-quote.sh: Encrypt quotes
3
4 # Will encrypt famous quotes in a simple monoalphabetic substitution.
5 # The result is similar to the "Crypto Quote" puzzles
6 #+ seen in the Op Ed pages of the Sunday paper.
7
8
9 key=ETAOINSHRDLUBCFGJMQPVWZYXK
10 # The "key" is nothing more than a scrambled alphabet.
11 # Changing the "key" changes the encryption.
12
13 # The 'cat "$@"' construction gets input either from stdin or from files.
14 # If using stdin, terminate input with a Control-D.
15 # Otherwise, specify filename as command-line parameter.
16
17 cat "$@" | tr "a-z" "A-Z" | tr "A-Z" "$key"
18 #           | to uppercase |      encrypt
19 # Will work on lowercase, uppercase, or mixed-case quotes.
20 # Passes non-alphabetic characters through unchanged.
21
22
23 # Try this script with something like:
24 # "Nothing so needs reforming as other people's habits."
25 # --Mark Twain
26 #
27 # Output is:
28 # "CFPHRCS QF CIIOQ MINFMBRCS EQ FPHIM GIFGUI'Q HETRPQ."
29 # --BEMLE PZERC
30
31 # To reverse the encryption:
32 # cat "$@" | tr "$key" "A-Z"
33
34
35 # This simple-minded cipher can be broken by an average 12-year old
36 #+ using only pencil and paper.
37
38 exit 0
39
40 # Exercise:
41 # -----
42 # Modify the script so that it will either encrypt or decrypt,
43 #+ depending on command-line argument(s).

```

Of course, *tr* lends itself to *code obfuscation*.

```

1 #!/bin/bash
2 # jabh.sh
3
4 x="wftedskaebjgdBstbdbsmnjgz"
5 echo $x | tr "a-z" 'oh, turtleneck Phrase Jar!'
6

```


tr variants

The **tr** utility has two historic variants. The BSD version does not use brackets (**tr a-z A-Z**), but the SysV one does (**tr '[a-z]' '[A-Z]'**). The GNU version of **tr** resembles the BSD one.

fold

A filter that wraps lines of input to a specified width. This is especially useful with the **-s** option, which breaks lines at word spaces (see [Example 16-26](#) and [Example A-1](#)).

fmt

Simple-minded file formatter, used as a filter in a pipe to "wrap" long lines of text output.

Example 16-26. Formatted file listing.

```
1 #!/bin/bash
2
3 WIDTH=40                # 40 columns wide.
4
5 b=`ls /usr/local/bin`   # Get a file listing...
6
7 echo $b | fmt -w $WIDTH
8
9 # Could also have been done by
10 #   echo $b | fold -s -w $WIDTH
11
12 exit 0
```

See also [Example 16-5](#).

 A powerful alternative to **fmt** is Kamil Toman's **par** utility, available from <http://www.cs.berkeley.edu/~amc/Par/>.

col

This deceptively named filter removes reverse line feeds from an input stream. It also attempts to replace whitespace with equivalent tabs. The chief use of **col** is in filtering the output from certain text processing utilities, such as **groff** and **tbl**.

column

Column formatter. This filter transforms list-type text output into a "pretty-printed" table by inserting tabs at appropriate places.

Example 16-27. Using *column* to format a directory listing

```
1 #!/bin/bash
2 # colms.sh
3 # A minor modification of the example file in the "column" man page.
4
5
6 (printf "PERMISSIONS LINKS OWNER GROUP SIZE MONTH DAY HH:MM PROG-NAME\n" \
7 ; ls -l | sed 1d) | column -t
8 #      ^^^^^^      ^^
9
10 # The "sed 1d" in the pipe deletes the first line of output,
11 #+ which would be "total      N",
12 #+ where "N" is the total number of files found by "ls -l".
13
```

```
14 # The -t option to "column" pretty-prints a table.
15
16 exit 0
```

colrm

Column removal filter. This removes columns (characters) from a file and writes the file, lacking the range of specified columns, back to `stdout`. **colrm 2 4 <filename** removes the second through fourth characters from each line of the text file `filename`.

⚠ If the file contains tabs or nonprintable characters, this may cause unpredictable behavior. In such cases, consider using [expand](#) and **unexpand** in a pipe preceding **colrm**.

nl

Line numbering filter: **nl filename** lists `filename` to `stdout`, but inserts consecutive numbers at the beginning of each non-blank line. If `filename` omitted, operates on `stdin`.

The output of **nl** is very similar to **cat -b**, since, by default **nl** does not list blank lines.

Example 16-28. *nl*: A self-numbering script.

```
1 #!/bin/bash
2 # line-number.sh
3
4 # This script echoes itself twice to stdout with its lines numbered.
5
6 echo "    line number = $LINENO" # 'nl' sees this as line 4
7 #                               (nl does not number blank lines).
8 #                               'cat -n' sees it correctly as line #6.
9
10 nl `basename $0`
11
12 echo; echo # Now, let's try it with 'cat -n'
13
14 cat -n `basename $0`
15 # The difference is that 'cat -n' numbers the blank lines.
16 # Note that 'nl -ba' will also do so.
17
18 exit 0
19 # -----
```

pr

Print formatting filter. This will paginate files (or `stdout`) into sections suitable for hard copy printing or viewing on screen. Various options permit row and column manipulation, joining lines, setting margins, numbering lines, adding page headers, and merging files, among other things. The **pr** command combines much of the functionality of **nl**, **paste**, **fold**, **column**, and **expand**.

pr -o 5 --width=65 fileZZZ | more gives a nice paginated listing to screen of `fileZZZ` with margins set at 5 and 65.

A particularly useful option is `-d`, forcing double-spacing (same effect as **sed -G**).

gettext

The GNU **gettext** package is a set of utilities for [localizing](#) and translating the text output of programs into foreign languages. While originally intended for C programs, it now supports quite a number of programming and scripting languages.

The **gettext** program works on shell scripts. See the *info* page.

msgfmt

A program for generating binary message catalogs. It is used for [localization](#).

iconv

A utility for converting file(s) to a different encoding (character set). Its chief use is for [localization](#).

```
1 # Convert a string from UTF-8 to UTF-16 and print to the BookList
2 function write_utf8_string {
3     STRING=$1
4     BOOKLIST=$2
5     echo -n "$STRING" | iconv -f UTF8 -t UTF16 | \
6     cut -b 3- | tr -d \\n >> "$BOOKLIST"
7 }
8
9 # From Peter Knowles' "booklistgen.sh" script
10 #+ for converting files to Sony Librie/PRS-50X format.
11 # (http://booklistgensh.peterknowles.com)
```

recode

Consider this a fancier version of **iconv**, above. This very versatile utility for converting a file to a different encoding scheme. Note that *recode* is not part of the standard Linux installation.

TeX, gs

TeX and **Postscript** are text markup languages used for preparing copy for printing or formatted video display.

TeX is Donald Knuth's elaborate typesetting system. It is often convenient to write a shell script encapsulating all the options and arguments passed to one of these markup languages.

Ghostscript (**gs**) is a GPL-ed Postscript interpreter.

texexec

Utility for processing *TeX* and *pdf* files. Found in `/usr/bin` on many Linux distros, it is actually a [shell wrapper](#) that calls [Perl](#) to invoke *TeX*.

```
1 texexec --pdfarrange --result=Concatenated.pdf *pdf
2
3 # Concatenates all the pdf files in the current working directory
4 #+ into the merged file, Concatenated.pdf . . .
5 # (The --pdfarrange option repaginates a pdf file. See also --pdfcombine.)
6 # The above command-line could be parameterized and put into a shell script.
```

enscript

Utility for converting plain text file to PostScript

For example, **enscript filename.txt -p filename.ps** produces the PostScript output file `filename.ps`.

groff, tbl, eqn

Yet another text markup and display formatting language is **groff**. This is the enhanced GNU version of the venerable UNIX **roff/troff** display and typesetting package. [Manpages](#) use **groff**.

The **tbl** table processing utility is considered part of **groff**, as its function is to convert table markup into **groff** commands.

The **eqn** equation processing utility is likewise part of **groff**, and its function is to convert equation markup into **groff** commands.

Example 16-29. *manview*: Viewing formatted manpages

```
1 #!/bin/bash
2 # manview.sh: Formats the source of a man page for viewing.
```

```
3
4 # This script is useful when writing man page source.
5 # It lets you look at the intermediate results on the fly
6 #+ while working on it.
7
8 E_WRONGARGS=85
9
10 if [ -z "$1" ]
11 then
12     echo "Usage: `basename $0` filename"
13     exit $E_WRONGARGS
14 fi
15
16 # -----
17 groff -Tascii -man $1 | less
18 # From the man page for groff.
19 # -----
20
21 # If the man page includes tables and/or equations,
22 #+ then the above code will barf.
23 # The following line can handle such cases.
24 #
25 #   gtbl < "$1" | geqn -Tlatin1 | groff -Tlatin1 -mtty-char -man
26 #
27 #   Thanks, S.C.
28
29 exit $? # See also the "maned.sh" script.
```

See also [Example A-39](#).

lex, yacc

The **lex** lexical analyzer produces programs for pattern matching. This has been replaced by the nonproprietary **flex** on Linux systems.

The **yacc** utility creates a parser based on a set of specifications. This has been replaced by the nonproprietary **bison** on Linux systems.

Notes

- [1] This is only true of the GNU version of **tr**, not the generic version often found on commercial UNIX systems.

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16.5. File and Archiving Commands


Archiving

tar

The standard UNIX archiving utility. [1] Originally a *Tape ARchiving* program, it has developed into a general purpose package that can handle all manner of archiving with all types of destination devices, ranging from tape drives to regular files to even `stdout` (see [Example 3-4](#)). GNU *tar* has been patched to accept various compression filters, for example: `tar czvf archive_name.tar.gz *`, which recursively archives and [gziPs](#) all files in a directory tree except [dotfiles](#) in the current working directory (`$PWD`). [2]

Some useful **tar** options:


1. `-c` create (a new archive)
2. `-x` extract (files from existing archive)
3. `--delete` delete (files from existing archive)

 This option will not work on magnetic tape devices.

4. `-r` append (files to existing archive)
5. `-A` append (*tar* files to existing archive)
6. `-t` list (contents of existing archive)
7. `-u` update archive
8. `-d` compare archive with specified filesystem
9. `--after-date` only process files with a date stamp *after* specified date
10. `-z` [gzip](#) the archive

(compress or uncompress, depending on whether combined with the `-c` or `-x`) option

11. `-j` [bzip2](#) the archive

 It may be difficult to recover data from a corrupted *gzipped* tar archive. When archiving important files, make multiple backups.

shar

Shell archiving utility. The text and/or binary files in a shell archive are concatenated without compression, and the resultant archive is essentially a shell script, complete with `#!/bin/sh` header, containing all the necessary unarchiving commands, as well as the files themselves. Unprintable binary characters in the target file(s) are converted to printable ASCII characters in the output *shar* file. *Shar archives* still show up in Usenet newsgroups, but otherwise **shar** has been replaced by **tar/gzip**. The **unshar** command unpacks *shar* archives.

The **mailshar** command is a Bash script that uses **shar** to concatenate multiple files into a single one for e-mailing. This script supports compression and [uuencoding](#).


ar

Creation and manipulation utility for archives, mainly used for binary object file libraries.

rpm

The *Red Hat Package Manager*, or **rpm** utility provides a wrapper for source or binary archives. It includes commands for installing and checking the integrity of packages, among other things.

A simple `rpm -i package_name.rpm` usually suffices to install a package, though there are many more options available.

 `rpm -qf` identifies which package a file originates from.

```
bash$ rpm -qf /bin/ls
coreutils-5.2.1-31
```

i `rpm -qa` gives a complete list of all installed *rpm* packages on a given system. An `rpm -qa package_name` lists only the package(s) corresponding to `package_name`.

```
bash$ rpm -qa
redhat-logos-1.1.3-1
glibc-2.2.4-13
cracklib-2.7-12
dosfstools-2.7-1
gdbm-1.8.0-10
ksymoops-2.4.1-1
mktemp-1.5-11
perl-5.6.0-17
reiserfs-utils-3.x.0j-2
...

bash$ rpm -qa docbook-utils
docbook-utils-0.6.9-2

bash$ rpm -qa docbook | grep docbook
docbook-dtd31-sgml-1.0-10
docbook-style-dsssl-1.64-3
docbook-dtd30-sgml-1.0-10
docbook-dtd40-sgml-1.0-11
docbook-utils-pdf-0.6.9-2
docbook-dtd41-sgml-1.0-10
docbook-utils-0.6.9-2
```

cpio

This specialized archiving copy command (**copy input and output**) is rarely seen any more, having been supplanted by **tar/gzip**. It still has its uses, such as moving a directory tree. With an appropriate block size (for copying) specified, it can be appreciably faster than **tar**.

Example 16-30. Using *cpio* to move a directory tree

```
1 #!/bin/bash
2
3 # Copying a directory tree using cpio.
4
5 # Advantages of using 'cpio':
6 #   Speed of copying. It's faster than 'tar' with pipes.
7 #   Well suited for copying special files (named pipes, etc.)
8 #+   that 'cp' may choke on.
9
10 ARGS=2
11 E_BADARGS=65
12
13 if [ $# -ne "$ARGS" ]
14 then
15     echo "Usage: `basename $0` source destination"
16     exit $E_BADARGS
17 fi
18
19 source="$1"
20 destination="$2"
21
```

```

22 #####
23 find "$source" -depth | cpio -admvp "$destination"
24 #           ^^^^^^          ^^^^^^
25 # Read the 'find' and 'cpio' info pages to decipher these options.
26 # The above works only relative to $PWD (current directory) . . .
27 #+ full pathnames are specified.
28 #####
29
30
31 # Exercise:
32 # -----
33
34 # Add code to check the exit status ($?) of the 'find | cpio' pipe
35 #+ and output appropriate error messages if anything went wrong.
36
37 exit $?

```

rpm2cpio

This command extracts a **cpio** archive from an [rpm](#) one.

Example 16-31. Unpacking an *rpm* archive

```

1 #!/bin/bash
2 # de-rpm.sh: Unpack an 'rpm' archive
3
4 : ${1?"Usage: `basename $0` target-file"}
5 # Must specify 'rpm' archive name as an argument.
6
7
8 TEMPFILE=$$.cpio           # Tempfile with "unique" name.
9                           # $$ is process ID of script.
10
11 rpm2cpio < $1 > $TEMPFILE  # Converts rpm archive into
12                           #+ cpio archive.
13 cpio --make-directories -F $TEMPFILE -i # Unpacks cpio archive.
14 rm -f $TEMPFILE           # Deletes cpio archive.
15
16 exit 0
17
18 # Exercise:
19 # Add check for whether 1) "target-file" exists and
20 #+                       2) it is an rpm archive.
21 # Hint:                   Parse output of 'file' command.

```

pax

The **pax** portable archive exchange toolkit facilitates periodic file backups and is designed to be cross-compatible between various flavors of UNIX. It was designed to replace [tar](#) and [cpio](#).

```

1 pax -wf daily_backup.pax ~/linux-server/files
2 # Creates a tar archive of all files in the target directory.
3 # Note that the options to pax must be in the correct order --
4 #+ pax -fw      has an entirely different effect.
5
6 pax -f daily_backup.pax
7 # Lists the files in the archive.
8
9 pax -rf daily_backup.pax ~/bsd-server/files
10 # Restores the backed-up files from the Linux machine
11 #+ onto a BSD one.

```

Note that **pax** handles many of the standard archiving and compression commands.


Compression

gzip

The standard GNU/UNIX compression utility, replacing the inferior and proprietary **compress**. The corresponding decompression command is **gunzip**, which is the equivalent of **gzip -d**.

 The `-c` option sends the output of **gzip** to `stdout`. This is useful when [piping](#) to other commands.

The **zcat** filter decompresses a *gzipped* file to `stdout`, as possible input to a pipe or redirection. This is, in effect, a **cat** command that works on compressed files (including files processed with the older [compress](#) utility). The **zcat** command is equivalent to **gzip -dc**.


 On some commercial UNIX systems, **zcat** is a synonym for **uncompress -c**, and will not work on *gzipped* files.

See also [Example 7-7](#).

bzip2


An alternate compression utility, usually more efficient (but slower) than **gzip**, especially on large files. The corresponding decompression command is **bunzip2**.

Similar to the **zcat** command, **bzcat** decompresses a *bzipped2-ed* file to `stdout`.

 Newer versions of [tar](#) have been patched with **bzip2** support.

compress, uncompress

This is an older, proprietary compression utility found in commercial UNIX distributions. The more efficient **gzip** has largely replaced it. Linux distributions generally include a **compress** workalike for compatibility, although **gunzip** can unarchive files treated with **compress**.

 The **znew** command transforms *compressed* files into *gzipped* ones.

sq

Yet another compression ([squeeze](#)) utility, a filter that works only on sorted [ASCII](#) word lists. It uses the standard invocation syntax for a filter, **sq < input-file > output-file**. Fast, but not nearly as efficient as [gzip](#). The corresponding uncompression filter is **unsq**, invoked like **sq**.

 The output of **sq** may be piped to **gzip** for further compression.

zip, unzip

Cross-platform file archiving and compression utility compatible with DOS *pkzip.exe*. "Zipped" archives seem to be a more common medium of file exchange on the Internet than "tarballs."

unarc, unarj, unrar

These Linux utilities permit unpacking archives compressed with the DOS *arc.exe*, *arj.exe*, and *rar.exe* programs.

lzma, unlzma, lzcat

Highly efficient Lempel-Ziv-Markov compression. The syntax of *lzma* is similar to that of *gzip*. The [7-zip Website](#) has more information.

xz, unxz, xzcat

A new high-efficiency compression tool, backward compatible with *lzma*, and with an invocation syntax similar to *gzip*. For more information, see the [Wikipedia entry](#).

File Information

file

A utility for identifying file types. The command **file file-name** will return a file specification for file-name, such as `ascii text` or `data`. It references the [magic numbers](#) found in `/usr/share/magic`, `/etc/magic`, or `/usr/lib/magic`, depending on the Linux/UNIX distribution.

The `-f` option causes **file** to run in [batch](#) mode, to read from a designated file a list of filenames to analyze. The `-z` option, when used on a compressed target file, forces an attempt to analyze the uncompressed file type.

```
bash$ file test.tar.gz
test.tar.gz: gzip compressed data, deflated,
last modified: Sun Sep 16 13:34:51 2001, os: Unix

bash file -z test.tar.gz
test.tar.gz: GNU tar archive (gzip compressed data, deflated,
last modified: Sun Sep 16 13:34:51 2001, os: Unix)
```

```
1 # Find sh and Bash scripts in a given directory:
2
3 DIRECTORY=/usr/local/bin
4 KEYWORD=Bourne
5 # Bourne and Bourne-Again shell scripts
6
7 file $DIRECTORY/* | fgrep $KEYWORD
8
9 # Output:
10
11 # /usr/local/bin/burn-cd:          Bourne-Again shell script text executable
12 # /usr/local/bin/burnit:         Bourne-Again shell script text executable
13 # /usr/local/bin/cassette.sh:    Bourne shell script text executable
14 # /usr/local/bin/copy-cd:       Bourne-Again shell script text executable
15 # . . .
```

Example 16-32. Stripping comments from C program files

```
1 #!/bin/bash
2 # strip-comment.sh: Strips out the comments (/* COMMENT */) in a C program.
3
4 E_NOARGS=0
5 E_ARGERROR=66
6 E_WRONG_FILE_TYPE=67
7
8 if [ $# -eq "$E_NOARGS" ]
9 then
10  echo "Usage: `basename $0` C-program-file" >&2 # Error message to stderr.
11  exit $E_ARGERROR
12 fi
13
14 # Test for correct file type.
15 type=`file $1 | awk '{ print $2, $3, $4, $5 }'`
16 # "file $1" echoes file type . . .
17 # Then awk removes the first field, the filename . . .
18 # Then the result is fed into the variable "type."
19 correct_type="ASCII C program text"
20
21 if [ "$type" != "$correct_type" ]
22 then
23  echo
24  echo "This script works on C program files only."
25  echo
```

```

26  exit $E_WRONG_FILE_TYPE
27  fi
28
29
30  # Rather cryptic sed script:
31  #-----
32  sed '
33  /^\\/*/d
34  /.\\*\\*\\/d
35  ' $1
36  #-----
37  # Easy to understand if you take several hours to learn sed fundamentals.
38
39
40  # Need to add one more line to the sed script to deal with
41  #+ case where line of code has a comment following it on same line.
42  # This is left as a non-trivial exercise.
43
44  # Also, the above code deletes non-comment lines with a "*" . . .
45  #+ not a desirable result.
46
47  exit 0
48
49
50  # -----
51  # Code below this line will not execute because of 'exit 0' above.
52
53  # Stephane Chazelas suggests the following alternative:
54
55  usage() {
56    echo "Usage: `basename $0` C-program-file" >&2
57    exit 1
58  }
59
60  WEIRD=`echo -n -e '\\377'` # or WEIRD='${\\377}'
61  [[ $# -eq 1 ]] || usage
62  case `file "$1" ` in
63    *"C program text"*) sed -e "s%\\*%${WEIRD}%g;s%\\*%/${WEIRD}%g" "$1" \
64      | tr '\\377\\n' '\\n\\377' \\
65      | sed -ne 'p;n' \\
66      | tr -d '\\n' | tr '\\377' '\\n';;
67    *) usage;;
68  esac
69
70  # This is still fooled by things like:
71  # printf("/");
72  # or
73  # /* /* buggy embedded comment */
74  #
75  # To handle all special cases (comments in strings, comments in string
76  #+ where there is a "\", \\\" ...),
77  #+ the only way is to write a C parser (using lex or yacc perhaps?).
78
79  exit 0

```

which

which command gives the full path to "command." This is useful for finding out whether a particular command or utility is installed on the system.

\$bash which rm

```
/usr/bin/rm
```

For an interesting use of this command, see [Example 36-16](#).

whereis

Similar to **which**, above, **whereis** command gives the full path to "command," but also to its [manpage](#).

```
$bash whereis rm
```

```
rm: /bin/rm /usr/share/man/man1/rm.1.bz2
```

whatis

whatis command looks up "command" in the *whatis* database. This is useful for identifying system commands and important configuration files. Consider it a simplified **man** command.

```
$bash whatis whatis
```

```
whatis (1) - search the whatis database for complete words
```

Example 16-33. Exploring /usr/X11R6/bin

```
1 #!/bin/bash
2
3 # What are all those mysterious binaries in /usr/X11R6/bin?
4
5 DIRECTORY="/usr/X11R6/bin"
6 # Try also "/bin", "/usr/bin", "/usr/local/bin", etc.
7
8 for file in $DIRECTORY/*
9 do
10  whatis `basename $file` # Echoes info about the binary.
11 done
12
13 exit 0
14
15 # Note: For this to work, you must create a "whatis" database
16 #+ with /usr/sbin/makewhatis.
17 # You may wish to redirect output of this script, like so:
18 # ./what.sh >>whatis.db
19 # or view it a page at a time on stdout,
20 # ./what.sh | less
```

See also [Example 11-3](#).

vdir

Show a detailed directory listing. The effect is similar to [ls -lb](#).

This is one of the GNU *fileutils*.

```
bash$ vdir
total 10
-rw-r--r--  1 bozo  bozo    4034 Jul 18 22:04 data1.xrolo
-rw-r--r--  1 bozo  bozo    4602 May 25 13:58 data1.xrolo.bak
-rw-r--r--  1 bozo  bozo     877 Dec 17  2000 employment.xrolo

bash ls -l
total 10
-rw-r--r--  1 bozo  bozo    4034 Jul 18 22:04 data1.xrolo
-rw-r--r--  1 bozo  bozo    4602 May 25 13:58 data1.xrolo.bak
-rw-r--r--  1 bozo  bozo     877 Dec 17  2000 employment.xrolo
```

locate, slocate

The **locate** command searches for files using a database stored for just that purpose. The **slocate** command is the secure version of **locate** (which may be aliased to **slocate**).

```
$bash locate hickson
```

```
/usr/lib/xephem/catalogs/hickson.edb
```

getfacl, setfacl

These commands *retrieve* or *set* the **file access control list** -- the *owner*, *group*, and file permissions.

```
bash$ getfacl *
# file: test1.txt
# owner: bozo
# group: bozgrp
user::rw-
group::rw-
other::r--

# file: test2.txt
# owner: bozo
# group: bozgrp
user::rw-
group::rw-
other::r--

bash$ setfacl -m u:bozo:rw yearly_budget.csv
bash$ getfacl yearly_budget.csv
# file: yearly_budget.csv
# owner: accountant
# group: budgetgrp
user::rw-
user:bozo:rw-
user:accountant:rw-
group::rw-
mask::rw-
other::r--
```

readlink

Disclose the file that a symbolic link points to.

```
bash$ readlink /usr/bin/awk
../../bin/gawk
```

strings

Use the **strings** command to find printable strings in a binary or data file. It will list sequences of printable characters found in the target file. This might be handy for a quick 'n dirty examination of a core dump or for looking at an unknown graphic image file (**strings image-file | more** might show something like *JFIF*, which would identify the file as a *jpeg* graphic). In a script, you would probably parse the output of **strings** with **grep** or **sed**. See [Example 11-8](#) and [Example 11-10](#).

Example 16-34. An "improved" strings command

```
1 #!/bin/bash
2 # wstrings.sh: "word-strings" (enhanced "strings" command)
3 #
4 # This script filters the output of "strings" by checking it
5 #+ against a standard word list file.
6 # This effectively eliminates gibberish and noise,
```



Comparison

diff, patch

diff: flexible file comparison utility. It compares the target files line-by-line sequentially. In some applications, such as comparing word dictionaries, it may be helpful to filter the files through [sort](#) and **uniq** before piping them to **diff**. **diff file-1 file-2** outputs the lines in the files that differ, with carets showing which file each particular line belongs to.

The `--side-by-side` option to **diff** outputs each compared file, line by line, in separate columns, with non-matching lines marked. The `-c` and `-u` options likewise make the output of the command easier to interpret.

There are available various fancy frontends for **diff**, such as **sdiff**, **wdiff**, **xdiff**, and **mgdiff**.

 The **diff** command returns an exit status of 0 if the compared files are identical, and 1 if they differ (or 2 when *binary* files are being compared). This permits use of **diff** in a test construct within a shell script (see below).


A common use for **diff** is generating difference files to be used with **patch**. The `-e` option outputs files suitable for **ed** or **ex** scripts.

patch: flexible versioning utility. Given a difference file generated by **diff**, **patch** can upgrade a previous version of a package to a newer version. It is much more convenient to distribute a relatively small "diff" file than the entire body of a newly revised package. Kernel "patches" have become the preferred method of distributing the frequent releases of the Linux kernel.

```
1 patch -p1 <patch-file
2 # Takes all the changes listed in 'patch-file'
3 # and applies them to the files referenced therein.
4 # This upgrades to a newer version of the package.
```


Patching the kernel:

```
1 cd /usr/src
2 gzip -cd patchXX.gz | patch -p0
3 # Upgrading kernel source using 'patch'.
4 # From the Linux kernel docs "README",
5 # by anonymous author (Alan Cox?).
```

 The **diff** command can also recursively compare directories (for the filenames present).

```
bash$ diff -r ~/notes1 ~/notes2
Only in /home/bozo/notes1: file02
Only in /home/bozo/notes1: file03
Only in /home/bozo/notes2: file04
```

 Use **zdiff** to compare *gzipped* files.

 Use **diffstat** to create a histogram (point-distribution graph) of output from **diff**.

diff3, merge

An extended version of **diff** that compares three files at a time. This command returns an exit value of 0 upon successful execution, but unfortunately this gives no information about the results of the comparison.

```
bash$ diff3 file-1 file-2 file-3
====
1:1c
   This is line 1 of "file-1".
2:1c
   This is line 1 of "file-2".
3:1c
   This is line 1 of "file-3"
```

The **merge** (3-way file merge) command is an interesting adjunct to *diff3*. Its syntax is **merge Mergefile file1 file2**. The result is to output to *Mergefile* the changes that lead from *file1* to *file2*. Consider this command a stripped-down version of *patch*.

sdiff

Compare and/or edit two files in order to merge them into an output file. Because of its interactive nature, this command would find little use in a script.

cmp

The **cmp** command is a simpler version of **diff**, above. Whereas **diff** reports the differences between two files, **cmp** merely shows at what point they differ.




Like **diff**, **cmp** returns an exit status of 0 if the compared files are identical, and 1 if they differ. This permits use in a test construct within a shell script.

Example 16-35. Using *cmp* to compare two files within a script.

```
1 #!/bin/bash
2 # file-comparison.sh
3
4 ARGS=2 # Two args to script expected.
5 E_BADARGS=85
6 E_UNREADABLE=86
7
8 if [ $# -ne "$ARGS" ]
9 then
10  echo "Usage: `basename $0` file1 file2"
11  exit $E_BADARGS
12 fi
13
14 if [[ ! -r "$1" || ! -r "$2" ]]
15 then
16  echo "Both files to be compared must exist and be readable."
17  exit $E_UNREADABLE
18 fi
19
20 cmp $1 $2 &> /dev/null
21 #   Redirection to /dev/null buries the output of the "cmp" command.
22 #   cmp -s $1 $2 has same result ("-s" silent flag to "cmp")
23 #   Thank you Anders Gustavsson for pointing this out.
24 #
25 #   Also works with 'diff', i.e.,
26 #+ diff $1 $2 &> /dev/null
27
28 if [ $? -eq 0 ]           # Test exit status of "cmp" command.
29 then
30  echo "File \"$1\" is identical to file \"$2\"."
31 else
32  echo "File \"$1\" differs from file \"$2\"."
```

```
33 fi
34
35 exit 0
```

 Use **zcmp** on *gzipped* files.

comm

Versatile file comparison utility. The files must be sorted for this to be useful.

comm *-options first-file second-file*

comm file-1 file-2 outputs three columns:

- ◇ column 1 = lines unique to *file-1*
- ◇ column 2 = lines unique to *file-2*
- ◇ column 3 = lines common to both.

The options allow suppressing output of one or more columns.

- ◇ -1 suppresses column 1
- ◇ -2 suppresses column 2
- ◇ -3 suppresses column 3
- ◇ -12 suppresses both columns 1 and 2, etc.

This command is useful for comparing "dictionaries" or *word lists* -- sorted text files with one word per line.

Utilities


basename

Strips the path information from a file name, printing only the file name. The construction **basename \$0** lets the script know its name, that is, the name it was invoked by. This can be used for "usage" messages if, for example a script is called with missing arguments:

```
1 echo "Usage: `basename $0` arg1 arg2 ... argn"
```

dirname

Strips the **basename** from a filename, printing only the path information.

 **basename** and **dirname** can operate on any arbitrary string. The argument does not need to refer to an existing file, or even be a filename for that matter (see [Example A-7](#)).

Example 16-36. *basename* and *dirname*

```
1 #!/bin/bash
2
3 address=/home/bozo/daily-journal.txt
4
5 echo "Basename of /home/bozo/daily-journal.txt = `basename $address`"
6 echo "Dirname of /home/bozo/daily-journal.txt = `dirname $address`"
7 echo
8 echo "My own home is `basename ~/`."          # `basename ~` also works.
9 echo "The home of my home is `dirname ~/`."  # `dirname ~` also works.
10
11 exit 0
```

split, csplit

These are utilities for splitting a file into smaller chunks. Their usual use is for splitting up large files in order to back them up on floppies or preparatory to e-mailing or uploading them.

The **csplit** command splits a file according to *context*, the split occurring where patterns are matched.

Example 16-37. A script that copies itself in sections

```
1 #!/bin/bash
2 # splitcopy.sh
3
4 # A script that splits itself into chunks,
5 #+ then reassembles the chunks into an exact copy
6 #+ of the original script.
7
8 CHUNKSIZE=4      # Size of first chunk of split files.
9 OUTPREFIX=xx     # csplit prefixes, by default,
10                  #+ files with "xx" ...
11
12 csplit "$0" "$CHUNKSIZE"
13
14 # Some comment lines for padding . . .
15 # Line 15
16 # Line 16
17 # Line 17
18 # Line 18
19 # Line 19
20 # Line 20
21
22 cat "$OUTPREFIX"* > "$0.copy" # Concatenate the chunks.
23 rm "$OUTPREFIX"*             # Get rid of the chunks.
24
25 exit $?
```

Encoding and Encryption

sum, cksum, md5sum, sha1sum

These are utilities for generating *checksums*. A *checksum* is a number [\[3\]](#) mathematically calculated from the contents of a file, for the purpose of checking its integrity. A script might refer to a list of checksums for security purposes, such as ensuring that the contents of key system files have not been altered or corrupted. For security applications, use the **md5sum** (**m**essage **d**igest **5** **c**heck**s**um) command, or better yet, the newer **sha1sum** (Secure Hash Algorithm). [\[4\]](#)

```
bash$ cksum /boot/vmlinuz
1670054224 804083 /boot/vmlinuz

bash$ echo -n "Top Secret" | cksum
3391003827 10

bash$ md5sum /boot/vmlinuz
0f43eccea8f09e0a0b2b5cf1dcf333ba /boot/vmlinuz

bash$ echo -n "Top Secret" | md5sum
8babc97a6f62a4649716f4df8d61728f -
```



The **cksum** command shows the size, in bytes, of its target, whether file or stdout.

The **md5sum** and **sha1sum** commands display a [dash](#) when they receive their input from stdout.

Example 16-38. Checking file integrity

```
1 #!/bin/bash
2 # file-integrity.sh: Checking whether files in a given directory
3 #                       have been tampered with.
4
5 E_DIR_NOMATCH=80
6 E_BAD_DBFILE=81
7
8 dbfile=File_record.md5
9 # Filename for storing records (database file).
10
11
12 set_up_database ()
13 {
14     echo "$directory" > "$dbfile"
15     # Write directory name to first line of file.
16     md5sum "$directory"/* >> "$dbfile"
17     # Append md5 checksums and filenames.
18 }
19
20 check_database ()
21 {
22     local n=0
23     local filename
24     local checksum
25
26     # ----- #
27     # This file check should be unnecessary,
28     #+ but better safe than sorry.
29
30     if [ ! -r "$dbfile" ]
31     then
32         echo "Unable to read checksum database file!"
33         exit $E_BAD_DBFILE
34     fi
35     # ----- #
36
37     while read record[n]
38     do
39
40         directory_checked="${record[0]}"
41         if [ "$directory_checked" != "$directory" ]
42         then
43             echo "Directories do not match up!"
44             # Tried to use file for a different directory.
45             exit $E_DIR_NOMATCH
46         fi
47
48         if [ "$n" -gt 0 ] # Not directory name.
49         then
50             filename[n]=$( echo ${record[$n]} | awk '{ print $2 }' )
51             # md5sum writes records backwards,
52             #+ checksum first, then filename.
53             checksum[n]=$( md5sum "${filename[n]}" )
54
55
56             if [ "${record[n]}" = "${checksum[n]}" ]
57             then
58                 echo "${filename[n]} unchanged."
```

```

59
60     elif [ "`basename ${filename[n]}`" != "$dbfile" ]
61         # Skip over checksum database file,
62         #+ as it will change with each invocation of script.
63         # ---
64         # This unfortunately means that when running
65         #+ this script on $PWD, tampering with the
66         #+ checksum database file will not be detected.
67         # Exercise: Fix this.
68     then
69         echo "${filename[n]} : CHECKSUM ERROR!"
70         # File has been changed since last checked.
71     fi
72
73     fi
74
75
76
77     let "n+=1"
78 done <"$dbfile"          # Read from checksum database file.
79
80 }
81
82 # ===== #
83 # main ()
84
85 if [ -z "$1" ]
86 then
87     directory="$PWD"      # If not specified,
88 else
89     directory="$1"        #+ use current working directory.
90 fi
91
92 clear                    # Clear screen.
93 echo " Running file integrity check on $directory"
94 echo
95
96 # ----- #
97 if [ ! -r "$dbfile" ] # Need to create database file?
98 then
99     echo "Setting up database file, \"$directory\"/\"$dbfile\".\""; echo
100     set_up_database
101 fi
102 # ----- #
103
104 check_database          # Do the actual work.
105
106 echo
107
108 # You may wish to redirect the stdout of this script to a file,
109 #+ especially if the directory checked has many files in it.
110
111 exit 0
112
113 # For a much more thorough file integrity check,
114 #+ consider the "Tripwire" package,
115 #+ http://sourceforge.net/projects/tripwire/.

```

Also see [Example A-19](#), [Example 36-16](#), and [Example 10-2](#) for creative uses of the **md5sum** command.



There have been reports that the 128-bit **md5sum** can be cracked, so the more secure 160-bit **sha1sum** is a welcome new addition to the checksum toolkit.

```

bash$ md5sum testfile
e181e2c8720c60522c4c4c981108e367  testfile

bash$ shasum testfile
5d7425a9c08a66c3177f1e31286fa40986ffc996  testfile

```

Security consultants have demonstrated that even **sha1sum** can be compromised. Fortunately, newer Linux distros include longer bit-length **sha224sum**, **sha256sum**, **sha384sum**, and **sha512sum** commands.

uuencode

This utility encodes binary files (images, sound files, compressed files, etc.) into [ASCII](#) characters, making them suitable for transmission in the body of an e-mail message or in a newsgroup posting. This is especially useful where MIME (multimedia) encoding is not available.

uudecode


This reverses the encoding, decoding *uencoded* files back into the original binaries.

Example 16-39. Uudecoding encoded files

```

1 #!/bin/bash
2 # Uudecodes all uencoded files in current working directory.
3
4 lines=35          # Allow 35 lines for the header (very generous).
5
6 for File in *    # Test all the files in $PWD.
7 do
8     search1=`head -n $lines $File | grep begin | wc -w`
9     search2=`tail -n $lines $File | grep end | wc -w`
10    # Uencoded files have a "begin" near the beginning,
11    #+ and an "end" near the end.
12    if [ "$search1" -gt 0 ]
13    then
14        if [ "$search2" -gt 0 ]
15        then
16            echo "uudecoding - $File -"
17            uudecode $File
18        fi
19    fi
20 done
21
22 # Note that running this script upon itself fools it
23 #+ into thinking it is a uencoded file,
24 #+ because it contains both "begin" and "end".
25
26 # Exercise:
27 # -----
28 # Modify this script to check each file for a newsgroup header,
29 #+ and skip to next if not found.
30
31 exit 0

```

 The [fold -s](#) command may be useful (possibly in a pipe) to process long uudecoded text messages downloaded from Usenet newsgroups.

mimencode, mmencode

The **mimencode** and **mmencode** commands process multimedia-encoded e-mail attachments. Although *mail user agents* (such as *pine* or *kmail*) normally handle this automatically, these particular utilities permit manipulating such attachments manually from the command-line or in [batch processing mode](#) by means of a shell script.

crypt

At one time, this was the standard UNIX file encryption utility. [5] Politically-motivated government regulations prohibiting the export of encryption software resulted in the disappearance of **crypt** from much of the UNIX world, and it is still missing from most Linux distributions. Fortunately, programmers have come up with a number of decent alternatives to it, among them the author's very own **cruft** (see [Example A-4](#)).

openssl

This is an Open Source implementation of *Secure Sockets Layer* encryption.

```
1 # To encrypt a file:
2 openssl aes-128-ecb -salt -in file.txt -out file.encrypted \
3 -pass pass:my_password
4 #          ^^^^^^^^^^^ User-selected password.
5 #          aes-128-ecb   is the encryption method chosen.
6
7 # To decrypt an openssl-encrypted file:
8 openssl aes-128-ecb -d -salt -in file.encrypted -out file.txt \
9 -pass pass:my_password
10 #          ^^^^^^^^^^^ User-selected password.
```

[Piping openssl to/from tar](#) makes it possible to encrypt an entire directory tree.

```
1 # To encrypt a directory:
2
3 sourcedir="/home/bozo/testfiles"
4 encrfile="encr-dir.tar.gz"
5 password=my_secret_password
6
7 tar czvf - "$sourcedir" |
8 openssl des3 -salt -out "$encrfile" -pass pass:"$password"
9 #          ^^^^ Uses des3 encryption.
10 # Writes encrypted file "encr-dir.tar.gz" in current working directory.
11
12 # To decrypt the resulting tarball:
13 openssl des3 -d -salt -in "$encrfile" -pass pass:"$password" |
14 tar -xzv
15 # Decrypts and unpacks into current working directory.
```

Of course, *openssl* has many other uses, such as obtaining signed *certificates* for Web sites. See the [info](#) page.

shred

Securely erase a file by overwriting it multiple times with random bit patterns before deleting it. This command has the same effect as [Example 16-61](#), but does it in a more thorough and elegant manner.

This is one of the GNU *fileutils*.



Advanced forensic technology may still be able to recover the contents of a file, even after application of **shred**.

Miscellaneous

mktemp

Create a *temporary file* [6] with a "unique" filename. When invoked from the command-line without additional arguments, it creates a zero-length file in the `/tmp` directory.

```
bash$ mktemp
/tmp/tmp.zzsvql3154
```

```
1 PREFIX=filename
2 tempfile=`mktemp $PREFIX.XXXXXX`
3 #          ^^^^^^ Need at least 6 placeholders
```

```

4 #+                               in the filename template.
5 #   If no filename template supplied,
6 #+ "tmp.XXXXXXXXXX" is the default.
7
8 echo "tempfile name = $tempfile"
9 # tempfile name = filename.QA2ZpY
10 #           or something similar...
11
12 #   Creates a file of that name in the current working directory
13 #+ with 600 file permissions.
14 #   A "umask 177" is therefore unnecessary,
15 #+ but it's good programming practice nevertheless.

```

make

Utility for building and compiling binary packages. This can also be used for any set of operations triggered by incremental changes in source files.

The *make* command checks a Makefile, a list of file dependencies and operations to be carried out.

The *make* utility is, in effect, a powerful scripting language similar in many ways to *Bash*, but with the capability of recognizing *dependencies*. For in-depth coverage of this useful tool set, see the [GNU software documentation site](#).

install

Special purpose file copying command, similar to [cp](#), but capable of setting permissions and attributes of the copied files. This command seems tailored for installing software packages, and as such it shows up frequently in Makefiles (in the *make install* : section). It could likewise prove useful in installation scripts.

dos2unix

This utility, written by Benjamin Lin and collaborators, converts DOS-formatted text files (lines terminated by CR-LF) to UNIX format (lines terminated by LF only), and [vice-versa](#).

ptx

The **ptx [targetfile]** command outputs a permuted index (cross-reference list) of the targetfile. This may be further filtered and formatted in a pipe, if necessary.

more, less

Pagers that display a text file or stream to `stdout`, one screenful at a time. These may be used to filter the output of `stdout` . . . or of a script.

An interesting application of *more* is to "test drive" a command sequence, to forestall potentially unpleasant consequences.

```

1 ls /home/bozo | awk '{print "rm -rf " $1}' | more
2 #                               ^^^^
3
4 # Testing the effect of the following (disastrous) command-line:
5 #   ls /home/bozo | awk '{print "rm -rf " $1}' | sh
6 #   Hand off to the shell to execute . . .   ^^

```

The *less* pager has the interesting property of doing a formatted display of *man page* source. See [Example A-39](#).

Notes

- [1] An *archive*, in the sense discussed here, is simply a set of related files stored in a single location.
- [2] A `tar czvf ArchiveName.tar.gz *` will include dotfiles in subdirectories *below* the current working directory. This is an undocumented GNU **tar** "feature."
- [3] The checksum may be expressed as a *hexadecimal* number, or to some other base.
- [4] For even *better* security, use the `sha256sum`, `sha512`, and `sh1pass` commands.

[5] This is a symmetric block cipher, used to encrypt files on a single system or local network, as opposed to the *public key* cipher class, of which *pgp* is a well-known example.

[6] Creates a temporary *directory* when invoked with the `-d` option.

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Communications Commands

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16.6. Communications Commands

Certain of the following commands find use in network data transfer and analysis, as well as in [chasing spammers](#).

Information and Statistics

host

Searches for information about an Internet host by name or IP address, using DNS.

```
bash$ host surfacemail.com
surfacemail.com. has address 202.92.42.236
```

ipcalc

Displays IP information for a host. With the `-h` option, **ipcalc** does a reverse DNS lookup, finding the name of the host (server) from the IP address.

```
bash$ ipcalc -h 202.92.42.236
HOSTNAME=surfacemail.com
```

nslookup

Do an Internet "name server lookup" on a host by IP address. This is essentially equivalent to **ipcalc -h** or **dig -x**. The command may be run either interactively or noninteractively, i.e., from within a script.

The **nslookup** command has allegedly been "deprecated," but it is still useful.

```
bash$ nslookup -sil 66.97.104.180
nslookup kuhleersparnis.ch
Server:          135.116.137.2
Address:         135.116.137.2#53

Non-authoritative answer:
Name:   kuhleersparnis.ch
```

dig

Domain Information Groper. Similar to **nslookup**, *dig* does an Internet *name server lookup* on a host. May be run from the command-line or from within a script.

Some interesting options to *dig* are `+time=N` for setting a query timeout to *N* seconds, `+nofail` for continuing to query servers until a reply is received, and `-x` for doing a reverse address lookup.

Compare the output of **dig -x** with **ipcalc -h** and **nslookup**.

```
bash$ dig -x 81.9.6.2
;; Got answer:
;; -->HEADER<<- opcode: QUERY, status: NXDOMAIN, id: 11649
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 0

;; QUESTION SECTION:
;2.6.9.81.in-addr.arpa.      IN      PTR

;; AUTHORITY SECTION:
6.9.81.in-addr.arpa.      3600   IN      SOA     ns.eltel.net. noc.eltel.net.
2002031705 900 600 86400 3600

;; Query time: 537 msec
;; SERVER: 135.116.137.2#53(135.116.137.2)
```

```
;; WHEN: Wed Jun 26 08:35:24 2002
;; MSG SIZE rcvd: 91
```

Example 16-40. Finding out where to report a spammer

```
1 #!/bin/bash
2 # spam-lookup.sh: Look up abuse contact to report a spammer.
3 # Thanks, Michael Zick.
4
5 # Check for command-line arg.
6 ARGCOUNT=1
7 E_WRONGARGS=85
8 if [ $# -ne "$ARGCOUNT" ]
9 then
10  echo "Usage: `basename $0` domain-name"
11  exit $E_WRONGARGS
12 fi
13
14
15 dig +short $1.contacts.abuse.net -c in -t txt
16 # Also try:
17 #     dig +nssearch $1
18 #     Tries to find "authoritative name servers" and display SOA records.
19
20 # The following also works:
21 #     whois -h whois.abuse.net $1
22 #     ^^ ^^^^^^^^^^^^^^^^^^^ Specify host.
23 #     Can even lookup multiple spammers with this, i.e."
24 #     whois -h whois.abuse.net $spamdomain1 $spamdomain2 . . .
25
26
27 # Exercise:
28 # -----
29 # Expand the functionality of this script
30 #+ so that it automatically e-mails a notification
31 #+ to the responsible ISP's contact address(es).
32 # Hint: use the "mail" command.
33
34 exit $?
35
36 # spam-lookup.sh chinatietong.com
37 #     A known spam domain.
38
39 # "crnet_mgr@chinatietong.com"
40 # "crnet_tec@chinatietong.com"
41 # "postmaster@chinatietong.com"
42
43
44 # For a more elaborate version of this script,
45 #+ see the SpamViz home page, http://www.spamviz.net/index.html.
```

Example 16-41. Analyzing a spam domain

```
1 #! /bin/bash
2 # is-spammer.sh: Identifying spam domains
3
4 # $Id: is-spammer, v 1.4 2004/09/01 19:37:52 mszick Exp $
5 # Above line is RCS ID info.
6 #
```

```

7 # This is a simplified version of the "is_spammer.bash
8 #+ script in the Contributed Scripts appendix.
9
10 # is-spammer <domain.name>
11
12 # Uses an external program: 'dig'
13 # Tested with version: 9.2.4rc5
14
15 # Uses functions.
16 # Uses IFS to parse strings by assignment into arrays.
17 # And even does something useful: checks e-mail blacklists.
18
19 # Use the domain.name(s) from the text body:
20 # http://www.good_stuff.spammer.biz/just_ignore_everything_else
21 #          ^^^^^^^^^^^^^^^
22 # Or the domain.name(s) from any e-mail address:
23 # Really_Good_Offer@spammer.biz
24 #
25 # as the only argument to this script.
26 # (PS: have your Inet connection running)
27 #
28 # So, to invoke this script in the above two instances:
29 #     is-spammer.sh spammer.biz
30
31
32 # Whitespace == :Space:Tab:Line Feed:Carriage Return:
33 WSP_IFS=$'\x20'\x09'\x0A'\x0D'
34
35 # No Whitespace == Line Feed:Carriage Return
36 No_WSP=$'\x0A'\x0D'
37
38 # Field separator for dotted decimal ip addresses
39 ADR_IFS=${No_WSP}'.'
40
41 # Get the dns text resource record.
42 # get_txt <error_code> <list_query>
43 get_txt() {
44
45     # Parse $1 by assignment at the dots.
46     local -a dns
47     IFS=$ADR_IFS
48     dns=( $1 )
49     IFS=$WSP_IFS
50     if [ "${dns[0]}" == '127' ]
51     then
52         # See if there is a reason.
53         echo $(dig +short $2 -t txt)
54     fi
55 }
56
57 # Get the dns address resource record.
58 # chk_adr <rev_dns> <list_server>
59 chk_adr() {
60     local reply
61     local server
62     local reason
63
64     server=${1}${2}
65     reply=$( dig +short ${server} )
66
67     # If reply might be an error code . . .
68     if [ ${#reply} -gt 6 ]
69     then
70         reason=$(get_txt ${reply} ${server} )
71         reason=${reason:-${reply}}
72     fi

```

```

73     echo ${reason:-' not blacklisted.'}
74 }
75
76 # Need to get the IP address from the name.
77 echo 'Get address of: '$1
78 ip_adr=$(dig +short $1)
79 dns_reply=${ip_adr:-' no answer '}
80 echo ' Found address: '${dns_reply}
81
82 # A valid reply is at least 4 digits plus 3 dots.
83 if [ ${#ip_adr} -gt 6 ]
84 then
85     echo
86     declare query
87
88     # Parse by assignment at the dots.
89     declare -a dns
90     IFS=$ADR_IFS
91     dns=( ${ip_adr} )
92     IFS=$WSP_IFS
93
94     # Reorder octets into dns query order.
95     rev_dns="${dns[3]}"."${dns[2]}"."${dns[1]}"."${dns[0]}".
96
97 # See: http://www.spamhaus.org (Conservative, well maintained)
98 echo -n 'spamhaus.org says: '
99 echo $(chk_adr ${rev_dns} 'sbl-xbl.spamhaus.org')
100
101 # See: http://ordb.org (Open mail relays)
102 echo -n ' ordb.org says: '
103 echo $(chk_adr ${rev_dns} 'relays.ordb.org')
104
105 # See: http://www.spamcop.net/ (You can report spammers here)
106 echo -n ' spamcop.net says: '
107 echo $(chk_adr ${rev_dns} 'bl.spamcop.net')
108
109 # # # other blacklist operations # # #
110
111 # See: http://cbl.abuseat.org.
112 echo -n ' abuseat.org says: '
113 echo $(chk_adr ${rev_dns} 'cbl.abuseat.org')
114
115 # See: http://dsbl.org/usage (Various mail relays)
116 echo
117 echo 'Distributed Server Listings'
118 echo -n ' list.dsbl.org says: '
119 echo $(chk_adr ${rev_dns} 'list.dsbl.org')
120
121 echo -n ' multihop.dsbl.org says: '
122 echo $(chk_adr ${rev_dns} 'multihop.dsbl.org')
123
124 echo -n 'unconfirmed.dsbl.org says: '
125 echo $(chk_adr ${rev_dns} 'unconfirmed.dsbl.org')
126
127 else
128     echo
129     echo 'Could not use that address.'
130 fi
131
132 exit 0
133
134 # Exercises:
135 # -----
136
137 # 1) Check arguments to script,
138 #     and exit with appropriate error message if necessary.

```

```

139
140 # 2) Check if on-line at invocation of script,
141 #     and exit with appropriate error message if necessary.
142
143 # 3) Substitute generic variables for "hard-coded" BHL domains.
144
145 # 4) Set a time-out for the script using the "+time=" option
146     to the 'dig' command.

```

For a much more elaborate version of the above script, see [Example A-28](#).

traceroute

Trace the route taken by packets sent to a remote host. This command works within a LAN, WAN, or over the Internet. The remote host may be specified by an IP address. The output of this command may be filtered by [grep](#) or [sed](#) in a pipe.

```

bash$ traceroute 81.9.6.2
traceroute to 81.9.6.2 (81.9.6.2), 30 hops max, 38 byte packets
 1  tc43.xjbnnbrb.com (136.30.178.8)  191.303 ms  179.400 ms  179.767 ms
 2  or0.xjbnnbrb.com (136.30.178.1)  179.536 ms  179.534 ms  169.685 ms
 3  192.168.11.101 (192.168.11.101)  189.471 ms  189.556 ms  *
...

```

ping

Broadcast an *ICMP ECHO_REQUEST* packet to another machine, either on a local or remote network. This is a diagnostic tool for testing network connections, and it should be used with caution.

```

bash$ ping localhost
PING localhost.localdomain (127.0.0.1) from 127.0.0.1 : 56(84) bytes of data.
64 bytes from localhost.localdomain (127.0.0.1): icmp_seq=0 ttl=255 time=709 usec
64 bytes from localhost.localdomain (127.0.0.1): icmp_seq=1 ttl=255 time=286 usec

--- localhost.localdomain ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max/mdev = 0.286/0.497/0.709/0.212 ms

```

A successful *ping* returns an [exit status](#) of 0. This can be tested for in a script.

```

1  HNAME=news-15.net # Notorious spammer.
2  # HNAME=$HOST     # Debug: test for localhost.
3  count=2 # Send only two pings.
4
5  if [[ `ping -c $count "$HNAME"` ]]
6  then
7    echo "$HNAME" still up and broadcasting spam your way."
8  else
9    echo "$HNAME" seems to be down. Pity."
10 fi

```

whois

Perform a DNS (Domain Name System) lookup. The `-h` option permits specifying which particular *whois* server to query. See [Example 4-6](#) and [Example 16-40](#).

finger

Retrieve information about users on a network. Optionally, this command can display a user's `~/ .plan`, `~/ .project`, and `~/ .forward` files, if present.

```

bash$ finger
Login  Name           Tty      Idle  Login Time   Office   Office Phone
bozo   Bozo Bozeman   tty1     8    Jun 25 16:59   (:0)
bozo   Bozo Bozeman   tty0     Jun 25 16:59   (:0.0)
bozo   Bozo Bozeman   tty1     Jun 25 17:07   (:0.0)

```

```
bash$ finger bozo
Login: bozo                               Name: Bozo Bozeman
Directory: /home/bozo                     Shell: /bin/bash
Office: 2355 Clown St., 543-1234
On since Fri Aug 31 20:13 (MST) on tty1    1 hour 38 minutes idle
On since Fri Aug 31 20:13 (MST) on pts/0   12 seconds idle
On since Fri Aug 31 20:13 (MST) on pts/1
On since Fri Aug 31 20:31 (MST) on pts/2   1 hour 16 minutes idle
Mail last read Tue Jul  3 10:08 2007 (MST)
No Plan.
```

Out of security considerations, many networks disable **finger** and its associated daemon. [\[1\]](#)

chfn

Change information disclosed by the **finger** command.

vrfy

Verify an Internet e-mail address.

This command seems to be missing from newer Linux distros.

Remote Host Access

sx, rx

The **sx** and **rx** command set serves to transfer files to and from a remote host using the *xmodem* protocol. These are generally part of a communications package, such as **minicom**.

sz, rz

The **sz** and **rz** command set serves to transfer files to and from a remote host using the *zmodem* protocol. *Zmodem* has certain advantages over *xmodem*, such as faster transmission rate and resumption of interrupted file transfers. Like **sx** and **rx**, these are generally part of a communications package.

ftp

Utility and protocol for uploading / downloading files to or from a remote host. An ftp session can be automated in a script (see [Example 19-6](#) and [Example A-4](#)).

uucp, uux, cu

uucp: *UNIX to UNIX copy*. This is a communications package for transferring files between UNIX servers. A shell script is an effective way to handle a **uucp** command sequence.


Since the advent of the Internet and e-mail, **uucp** seems to have faded into obscurity, but it still exists and remains perfectly workable in situations where an Internet connection is not available or appropriate. The advantage of **uucp** is that it is fault-tolerant, so even if there is a service interruption the copy operation will resume where it left off when the connection is restored.

uux: *UNIX to UNIX execute*. Execute a command on a remote system. This command is part of the **uucp** package.

cu: **Call Up** a remote system and connect as a simple terminal. It is a sort of dumbed-down version of [telnet](#). This command is part of the **uucp** package.

telnet

Utility and protocol for connecting to a remote host.

 The *telnet* protocol contains security holes and should therefore probably be avoided. Its use within a shell script is *not* recommended.

wget

The **wget** utility *noninteractively* retrieves or downloads files from a Web or ftp site. It works well in a script.

```
1 wget -p http://www.xyz23.com/file01.html
2 # The -p or --page-requisite option causes wget to fetch all files
3 #+ required to display the specified page.
4
5 wget -r ftp://ftp.xyz24.net/~bozo/project_files/ -O $SAVEFILE
6 # The -r option recursively follows and retrieves all links
7 #+ on the specified site.
8
9 wget -c ftp://ftp.xyz25.net/bozofiles/filename.tar.bz2
10 # The -c option lets wget resume an interrupted download.
11 # This works with ftp servers and many HTTP sites.
```

Example 16-42. Getting a stock quote

```
1 #!/bin/bash
2 # quote-fetch.sh: Download a stock quote.
3
4
5 E_NOPARAMS=86
6
7 if [ -z "$1" ] # Must specify a stock (symbol) to fetch.
8   then echo "Usage: `basename $0` stock-symbol"
9   exit $E_NOPARAMS
10 fi
11
12 stock_symbol=$1
13
14 file_suffix=.html
15 # Fetches an HTML file, so name it appropriately.
16 URL='http://finance.yahoo.com/q?s='
17 # Yahoo finance board, with stock query suffix.
18
19 # -----
20 wget -O "${stock_symbol}${file_suffix}" "${URL}${stock_symbol}"
21 # -----
22
23
24 # To look up stuff on http://search.yahoo.com:
25 # -----
26 # URL="http://search.yahoo.com/search?fr=ush-news&p=${query}"
27 # wget -O "$savefilename" "${URL}"
28 # -----
29 # Saves a list of relevant URLs.
30
31 exit $?
32
33 # Exercises:
34 # -----
35 #
36 # 1) Add a test to ensure the user running the script is on-line.
37 #     (Hint: parse the output of 'ps -ax' for "ppp" or "connect.")
38 #
39 # 2) Modify this script to fetch the local weather report,
40 #+ taking the user's zip code as an argument.
```

See also [Example A-30](#) and [Example A-31](#).

lynx

The **lynx** Web and file browser can be used inside a script (with the `-dump` option) to retrieve a file from a Web or ftp site noninteractively.

```
1 lynx -dump http://www.xyz23.com/file01.html >${SAVEFILE}
```

With the `-traversal` option, **lynx** starts at the HTTP URL specified as an argument, then "crawls" through all links located on that particular server. Used together with the `-crawl` option, outputs page text to a log file.

rlogin

Remote login, initiates a session on a remote host. This command has security issues, so use [ssh](#) instead.

rsh

Remote shell, executes command(s) on a remote host. This has security issues, so use **ssh** instead.

rcp

Remote copy, copies files between two different networked machines.

rsync

Remote synchronize, updates (synchronizes) files between two different networked machines.

```
bash$ rsync -a ~/sourcedir/*.txt /node1/subdirectory/
```

Example 16-43. Updating FC4

```
1 #!/bin/bash
2 # fc4upd.sh
3
4 # Script author: Frank Wang.
5 # Slight stylistic modifications by ABS Guide author.
6 # Used in ABS Guide with permission.
7
8
9 # Download Fedora Core 4 update from mirror site using rsync.
10 # Should also work for newer Fedora Cores -- 5, 6, . . .
11 # Only download latest package if multiple versions exist,
12 #+ to save space.
13
14 URL=rsync://distro.ibiblio.org/fedora-linux-core/updates/
15 # URL=rsync://ftp.kddilabs.jp/fedora/core/updates/
16 # URL=rsync://rsync.planetmirror.com/fedora-linux-core/updates/
17
18 DEST=${1:-/var/www/html/fedora/updates/}
19 LOG=/tmp/repo-update-$(/bin/date +%Y-%m-%d).txt
20 PID_FILE=/var/run/${0##*/}.pid
21
22 E_RETURN=85          # Something unexpected happened.
23
24
25 # General rsync options
26 # -r: recursive download
27 # -t: reserve time
28 # -v: verbose
29
30 OPTS="-rtv --delete-excluded --delete-after --partial"
31
32 # rsync include pattern
33 # Leading slash causes absolute path name match.
34 INCLUDE=(
```



```

35     "/4/i386/kde-i18n-Chinese*"
36 #   ^                               ^
37 # Quoting is necessary to prevent globbing.
38 )
39
40
41 # rsync exclude pattern
42 # Temporarily comment out unwanted pkgs using "#" . . .
43 EXCLUDE=(
44     /1
45     /2
46     /3
47     /testing
48     /4/SRPMS
49     /4/ppc
50     /4/x86_64
51     /4/i386/debug
52     "/4/i386/kde-i18n-*"
53     "/4/i386/openoffice.org-langpack-*"
54     "/4/i386/*i586.rpm"
55     "/4/i386/GFS-*"
56     "/4/i386/cman-*"
57     "/4/i386/dlm-*"
58     "/4/i386/gnbd-*"
59     "/4/i386/kernel-smp*"
60 #   "/4/i386/kernel-xen*"
61 #   "/4/i386/xen-*"
62 )
63
64
65 init () {
66     # Let pipe command return possible rsync error, e.g., stalled network.
67     set -o pipefail                               # Newly introduced in Bash, version 3.
68
69     TMP=${TMPDIR:-/tmp}/${0##*/}.$$ # Store refined download list.
70     trap "{
71         rm -f $TMP 2>/dev/null
72     }" EXIT # Clear temporary file on exit.
73 }
74
75
76 check_pid () {
77 # Check if process exists.
78     if [ -s "$PID_FILE" ]; then
79         echo "PID file exists. Checking ..."
80         PID=$(/bin/egrep -o "^[[:digit:]]+" $PID_FILE)
81         if /bin/ps --pid $PID &>/dev/null; then
82             echo "Process $PID found. ${0##*/} seems to be running!"
83             /usr/bin/logger -t ${0##*/} \
84                 "Process $PID found. ${0##*/} seems to be running!"
85             exit $E_RETURN
86         fi
87         echo "Process $PID not found. Start new process . . ."
88     fi
89 }
90
91
92 # Set overall file update range starting from root or $URL,
93 #+ according to above patterns.
94 set_range () {
95     include=
96     exclude=
97     for p in "${INCLUDE[@]}"; do
98         include="$include --include \"$p\" "
99     done
100

```

```

101     for p in "${EXCLUDE[@]}; do
102         exclude="$exclude --exclude \"$p\""
103     done
104 }
105
106
107 # Retrieve and refine rsync update list.
108 get_list () {
109     echo $$ > $PID_FILE || {
110         echo "Can't write to pid file $PID_FILE"
111         exit $E_RETURN
112     }
113
114     echo -n "Retrieving and refining update list . . ."
115
116     # Retrieve list -- 'eval' is needed to run rsync as a single command.
117     # $3 and $4 is the date and time of file creation.
118     # $5 is the full package name.
119     previous=
120     pre_file=
121     pre_date=0
122     eval /bin/nice /usr/bin/rsync \
123         -r $include $exclude $URL | \
124         egrep '^dr.x|^-r' | \
125         awk '{print $3, $4, $5}' | \
126         sort -k3 | \
127         { while read line; do
128             # Get seconds since epoch, to filter out obsolete pkgs.
129             cur_date=$(date -d "$(echo $line | awk '{print $1, $2}')" +%s)
130             # echo $cur_date
131
132             # Get file name.
133             cur_file=$(echo $line | awk '{print $3}')
134             # echo $cur_file
135
136             # Get rpm pkg name from file name, if possible.
137             if [[ $cur_file == *rpm ]]; then
138                 pkg_name=$(echo $cur_file | sed -r -e \
139                     's/^(^[_-]+[_-]+)[[:digit:]]+\.\.*[_-].*$/\1/')
140             else
141                 pkg_name=
142             fi
143             # echo $pkg_name
144
145             if [ -z "$pkg_name" ]; then # If not a rpm file,
146                 echo $cur_file >> $TMP #+ then append to download list.
147             elif [ "$pkg_name" != "$previous" ]; then # A new pkg found.
148                 echo $pre_file >> $TMP # Output latest file.
149                 previous=$pkg_name # Save current.
150                 pre_date=$cur_date
151                 pre_file=$cur_file
152             elif [ "$cur_date" -gt "$pre_date" ]; then
153                 # If same pkg, but newer,
154                 pre_date=$cur_date #+ then update latest pointer.
155                 pre_file=$cur_file
156             fi
157             done
158             echo $pre_file >> $TMP # TMP contains ALL
159                                 #+ of refined list now.
160             # echo "subshell=$BASH_SUBSHELL"
161         }
162     } # Bracket required here to let final "echo $pre_file >> $TMP"
163     # Remained in the same subshell ( 1 ) with the entire loop.
164
165     RET=$? # Get return code of the pipe command.
166

```

```

167     [ "$RET" -ne 0 ] && {
168         echo "List retrieving failed with code $RET"
169         exit $E_RETURN
170     }
171
172     echo "done"; echo
173 }
174
175 # Real rsync download part.
176 get_file () {
177
178     echo "Downloading..."
179     /bin/nice /usr/bin/rsync \
180         $OPTS \
181         --filter "merge,+/ $TMP" \
182         --exclude '*' \
183         $URL $DEST \
184         | /usr/bin/tee $LOG
185
186     RET=$?
187
188     # --filter merge,+/ is crucial for the intention.
189     # + modifier means include and / means absolute path.
190     # Then sorted list in $TMP will contain ascending dir name and
191     #+ prevent the following --exclude '*' from "shortcutting the circuit."
192
193     echo "Done"
194
195     rm -f $PID_FILE 2>/dev/null
196
197     return $RET
198 }
199
200 # -----
201 # Main
202 init
203 check_pid
204 set_range
205 get_list
206 get_file
207 RET=$?
208 # -----
209
210 if [ "$RET" -eq 0 ]; then
211     /usr/bin/logger -t ${0##*/} "Fedora update mirrored successfully."
212 else
213     /usr/bin/logger -t ${0##*/} \
214         "Fedora update mirrored with failure code: $RET"
215 fi
216
217 exit $RET

```

See also [Example A-32](#).



Using [rcp](#), [rsync](#), and similar utilities with security implications in a shell script may not be advisable. Consider, instead, using [ssh](#), [scp](#), or an **expect** script.


ssh

Secure shell, logs onto a remote host and executes commands there. This secure replacement for **telnet**, **rlogin**, **rcp**, and **rsh** uses identity authentication and encryption. See its [manpage](#) for details.

Example 16-44. Using *ssh*

```
1 #!/bin/bash
2 # remote.bash: Using ssh.
3
4 # This example by Michael Zick.
5 # Used with permission.
6
7
8 #   Presumptions:
9 #   -----
10 #   fd-2 isn't being captured ( '2>/dev/null' ).
11 #   ssh/sshd presumes stderr ('2') will display to user.
12 #
13 #   sshd is running on your machine.
14 #   For any 'standard' distribution, it probably is,
15 #+ and without any funky ssh-keygen having been done.
16
17 # Try ssh to your machine from the command-line:
18 #
19 # $ ssh $HOSTNAME
20 # Without extra set-up you'll be asked for your password.
21 #   enter password
22 #   when done, $ exit
23 #
24 # Did that work? If so, you're ready for more fun.
25
26 # Try ssh to your machine as 'root':
27 #
28 #   $ ssh -l root $HOSTNAME
29 #   When asked for password, enter root's, not yours.
30 #           Last login: Tue Aug 10 20:25:49 2004 from localhost.localdomain
31 #   Enter 'exit' when done.
32
33 # The above gives you an interactive shell.
34 # It is possible for sshd to be set up in a 'single command' mode,
35 #+ but that is beyond the scope of this example.
36 # The only thing to note is that the following will work in
37 #+ 'single command' mode.
38
39
40 # A basic, write stdout (local) command.
41
42 ls -l
43
44 # Now the same basic command on a remote machine.
45 # Pass a different 'USERNAME' 'HOSTNAME' if desired:
46 USER=${USERNAME:-$(whoami)}
47 HOST=${HOSTNAME:-$(hostname)}
48
49 # Now excute the above command-line on the remote host,
50 #+ with all transmissions encrypted.
51
52 ssh -l ${USER} ${HOST} " ls -l "
53
54 # The expected result is a listing of your username's home
55 #+ directory on the remote machine.
56 # To see any difference, run this script from somewhere
57 #+ other than your home directory.
58
59 # In other words, the Bash command is passed as a quoted line
60 #+ to the remote shell, which executes it on the remote machine.
61 # In this case, sshd does ' bash -c "ls -l" ' on your behalf.
62
63 # For information on topics such as not having to enter a
64 #+ password/passphrase for every command-line, see
65 #+ man ssh
66 #+ man ssh-keygen
```

```
67 #+    man sshd_config.
68
69 exit 0
```

 Within a loop, **ssh** may cause unexpected behavior. According to a [Usenet post](#) in the comp.unix shell archives, **ssh** inherits the loop's `stdin`. To remedy this, pass **ssh** either the `-n` or `-f` option.

Thanks, Jason Bechtel, for pointing this out.

scp

Secure copy, similar in function to **rcp**, copies files between two different networked machines, but does so using authentication, and with a security level similar to **ssh**.

Local Network

write

This is a utility for terminal-to-terminal communication. It allows sending lines from your terminal (console or *xterm*) to that of another user. The [mesg](#) command may, of course, be used to disable write access to a terminal

Since **write** is interactive, it would not normally find use in a script.

netconfig

A command-line utility for configuring a network adapter (using *DHCP*). This command is native to Red Hat centric Linux distros.

Mail

mail

Send or read e-mail messages.

This stripped-down command-line mail client works fine as a command embedded in a script.

Example 16-45. A script that mails itself

```
1 #!/bin/sh
2 # self-mailer.sh: Self-mailing script
3
4 adr=${1:-`whoami`}      # Default to current user, if not specified.
5 # Typing 'self-mailer.sh wiseguy@superdupergenius.com'
6 #+ sends this script to that addressee.
7 # Just 'self-mailer.sh' (no argument) sends the script
8 #+ to the person invoking it, for example, bozo@localhost.localdomain.
9 #
10 # For more on the ${parameter:-default} construct,
11 #+ see the "Parameter Substitution" section
12 #+ of the "Variables Revisited" chapter.
13
14 # =====
15 cat $0 | mail -s "Script \"`basename $0`\" has mailed itself to you." "$adr"
16 # =====
17
18 # -----
19 # Greetings from the self-mailing script.
20 # A mischievous person has run this script,
21 #+ which has caused it to mail itself to you.
22 # Apparently, some people have nothing better
23 #+ to do with their time.
```

```
24 # -----
25
26 echo "At `date`, script \"`basename $0`\" mailed to \"$adr\"."
27
28 exit 0
29
30 # Note that the "mailx" command (in "send" mode) may be substituted
31 #+ for "mail" ... but with somewhat different options.
```

mailto

Similar to the **mail** command, **mailto** sends e-mail messages from the command-line or in a script. However, **mailto** also permits sending MIME (multimedia) messages.

mailstats

Show *mail statistics*. This command may be invoked only by *root*.

```
root# mailstats
Statistics from Tue Jan  1 20:32:08 2008
 M  msgsfr  bytes_from  msgsto  bytes_to  msgsrej  msgsdis  msgsqur  Mailer
 4   1682    24118K      0         0K         0         0         0  esmtp
 9    212     640K      1894    25131K         0         0         0  local
-----
 T   1894    24758K      1894    25131K         0         0         0
 C    414         0
```

vacation

This utility automatically replies to e-mails that the intended recipient is on vacation and temporarily unavailable. It runs on a network, in conjunction with **sendmail**, and is not applicable to a dial-up POPmail account.

Notes

[1]

A *daemon* is a background process not attached to a terminal session. Daemons perform designated services either at specified times or explicitly triggered by certain events.

The word "daemon" means ghost in Greek, and there is certainly something mysterious, almost supernatural, about the way UNIX daemons wander about behind the scenes, silently carrying out their appointed tasks.

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16.7. Terminal Control Commands

Command affecting the console or terminal

tput

Initialize terminal and/or fetch information about it from terminfo data. Various options permit certain terminal operations: **tput clear** is the equivalent of [clear](#); **tput reset** is the equivalent of [reset](#).

```
bash$ tput longname
xterm terminal emulator (X Window System)
```

Issuing a **tput cup X Y** moves the cursor to the (X,Y) coordinates in the current terminal. A **clear** to erase the terminal screen would normally precede this.

Some interesting options to *tput* are:

- ◇ **bold**, for high-intensity text
- ◇ **smul**, to underline text in the terminal
- ◇ **sms0**, to render text in reverse
- ◇ **sgr0**, to reset the terminal parameters (to normal), without clearing the screen

Example scripts using *tput*:

1. [Example 36-15](#)
2. [Example 36-13](#)
3. [Example A-44](#)
4. [Example A-42](#)
5. [Example 27-2](#)

Note that [stty](#) offers a more powerful command set for controlling a terminal.

infocmp

This command prints out extensive information about the current terminal. It references the *terminfo* database.

```
bash$ infocmp
#       Reconstructed via infocmp from file:
/usr/share/terminfo/r/rxvt
rxvt|rxvt terminal emulator (X Window System),
    am, bce, eo, km, mir, msgr, xenl, xon,
    colors#8, cols#80, it#8, lines#24, pairs#64,
    acsc=``aaffggjjkkllmmnnooppqrrssttuuvvwxxyyz{|}|}~~,
    bel=^G, blink=\E[5m, bold=\E[1m,
    civis=\E[?25l,
    clear=\E[H\E[2J, cnorm=\E[?25h, cr=^M,
    ...
```

reset

Reset terminal parameters and clear text screen. As with **clear**, the cursor and prompt reappear in the upper lefthand corner of the terminal.

clear

The **clear** command simply clears the text screen at the console or in an *xterm*. The prompt and cursor reappear at the upper lefthand corner of the screen or *xterm* window. This command may be used either at the command line or in a script. See [Example 11-26](#).

resize

Echoes commands necessary to set `$TERM` and `$TERMCAP` to duplicate the *size* (dimensions) of the current terminal.

```
bash$ resize
set noglob;
setenv COLUMNS '80';
setenv LINES '24';
unset noglob;
```

script

This utility records (saves to a file) all the user keystrokes at the command-line in a console or an xterm window. This, in effect, creates a record of a session.

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16.8. Math Commands

"Doing the numbers"

factor

Decompose an integer into prime factors.

```
bash$ factor 27417
27417: 3 13 19 37
```

Example 16-46. Generating prime numbers

```
1 #!/bin/bash
2 # primes2.sh
3
4 # Generating prime numbers the quick-and-easy way,
5 #+ without resorting to fancy algorithms.
6
7 CEILING=10000 # 1 to 10000
8 PRIME=0
9 E_NOTPRIME=
10
11 is_prime ()
12 {
13     local factors
14     factors=( $(factor $1) ) # Load output of `factor` into array.
15
16     if [ -z "${factors[2]}" ]
17     # Third element of "factors" array:
18     #+ ${factors[2]} is 2nd factor of argument.
19     # If it is blank, then there is no 2nd factor,
20     #+ and the argument is therefore prime.
21     then
22         return $PRIME # 0
23     else
24         return $E_NOTPRIME # null
25     fi
26 }
27
28 echo
29 for n in $(seq $CEILING)
30 do
31     if is_prime $n
32     then
33         printf %5d $n
34     fi # ^ Five positions per number suffices.
35 done # For a higher $CEILING, adjust upward, as necessary.
36
37 echo
38
39 exit
```

bc

Bash can't handle floating point calculations, and it lacks operators for certain important mathematical functions. Fortunately, **bc** gallops to the rescue.

Not just a versatile, arbitrary precision calculation utility, **bc** offers many of the facilities of a programming language. It has a syntax vaguely resembling C.

Since it is a fairly well-behaved UNIX utility, and may therefore be used in a [pipe](#), `bc` comes in handy in scripts.

Here is a simple template for using `bc` to calculate a script variable. This uses [command substitution](#).

```
variable=$(echo "OPTIONS; OPERATIONS" | bc)
```

Example 16-47. Monthly Payment on a Mortgage

```
1 #!/bin/bash
2 # monthlypmt.sh: Calculates monthly payment on a mortgage.
3
4
5 # This is a modification of code in the
6 ## "mcalc" (mortgage calculator) package,
7 ## by Jeff Schmidt
8 ## and
9 ## Mendel Cooper (yours truly, the ABS Guide author).
10 # http://www.ibiblio.org/pub/Linux/apps/financial/mcalc-1.6.tar.gz
11
12 echo
13 echo "Given the principal, interest rate, and term of a mortgage,"
14 echo "calculate the monthly payment."
15
16 bottom=1.0
17
18 echo
19 echo -n "Enter principal (no commas) "
20 read principal
21 echo -n "Enter interest rate (percent) " # If 12%, enter "12", not ".12".
22 read interest_r
23 echo -n "Enter term (months) "
24 read term
25
26
27 interest_r=$(echo "scale=9; $interest_r/100.0" | bc) # Convert to decimal.
28 # ^^^^^^^^^^^^^^^^^^^^^^^^^ Divide by 100.
29 # "scale" determines how many decimal places.
30
31 interest_rate=$(echo "scale=9; $interest_r/12 + 1.0" | bc)
32
33
34 top=$(echo "scale=9; $principal*$interest_rate^$term" | bc)
35 # ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
36 # Standard formula for figuring interest.
37
38 echo; echo "Please be patient. This may take a while."
39
40 let "months = $term - 1"
41 # =====
42 for ((x=$months; x > 0; x--))
43 do
44     bot=$(echo "scale=9; $interest_rate^$x" | bc)
45     bottom=$(echo "scale=9; $bottom+$bot" | bc)
46 # bottom = (($bottom + $bot))
47 done
48 # =====
49
50 # -----
51 # Rick Boivie pointed out a more efficient implementation
```

```

52 #+ of the above loop, which decreases computation time by 2/3.
53
54 # for ((x=1; x <= $months; x++))
55 # do
56 #     bottom=$(echo "scale=9; $bottom * $interest_rate + 1" | bc)
57 # done
58
59
60 # And then he came up with an even more efficient alternative,
61 #+ one that cuts down the run time by about 95%!
62
63 # bottom={`
64 #     echo "scale=9; bottom=$bottom; interest_rate=$interest_rate"
65 #     for ((x=1; x <= $months; x++))
66 #     do
67 #         echo 'bottom = bottom * interest_rate + 1'
68 #     done
69 #     echo 'bottom'
70 #     } | bc`      # Embeds a 'for loop' within command substitution.
71 # -----
72 # On the other hand, Frank Wang suggests:
73 # bottom=$(echo "scale=9; ($interest_rate^$term-1)/($interest_rate-1)" | bc)
74
75 # Because . . .
76 # The algorithm behind the loop
77 #+ is actually a sum of geometric proportion series.
78 # The sum formula is  $e_0(1-q^n)/(1-q)$ ,
79 #+ where  $e_0$  is the first element and  $q=e(n+1)/e(n)$ 
80 #+ and  $n$  is the number of elements.
81 # -----
82
83
84 # let "payment = $top/$bottom"
85 payment=$(echo "scale=2; $top/$bottom" | bc)
86 # Use two decimal places for dollars and cents.
87
88 echo
89 echo "monthly payment = \$$payment" # Echo a dollar sign in front of amount.
90 echo
91
92
93 exit 0
94
95
96 # Exercises:
97 # 1) Filter input to permit commas in principal amount.
98 # 2) Filter input to permit interest to be entered as percent or decimal.
99 # 3) If you are really ambitious,
100 #+ expand this script to print complete amortization tables.

```

Example 16-48. Base Conversion

```

1 #!/bin/bash
2 #####
3 # Shellscript:      base.sh - print number to different bases (Bourne Shell)
4 # Author           :      Heiner Steven (heiner.steven@odn.de)
5 # Date             :      07-03-95
6 # Category         :      Desktop
7 # $Id: base.sh,v 1.2 2000/02/06 19:55:35 heiner Exp $
8 # ==> Above line is RCS ID info.
9 #####
10 # Description

```

```

11 #
12 # Changes
13 # 21-03-95 stv      fixed error occuring with 0xb as input (0.2)
14 #####
15
16 # ==> Used in ABS Guide with the script author's permission.
17 # ==> Comments added by ABS Guide author.
18
19 NOARGS=85
20 PN=`basename "$0"`          # Program name
21 VER=`echo '$Revision: 1.2 $' | cut -d' ' -f2` # ==> VER=1.2
22
23 Usage () {
24     echo "$PN - print number to different bases, $VER (stv '95)
25 usage: $PN [number ...]
26
27 If no number is given, the numbers are read from standard input.
28 A number may be
29     binary (base 2)          starting with 0b (i.e. 0b1100)
30     octal (base 8)          starting with 0   (i.e. 014)
31     hexadecimal (base 16)   starting with 0x (i.e. 0xc)
32     decimal                 otherwise (i.e. 12)" >&2
33     exit $NOARGS
34 } # ==> Prints usage message.
35
36 Msg () {
37     for i # ==> in [list] missing. Why?
38     do echo "$PN: $i" >&2
39     done
40 }
41
42 Fatal () { Msg "$@"; exit 66; }
43
44 PrintBases () {
45     # Determine base of the number
46     for i # ==> in [list] missing...
47     do # ==> so operates on command-line arg(s).
48     case "$i" in
49         0b*)          ibase=2;;          # binary
50         0x*|[a-f]*|[A-F]*) ibase=16;;    # hexadecimal
51         0*)           ibase=8;;         # octal
52         [1-9]*)       ibase=10;;       # decimal
53         *)
54             Msg "illegal number $i - ignored"
55             continue;;
56     esac
57
58     # Remove prefix, convert hex digits to uppercase (bc needs this).
59     number=`echo "$i" | sed -e 's:^0[bBxX]::' | tr '[a-f]' '[A-F]'`
60     # ==> Uses ":" as sed separator, rather than "/".
61
62     # Convert number to decimal
63     dec=`echo "ibase=$ibase; $number" | bc` # ==> 'bc' is calculator utility.
64     case "$dec" in
65         [0-9]*)      ;;                # number ok
66         *)           continue;;       # error: ignore
67     esac
68
69     # Print all conversions in one line.
70     # ==> 'here document' feeds command list to 'bc'.
71     echo `bc <<!
72         obase=16; "hex="; $dec
73         obase=10; "dec="; $dec
74         obase=8;  "oct="; $dec
75         obase=2;  "bin="; $dec
76 !

```

```

77     ` | sed -e 's: :      :g'
78
79     done
80 }
81
82 while [ $# -gt 0 ]
83 # ==> Is a "while loop" really necessary here,
84 # ==>+ since all the cases either break out of the loop
85 # ==>+ or terminate the script.
86 # ==> (Above comment by Paulo Marcel Coelho Aragao.)
87 do
88     case "$1" in
89     --)      shift; break;;
90     -h)      Usage;;                # ==> Help message.
91     -*)      Usage;;
92     *)      break;;                # First number
93     esac    # ==> Error checking for illegal input might be appropriate.
94     shift
95 done
96
97 if [ $# -gt 0 ]
98 then
99     PrintBases "$@"
100 else
101                                     # Read from stdin.
102     while read line
103     do
104         PrintBases $line
105     done
106 fi
107
108 exit

```

An alternate method of invoking **bc** involves using a [here document](#) embedded within a [command substitution](#) block. This is especially appropriate when a script needs to pass a list of options and commands to **bc**.

```

1 variable=`bc << LIMIT_STRING
2 options
3 statements
4 operations
5 LIMIT_STRING
6 `
7
8 ...or...
9
10
11 variable=$(bc << LIMIT_STRING
12 options
13 statements
14 operations
15 LIMIT_STRING
16 )

```

Example 16-49. Invoking *bc* using a *here document*

```

1 #!/bin/bash
2 # Invoking 'bc' using command substitution
3 # in combination with a 'here document'.
4
5

```

```

6 var1=`bc << EOF
7 18.33 * 19.78
8 EOF
9 `
10 echo $var1          # 362.56
11
12
13 # $( ... ) notation also works.
14 v1=23.53
15 v2=17.881
16 v3=83.501
17 v4=171.63
18
19 var2=$(bc << EOF
20 scale = 4
21 a = ( $v1 + $v2 )
22 b = ( $v3 * $v4 )
23 a * b + 15.35
24 EOF
25 )
26 echo $var2          # 593487.8452
27
28
29 var3=$(bc -l << EOF
30 scale = 9
31 s ( 1.7 )
32 EOF
33 )
34 # Returns the sine of 1.7 radians.
35 # The "-l" option calls the 'bc' math library.
36 echo $var3          # .991664810
37
38
39 # Now, try it in a function...
40 hypotenuse ()      # Calculate hypotenuse of a right triangle.
41 {                  # c = sqrt( a^2 + b^2 )
42 hyp=$(bc -l << EOF
43 scale = 9
44 sqrt ( $1 * $1 + $2 * $2 )
45 EOF
46 )
47 # Can't directly return floating point values from a Bash function.
48 # But, can echo-and-capture:
49 echo "$hyp"
50 }
51
52 hyp=$(hypotenuse 3.68 7.31)
53 echo "hypotenuse = $hyp"    # 8.184039344
54
55
56 exit 0

```

Example 16-50. Calculating PI

```

1 #!/bin/bash
2 # cannon.sh: Approximating PI by firing cannonballs.
3
4 # Author: Mendel Cooper
5 # License: Public Domain
6 # Version 2.2, reldate 13oct08.
7
8 # This is a very simple instance of a "Monte Carlo" simulation:

```

```

9  ## a mathematical model of a real-life event,
10 ## using pseudorandom numbers to emulate random chance.
11
12 #   Consider a perfectly square plot of land, 10000 units on a side.
13 #   This land has a perfectly circular lake in its center,
14 ## with a diameter of 10000 units.
15 #   The plot is actually mostly water, except for land in the four corners.
16 #   (Think of it as a square with an inscribed circle.)
17 #
18 #   We will fire iron cannonballs from an old-style cannon
19 ## at the square.
20 #   All the shots impact somewhere on the square,
21 ## either in the lake or on the dry corners.
22 #   Since the lake takes up most of the area,
23 ## most of the shots will SPLASH! into the water.
24 #   Just a few shots will THUD! into solid ground
25 ## in the four corners of the square.
26 #
27 #   If we take enough random, unaimed shots at the square,
28 ## Then the ratio of SPLASHES to total shots will approximate
29 ## the value of PI/4.
30 #
31 #   The simplified explanation is that the cannon is actually
32 ## shooting only at the upper right-hand quadrant of the square,
33 ## i.e., Quadrant I of the Cartesian coordinate plane.
34 #
35 #
36 #   Theoretically, the more shots taken, the better the fit.
37 #   However, a shell script, as opposed to a compiled language
38 ## with floating-point math built in, requires some compromises.
39 #   This decreases the accuracy of the simulation.
40
41
42 DIMENSION=10000 # Length of each side of the plot.
43                 # Also sets ceiling for random integers generated.
44
45 MAXSHOTS=1000   # Fire this many shots.
46                 # 10000 or more would be better, but would take too long.
47 PMULTIPLIER=4.0 # Scaling factor.
48
49 declare -r M_PI=3.141592654
50                 # Actual 9-place value of PI, for comparison purposes.
51
52 get_random ()
53 {
54 SEED=$(head -n 1 /dev/urandom | od -N 1 | awk '{ print $2 }')
55 RANDOM=$SEED      # From "seeding-random.sh"
56                 ##+ example script.
57 let "rnum = $RANDOM % $DIMENSION"      # Range less than 10000.
58 echo $rnum
59 }
60
61 distance=        # Declare global variable.
62 hypotenuse ()   # Calculate hypotenuse of a right triangle.
63 {               # From "alt-bc.sh" example.
64 distance=$(bc -l << EOF
65 scale = 0
66 sqrt ( $1 * $1 + $2 * $2 )
67 EOF
68 )
69 #   Setting "scale" to zero rounds down result to integer value,
70 ## a necessary compromise in this script.
71 #   It decreases the accuracy of this simulation.
72 }
73
74

```

```

75 # =====
76 # main() {
77 # "Main" code block, mimicking a C-language main() function.
78
79 # Initialize variables.
80 shots=0
81 splashes=0
82 thuds=0
83 Pi=0
84 error=0
85
86 while [ "$shots" -lt "$MAXSHOTS" ]           # Main loop.
87 do
88
89     xCoord=$(get_random)                       # Get random X and Y coords.
90     yCoord=$(get_random)
91     hypotenuse $xCoord $yCoord                 # Hypotenuse of
92                                             #+ right-triangle = distance.
93     ((shots++))
94
95     printf "%#4d  " $shots
96     printf "Xc = %4d  " $xCoord
97     printf "Yc = %4d  " $yCoord
98     printf "Distance = %5d  " $distance        # Distance from
99                                             #+ center of lake
100                                             #+ -- the "origin" --
101                                             #+ coordinate (0,0).
102
103     if [ "$distance" -le "$DIMENSION" ]
104     then
105         echo -n "SPLASH!  "
106         ((splashes++))
107     else
108         echo -n "THUD!    "
109         ((thuds++))
110     fi
111
112     Pi=$(echo "scale=9; $PMULTIPLIER*$splashes/$shots" | bc)
113     # Multiply ratio by 4.0.
114     echo -n "PI ~ $Pi"
115     echo
116
117 done
118
119 echo
120 echo "After $shots shots, PI looks like approximately  $Pi"
121 # Tends to run a bit high,
122 #+ possibly due to round-off error and imperfect randomness of $RANDOM.
123 # But still usually within plus-or-minus 5% . . .
124 #+ a pretty fair rough approximation.
125 error=$(echo "scale=9; $Pi - $M_PI" | bc)
126 pct_error=$(echo "scale=2; 100.0 * $error / $M_PI" | bc)
127 echo -n "Deviation from mathematical value of PI =      $error"
128 echo " ($pct_error% error)"
129 echo
130
131 # End of "main" code block.
132 # }
133 # =====
134
135 exit 0
136
137 # One might well wonder whether a shell script is appropriate for
138 #+ an application as complex and computation-intensive as a simulation.
139 #
140 # There are at least two justifications.

```



```
141 # 1) As a proof of concept: to show it can be done.
142 # 2) To prototype and test the algorithms before rewriting
143 #+ it in a compiled high-level language.
```

See also [Example A-37](#).

dc

The **dc** (desk calculator) utility is [stack-oriented](#) and uses RPN (*Reverse Polish Notation*). Like **bc**, it has much of the power of a programming language.

Similar to the procedure with **bc**, [echo](#) a command-string to **dc**.

```
1 echo "[Printing a string ... ]P" | dc
2 # The P command prints the string between the preceding brackets.
3
4 # And now for some simple arithmetic.
5 echo "7 8 * p" | dc      # 56
6 # Pushes 7, then 8 onto the stack,
7 #+ multiplies ("*" operator), then prints the result ("p" operator).
```

Most persons avoid **dc**, because of its non-intuitive input and rather cryptic operators. Yet, it has its uses.

Example 16-51. Converting a decimal number to hexadecimal

```
1 #!/bin/bash
2 # hexconvert.sh: Convert a decimal number to hexadecimal.
3
4 E_NOARGS=85 # Command-line arg missing.
5 BASE=16     # Hexadecimal.
6
7 if [ -z "$1" ]
8 then
9     echo "Usage: $0 number"
10    exit $E_NOARGS
11 fi
12
13
14 hexcvt ()
15 {
16     if [ -z "$1" ]
17     then
18         echo 0
19         return # "Return" 0 if no arg passed to function.
20     fi
21
22     echo "$1" "$BASE" o p" | dc
23 #
24 #         o sets radix (numerical base) of output.
25 #         p prints the top of stack.
26 # For other options: 'man dc' ...
27 return
28 }
29 hexcvt "$1"
30
31 exit
```

Studying the [info](#) page for **dc** is a painful path to understanding its intricacies. There seems to be a small, select group of *dc wizards* who delight in showing off their mastery of this powerful, but arcane utility.

```
bash$ echo "16i[q]sa[ln0=aln100%Pln100/snlbx]sbA0D68736142snlboxq" | dc
Bash
```

```
1 dc <<< 10k5v1+2/p # 1.6180339887
2 #   ^^^      Feed operations to dc using a Here String.
3 #     ^^^     Pushes 10 and sets that as the precision (10k).
4 #       ^^    Pushes 5 and takes its square root
5 #           (5v, v = square root).
6 #         ^^  Pushes 1 and adds it to the running total (1+).
7 #           ^^ Pushes 2 and divides the running total by that (2/).
8 #             ^ Pops and prints the result (p)
9 # The result is 1.6180339887 ...
10 # ... which happens to be the Pythagorean Golden Ratio, to 10 places.
```

Example 16-52. Factoring

```
1 #!/bin/bash
2 # factr.sh: Factor a number
3
4 MIN=2      # Will not work for number smaller than this.
5 E_NOARGS=85
6 E_TOOSMALL=86
7
8 if [ -z $1 ]
9 then
10  echo "Usage: $0 number"
11  exit $E_NOARGS
12 fi
13
14 if [ "$1" -lt "$MIN" ]
15 then
16  echo "Number to factor must be $MIN or greater."
17  exit $E_TOOSMALL
18 fi
19
20 # Exercise: Add type checking (to reject non-integer arg).
21
22 echo "Factors of $1:"
23 # -----
24 echo "$1[p]s2[lip/dli%0=1dvsvr]s12sid2%0=13sidvsvr[dli%0=\
25 1lrli2+dsi!>.]ds.xd1<2" | dc
26 # -----
27 # Above code written by Michel Charpentier <charpov@cs.unh.edu>
28 # (as a one-liner, here broken into two lines for display purposes).
29 # Used in ABS Guide with permission (thanks!).
30
31 exit
32
33 # $ sh factr.sh 270138
34 # 2
35 # 3
36 # 11
37 # 4093
```

awk

Yet another way of doing floating point math in a script is using [awk's](#) built-in math functions in a [shell wrapper](#).

Example 16-53. Calculating the hypotenuse of a triangle

```
1 #!/bin/bash
2 # hypotenuse.sh: Returns the "hypotenuse" of a right triangle.
3 #           (square root of sum of squares of the "legs")
4
5 ARGS=2           # Script needs sides of triangle passed.
6 E_BADARGS=85    # Wrong number of arguments.
7
8 if [ $# -ne "$ARGS" ] # Test number of arguments to script.
9 then
10  echo "Usage: `basename $0` side_1 side_2"
11  exit $E_BADARGS
12 fi
13
14
15 AWKSCRIPT=' { printf( "%3.7f\n", sqrt($1*$1 + $2*$2) ) } '
16 #           command(s) / parameters passed to awk
17
18
19 # Now, pipe the parameters to awk.
20  echo -n "Hypotenuse of $1 and $2 = "
21  echo $1 $2 | awk "$AWKSCRIPT"
22 #  ^^^^^^^^^^^^^
23 # An echo-and-pipe is an easy way of passing shell parameters to awk.
24
25 exit
26
27 # Exercise: Rewrite this script using 'bc' rather than awk.
28 #           Which method is more intuitive?
```

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16.9. Miscellaneous Commands

Command that fit in no special category

jot, seq

These utilities emit a sequence of integers, with a user-selectable increment.

The default separator character between each integer is a newline, but this can be changed with the `-s` option.

```
bash$ seq 5
1
2
3
4
5

bash$ seq -s : 5
1:2:3:4:5
```

Both `jot` and `seq` come in handy in a [for loop](#).

Example 16-54. Using `seq` to generate loop arguments

```
1 #!/bin/bash
2 # Using "seq"
3
4 echo
5
6 for a in `seq 80` # or for a in $( seq 80 )
7 # Same as for a in 1 2 3 4 5 ... 80 (saves much typing!).
8 # May also use 'jot' (if present on system).
9 do
10  echo -n "$a "
11 done # 1 2 3 4 5 ... 80
12 # Example of using the output of a command to generate
13 # the [list] in a "for" loop.
14
15 echo; echo
16
17
18 COUNT=80 # Yes, 'seq' also accepts a replaceable parameter.
19
20 for a in `seq $COUNT` # or for a in $( seq $COUNT )
21 do
22  echo -n "$a "
23 done # 1 2 3 4 5 ... 80
24
25 echo; echo
26
27 BEGIN=75
28 END=80
29
30 for a in `seq $BEGIN $END`
31 # Giving "seq" two arguments starts the count at the first one,
32 #+ and continues until it reaches the second.
33 do
34  echo -n "$a "
```

```

35 done          # 75 76 77 78 79 80
36
37 echo; echo
38
39 BEGIN=45
40 INTERVAL=5
41 END=80
42
43 for a in `seq $BEGIN $INTERVAL $END`
44 # Giving "seq" three arguments starts the count at the first one,
45 #+ uses the second for a step interval,
46 #+ and continues until it reaches the third.
47 do
48     echo -n "$a "
49 done          # 45 50 55 60 65 70 75 80
50
51 echo; echo
52
53 exit 0

```

A simpler example:

```

1 # Create a set of 10 files,
2 #+ named file.1, file.2 . . . file.10.
3 COUNT=10
4 PREFIX=file
5
6 for filename in `seq $COUNT`
7 do
8     touch $PREFIX.$filename
9     # Or, can do other operations,
10    #+ such as rm, grep, etc.
11 done

```

Example 16-55. Letter Count"

```


1 #!/bin/bash
2 # letter-count.sh: Counting letter occurrences in a text file.
3 # Written by Stefano Palmeri.
4 # Used in ABS Guide with permission.
5 # Slightly modified by document author.
6
7 MINARGS=2          # Script requires at least two arguments.
8 E_BADARGS=65
9 FILE=$1
10
11 let LETTERS=$#-1   # How many letters specified (as command-line args).
12                   # (Subtract 1 from number of command-line args.)
13
14
15 show_help(){
16     echo
17     echo Usage: `basename $0` file letters
18     echo Note: `basename $0` arguments are case sensitive.
19     echo Example: `basename $0` foobar.txt G n U L i N U x.
20     echo
21 }
22
23 # Checks number of arguments.
24 if [ $# -lt $MINARGS ]; then
25     echo
26     echo "Not enough arguments."
27     echo

```

```

28     show_help
29     exit $_BADARGS
30 fi
31
32
33 # Checks if file exists.
34 if [ ! -f $FILE ]; then
35     echo "File \"$FILE\" does not exist."
36     exit $_BADARGS
37 fi
38
39
40
41 # Counts letter occurrences .
42 for n in `seq $LETTERS`; do
43     shift
44     if [[ `echo -n "$1" | wc -c` -eq 1 ]]; then           # Checks arg.
45         echo "$1" -\> `cat $FILE | tr -cd "$1" | wc -c` # Counting.
46     else
47         echo "$1 is not a single char."
48     fi
49 done
50
51 exit $?
52
53 # This script has exactly the same functionality as letter-count2.sh,
54 #+ but executes faster.
55 # Why?

```

 Somewhat more capable than *seq*, **jot** is a classic UNIX utility that is not normally included in a standard Linux distro. However, the source *rpm* is available for download from the [MIT repository](#).

Unlike *seq*, **jot** can generate a sequence of random numbers, using the `-r` option.

```

bash$ jot -r 3 999
1069
1272
1428

```

getopt

The **getopt** command parses command-line options preceded by a [dash](#). This external command corresponds to the [getopts](#) Bash builtin. Using **getopt** permits handling long options by means of the `-l` flag, and this also allows parameter reshuffling.

Example 16-56. Using *getopt* to parse command-line options

```

1 #!/bin/bash
2 # Using getopt
3
4 # Try the following when invoking this script:
5 #   sh ex33a.sh -a
6 #   sh ex33a.sh -abc
7 #   sh ex33a.sh -a -b -c
8 #   sh ex33a.sh -d
9 #   sh ex33a.sh -dXYZ
10 #  sh ex33a.sh -d XYZ
11 #  sh ex33a.sh -abcd
12 #  sh ex33a.sh -abcdZ
13 #  sh ex33a.sh -z

```

```

14 #   sh ex33a.sh a
15 # Explain the results of each of the above.
16
17 E_OPTERR=65
18
19 if [ "$#" -eq 0 ]
20 then # Script needs at least one command-line argument.
21     echo "Usage $0 -[options a,b,c]"
22     exit $E_OPTERR
23 fi
24
25 set -- `getopt "abcd:" "$@"`
26 # Sets positional parameters to command-line arguments.
27 # What happens if you use "$*" instead of "$@"?
28
29 while [ ! -z "$1" ]
30 do
31     case "$1" in
32         -a) echo "Option \"a\"";;
33         -b) echo "Option \"b\"";;
34         -c) echo "Option \"c\"";;
35         -d) echo "Option \"d\" \"$2";;
36         *) break;;
37     esac
38
39     shift
40 done
41
42 # It is usually better to use the 'getopts' builtin in a script.
43 # See "ex33.sh."
44
45 exit 0

```



As *Peggy Russell* points out:

It is often necessary to include an [eval](#) to correctly process [whitespace](#) and *quotes*.

```

1 args=$(getopt -o a:bc:d -- "$@")
2 eval set -- "$args"

```

See [Example 10-5](#) for a simplified emulation of **getopt**.

run-parts

The **run-parts** command [\[1\]](#) executes all the scripts in a target directory, sequentially in ASCII-sorted filename order. Of course, the scripts need to have execute permission.

The [cron daemon](#) invokes **run-parts** to run the scripts in the `/etc/cron.*` directories.


yes


In its default behavior the **yes** command feeds a continuous string of the character `y` followed by a line feed to `stdout`. A **control-C** terminates the run. A different output string may be specified, as in **yes different string**, which would continually output `different string` to `stdout`.

One might well ask the purpose of this. From the command-line or in a script, the output of **yes** can be redirected or piped into a program expecting user input. In effect, this becomes a sort of poor man's version of *expect*.

yes | fsck /dev/hda1 runs **fsck** non-interactively (careful!).

yes | rm -r dirname has same effect as **rm -rf dirname** (careful!).

 Caution advised when piping `yes` to a potentially dangerous system command, such as `fsck` or `fdisk`. It might have unintended consequences.

 The `yes` command parses variables, or more accurately, it echoes parsed variables. For example:

```
bash$ yes $BASH_VERSION
3.1.17(1)-release
3.1.17(1)-release
3.1.17(1)-release
3.1.17(1)-release
3.1.17(1)-release
. . .
```

This particular "feature" may be used to create a *very large* ASCII file on the fly:

```
bash$ yes $PATH > huge_file.txt
Ct1-C
```

Hit **Ct1-C** *very quickly*, or you just might get more than you bargained for. . . .

The `yes` command may be emulated in a very simple script [function](#).

```
1 yes ()
2 { # Trivial emulation of "yes" ...
3   local DEFAULT_TEXT="y"
4   while [ true ] # Endless loop.
5   do
6     if [ -z "$1" ]
7     then
8       echo "$DEFAULT_TEXT"
9     else # If argument ...
10      echo "$1" # ... expand and echo it.
11    fi
12  done # The only things missing are the
13 } #+ --help and --version options.
```

banner

Prints arguments as a large vertical banner to `stdout`, using an [ASCII](#) character (default '#'). This may be redirected to a printer for hardcopy.

Note that `banner` has been dropped from many Linux distros, presumably because it is no longer considered useful.

printenv

Show all the [environmental variables](#) set for a particular user.

```
bash$ printenv | grep HOME
HOME=/home/bozo
```

lp

The `lp` and `lpr` commands send file(s) to the print queue, to be printed as hard copy. [\[2\]](#) These commands trace the origin of their names to the line printers of another era. [\[3\]](#)

```
bash$ lp file1.txt or bash lp <file1.txt
```

It is often useful to pipe the formatted output from `pr` to `lp`.

```
bash$ pr -options file1.txt | lp
```

Formatting packages, such as [groff](#) and *Ghostscript* may send their output directly to `lp`.

```
bash$ groff -Tascii file.tr | lp
```

```
bash$ gs -options | lp file.ps
```

Related commands are **lpq**, for viewing the print queue, and **lprm**, for removing jobs from the print queue.

tee

[UNIX borrows an idea from the plumbing trade.]

This is a redirection operator, but with a difference. Like the plumber's *tee*, it permits "siphoning off" to a file the output of a command or commands within a pipe, but without affecting the result. This is useful for printing an ongoing process to a file or paper, perhaps to keep track of it for debugging purposes.

```

                                (redirection)
                                |----> to file
                                |
=====|=====
command ---> command ---> |tee ---> command ---> ---> output of pipe
=====|=====
```

```
1 cat listfile* | sort | tee check.file | uniq > result.file
2 #
3
4 # The file "check.file" contains the concatenated sorted "listfiles,"
5 #+ before the duplicate lines are removed by 'uniq.'
```

mkfifo

This obscure command creates a *named pipe*, a temporary *first-in-first-out buffer* for transferring data between processes. [4] Typically, one process writes to the FIFO, and the other reads from it. See [Example A-14](#).

```
1 #!/bin/bash
2 # This short script by Omair Eshkenazi.
3 # Used in ABS Guide with permission (thanks!).
4
5 mkfifo pipe1 # Yes, pipes can be given names.
6 mkfifo pipe2 # Hence the designation "named pipe."
7
8 (cut -d' ' -f1 | tr "a-z" "A-Z") >pipe2 <pipe1 &
9 ls -l | tr -s ' ' | cut -d' ' -f3,9- | tee pipe1 |
10 cut -d' ' -f2 | paste - pipe2
11
12 rm -f pipe1
13 rm -f pipe2
14
15 # No need to kill background processes when script terminates (why not?).
16
17 exit $?
18
19 Now, invoke the script and explain the output:
20 sh mkfifo-example.sh
21
22 4830.tar.gz          BOZO
23 pipe1              BOZO
24 pipe2              BOZO
25 mkfifo-example.sh  BOZO
26 Mixed.msg          BOZO
```

pathchk

This command checks the validity of a filename. If the filename exceeds the maximum allowable length (255 characters) or one or more of the directories in its path is not searchable, then an error message results.

Unfortunately, **pathchk** does not return a recognizable error code, and it is therefore pretty much useless in a script. Consider instead the [file test operators](#).

dd

Though this somewhat obscure and much feared **data duplicator** command originated as a utility for exchanging data on magnetic tapes between UNIX minicomputers and IBM mainframes, it still has its uses. The **dd** command simply copies a file (or `stdin/stdout`), but with conversions. Possible conversions include ASCII/EBCDIC, [5] upper/lower case, swapping of byte pairs between input and output, and skipping and/or truncating the head or tail of the input file.

```
1 # Converting a file to all uppercase:
2
3 dd if=$filename conv=ucase > $filename.uppercase
4 #                               lcase # For lower case conversion
```

Some basic options to **dd** are:

◇ `if=INFILE`

INFILE is the *source* file.

◇ `of=OUTFILE`

OUTFILE is the *target* file, the file that will have the data written to it.

◇ `bs=BLOCKSIZE`

This is the size of each block of data being read and written, usually a power of 2.

◇ `skip=BLOCKS`

How many blocks of data to skip in INFILE before starting to copy. This is useful when the INFILE has "garbage" or garbled data in its header or when it is desirable to copy only a portion of the INFILE.

◇ `seek=BLOCKS`

How many blocks of data to skip in OUTFILE before starting to copy, leaving blank data at beginning of OUTFILE.

◇ `count=BLOCKS`

Copy only this many blocks of data, rather than the entire INFILE.

◇ `conv=CONVERSION`

Type of conversion to be applied to INFILE data before copying operation.

A **dd --help** lists all the options this powerful utility takes.

Example 16-57. A script that copies itself

```
1 #!/bin/bash
2 # self-copy.sh
3
4 # This script copies itself.
5
6 file_subscript=copy
7
```

```

8 dd if=$0 of=$0.$file_subscript 2>/dev/null
9 # Suppress messages from dd:  ^^^^^^^^^^^
10
11 exit $?
12
13 # A program whose only output is its own source code
14 #+ is called a "quine" per Willard Quine.
15 # Does this script qualify as a quine?

```

Example 16-58. Exercising *dd*

```

1 #!/bin/bash
2 # exercising-dd.sh
3
4 # Script by Stephane Chazelas.
5 # Somewhat modified by ABS Guide author.
6
7 infile=$0          # This script.
8 outfile=log.txt    # Output file left behind.
9 n=8
10 p=11
11
12 dd if=$infile of=$outfile bs=1 skip=$((n-1)) count=$((p-n+1)) 2> /dev/null
13 # Extracts characters n to p (8 to 11) from this script ("bash").
14
15 # -----
16
17 echo -n "hello vertical world" | dd cbs=1 conv=unblock 2> /dev/null
18 # Echoes "hello vertical world" vertically downward.
19 # Why? A newline follows each character dd emits.
20
21 exit $?

```

To demonstrate just how versatile **dd** is, let's use it to capture keystrokes.

Example 16-59. Capturing Keystrokes

```

1 #!/bin/bash
2 # dd-keypress.sh: Capture keystrokes without needing to press ENTER.
3
4
5 keypresses=4          # Number of keypresses to capture.
6
7
8 old_tty_setting=$(stty -g) # Save old terminal settings.
9
10 echo "Press $keypresses keys."
11 stty -icanon -echo      # Disable canonical mode.
12                        # Disable local echo.
13 keys=$(dd bs=1 count=$keypresses 2> /dev/null)
14 # 'dd' uses stdin, if "if" (input file) not specified.
15
16 stty "$old_tty_setting" # Restore old terminal settings.
17
18 echo "You pressed the \"$keys\" keys."
19
20 # Thanks, Stephane Chazelas, for showing the way.
21 exit 0

```

The **dd** command can do random access on a data stream.

```
1 echo -n . | dd bs=1 seek=4 of=file conv=notrunc
2 # The "conv=notrunc" option means that the output file
3 #+ will not be truncated.
4
5 # Thanks, S.C.
```

The **dd** command can copy raw data and disk images to and from devices, such as floppies and tape drives ([Example A-5](#)). A common use is creating boot floppies.

```
dd if=kernel-image of=/dev/fd0H1440
```

Similarly, **dd** can copy the entire contents of a floppy, even one formatted with a "foreign" OS, to the hard drive as an image file.

```
dd if=/dev/fd0 of=/home/bozo/projects/floppy.img
```

Likewise, **dd** can create bootable flash drives and SD cards.

```
dd if=image.iso of=/dev/sdb
```

Example 16-60. Preparing a bootable SD card for the *Raspberry Pi*

```
1 #!/bin/bash
2 # rp.sdcard.sh
3 # Preparing an SD card with a bootable image for the Raspberry Pi.
4
5 # $1 = imagefile name
6 # $2 = sdcard (device file)
7 # Otherwise defaults to the defaults, see below.
8
9 DEFAULTbs=4M # Block size, 4 mb default.
10 DEFAULTif="2013-07-26-wheezy-raspbian.img" # Commonly used distro.
11 DEFAULTsdcard="/dev/mmcblk0" # May be different. Check!
12 ROOTUSER_NAME=root # Must run as root!
13 E_NOTROOT=81
14 E_NOIMAGE=82
15
16 username=$(id -nu) # Who is running this script?
17 if [ "$username" != "$ROOTUSER_NAME" ]
18 then
19     echo "This script must run as root or with root privileges."
20     exit $E_NOTROOT
21 fi
22
23 if [ -n "$1" ]
24 then
25     imagefile="$1"
26 else
27     imagefile="$DEFAULTif"
28 fi
29
30 if [ -n "$2" ]
31 then
32     sdcard="$2"
```

```

33 else
34   sdcard="$DEFAULTsdcard"
35 fi
36
37 if [ ! -e $imagefile ]
38 then
39   echo "Image file \"$imagefile\" not found!"
40   exit $E_NOIMAGE
41 fi
42
43 echo "Last chance to change your mind!"; echo
44 read -s -n1 -p "Hit a key to write $imagefile to $sdcard [Ctl-c to exit]."
45 echo; echo
46
47 echo "Writing $imagefile to $sdcard ..."
48 dd bs=$DEFAULTbs if=$imagefile of=$sdcard
49
50 exit $?
51
52 # Exercises:
53 # -----
54 # 1) Provide additional error checking.
55 # 2) Have script autodetect device file for SD card (difficult!).
56 # 3) Have script autodetect image file (*img) in $PWD.

```

Other applications of **dd** include initializing temporary swap files ([Example 31-2](#)) and ramdisks ([Example 31-3](#)). It can even do a low-level copy of an entire hard drive partition, although this is not necessarily recommended.

People (with presumably nothing better to do with their time) are constantly thinking of interesting applications of **dd**.

Example 16-61. Securely deleting a file

```

1  #!/bin/bash
2  # blot-out.sh: Erase "all" traces of a file.
3
4  # This script overwrites a target file alternately
5  #+ with random bytes, then zeros before finally deleting it.
6  # After that, even examining the raw disk sectors by conventional methods
7  #+ will not reveal the original file data.
8
9  PASSES=7           # Number of file-shredding passes.
10                     # Increasing this slows script execution,
11                     #+ especially on large target files.
12 BLOCKSIZE=1        # I/O with /dev/urandom requires unit block size,
13                     #+ otherwise you get weird results.
14 E_BADARGS=70       # Various error exit codes.
15 E_NOT_FOUND=71
16 E_CHANGED_MIND=72
17
18 if [ -z "$1" ]     # No filename specified.
19 then
20   echo "Usage: `basename $0` filename"
21   exit $E_BADARGS
22 fi
23
24 file=$1
25
26 if [ ! -e "$file" ]

```

```

27 then
28     echo "File \"\$file\" not found."
29     exit $E_NOT_FOUND
30 fi
31
32 echo; echo -n "Are you absolutely sure you want to blot out \"\$file\" (y/n)? "
33 read answer
34 case "$answer" in
35 [nN]) echo "Changed your mind, huh?"
36         exit $E_CHANGED_MIND
37         ;;
38 *)     echo "Blotting out file \"\$file\".>";;
39 esac
40
41
42 flength=$(ls -l "$file" | awk '{print $5}') # Field 5 is file length.
43 pass_count=1
44
45 chmod u+w "$file" # Allow overwriting/deleting the file.
46
47 echo
48
49 while [ "$pass_count" -le "$PASSES" ]
50 do
51     echo "Pass #$pass_count"
52     sync # Flush buffers.
53     dd if=/dev/urandom of=$file bs=$BLOCKSIZE count=$flength
54         # Fill with random bytes.
55     sync # Flush buffers again.
56     dd if=/dev/zero of=$file bs=$BLOCKSIZE count=$flength
57         # Fill with zeros.
58     sync # Flush buffers yet again.
59     let "pass_count += 1"
60     echo
61 done
62
63
64 rm -f $file # Finally, delete scrambled and shredded file.
65 sync # Flush buffers a final time.
66
67 echo "File \"\$file\" blotted out and deleted.>"; echo
68
69
70 exit 0
71
72 # This is a fairly secure, if inefficient and slow method
73 #+ of thoroughly "shredding" a file.
74 # The "shred" command, part of the GNU "fileutils" package,
75 #+ does the same thing, although more efficiently.
76
77 # The file cannot not be "undeleted" or retrieved by normal methods.
78 # However . . .
79 #+ this simple method would *not* likely withstand
80 #+ sophisticated forensic analysis.
81
82 # This script may not play well with a journaled file system.
83 # Exercise (difficult): Fix it so it does.
84
85
86
87 # Tom Vier's "wipe" file-deletion package does a much more thorough job
88 #+ of file shredding than this simple script.
89 # http://www.ibiblio.org/pub/Linux/utils/file/wipe-2.0.0.tar.bz2
90
91 # For an in-depth analysis on the topic of file deletion and security,
92 #+ see Peter Gutmann's paper,

```

```
93 #+ "Secure Deletion of Data From Magnetic and Solid-State Memory".
94 # http://www.cs.auckland.ac.nz/~pgut001/pubs/secure_del.html
```

See also the [dd thread](#) entry in the [bibliography](#).

od

The **od**, or *octal dump* filter converts input (or files) to octal (base-8) or other bases. This is useful for viewing or processing binary data files or otherwise unreadable system [device files](#), such as `/dev/urandom`, and as a filter for binary data.

```
1 head -c4 /dev/urandom | od -N4 -tu4 | sed -ne 'ls/. * //p'
2 # Sample output: 1324725719, 3918166450, 2989231420, etc.
3
4 # From rnd.sh example script, by Stéphane Chazelas
```

See also [Example 9-16](#) and [Example A-36](#).

hexdump

Performs a hexadecimal, octal, decimal, or ASCII dump of a binary file. This command is the rough equivalent of **od**, above, but not nearly as useful. May be used to view the contents of a binary file, in combination with [dd](#) and [less](#).

```
1 dd if=/bin/ls | hexdump -C | less
2 # The -C option nicely formats the output in tabular form.
```

objdump

Displays information about an object file or binary executable in either hexadecimal form or as a disassembled listing (with the `-d` option).

```
bash$ objdump -d /bin/ls
/bin/ls:      file format elf32-i386

Disassembly of section .init:

080490bc <.init>:
 80490bc:      55                push   %ebp
 80490bd:      89 e5             mov   %esp,%ebp
  . . .
```

mcookie

This command generates a "magic cookie," a 128-bit (32-character) pseudorandom hexadecimal number, normally used as an authorization "signature" by the X server. This also available for use in a script as a "quick 'n dirty" random number.

```
1 random000=$(mcookie)
```

Of course, a script could use [md5sum](#) for the same purpose.

```
1 # Generate md5 checksum on the script itself.
2 random001=`md5sum $0 | awk '{print $1}'`
3 # Uses 'awk' to strip off the filename.
```

The **mcookie** command gives yet another way to generate a "unique" filename.

Example 16-62. Filename generator

```
1 #!/bin/bash
2 # tempfile-name.sh:  temp filename generator
3
4 BASE_STR=`mcookie`  # 32-character magic cookie.
5 POS=11              # Arbitrary position in magic cookie string.
6 LEN=5               # Get $LEN consecutive characters.
7
```



```

8 prefix=temp          # This is, after all, a "temp" file.
9                     # For more "uniqueness," generate the
10                    #+ filename prefix using the same method
11                    #+ as the suffix, below.
12
13 suffix=${BASE_STR:POS:LEN}
14                    # Extract a 5-character string,
15                    #+ starting at position 11.
16
17 temp_filename=$prefix.$suffix
18                    # Construct the filename.
19
20 echo "Temp filename = "$temp_filename""
21
22 # sh tempfile-name.sh
23 # Temp filename = temp.e19ea
24
25 # Compare this method of generating "unique" filenames
26 #+ with the 'date' method in ex51.sh.
27
28 exit 0

```

units

This utility converts between different *units of measure*. While normally invoked in interactive mode, **units** may find use in a script.

Example 16-63. Converting meters to miles

```

1 #!/bin/bash
2 # unit-conversion.sh
3 # Must have 'units' utility installed.
4
5
6 convert_units () # Takes as arguments the units to convert.
7 {
8   cf=$(units "$1" "$2" | sed --silent -e '1p' | awk '{print $2}')
9   # Strip off everything except the actual conversion factor.
10  echo "$cf"
11 }
12
13 Unit1=miles
14 Unit2=meters
15 cfactor=`convert_units $Unit1 $Unit2`
16 quantity=3.73
17
18 result=$(echo $quantity*$cfactor | bc)
19
20 echo "There are $result $Unit2 in $quantity $Unit1."
21
22 # What happens if you pass incompatible units,
23 #+ such as "acres" and "miles" to the function?
24
25 exit 0
26
27 # Exercise: Edit this script to accept command-line parameters,
28 #           with appropriate error checking, of course.

```

m4

A hidden treasure, **m4** is a powerful macro [\[6\]](#) processing filter, virtually a complete language. Although originally written as a pre-processor for *RatFor*, **m4** turned out to be useful as a stand-alone utility. In fact, **m4** combines some of the functionality of [eval](#), [tr](#), and [awk](#), in addition to its extensive

macro expansion facilities.

The April, 2002 issue of [Linux Journal](#) has a very nice article on **m4** and its uses.

Example 16-64. Using *m4*

```
1 #!/bin/bash
2 # m4.sh: Using the m4 macro processor
3
4 # Strings
5 string=abcdA01
6 echo "len($string)" | m4           # 7
7 echo "substr($string,4)" | m4     # A01
8 echo "regexp($string,[0-1][0-1],\&Z)" | m4 # 01Z
9
10 # Arithmetic
11 var=99
12 echo "incr($var)" | m4           # 100
13 echo "eval($var / 3)" | m4      # 33
14
15 exit
```

xmessage

This X-based variant of [echo](#) pops up a message/query window on the desktop.

```
1 xmessage Left click to continue -button okay
```

zenity

The [zenity](#) utility is adept at displaying *GTK+* dialog [widgets](#) and [very suitable for scripting purposes](#).

doexec

The **doexec** command enables passing an arbitrary list of arguments to a *binary executable*. In particular, passing *argv[0]* (which corresponds to **\$0** in a script) lets the executable be invoked by various names, and it can then carry out different sets of actions, according to the name by which it was called. What this amounts to is roundabout way of passing options to an executable.

For example, the `/usr/local/bin` directory might contain a binary called "aaa". Invoking **doexec /usr/local/bin/aaa list** would *list* all those files in the current working directory beginning with an "a", while invoking (the same executable with) **doexec /usr/local/bin/aaa delete** would *delete* those files.



The various behaviors of the executable must be defined within the code of the executable itself, analogous to something like the following in a shell script:

```
1 case `basename $0` in
2 "name1" ) do_something;;
3 "name2" ) do_something_else;;
4 "name3" ) do_yet_another_thing;;
5 *      ) bail_out;;
6 esac
```

dialog

The [dialog](#) family of tools provide a method of calling interactive "dialog" boxes from a script. The more elaborate variations of **dialog -- gdialog**, **Xdialog**, and **kdialog --** actually invoke X-*Windows widgets*.

sox

The **sox**, or "sound exchange" command plays and performs transformations on sound files. In fact, the `/usr/bin/play` executable (now deprecated) is nothing but a shell wrapper for *sox*.

For example, `sox soundfile.wav soundfile.au` changes a WAV sound file into a (Sun audio format) AU sound file.

Shell scripts are ideally suited for batch-processing `sox` operations on sound files. For examples, see the [Linux Radio Timeshift HOWTO](#) and the [MP3do Project](#).

Notes

- [1] This is actually a script adapted from the Debian Linux distribution.
- [2] The *print queue* is the group of jobs "waiting in line" to be printed.
- [3] Large mechanical *line printers* printed a single line of type at a time onto joined sheets of *greenbar* paper, to the accompaniment of [a great deal of noise](#). The hardcopy thusly printed was referred to as a *printout*.
- [4] For an excellent overview of this topic, see Andy Vaught's article, [Introduction to Named Pipes](#), in the September, 1997 issue of [Linux Journal](#).
- [5] EBCDIC (pronounced "ebb-sid-ick") is an acronym for Extended Binary Coded Decimal Interchange Code, an obsolete IBM data format. A bizarre application of the `conv=ebcdic` option of `dd` is as a quick 'n easy, but not very secure text file encoder.

```
1 cat $file | dd conv=swab,ebcdic > $file_encrypted
2 # Encode (looks like gibberish).
3 # Might as well switch bytes (swab), too, for a little extra obscurity.
4
5 cat $file_encrypted | dd conv=swab,ascii > $file_plaintext
6 # Decode.
```

- [6] A *macro* is a symbolic constant that expands into a command string or a set of operations on parameters. Simply put, it's a shortcut or abbreviation.

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Chapter 17. System and Administrative Commands

The startup and shutdown scripts in `/etc/rc.d` illustrate the uses (and usefulness) of many of these commands. These are usually invoked by `root` and used for system maintenance or emergency filesystem repairs. Use with caution, as some of these commands may damage your system if misused.

Users and Groups

users

Show all logged on users. This is the approximate equivalent of `who -q`.

groups

Lists the current user and the groups she belongs to. This corresponds to the `$GROUPS` internal variable, but gives the group names, rather than the numbers.

```
bash$ groups
bozita cdrom cdwriter audio xgrp

bash$ echo $GROUPS
501
```

chown, chgrp

The `chown` command changes the ownership of a file or files. This command is a useful method that `root` can use to shift file ownership from one user to another. An ordinary user may not change the ownership of files, not even her own files. [1]

```
root# chown bozo *.txt
```

The `chgrp` command changes the `group` ownership of a file or files. You must be owner of the file(s) as well as a member of the destination group (or `root`) to use this operation.

```
1 chgrp --recursive dunderheads *.data
2 # The "dunderheads" group will now own all the "*.data" files
3 #+ all the way down the $PWD directory tree (that's what "recursive" means).
```

useradd, userdel

The `useradd` administrative command adds a user account to the system and creates a home directory for that particular user, if so specified. The corresponding `userdel` command removes a user account from the system [2] and deletes associated files.



The `adduser` command is a synonym for `useradd` and is usually a symbolic link to it.

usermod

Modify a user account. Changes may be made to the password, group membership, expiration date, and other attributes of a given user's account. With this command, a user's password may be locked, which has the effect of disabling the account.

groupmod

Modify a given group. The group name and/or ID number may be changed using this command.

id

The `id` command lists the real and effective user IDs and the group IDs of the user associated with the current process. This is the counterpart to the `$UID`, `$EUID`, and `$GROUPS` internal Bash variables.

```
bash$ id
uid=501(bozo) gid=501(bozo) groups=501(bozo),22(cdrom),80(cdwriter),81(audio)

bash$ echo $UID
501
```

 The **id** command shows the *effective* IDs only when they differ from the *real* ones.

Also see [Example 9-5](#).

lid

The *lid* (list ID) command shows the group(s) that a given user belongs to, or alternately, the users belonging to a given group. May be invoked only by root.

```
root# lid bozo
bozo(gid=500)

root# lid daemon
bin(gid=1)
daemon(gid=2)
adm(gid=4)
lp(gid=7)
```

who

Show all users logged on to the system.

```
bash$ who
bozo  tty1      Apr 27 17:45
bozo  pts/0      Apr 27 17:46
bozo  pts/1      Apr 27 17:47
bozo  pts/2      Apr 27 17:49
```

The **-m** gives detailed information about only the current user. Passing any two arguments to **who** is the equivalent of **who -m**, as in **who am i** or **who The Man**.

```
bash$ who -m
localhost.localdomain!bozo pts/2 Apr 27 17:49
```

whoami is similar to **who -m**, but only lists the user name.

```
bash$ whoami
bozo
```

w

Show all logged on users and the processes belonging to them. This is an extended version of **who**. The output of **w** may be piped to [grep](#) to find a specific user and/or process.

```
bash$ w | grep startx
bozo  tty1      -                4:22pm  6:41    4.47s  0.45s  startx
```

logname

Show current user's login name (as found in `/var/run/utmp`). This is a near-equivalent to [whoami](#), above.

```
bash$ logname
bozo

bash$ whoami
bozo
```

However ...

```
bash$ su
Password: .....

bash# whoami
root
bash# logname
```

bozo



While **logname** prints the name of the logged in user, **whoami** gives the name of the user attached to the current process. As we have just seen, sometimes these are not the same.

su

Runs a program or script as a **substitute user**. **su rjones** starts a shell as user *rjones*. A naked **su** defaults to *root*. See [Example A-14](#).

sudo

Runs a command as *root* (or another user). This may be used in a script, thus permitting a *regular user* to run the script.

```
1 #!/bin/bash
2
3 # Some commands.
4 sudo cp /root/secretfile /home/bozo/secret
5 # Some more commands.
```

The file `/etc/sudoers` holds the names of users permitted to invoke **sudo**.

passwd

Sets, changes, or manages a user's password.

The **passwd** command can be used in a script, but probably *should not* be.

Example 17-1. Setting a new password

```
1 #!/bin/bash
2 # setnew-password.sh: For demonstration purposes only.
3 #                               Not a good idea to actually run this script.
4 # This script must be run as root.
5
6 ROOT_UID=0           # Root has $UID 0.
7 E_WRONG_USER=65     # Not root?
8
9 E_NOSUCHUSER=70
10 SUCCESS=0
11
12
13 if [ "$UID" -ne "$ROOT_UID" ]
14 then
15     echo; echo "Only root can run this script."; echo
16     exit $E_WRONG_USER
17 else
18     echo
19     echo "You should know better than to run this script, root."
20     echo "Even root users get the blues... "
21     echo
22 fi
23
24
25 username=bozo
26 NEWPASSWORD=security_violation
27
28 # Check if bozo lives here.
29 grep -q "$username" /etc/passwd
30 if [ $? -ne $SUCCESS ]
31 then
32     echo "User $username does not exist."
33     echo "No password changed."
34     exit $E_NOSUCHUSER
35 fi
36
```

```
37 echo "$NEWPASSWORD" | passwd --stdin "$username"
38 # The '--stdin' option to 'passwd' permits
39 #+ getting a new password from stdin (or a pipe).
40
41 echo; echo "User $username's password changed!"
42
43 # Using the 'passwd' command in a script is dangerous.
44
45 exit 0
```

The **passwd** command's **-l**, **-u**, and **-d** options permit locking, unlocking, and deleting a user's password. Only *root* may use these options.

ac

Show users' logged in time, as read from `/var/log/wtmp`. This is one of the GNU accounting utilities.

```
bash$ ac
      total          68.08
```

last

List *last* logged in users, as read from `/var/log/wtmp`. This command can also show remote logins.

For example, to show the last few times the system rebooted:

```
bash$ last reboot
reboot  system boot  2.6.9-1.667      Fri Feb  4 18:18      (00:02)
reboot  system boot  2.6.9-1.667      Fri Feb  4 15:20      (01:27)
reboot  system boot  2.6.9-1.667      Fri Feb  4 12:56      (00:49)
reboot  system boot  2.6.9-1.667      Thu Feb  3 21:08      (02:17)
. . .
wtmp begins Tue Feb  1 12:50:09 2005
```

newgrp

Change user's *group ID* without logging out. This permits access to the new group's files. Since users may be members of multiple groups simultaneously, this command finds only limited use.



Kurt Glaesemann points out that the *newgrp* command could prove helpful in setting the default group permissions for files a user writes. However, the [chgrp](#) command might be more convenient for this purpose.

Terminals

tty

Echoes the name (filename) of the current user's terminal. Note that each separate *xterm* window counts as a different terminal.

```
bash$ tty
/dev/pts/1
```

stty

Shows and/or changes terminal settings. This complex command, used in a script, can control terminal behavior and the way output displays. See the info page, and study it carefully.

Example 17-2. Setting an *erase* character

```
1 #!/bin/bash
2 # erase.sh: Using "stty" to set an erase character when reading input.
```



```

3
4 echo -n "What is your name? "
5 read name                # Try to backspace
6                          #+ to erase characters of input.
7                          # Problems?
8 echo "Your name is $name."
9
10 stty erase '#'          # Set "hashmark" (#) as erase character.
11 echo -n "What is your name? "
12 read name                # Use # to erase last character typed.
13 echo "Your name is $name."
14
15 exit 0
16
17 # Even after the script exits, the new key value remains set.
18 # Exercise: How would you reset the erase character to the default value?

```

Example 17-3. *secret password*: Turning off terminal echoing

```

1 #!/bin/bash
2 # secret-pw.sh: secret password
3
4 echo
5 echo -n "Enter password "
6 read passwd
7 echo "password is $passwd"
8 echo -n "If someone had been looking over your shoulder, "
9 echo "your password would have been compromised."
10
11 echo && echo # Two line-feeds in an "and list."
12
13
14 stty -echo # Turns off screen echo.
15 # May also be done with
16 # read -sp passwd
17 # A big Thank You to Leigh James for pointing this out.
18
19 echo -n "Enter password again "
20 read passwd
21 echo
22 echo "password is $passwd"
23 echo
24
25 stty echo # Restores screen echo.
26
27 exit 0
28
29 # Do an 'info stty' for more on this useful-but-tricky command.

```

A creative use of **stty** is detecting a user keypress (without hitting **ENTER**).

Example 17-4. Keypress detection

```

1 #!/bin/bash
2 # keypress.sh: Detect a user keypress ("hot keys").
3
4 echo
5
6 old_tty_settings=$(stty -g) # Save old settings (why?).

```

```

7 stty -icanon
8 Keypress=$(head -c1)           # or $(dd bs=1 count=1 2> /dev/null)
9                               # on non-GNU systems
10
11 echo
12 echo "Key pressed was \"'$Keypress'\"."
13 echo
14
15 stty "$old_tty_settings"      # Restore old settings.
16
17 # Thanks, Stephane Chazelas.
18
19 exit 0

```

Also see [Example 9-3](#) and [Example A-43](#).

terminals and modes

Normally, a terminal works in the *canonical* mode. When a user hits a key, the resulting character does not immediately go to the program actually running in this terminal. A buffer local to the terminal stores keystrokes. When the user hits the **ENTER** key, this sends all the stored keystrokes to the program running. There is even a basic line editor inside the terminal.

```

bash$ stty -a
speed 9600 baud; rows 36; columns 96; line = 0;
intr = ^C; quit = ^\; erase = ^H; kill = ^U; eof = ^D; eol = <undef>; eol2 = <undef>;
start = ^Q; stop = ^S; susp = ^Z; rprnt = ^R; werase = ^W; lnext = ^V; flush = ^O;
...
isig icanon ixten echo echoe echok -echonl -noflsh -xcase -tostop -echoprt

```

Using canonical mode, it is possible to redefine the special keys for the local terminal line editor.

```

bash$ cat > filexxx
wha<ctl-W>I<ctl-H>foo bar<ctl-U>hello world<ENTER>
<ctl-D>
bash$ cat filexxx
hello world
bash$ wc -c < filexxx
12

```

The process controlling the terminal receives only 12 characters (11 alphabetic ones, plus a newline), although the user hit 26 keys.

In non-canonical ("raw") mode, every key hit (including special editing keys such as **ctl-H**) sends a character immediately to the controlling process.

The Bash prompt disables both `icanon` and `echo`, since it replaces the basic terminal line editor with its own more elaborate one. For example, when you hit **ctl-A** at the Bash prompt, there's no **^A** echoed by the terminal, but Bash gets a **\1** character, interprets it, and moves the cursor to the beginning of the line.

Stéphane Chazelas

setterm

Set certain terminal attributes. This command writes to its terminal's `stdout` a string that changes the behavior of that terminal.

```
bash$ setterm -cursor off
bash$
```

The **setterm** command can be used within a script to change the appearance of text written to `stdout`, although there are certainly [better tools](#) available for this purpose.

```
1 setterm -bold on
2 echo bold hello
3
4 setterm -bold off
5 echo normal hello
```

tset

Show or initialize terminal settings. This is a less capable version of **stty**.

```
bash$ tset -r
Terminal type is xterm-xfree86.
Kill is control-U (^U).
Interrupt is control-C (^C).
```

setserial

Set or display serial port parameters. This command must be run by *root* and is usually found in a system setup script.


```
1 # From /etc/pcmcia/serial script:
2
3 IRQ=`setserial /dev/$DEVICE | sed -e 's/.*IRQ: //'`
4 setserial /dev/$DEVICE irq 0 ; setserial /dev/$DEVICE irq $IRQ
```

getty, agetty

The initialization process for a terminal uses **getty** or **agetty** to set it up for login by a user. These commands are not used within user shell scripts. Their scripting counterpart is **stty**.

mesg

Enables or disables write access to the current user's terminal. Disabling access would prevent another user on the network to [write](#) to the terminal.


 It can be quite annoying to have a message about ordering pizza suddenly appear in the middle of the text file you are editing. On a multi-user network, you might therefore wish to disable write access to your terminal when you need to avoid interruptions.

wall

This is an acronym for "[write](#) all," i.e., sending a message to all users at every terminal logged into the network. It is primarily a system administrator's tool, useful, for example, when warning everyone that the system will shortly go down due to a problem (see [Example 19-1](#)).

```
bash$ wall System going down for maintenance in 5 minutes!
Broadcast message from bozo (pts/1) Sun Jul  8 13:53:27 2001...

System going down for maintenance in 5 minutes!
```

 If write access to a particular terminal has been disabled with **mesg**, then **wall** cannot send a message to that terminal.

Information and Statistics

uname

Output system specifications (OS, kernel version, etc.) to `stdout`. Invoked with the `-a` option, gives verbose system info (see [Example 16-5](#)). The `-s` option shows only the OS type.

```

bash$ uname
Linux

bash$ uname -s
Linux

bash$ uname -a
Linux iron.bozo 2.6.15-1.2054_FC5 #1 Tue Mar 14 15:48:33 EST 2006
i686 i686 i386 GNU/Linux

```

arch

Show system architecture. Equivalent to **uname -m**. See [Example 11-27](#).

```

bash$ arch
i686

bash$ uname -m
i686

```

lastcomm

Gives information about previous commands, as stored in the `/var/account/pacct` file. Command name and user name can be specified by options. This is one of the GNU accounting utilities.

lastlog

List the last login time of all system users. This references the `/var/log/lastlog` file.

```

bash$ lastlog
root          tty1          Fri Dec  7 18:43:21 -0700 2001
bin           **Never logged in**
daemon       **Never logged in**
...
bozo         tty1          Sat Dec  8 21:14:29 -0700 2001

bash$ lastlog | grep root
root          tty1          Fri Dec  7 18:43:21 -0700 2001

```



This command will fail if the user invoking it does not have read permission for the `/var/log/lastlog` file.

lsof

List open files. This command outputs a detailed table of all currently open files and gives information about their owner, size, the processes associated with them, and more. Of course, **lsof** may be piped to [grep](#) and/or [awk](#) to parse and analyze its results.

```

bash$ lsof
COMMAND  PID  USER  FD  TYPE  DEVICE  SIZE  NODE NAME
init     1   root  mem  REG   3,5    30748 30303 /sbin/init
init     1   root  mem  REG   3,5    73120 8069  /lib/ld-2.1.3.so
init     1   root  mem  REG   3,5   931668 8075  /lib/libc-2.1.3.so
cardmgr 213  root  mem  REG   3,5    36956 30357 /sbin/cardmgr
...

```

The **lsof** command is a useful, if complex administrative tool. If you are unable to dismount a filesystem and get an error message that it is still in use, then running *lsof* helps determine which files are still open on that filesystem. The `-i` option lists open network socket files, and this can help trace intrusion or hack attempts.

```

bash$ lsof -an -i tcp
COMMAND  PID  USER  FD  TYPE  DEVICE  SIZE  NODE NAME
firefox 2330 bozo  32u  IPv4  9956          TCP 66.0.118.137:57596->67.112.7.104:http ...

```

```
firefox 2330 bozo 38u IPv4 10535 TCP 66.0.118.137:57708->216.79.48.24:http ...
```

See [Example 30-2](#) for an effective use of **lsof**.

strace

System trace: diagnostic and debugging tool for tracing *system calls* and signals. This command and **ltrace**, following, are useful for diagnosing why a given program or package fails to run . . . perhaps due to missing libraries or related causes.

```
bash$ strace df
execve("/bin/df", ["df"], [/* 45 vars */]) = 0
uname({sys="Linux", node="bozo.localdomain", ...}) = 0
brk(0) = 0x804f5e4
...

```

This is the Linux equivalent of the Solaris **truss** command.

ltrace

Library trace: diagnostic and debugging tool that traces *library calls* invoked by a given command.

```
bash$ ltrace df
__libc_start_main(0x804a910, 1, 0xbfb589a4, 0x804fb70, 0x804fb68 <unfinished ...>:
  setlocale(6, "") = "en_US.UTF-8"
bindtextdomain("coreutils", "/usr/share/locale") = "/usr/share/locale"
textdomain("coreutils") = "coreutils"
__cxa_atexit(0x804b650, 0, 0, 0x8052bf0, 0xbfb58908) = 0
getenv("DF_BLOCK_SIZE") = NULL
...

```

nc

The **nc** (*netcat*) utility is a complete toolkit for connecting to and listening to TCP and UDP ports. It is useful as a diagnostic and testing tool and as a component in simple script-based HTTP clients and servers.

```
bash$ nc localhost.localdomain 25
220 localhost.localdomain ESMTP Sendmail 8.13.1/8.13.1;
Thu, 31 Mar 2005 15:41:35 -0700

```

A real-life [usage example](#).

Example 17-5. Checking a remote server for *identd*

```
1 #! /bin/sh
2 ## Duplicate DaveG's ident-scan thingie using netcat. Oooh, he'll be p*ssed.
3 ## Args: target port [port port port ...]
4 ## Hose stdout _and_ stderr together.
5 ##
6 ## Advantages: runs slower than ident-scan, giving remote inetd less cause
7 ##+ for alarm, and only hits the few known daemon ports you specify.
8 ## Disadvantages: requires numeric-only port args, the output sleazitude,
9 ##+ and won't work for r-services when coming from high source ports.
10 # Script author: Hobbit <hobbit@avian.org>
11 # Used in ABS Guide with permission.
12
13 # -----
14 E_BADARGS=65 # Need at least two args.
15 TWO_WINKS=2 # How long to sleep.
16 THREE_WINKS=3
17 IDPORT=113 # Authentication "tap ident" port.
18 RAND1=999

```

```

19 RAND2=31337
20 TIMEOUT0=9
21 TIMEOUT1=8
22 TIMEOUT2=4
23 # -----
24
25 case "${2}" in
26   "" ) echo "Need HOST and at least one PORT." ; exit $E_BADARGS ;;
27 esac
28
29 # Ping 'em once and see if they *are* running identd.
30 nc -z -w $TIMEOUT0 "$1" $IDPORT || \
31 { echo "Oops, $1 isn't running identd." ; exit 0 ; }
32 # -z scans for listening daemons.
33 # -w $TIMEOUT = How long to try to connect.
34
35 # Generate a randomish base port.
36 RP=`expr $$ % $RAND1 + $RAND2`
37
38 TRG="$1"
39 shift
40
41 while test "$1" ; do
42   nc -v -w $TIMEOUT1 -p ${RP} "$TRG" ${1} < /dev/null > /dev/null &
43   PROC=$!
44   sleep $THREE_WINKS
45   echo "${1},${RP}" | nc -w $TIMEOUT2 -r "$TRG" $IDPORT 2>&1
46   sleep $TWO_WINKS
47
48 # Does this look like a lamer script or what . . . ?
49 # ABS Guide author comments: "Ain't really all that bad . . .
50 #+                               kinda clever, actually."
51
52   kill -HUP $PROC
53   RP=`expr ${RP} + 1`
54   shift
55 done
56
57 exit $?
58
59 # Notes:
60 # -----
61
62 # Try commenting out line 30 and running this script
63 #+ with "localhost.localdomain 25" as arguments.
64
65 # For more of Hobbit's 'nc' example scripts,
66 #+ look in the documentation:
67 #+ the /usr/share/doc/nc-X.XX/scripts directory.

```

And, of course, there's Dr. Andrew Tridgell's notorious one-line script in the BitKeeper Affair:

```
1 echo clone | nc think.org 5000 > e2fsprogs.dat
```

free

Shows memory and cache usage in tabular form. The output of this command lends itself to parsing, using [grep](#), [awk](#) or [Perl](#). The **procinfo** command shows all the information that **free** does, and much more.

```
bash$ free
```

	total	used	free	shared	buffers	cached
Mem:	30504	28624	1880	15820	1608	16376
-/+ buffers/cache:		10640	19864			
Swap:	68540	3128	65412			

To show unused RAM memory:

```
bash$ free | grep Mem | awk '{ print $4 }'  
1880
```

procinfo

Extract and list information and statistics from the [/proc pseudo-filesystem](#). This gives a very extensive and detailed listing.

```
bash$ procinfo | grep Bootup  
Bootup: Wed Mar 21 15:15:50 2001      Load average: 0.04 0.21 0.34 3/47 6829
```

lsdev

List devices, that is, show installed hardware.

```
bash$ lsdev  
Device          DMA   IRQ   I/O Ports  
-----  
cascade         4     2  
dma              0080-008f  
dma1            0000-001f  
dma2            00c0-00df  
fpu             00f0-00ff  
ide0            14    01f0-01f7 03f6-03f6  
...
```

du

Show (disk) file usage, recursively. Defaults to current working directory, unless otherwise specified.

```
bash$ du -ach  
1.0k  ./wi.sh  
1.0k  ./tst.sh  
1.0k  ./random.file  
6.0k  .  
6.0k  total
```

df

Shows filesystem usage in tabular form.

```
bash$ df  
Filesystem      1k-blocks    Used Available Use% Mounted on  
/dev/hda5        273262     92607   166547   36% /  
/dev/hda8        222525    123951    87085   59% /home  
/dev/hda7        1408796   1075744   261488   80% /usr
```

dmesg

Lists all system bootup messages to `stdout`. Handy for debugging and ascertaining which device drivers were installed and which system interrupts in use. The output of `dmesg` may, of course, be parsed with [grep](#), [sed](#), or [awk](#) from within a script.

```
bash$ dmesg | grep hda  
Kernel command line: ro root=/dev/hda2  
hda: IBM-DLGA-23080, ATA DISK drive  
hda: 6015744 sectors (3080 MB) w/96KiB Cache, CHS=746/128/63  
hda: hda1 hda2 hda3 < hda5 hda6 hda7 > hda4
```

stat

Gives detailed and verbose *statistics* on a given file (even a directory or device file) or set of files.

```
bash$ stat test.cru  
File: "test.cru"  
Size: 49970      Allocated Blocks: 100      Filetype: Regular File  
Mode: (0664/-rw-rw-r--)      Uid: ( 501/ bozo)  Gid: ( 501/ bozo)
```

```
Device: 3,8   Inode: 18185   Links: 1
Access: Sat Jun  2 16:40:24 2001
Modify: Sat Jun  2 16:40:24 2001
Change: Sat Jun  2 16:40:24 2001
```

If the target file does not exist, **stat** returns an error message.

```
bash$ stat nonexistent-file
nonexistent-file: No such file or directory
```

In a script, you can use **stat** to extract information about files (and filesystems) and set variables accordingly.

```
1 #!/bin/bash
2 # fileinfo2.sh
3
4 # Per suggestion of Joël Bourquard and . . .
5 # http://www.linuxquestions.org/questions/showthread.php?t=410766
6
7
8 FILENAME=testfile.txt
9 file_name=$(stat -c%n "$FILENAME") # Same as "$FILENAME" of course.
10 file_owner=$(stat -c%U "$FILENAME")
11 file_size=$(stat -c%s "$FILENAME")
12 # Certainly easier than using "ls -l $FILENAME"
13 #+ and then parsing with sed.
14 file_inode=$(stat -c%i "$FILENAME")
15 file_type=$(stat -c%F "$FILENAME")
16 file_access_rights=$(stat -c%A "$FILENAME")
17
18 echo "File name:          $file_name"
19 echo "File owner:         $file_owner"
20 echo "File size:           $file_size"
21 echo "File inode:          $file_inode"
22 echo "File type:            $file_type"
23 echo "File access rights: $file_access_rights"
24
25 exit 0
26
27 sh fileinfo2.sh
28
29 File name:          testfile.txt
30 File owner:         bozo
31 File size:          418
32 File inode:         1730378
33 File type:          regular file
34 File access rights: -rw-rw-r--
```

vmstat

Display virtual memory statistics.

```
bash$ vmstat
procs          memory  swap          io system          cpu
 r  b  w  swpd  free  buff  cache  si  so  bi  bo  in  cs  us  sy  id
0  0  0    0 11040 2636 38952  0  0  33  7 271  88  8  3 89
```

uptime

Shows how long the system has been running, along with associated statistics.

```
bash$ uptime
10:28pm up 1:57, 3 users, load average: 0.17, 0.34, 0.27
```



A *load average* of 1 or less indicates that the system handles processes immediately. A load average greater than 1 means that processes are being

queued. When the load average gets above 3 (on a single-core processor), then system performance is significantly degraded.

hostname

Lists the system's host name. This command sets the host name in an `/etc/rc.d` setup script (`/etc/rc.d/rc.sysinit` or similar). It is equivalent to **uname -n**, and a counterpart to the [\\$HOSTNAME](#) internal variable.

```
bash$ hostname
localhost.localdomain

bash$ echo $HOSTNAME
localhost.localdomain
```

Similar to the **hostname** command are the **domainname**, **dnsdomainname**, **nisdomainname**, and **ypdomainname** commands. Use these to display or set the system DNS or NIS/YP domain name. Various options to **hostname** also perform these functions.

hostid

Echo a 32-bit hexadecimal numerical identifier for the host machine.

```
bash$ hostid
7f0100
```



This command allegedly fetches a "unique" serial number for a particular system. Certain product registration procedures use this number to brand a particular user license. Unfortunately, **hostid** only returns the machine network address in hexadecimal, with pairs of bytes transposed.

The network address of a typical non-networked Linux machine, is found in `/etc/hosts`.

```
bash$ cat /etc/hosts
127.0.0.1          localhost.localdomain localhost
```

As it happens, transposing the bytes of `127.0.0.1`, we get `0.127.1.0`, which translates in hex to `007f0100`, the exact equivalent of what **hostid** returns, above. There exist only a few million other Linux machines with this identical *hostid*.

sar

Invoking **sar** (System Activity Reporter) gives a very detailed rundown on system statistics. The Santa Cruz Operation ("Old" SCO) released **sar** as Open Source in June, 1999.

This command is not part of the base Linux distribution, but may be obtained as part of the [sysstat utilities](#) package, written by [Sebastien Godard](#).

```
bash$ sar
Linux 2.4.9 (brooks.seringas.fr)          09/26/03

10:30:00      CPU      %user    %nice    %system  %iowait  %idle
10:40:00      all       2.21     10.90    65.48    0.00    21.41
10:50:00      all       3.36     0.00    72.36    0.00    24.28
11:00:00      all       1.12     0.00    80.77    0.00    18.11
Average:      all       2.23     3.63    72.87    0.00    21.27

14:32:30      LINUX RESTART

15:00:00      CPU      %user    %nice    %system  %iowait  %idle
15:10:00      all       8.59     2.40    17.47    0.00    71.54
15:20:00      all       4.07     1.00    11.95    0.00    82.98
15:30:00      all       0.79     2.94     7.56    0.00    88.71
Average:      all       6.33     1.70    14.71    0.00    77.26
```

readelf

Show information and statistics about a designated *elf* binary. This is part of the *binutils* package.

```
bash$ readelf -h /bin/bash
ELF Header:
  Magic:   7f 45 4c 46 01 01 01 00 00 00 00 00 00 00 00
  Class:                               ELF32
  Data:                                   2's complement, little endian
  Version:                               1 (current)
  OS/ABI:                                UNIX - System V
  ABI Version:                           0
  Type:                                   EXEC (Executable file)
  . . .
```

size

The **size** [/path/to/binary] command gives the segment sizes of a binary executable or archive file. This is mainly of use to programmers.

```
bash$ size /bin/bash
   text    data     bss       dec       hex filename
495971    22496    17392   535859   82d33 /bin/bash
```

System Logs

logger

Appends a user-generated message to the system log (/var/log/messages). You do not have to be *root* to invoke **logger**.

```
1 logger Experiencing instability in network connection at 23:10, 05/21.
2 # Now, do a 'tail /var/log/messages'.
```

By embedding a **logger** command in a script, it is possible to write debugging information to /var/log/messages.

```
1 logger -t $0 -i Logging at line "$LINENO".
2 # The "-t" option specifies the tag for the logger entry.
3 # The "-i" option records the process ID.
4
5 # tail /var/log/message
6 # ...
7 # Jul  7 20:48:58 localhost ./test.sh[1712]: Logging at line 3.
```

logrotate

This utility manages the system log files, rotating, compressing, deleting, and/or e-mailing them, as appropriate. This keeps the /var/log from getting cluttered with old log files. Usually [cron](#) runs **logrotate** on a daily basis.

Adding an appropriate entry to /etc/logrotate.conf makes it possible to manage personal log files, as well as system-wide ones.



Stefano Falsetto has created [rottlog](#), which he considers to be an improved version of **logrotate**.

Job Control

ps

Process Statistics: lists currently executing processes by owner and PID (process ID). This is usually invoked with *ax* or *aux* options, and may be piped to [grep](#) or [sed](#) to search for a specific process (see [Example 15-14](#) and [Example 29-3](#)).

```
bash$ ps ax | grep sendmail
295 ?      S          0:00 sendmail: accepting connections on port 25
```

To display system processes in graphical "tree" format: **ps afjx** or **ps ax --forest**.

pgrep, pkill

Combining the **ps** command with [grep](#) or [kill](#).

```
bash$ ps a | grep mingetty
2212 tty2      Ss+      0:00 /sbin/mingetty tty2
2213 tty3      Ss+      0:00 /sbin/mingetty tty3
2214 tty4      Ss+      0:00 /sbin/mingetty tty4
2215 tty5      Ss+      0:00 /sbin/mingetty tty5
2216 tty6      Ss+      0:00 /sbin/mingetty tty6
4849 pts/2     S+       0:00 grep mingetty
```

```
bash$ pgrep mingetty
2212 mingetty
2213 mingetty
2214 mingetty
2215 mingetty
2216 mingetty
```

Compare the action of **pkill** with [killall](#).

pstree

Lists currently executing processes in "tree" format. The **-p** option shows the PIDs, as well as the process names.

top

Continuously updated display of most cpu-intensive processes. The **-b** option displays in text mode, so that the output may be parsed or accessed from a script.

```
bash$ top -b
 8:30pm up 3 min,  3 users,  load average: 0.49, 0.32, 0.13
45 processes: 44 sleeping, 1 running, 0 zombie, 0 stopped
CPU states: 13.6% user,  7.3% system,  0.0% nice, 78.9% idle
Mem:      78396K av,    65468K used,   12928K free,        0K shrd,    2352K buff
Swap:    157208K av,        0K used,   157208K free          37244K cached

  PID USER      PRI  NI  SIZE  RSS SHARE STAT  %CPU %MEM   TIME COMMAND
  848 bozo      17   0   996   996   800 R    5.6  1.2   0:00 top
     1 root        8   0   512   512   444 S    0.0  0.6   0:04 init
     2 root        9   0     0     0     0 SW   0.0  0.0   0:00 keventd
  ...
```

nice

Run a background job with an altered priority. Priorities run from 19 (lowest) to -20 (highest). Only *root* may set the negative (higher) priorities. Related commands are **renice** and **snice**, which change the priority of a running process or processes, and **skill**, which sends a [kill](#) signal to a process or processes.

nohup

Keeps a command running even after user logs off. The command will run as a foreground process unless followed by **&**. If you use **nohup** within a script, consider coupling it with a [wait](#) to avoid creating an *orphan* or [zombie](#) process.

pidof

Identifies *process ID (PID)* of a running job. Since job control commands, such as [kill](#) and [renice](#) act on the *PID* of a process (not its name), it is sometimes necessary to identify that *PID*. The **pidof** command is the approximate counterpart to the [\\$PPID](#) internal variable.

```
bash$ pidof xclock
```

Example 17-6. *pidof* helps kill a process

```

1 #!/bin/bash
2 # kill-process.sh
3
4 NOPROCESS=2
5
6 process=xxxxyyyzzz # Use nonexistent process.
7 # For demo purposes only...
8 # ... don't want to actually kill any actual process with this script.
9 #
10 # If, for example, you wanted to use this script to logoff the Internet,
11 #     process=pppd
12
13 t=`pidof $process` # Find pid (process id) of $process.
14 # The pid is needed by 'kill' (can't 'kill' by program name).
15
16 if [ -z "$t" ] # If process not present, 'pidof' returns null.
17 then
18     echo "Process $process was not running."
19     echo "Nothing killed."
20     exit $NOPROCESS
21 fi
22
23 kill $t # May need 'kill -9' for stubborn process.
24
25 # Need a check here to see if process allowed itself to be killed.
26 # Perhaps another " t=`pidof $process` " or ...
27
28
29 # This entire script could be replaced by
30 #     kill $(pidof -x process_name)
31 # or
32 #     killall process_name
33 # but it would not be as instructive.
34
35 exit 0

```

fuser

Identifies the processes (by PID) that are accessing a given file, set of files, or directory. May also be invoked with the `-k` option, which kills those processes. This has interesting implications for system security, especially in scripts preventing unauthorized users from accessing system services.

```

bash$ fuser -u /usr/bin/vim
/usr/bin/vim:          3207e (bozo)

bash$ fuser -u /dev/null
/dev/null:            3009 (bozo)  3010 (bozo)  3197 (bozo)  3199 (bozo)

```

One important application for **fuser** is when physically inserting or removing storage media, such as CD ROM disks or USB flash drives. Sometimes trying a [umount](#) fails with a device is busy error message. This means that some user(s) and/or process(es) are accessing the device. An **fuser -um /dev/device_name** will clear up the mystery, so you can kill any relevant processes.

```

bash$ umount /mnt/usbdrive
umount: /mnt/usbdrive: device is busy

```

```
bash$ fuser -um /dev/usbdrive
/mnt/usbdrive:          1772c(bozo)

bash$ kill -9 1772
bash$ umount /mnt/usbdrive
```

The **fuser** command, invoked with the `-n` option identifies the processes accessing a *port*. This is especially useful in combination with [nmap](#).

```
root# nmap localhost.localdomain
PORT      STATE SERVICE
25/tcp    open  smtp

root# fuser -un tcp 25
25/tcp:          2095(root)

root# ps ax | grep 2095 | grep -v grep
2095 ?          Ss      0:00 sendmail: accepting connections
```

cron

Administrative program scheduler, performing such duties as cleaning up and deleting system log files and updating the slocate database. This is the *superuser* version of [at](#) (although each user may have their own `crontab` file which can be changed with the **crontab** command). It runs as a [daemon](#) and executes scheduled entries from `/etc/crontab`.



Some flavors of Linux run **crond**, Matthew Dillon's version of **cron**.

Process Control and Booting

init

The **init** command is the [parent](#) of all processes. Called in the final step of a bootup, **init** determines the runlevel of the system from `/etc/inittab`. Invoked by its alias **telinit**, and by *root* only.

telinit

Symlinked to **init**, this is a means of changing the system runlevel, usually done for system maintenance or emergency filesystem repairs. Invoked only by *root*. This command can be dangerous -- be certain you understand it well before using!

runlevel

Shows the current and last runlevel, that is, whether the system is halted (runlevel 0), in single-user mode (1), in multi-user mode (2 or 3), in X Windows (5), or rebooting (6). This command accesses the `/var/run/utmp` file.

halt, shutdown, reboot

Command set to shut the system down, usually just prior to a power down.



On some Linux distros, the **halt** command has 755 permissions, so it can be invoked by a non-root user. A careless *halt* in a terminal or a script may shut down the system!

service

Starts or stops a system *service*. The startup scripts in `/etc/init.d` and `/etc/rc.d` use this command to start services at bootup.

```

root# /sbin/service iptables stop
Flushing firewall rules:           [ OK ]
Setting chains to policy ACCEPT: filter [ OK ]
Unloading iptables modules:       [ OK ]

```

Network

nmap

Network **m**apper and port scanner. This command scans a server to locate open ports and the services associated with those ports. It can also report information about packet filters and firewalls. This is an important security tool for locking down a network against hacking attempts.

```

1 #!/bin/bash
2
3 SERVER=$HOST                # localhost.localdomain (127.0.0.1).
4 PORT_NUMBER=25              # SMTP port.
5
6 nmap $SERVER | grep -w "$PORT_NUMBER" # Is that particular port open?
7 #                             grep -w matches whole words only,
8 #+                             so this wouldn't match port 1025, for example.
9
10 exit 0
11
12 # 25/tcp      open      smtp

```

ifconfig

Network *interface configuration* and tuning utility.

```

bash$ ifconfig -a
lo          Link encap:Local Loopback
            inet addr:127.0.0.1  Mask:255.0.0.0
            UP LOOPBACK RUNNING  MTU:16436  Metric:1
            RX packets:10 errors:0 dropped:0 overruns:0 frame:0
            TX packets:10 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:0
            RX bytes:700 (700.0 b)  TX bytes:700 (700.0 b)

```

The **ifconfig** command is most often used at bootup to set up the interfaces, or to shut them down when rebooting.

```

1 # Code snippets from /etc/rc.d/init.d/network
2
3 # ...
4
5 # Check that networking is up.
6 [ ${NETWORKING} = "no" ] && exit 0
7
8 [ -x /sbin/ifconfig ] || exit 0
9
10 # ...
11
12 for i in $interfaces ; do
13     if ifconfig $i 2>/dev/null | grep -q "UP" >/dev/null 2>&1 ; then
14         action "Shutting down interface $i: " ./ifdown $i boot
15     fi
16 # The GNU-specific "-q" option to "grep" means "quiet", i.e.,
17 #+ producing no output.
18 # Redirecting output to /dev/null is therefore not strictly necessary.
19
20 # ...
21
22 echo "Currently active devices:"
23 echo ` /sbin/ifconfig | grep ^[a-z] | awk '{print $1}' `

```

```

24 #           ^^^^^ should be quoted to prevent globbing.
25 # The following also work.
26 #   echo $(/sbin/ifconfig | awk '/^[a-z]/ { print $1 }')
27 #   echo $(/sbin/ifconfig | sed -e 's/ .*//')
28 # Thanks, S.C., for additional comments.

```

See also [Example 32-6](#).

netstat

Show current network statistics and information, such as routing tables and active connections. This utility accesses information in `/proc/net` ([Chapter 29](#)). See [Example 29-4](#).

netstat -r is equivalent to [route](#).

```

bash$ netstat
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
Active UNIX domain sockets (w/o servers)
Proto RefCnt Flags               Type                   State                  I-Node Path
unix  11      [ ]                DGRAM                  CONNECTED              906   /dev/log
unix  3       [ ]                STREAM                 CONNECTED              4514  /tmp/.X11-unix/X0
unix  3       [ ]                STREAM                 CONNECTED              4513
. . .

```



A **netstat -lptu** shows [sockets](#) that are listening to ports, and the associated processes. This can be useful for determining whether a computer has been hacked or compromised.

iwconfig

This is the command set for configuring a wireless network. It is the wireless equivalent of **ifconfig**, above.

ip

General purpose utility for setting up, changing, and analyzing *IP* (Internet Protocol) networks and attached devices. This command is part of the *iproute2* package.

```

bash$ ip link show
1: lo: <LOOPBACK,UP> mtu 16436 qdisc noqueue
   link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: eth0: <BROADCAST,MULTICAST> mtu 1500 qdisc pfifo_fast qlen 1000
   link/ether 00:d0:59:ce:af:da brd ff:ff:ff:ff:ff:ff
3: sit0: <NOARP> mtu 1480 qdisc noop
   link/sit 0.0.0.0 brd 0.0.0.0

bash$ ip route list
169.254.0.0/16 dev lo scope link

```

Or, in a script:

```

1 #!/bin/bash
2 # Script by Juan Nicolas Ruiz
3 # Used with his kind permission.
4
5 # Setting up (and stopping) a GRE tunnel.
6
7
8 # --- start-tunnel.sh ---
9
10 LOCAL_IP="192.168.1.17"
11 REMOTE_IP="10.0.5.33"
12 OTHER_IFACE="192.168.0.100"
13 REMOTE_NET="192.168.3.0/24"
14
15 /sbin/ip tunnel add netb mode gre remote $REMOTE_IP \

```

```

16 local $LOCAL_IP ttl 255
17 /sbin/ip addr add $OTHER_IFACE dev netb
18 /sbin/ip link set netb up
19 /sbin/ip route add $REMOTE_NET dev netb
20
21 exit 0 #####
22
23 # --- stop-tunnel.sh ---
24
25 REMOTE_NET="192.168.3.0/24"
26
27 /sbin/ip route del $REMOTE_NET dev netb
28 /sbin/ip link set netb down
29 /sbin/ip tunnel del netb
30
31 exit 0

```

route

Show info about or make changes to the kernel routing table.

```

bash$ route

```

Destination	Gateway	Genmask	Flags	MSS	Window	irtt	Iface
pm3-67.bozosisp	*	255.255.255.255	UH	40	0	0	ppp0
127.0.0.0	*	255.0.0.0	U	40	0	0	lo
default	pm3-67.bozosisp	0.0.0.0	UG	40	0	0	ppp0

iptables

The **iptables** command set is a packet filtering tool used mainly for such security purposes as setting up network firewalls. This is a complex tool, and a detailed explanation of its use is beyond the scope of this document. [Oskar Andreasson's tutorial](#) is a reasonable starting point.

See also [shutting down iptables](#) and [Example 30-2](#).

chkconfig

Check network and system configuration. This command lists and manages the network and system services started at bootup in the `/etc/rc?.d` directory.

Originally a port from IRIX to Red Hat Linux, **chkconfig** may not be part of the core installation of some Linux flavors.

```

bash$ chkconfig --list

```

atd	0:off	1:off	2:off	3:on	4:on	5:on	6:off
rwhod	0:off	1:off	2:off	3:off	4:off	5:off	6:off
...							

tcpdump

Network packet "sniffer." This is a tool for analyzing and troubleshooting traffic on a network by dumping packet headers that match specified criteria.

Dump ip packet traffic between hosts *bozoville* and *caduceus*:

```

bash$ tcpdump ip host bozoville and caduceus

```

Of course, the output of **tcpdump** can be parsed with certain of the previously discussed [text processing utilities](#).

Filesystem

mount

Mount a filesystem, usually on an external device, such as a floppy or CDROM. The file

`/etc/fstab` provides a handy listing of available filesystems, partitions, and devices, including options, that may be automatically or manually mounted. The file `/etc/mtab` shows the currently mounted filesystems and partitions (including the virtual ones, such as `/proc`).

mount -a mounts all filesystems and partitions listed in `/etc/fstab`, except those with a `noauto` option. At bootup, a startup script in `/etc/rc.d` (`rc.sysinit` or something similar) invokes this to get everything mounted.

```
1 mount -t iso9660 /dev/cdrom /mnt/cdrom
2 # Mounts CD ROM. ISO 9660 is a standard CD ROM filesystem.
3 mount /mnt/cdrom
4 # Shortcut, if /mnt/cdrom listed in /etc/fstab
```

The versatile `mount` command can even mount an ordinary file on a block device, and the file will act as if it were a filesystem. `Mount` accomplishes that by associating the file with a [loopback device](#). One application of this is to mount and examine an ISO9660 filesystem image before burning it onto a CDR. [3]

Example 17-7. Checking a CD image

```
1 # As root...
2
3 mkdir /mnt/cdtest # Prepare a mount point, if not already there.
4
5 mount -r -t iso9660 -o loop cd-image.iso /mnt/cdtest # Mount the image.
6 #
7 cd /mnt/cdtest # Now, check the image.
8 ls -alR # List the files in the directory tree there.
9 # And so forth.
```

umount

Unmount a currently mounted filesystem. Before physically removing a previously mounted floppy or CDROM disk, the device must be **unmounted**, else filesystem corruption may result.

```
1 umount /mnt/cdrom
2 # You may now press the eject button and safely remove the disk.
```



The **automount** utility, if properly installed, can mount and unmount floppies or CDROM disks as they are accessed or removed. On "multispindle" laptops with swappable floppy and optical drives, this can cause problems, however.

gnome-mount

The newer Linux distros have deprecated **mount** and **umount**. The successor, for command-line mounting of removable storage devices, is **gnome-mount**. It can take the `-d` option to mount a [device file](#) by its listing in `/dev`.

For example, to mount a USB flash drive:

```
bash$ gnome-mount -d /dev/sda1
gnome-mount 0.4

bash$ df
. . .
/dev/sda1          63584      12034      51550   19% /media/disk
```

sync

Forces an immediate write of all updated data from buffers to hard drive (synchronize drive with buffers). While not strictly necessary, a **sync** assures the sys admin or user that the data just changed will survive a sudden power failure. In the olden days, a **sync; sync** (twice, just to make absolutely sure) was a useful precautionary measure before a system reboot.

At times, you may wish to force an immediate buffer flush, as when securely deleting a file (see [Example 16-61](#)) or when the lights begin to flicker.

losetup

Sets up and configures [loopback devices](#).

Example 17-8. Creating a filesystem in a file

```
1 SIZE=1000000 # 1 meg
2
3 head -c $SIZE < /dev/zero > file # Set up file of designated size.
4 losetup /dev/loop0 file # Set it up as loopback device.
5 mke2fs /dev/loop0 # Create filesystem.
6 mount -o loop /dev/loop0 /mnt # Mount it.
7
8 # Thanks, S.C.
```

mkswap

Creates a swap partition or file. The swap area must subsequently be enabled with **swapon**.

swapon, swapon

Enable / disable swap partition or file. These commands usually take effect at bootup and shutdown.

mke2fs

Create a Linux *ext2* filesystem. This command must be invoked as *root*.

Example 17-9. Adding a new hard drive

```
1 #!/bin/bash
2
3 # Adding a second hard drive to system.
4 # Software configuration. Assumes hardware already mounted.
5 # From an article by the author of the ABS Guide.
6 # In issue #38 of _Linux Gazette_, http://www.linuxgazette.com.
7
8 ROOT_UID=0 # This script must be run as root.
9 E_NOTROOT=67 # Non-root exit error.
10
11 if [ "$UID" -ne "$ROOT_UID" ]
12 then
13 echo "Must be root to run this script."
14 exit $E_NOTROOT
15 fi
16
17 # Use with extreme caution!
18 # If something goes wrong, you may wipe out your current filesystem.
19
20
21 NEWDISK=/dev/hdb # Assumes /dev/hdb vacant. Check!
22 MOUNTPOINT=/mnt/newdisk # Or choose another mount point.
23
24
25 fdisk $NEWDISK
26 mke2fs -cv $NEWDISK1 # Check for bad blocks (verbose output).
27 # Note: ^ /dev/hdb1, *not* /dev/hdb!
28 mkdir $MOUNTPOINT
```

```
29 chmod 777 $MOUNTPOINT # Makes new drive accessible to all users.
30
31
32 # Now, test ...
33 # mount -t ext2 /dev/hdb1 /mnt/newdisk
34 # Try creating a directory.
35 # If it works, umount it, and proceed.
36
37 # Final step:
38 # Add the following line to /etc/fstab.
39 # /dev/hdb1 /mnt/newdisk ext2 defaults 1 1
40
41 exit
```

See also [Example 17-8](#) and [Example 31-3](#).

mkdosfs

Create a DOS *FAT* filesystem.

tune2fs

Tune *ext2* filesystem. May be used to change filesystem parameters, such as maximum mount count. This must be invoked as *root*.



This is an extremely dangerous command. Use it at your own risk, as you may inadvertently destroy your filesystem.

dumpe2fs

Dump (list to `stdout`) very verbose filesystem info. This must be invoked as *root*.

```
root# dumpe2fs /dev/hda7 | grep 'ount count'
dumpe2fs 1.19, 13-Jul-2000 for EXT2 FS 0.5b, 95/08/09
Mount count:                6
Maximum mount count:        20
```

hdparm

List or change hard disk parameters. This command must be invoked as *root*, and it may be dangerous if misused.

fdisk

Create or change a partition table on a storage device, usually a hard drive. This command must be invoked as *root*.



Use this command with extreme caution. If something goes wrong, you may destroy an existing filesystem.

fsck, e2fsck, debugfs

Filesystem check, repair, and debug command set.

fsck: a front end for checking a UNIX filesystem (may invoke other utilities). The actual filesystem type generally defaults to *ext2*.

e2fsck: *ext2* filesystem checker.

debugfs: *ext2* filesystem debugger. One of the uses of this versatile, but dangerous command is to (attempt to) recover deleted files. For advanced users only!



All of these should be invoked as *root*, and they can damage or destroy a filesystem if misused.

badblocks

Checks for bad blocks (physical media flaws) on a storage device. This command finds use when formatting a newly installed hard drive or testing the integrity of backup media. [4] As an example, **badblocks /dev/fd0** tests a floppy disk.

The **badblocks** command may be invoked destructively (overwrite all data) or in non-destructive read-only mode. If *root user* owns the device to be tested, as is generally the case, then *root* must invoke this command.

lsusb, usbmodules

The **lsusb** command lists all USB (Universal Serial Bus) buses and the devices hooked up to them.

The **usbmodules** command outputs information about the driver modules for connected USB devices.

```
bash$ lsusb
Bus 001 Device 001: ID 0000:0000
Device Descriptor:
  bLength                18
  bDescriptorType        1
  bcdUSB                  1.00
  bDeviceClass            9 Hub
  bDeviceSubClass         0
  bDeviceProtocol         0
  bMaxPacketSize0         8
  idVendor                 0x0000
  idProduct                0x0000
  . . .
```

lspci

Lists *pci* busses present.

```
bash$ lspci
00:00.0 Host bridge: Intel Corporation 82845 845
(Brookdale) Chipset Host Bridge (rev 04)
00:01.0 PCI bridge: Intel Corporation 82845 845
(Brookdale) Chipset AGP Bridge (rev 04)
00:1d.0 USB Controller: Intel Corporation 82801CA/CAM USB (Hub #1) (rev 02)
00:1d.1 USB Controller: Intel Corporation 82801CA/CAM USB (Hub #2) (rev 02)
00:1d.2 USB Controller: Intel Corporation 82801CA/CAM USB (Hub #3) (rev 02)
00:1e.0 PCI bridge: Intel Corporation 82801 Mobile PCI Bridge (rev 42)
. . .
```

mkbootdisk

Creates a boot floppy which can be used to bring up the system if, for example, the MBR (master boot record) becomes corrupted. Of special interest is the `--iso` option, which uses **mkisofs** to create a bootable *ISO9660* filesystem image suitable for burning a bootable CDR.

The **mkbootdisk** command is actually a Bash script, written by Erik Troan, in the `/sbin` directory.

mkisofs

Creates an *ISO9660* filesystem suitable for a CDR image.

chroot

Change ROOT directory. Normally commands are fetched from `$PATH`, relative to `/`, the default *root directory*. This changes the *root* directory to a different one (and also changes the working directory to there). This is useful for security purposes, for instance when the system administrator wishes to restrict certain users, such as those [telnetting](#) in, to a secured portion of the filesystem (this is sometimes referred to as confining a guest user to a "chroot jail"). Note that after a **chroot**, the execution path for system binaries is no longer valid.

A **chroot /opt** would cause references to `/usr/bin` to be translated to `/opt/usr/bin`. Likewise, **chroot /aaa/bbb /bin/ls** would redirect future instances of **ls** to `/aaa/bbb` as the base directory, rather than `/` as is normally the case. An **alias XX 'chroot /aaa/bbb ls'** in a user's `~/.bashrc` effectively restricts which portion of the filesystem she may run command "XX" on.

The **chroot** command is also handy when running from an emergency boot floppy (**chroot** to /dev/fd0), or as an option to **lilo** when recovering from a system crash. Other uses include installation from a different filesystem (an [rpm](#) option) or running a readonly filesystem from a CD ROM. Invoke only as *root*, and use with care.



It might be necessary to copy certain system files to a *chrooted* directory, since the normal \$PATH can no longer be relied upon.

lockfile

This utility is part of the **procmail** package (www.procmail.org). It creates a *lock file*, a *semaphore* that controls access to a file, device, or resource.

Definition: A *semaphore* is a flag or signal. (The usage originated in railroading, where a colored flag, lantern, or striped movable arm *semaphore* indicated whether a particular track was in use and therefore unavailable for another train.) A UNIX process can check the appropriate semaphore to determine whether a particular resource is available/accessible.

The lock file serves as a flag that this particular file, device, or resource is in use by a process (and is therefore "busy"). The presence of a lock file permits only restricted access (or no access) to other processes.

```
1 lockfile /home/bozo/lockfiles/$0.lock
2 # Creates a write-protected lockfile prefixed with the name of the script.
3
4 lockfile /home/bozo/lockfiles/${0##*/}.lock
5 # A safer version of the above, as pointed out by E. Choroba.
```

Lock files are used in such applications as protecting system mail folders from simultaneously being changed by multiple users, indicating that a modem port is being accessed, and showing that an instance of Firefox is using its cache. Scripts may check for the existence of a lock file created by a certain process to check if that process is running. Note that if a script attempts to create a lock file that already exists, the script will likely hang.

Normally, applications create and check for lock files in the /var/lock directory. [5] A script can test for the presence of a lock file by something like the following.

```
1 appname=xyzip
2 # Application "xyzip" created lock file "/var/lock/xyzip.lock".
3
4 if [ -e "/var/lock/$appname.lock" ]
5 then    #+ Prevent other programs & scripts
6        # from accessing files/resources used by xysize.
7    ...
```

flock

Much less useful than the **lockfile** command is **flock**. It sets an "advisory" lock on a file and then executes a command while the lock is on. This is to prevent any other process from setting a lock on that file until completion of the specified command.

```
1 flock $0 cat $0 > lockfile__$0
2 # Set a lock on the script the above line appears in,
3 #+ while listing the script to stdout.
```



Unlike **lockfile**, **flock** does *not* automatically create a lock file.

mknod

Creates block or character [device files](#) (may be necessary when installing new hardware on the system). The **MAKEDEV** utility has virtually all of the functionality of **mknod**, and is easier to use.

MAKEDEV

Utility for creating device files. It must be run as *root*, and in the `/dev` directory. It is a sort of advanced version of **mknod**.

tmpwatch

Automatically deletes files which have not been accessed within a specified period of time. Usually invoked by [cron](#) to remove stale log files.

Backup

dump, restore

The **dump** command is an elaborate filesystem backup utility, generally used on larger installations and networks. [\[6\]](#) It reads raw disk partitions and writes a backup file in a binary format. Files to be backed up may be saved to a variety of storage media, including disks and tape drives. The **restore** command restores backups made with **dump**.

fdformat

Perform a low-level format on a floppy disk (`/dev/fd0*`).

System Resources

ulimit

Sets an *upper limit* on use of system resources. Usually invoked with the `-f` option, which sets a limit on file size (**ulimit -f 1000** limits files to 1 meg maximum). [\[7\]](#) The `-t` option limits the coredump size (**ulimit -c 0** eliminates coredumps). Normally, the value of **ulimit** would be set in `/etc/profile` and/or `~/.bash_profile` (see [Appendix H](#)).



Judicious use of **ulimit** can protect a system against the dreaded *fork bomb*.

```
1 #!/bin/bash
2 # This script is for illustrative purposes only.
3 # Run it at your own peril -- it WILL freeze your system.
4
5 while true # Endless loop.
6 do
7   $0 & # This script invokes itself . . .
8       #+ forks an infinite number of times . . .
9       #+ until the system freezes up because all resources exhausted.
10 done # This is the notorious "sorcerer's apprentice" scenario.
11
12 exit 0 # Will not exit here, because this script will never terminate.
```

A **ulimit -Hu XX** (where *XX* is the user process limit) in `/etc/profile` would abort this script when it exceeded the preset limit.

quota

Display user or group disk quotas.

setquota

Set user or group disk quotas from the command-line.

umask

User file creation permissions *mask*. Limit the default file attributes for a particular user. All files created by that user take on the attributes specified by **umask**. The (octal) value passed to **umask** defines the file permissions *disabled*. For example, **umask 022** ensures that new files will have at most 755 permissions (777 NAND 022). [\[8\]](#) Of course, the user may later change the attributes of particular files with [chmod](#). The usual practice is to set the value of **umask** in `/etc/profile` and/or `~/.bash_profile` (see [Appendix H](#)).

Example 17-10. Using *umask* to hide an output file from prying eyes

```

1 #!/bin/bash
2 # rot13a.sh: Same as "rot13.sh" script, but writes output to "secure" file.
3
4 # Usage: ./rot13a.sh filename
5 # or     ./rot13a.sh <filename
6 # or     ./rot13a.sh and supply keyboard input (stdin)
7
8 umask 177                # File creation mask.
9                          # Files created by this script
10                         #+ will have 600 permissions.
11
12 OUTFILE=decrypted.txt   # Results output to file "decrypted.txt"
13                         #+ which can only be read/written
14                         # by invoker of script (or root).
15
16 cat "$@" | tr 'a-zA-Z' 'n-zA-mN-ZA-M' > $OUTFILE
17 #     ^^ Input from stdin or a file.  ^^^^^^^^^^^ Output redirected to file.
18
19 exit 0

```

rdev

Get info about or make changes to root device, swap space, or video mode. The functionality of **rdev** has generally been taken over by **lilo**, but **rdev** remains useful for setting up a ram disk. This is a dangerous command, if misused.

Modules

lsmod

List installed kernel modules.

```

bash$ lsmod
Module                Size  Used by
autofs                 9456  2 (autoclean)
opl3                   11376  0
serial_cs              5456  0 (unused)
sb                     34752  0
uart401                6384  0 [sb]
sound                  58368  0 [opl3 sb uart401]
soundlow               464  0 [sound]
soundcore              2800  6 [sb sound]
ds                     6448  2 [serial_cs]
i82365                 22928  2
pcmcia_core            45984  0 [serial_cs ds i82365]

```

 Doing a **cat /proc/modules** gives the same information.

insmod

Force installation of a kernel module (use **modprobe** instead, when possible). Must be invoked as *root*.

rmmod

Force unloading of a kernel module. Must be invoked as *root*.

modprobe

Module loader that is normally invoked automatically in a startup script. Must be invoked as *root*.

depmod

Creates module dependency file. Usually invoked from a startup script.

modinfo

Output information about a loadable module.

```

bash$ modinfo hid
filename:    /lib/modules/2.4.20-6/kernel/drivers/usb/hid.o

```

```
description: "USB HID support drivers"
author:      "Andreas Gal, Vojtech Pavlik <vojtech@suse.cz>"
license:     "GPL"
```

Miscellaneous

env

Runs a program or script with certain [environmental variables](#) set or changed (without changing the overall system environment). The `[varname=xxx]` permits changing the environmental variable `varname` for the duration of the script. With no options specified, this command lists all the environmental variable settings. [\[9\]](#)



The first line of a script (the "sha-bang" line) may use **env** when the path to the shell or interpreter is unknown.

```
1 #!/usr/bin/env perl
2
3 print "This Perl script will run,\n";
4 print "even when I don't know where to find Perl.\n";
5
6 # Good for portable cross-platform scripts,
7 # where the Perl binaries may not be in the expected place.
8 # Thanks, S.C.
```

Or even ...

```
1 #!/bin/env bash
2 # Queries the $PATH environmental variable for the location of bash.
3 # Therefore ...
4 # This script will run where Bash is not in its usual place, in /bin.
5 ...
```

ldd

Show shared lib dependencies for an executable file.

```
bash$ ldd /bin/ls
libc.so.6 => /lib/libc.so.6 (0x4000c000)
/lib/ld-linux.so.2 => /lib/ld-linux.so.2 (0x80000000)
```

watch

Run a command repeatedly, at specified time intervals.

The default is two-second intervals, but this may be changed with the `-n` option.

```
1 watch -n 5 tail /var/log/messages
2 # Shows tail end of system log, /var/log/messages, every five seconds.
```



Unfortunately, [piping](#) the output of **watch** command to [grep](#) does not work.

strip

Remove the debugging symbolic references from an executable binary. This decreases its size, but makes debugging it impossible.

This command often occurs in a [Makefile](#), but rarely in a shell script.

nm

List symbols in an unstripped compiled binary.

xrandr

Command-line tool for manipulating the root window of the screen.

Example 17-11. *Backlight*: changes the brightness of the (laptop) screen backlight

```
1 #!/bin/bash
2 # backlight.sh
3 # reldate 02dec2011
4
5 # A bug in Fedora Core 16/17 messes up the keyboard backlight controls.
6 # This script is a quick-n-dirty workaround, essentially a shell wrapper
7 #+ for xrandr. It gives more control than on-screen sliders and widgets.
8
9 OUTPUT=$(xrandr | grep LV | awk '{print $1}') # Get display name!
10 INCR=.05 # For finer-grained control, set INCR to .03 or .02.
11
12 old_brightness=$(xrandr --verbose | grep rightness | awk '{ print $2 }')
13
14
15 if [ -z "$1" ]
16 then
17     bright=1 # If no command-line arg, set brightness to 1.0 (default).
18
19 else
20     if [ "$1" = "+" ]
21     then
22         bright=$(echo "scale=2; $old_brightness + $INCR" | bc) # +.05
23
24     else
25         if [ "$1" = "-" ]
26         then
27             bright=$(echo "scale=2; $old_brightness - $INCR" | bc) # -.05
28
29         else
30             if [ "$1" = "#" ] # Echoes current brightness; does not change it.
31             then
32                 bright=$old_brightness
33
34             else
35                 if [[ "$1" = "h" || "$1" = "H" ]]
36                 then
37                     echo
38                     echo "Usage:"
39                     echo "$0 [No args] Sets/resets brightness to default (1.0).\"
40                     echo \"$0 + Increments brightness by 0.5.\"
41                     echo \"$0 - Decrements brightness by 0.5.\"
42                     echo \"$0 # Echoes current brightness without changing it.\"
43                     echo \"$0 N (number) Sets brightness to N (useful range .7 - 1.2).\"
44                     echo \"$0 h [H] Echoes this help message.\"
45                     echo \"$0 any-other Gives xrandr usage message.\"
46
47                     bright=$old_brightness
48
49                 else
50                     bright=\"$1\"
51
52                     fi
53                 fi
54             fi
55         fi
56     fi
57
58
59 xrandr --output \"$OUTPUT\" --brightness \"$bright\" # See xrandr manpage.
60 # As root!
61 E_CHANGE0=$?
62 echo \"Current brightness = $bright\"
63
64 exit $E_CHANGE0
```

```

65
66
67 # ===== Or, alternately . . . ===== #
68
69 #!/bin/bash
70 # backlight2.sh
71 # reldate 20jun2012
72
73 # A bug in Fedora Core 16/17 messes up the keyboard backlight controls.
74 # This is a quick-n-dirty workaround, an alternate to backlight.sh.
75
76 target_dir=\
77 /sys/devices/pci0000:00/0000:00:01.0/0000:01:00.0/backlight/acpi_video0
78 # Hardware directory.
79
80 actual_brightness=$(cat $target_dir/actual_brightness)
81 max_brightness=$(cat $target_dir/max_brightness)
82 Brightness=$target_dir/brightness
83
84 let "req_brightness = actual_brightness" # Requested brightness.
85
86 if [ "$1" = "-" ]
87 then # Decrement brightness 1 notch.
88     let "req_brightness = $actual_brightness - 1"
89 else
90     if [ "$1" = "+" ]
91     then # Increment brightness 1 notch.
92         let "req_brightness = $actual_brightness + 1"
93     fi
94 fi
95
96 if [ $req_brightness -gt $max_brightness ]
97 then
98     req_brightness=$max_brightness
99 fi # Do not exceed max. hardware design brightness.
100
101 echo
102
103 echo "Old brightness = $actual_brightness"
104 echo "Max brightness = $max_brightness"
105 echo "Requested brightness = $req_brightness"
106 echo
107
108 # =====
109 echo $req_brightness > $Brightness
110 # Must be root for this to take effect.
111 E_CHANGE1=$? # Successful?
112 # =====
113
114 if [ "$?" -eq 0 ]
115 then
116     echo "Changed brightness!"
117 else
118     echo "Failed to change brightness!"
119 fi
120
121 act_brightness=$(cat $Brightness)
122 echo "Actual brightness = $act_brightness"
123
124 scale0=2
125 sf=100 # Scale factor.
126 pct=$(echo "scale=$scale0; $act_brightness / $max_brightness * $sf" | bc)
127 echo "Percentage brightness = $pct%"
128
129 exit $E_CHANGE1

```

rdist

Remote distribution client: synchronizes, clones, or backs up a file system on a remote server.

17.1. Analyzing a System Script

Using our knowledge of administrative commands, let us examine a system script. One of the shortest and simplest to understand scripts is "killall," [\[10\]](#) used to suspend running processes at system shutdown.

Example 17-12. *killall*, from `/etc/rc.d/init.d`

```
1 #!/bin/sh
2
3 # --> Comments added by the author of this document marked by "# -->".
4
5 # --> This is part of the 'rc' script package
6 # --> by Miquel van Smoorenburg, <miquels@drinkel.nl.mugnet.org>.
7
8 # --> This particular script seems to be Red Hat / FC specific
9 # --> (may not be present in other distributions).
10
11 # Bring down all unneeded services that are still running
12 #+ (there shouldn't be any, so this is just a sanity check)
13
14 for i in /var/lock/subsys/*; do
15     # --> Standard for/in loop, but since "do" is on same line,
16     # --> it is necessary to add ";".
17     # Check if the script is there.
18     [ ! -f $i ] && continue
19     # --> This is a clever use of an "and list", equivalent to:
20     # --> if [ ! -f "$i" ]; then continue
21
22     # Get the subsystem name.
23     subsys=${i#/var/lock/subsys/}
24     # --> Match variable name, which, in this case, is the file name.
25     # --> This is the exact equivalent of subsys=`basename $i`.
26
27     # --> It gets it from the lock file name
28     # -->+ (if there is a lock file,
29     # -->+ that's proof the process has been running).
30     # --> See the "lockfile" entry, above.
31
32
33     # Bring the subsystem down.
34     if [ -f /etc/rc.d/init.d/$subsys.init ]; then
35         /etc/rc.d/init.d/$subsys.init stop
36     else
37         /etc/rc.d/init.d/$subsys stop
38     # --> Suspend running jobs and daemons.
39     # --> Note that "stop" is a positional parameter,
40     # -->+ not a shell builtin.
41     fi
42 done
```

That wasn't so bad. Aside from a little fancy footwork with variable matching, there is no new material there.

Exercise 1. In `/etc/rc.d/init.d`, analyze the `halt` script. It is a bit longer than `killall`, but similar in concept. Make a copy of this script somewhere in your home directory and experiment with it (do *not* run it as *root*). Do a simulated run with the `-vn` flags (`sh -vn scriptname`). Add extensive comments. Change the commands to `echos`.

Exercise 2. Look at some of the more complex scripts in `/etc/rc.d/init.d`. Try to understand at least

portions of them. Follow the above procedure to analyze them. For some additional insight, you might also examine the file `sysvinitfiles` in `/usr/share/doc/initscripts-?.??`, which is part of the "initscripts" documentation.

Notes

- [1] This is the case on a Linux machine or a UNIX system with disk quotas.
- [2] The `userdel` command will fail if the particular user being deleted is still logged on.
- [3] For more detail on burning CDRs, see Alex Withers' article, [Creating CDs](#), in the October, 1999 issue of *Linux Journal*.
- [4] The `-c` option to `mke2fs` also invokes a check for bad blocks.
- [5] Since only `root` has write permission in the `/var/lock` directory, a user script cannot set a lock file there.
- [6] Operators of single-user Linux systems generally prefer something simpler for backups, such as `tar`.
- [7] As of the [version 4 update](#) of Bash, the `-f` and `-c` options take a block size of 512 when in [POSIX](#) mode. Additionally, there are two new options: `-b` for [socket](#) buffer size, and `-T` for the limit on the number of *threads*.
- [8] NAND is the logical *not-and* operator. Its effect is somewhat similar to subtraction.
- [9] In Bash and other Bourne shell derivatives, it is possible to set variables in a single command's environment.

```
1 var1=value1 var2=value2 commandXXX
2 # $var1 and $var2 set in the environment of 'commandXXX' only.
```

- [10] The `killall` system script should not be confused with the [killall](#) command in `/usr/bin`.

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Part 5. Advanced Topics

At this point, we are ready to delve into certain of the difficult and unusual aspects of scripting. Along the way, we will attempt to "push the envelope" in various ways and examine *boundary conditions* (what happens when we move into uncharted territory?).

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Chapter 18. Regular Expressions

. . . the intellectual activity associated with software development is largely one of gaining insight.

--Stowe Boyd

To fully utilize the power of shell scripting, you need to master Regular Expressions. Certain commands and utilities commonly used in scripts, such as [grep](#), [expr](#), [sed](#) and [awk](#), interpret and use REs. As of [version 3](#), Bash has acquired its own [RE-match operator](#): =~.

18.1. A Brief Introduction to Regular Expressions

An expression is a string of characters. Those characters having an interpretation above and beyond their literal meaning are called *metacharacters*. A quote symbol, for example, may denote speech by a person, *ditto*, or a meta-meaning [1] for the symbols that follow. Regular Expressions are sets of characters and/or metacharacters that match (or specify) patterns.

A Regular Expression contains one or more of the following:

- A *character set*. These are the characters retaining their literal meaning. The simplest type of Regular Expression consists *only* of a character set, with no metacharacters.
- An *anchor*. These designate (*anchor*) the position in the line of text that the RE is to match. For example, ^, and \$ are anchors.
- *Modifiers*. These expand or narrow (*modify*) the range of text the RE is to match. Modifiers include the asterisk, brackets, and the backslash.

The main uses for Regular Expressions (*REs*) are text searches and string manipulation. An RE *matches* a single character or a set of characters -- a string or a part of a string.

- The asterisk -- * -- matches any number of repeats of the character string or RE preceding it, including *zero* instances.

"1133*" matches *11 + one or more 3's: 113, 1133, 1133333, and so forth.*

- The *dot* -- . -- matches any one character, except a newline. [2]

"13." matches *13 + at least one of any character (including a space): 1133, 11333, but not 13 (additional character missing).*

See [Example 16-18](#) for a demonstration of *dot single-character* matching.

- The caret -- ^ -- matches the beginning of a line, but sometimes, depending on context, negates the meaning of a set of characters in an RE.

The dollar sign -- \$ -- at the end of an RE matches the end of a line.

"XXX\$" matches XXX at the end of a line.

"^\$" matches blank lines.

Brackets -- [...] -- enclose a set of characters to match in a single RE.

"[xyz]" matches any one of the characters *x, y, or z.*

"[c-n]" matches any one of the characters in the range *c to n.*

"[B-Pk-y]" matches any one of the characters in the ranges *B to P* and *k to y.*

"[a-z0-9]" matches any single lowercase letter or any digit.

"[^b-d]" matches any character *except* those in the range *b to d.* This is an instance of ^ negating or inverting the meaning of the following RE (taking on a role similar to ! in a different context).

Combined sequences of bracketed characters match common word patterns. "[Yy][Ee][Ss]" matches *yes, Yes, YES, yEs*, and so forth. "[0-9][0-9][0-9]-[0-9][0-9]-[0-9][0-9][0-9]" matches any Social Security number.

- The backslash -- \ -- [escapes](#) a special character, which means that character gets interpreted literally (and is therefore no longer *special*).

A "\$" reverts back to its literal meaning of "\$", rather than its RE meaning of end-of-line. Likewise a "\" has the literal meaning of "\".

- [Escaped](#) "angle brackets" -- \<...\> -- mark word boundaries.

The angle brackets must be escaped, since otherwise they have only their literal character meaning.

"\<the\>" matches the word "the," but not the words "them," "there," "other," etc.

```
bash$ cat textfile
This is line 1, of which there is only one instance.
This is the only instance of line 2.
This is line 3, another line.
This is line 4.

bash$ grep 'the' textfile
This is line 1, of which there is only one instance.
This is the only instance of line 2.
This is line 3, another line.

bash$ grep '\<the\>' textfile
This is the only instance of line 2.
```

The only way to be certain that a particular RE works is to test it.

```
1 TEST FILE: tstfile # No match.
2 # No match.
3 Run grep "1133*" on this file. # Match.
4 # No match.
5 # No match.
6 This line contains the number 113. # Match.
7 This line contains the number 13. # No match.
8 This line contains the number 133. # No match.
9 This line contains the number 1133. # Match.
10 This line contains the number 113312. # Match.
11 This line contains the number 1112. # No match.
12 This line contains the number 113312312. # Match.
13 This line contains no numbers at all. # No match.

bash$ grep "1133*" tstfile
Run grep "1133*" on this file. # Match.
This line contains the number 113. # Match.
This line contains the number 1133. # Match.
This line contains the number 113312. # Match.
This line contains the number 113312312. # Match.
```

- **Extended REs.** Additional metacharacters added to the basic set. Used in [egrep](#), [awk](#), and [Perl](#).

- The question mark -- ? -- matches zero or one of the previous RE. It is generally used for matching single characters.
- The plus -- + -- matches one or more of the previous RE. It serves a role similar to the *, but does *not* match zero occurrences.

```
1 # GNU versions of sed and awk can use "+",
2 # but it needs to be escaped.
3
4 echo a111b | sed -ne '/a1\+b/p'
5 echo a111b | grep 'a1\+b'
6 echo a111b | gawk '/a1+b/'
7 # All of above are equivalent.
8
9 # Thanks, S.C.
```

- Escaped "curly brackets" -- \{ \} -- indicate the number of occurrences of a preceding RE to match.

It is necessary to escape the curly brackets since they have only their literal character meaning otherwise. This usage is technically not part of the basic RE set.

"[0-9]\{5\}" matches exactly five digits (characters in the range of 0 to 9).



Curly brackets are not available as an RE in the "classic" (non-POSIX compliant) version of [awk](#). However, the GNU extended version of *awk*, **gawk**, has the `--re-interval` option that permits them (without being escaped).

```
bash$ echo 2222 | gawk --re-interval '/2{3}/'
2222
```

Perl and some **egrep** versions do not require escaping the curly brackets.

- Parentheses -- () -- enclose a group of REs. They are useful with the following "|" operator and in [substring extraction](#) using [expr](#).
- The -- | -- "or" RE operator matches any of a set of alternate characters.

```
bash$ egrep 're(a|e)d' misc.txt
People who read seem to be better informed than those who do not.
The clarinet produces sound by the vibration of its reed.
```




Some versions of **sed**, **ed**, and **ex** support escaped versions of the extended Regular Expressions described above, as do the GNU utilities.

• POSIX Character Classes. [:class:]

This is an alternate method of specifying a range of characters to match.

- [:alnum:] matches alphabetic or numeric characters. This is equivalent to **A-Za-z0-9**.
- [:alpha:] matches alphabetic characters. This is equivalent to **A-Za-z**.
- [:blank:] matches a space or a tab.
- [:cntrl:] matches control characters.
- [:digit:] matches (decimal) digits. This is equivalent to **0-9**.
- [:graph:] (graphic printable characters). Matches characters in the range of [ASCII](#) 33 - 126. This is the same as [:print:], below, but excluding the space character.
- [:lower:] matches lowercase alphabetic characters. This is equivalent to **a-z**.
- [:print:] (printable characters). Matches characters in the range of ASCII 32 - 126. This is the same as [:graph:], above, but adding the space character.

- `[:space:]` matches whitespace characters (space and horizontal tab).
- `[:upper:]` matches uppercase alphabetic characters. This is equivalent to `A-Z`.
- `[:xdigit:]` matches hexadecimal digits. This is equivalent to `0-9A-Fa-f`.

 POSIX character classes generally require quoting or [double brackets](#) (`[[]]`).

```
bash$ grep [[:digit:]] test.file
abc=723
```

```
1 # ...
2 if [[ $arrow =~ [[:digit:]] ]] # Numerical input?
3 then # POSIX char class
4   if [[ $acol =~ [[:alpha:]] ]] # Number followed by a letter? Illegal!
5 # ...
6 # From ktour.sh example script.
```

These character classes may even be used with [globbing](#), to a limited extent.

```
bash$ ls -l ?[[:digit:]][[:digit:]]?
-rw-rw-r-- 1 bozo bozo 0 Aug 21 14:47 a33b
```

POSIX character classes are used in [Example 16-21](#) and [Example 16-22](#).

[Sed](#), [awk](#), and [Perl](#), used as filters in scripts, take REs as arguments when "sifting" or transforming files or I/O streams. See [Example A-12](#) and [Example A-16](#) for illustrations of this.

The standard reference on this complex topic is Friedl's *Mastering Regular Expressions. Sed & Awk*, by Dougherty and Robbins, also gives a very lucid treatment of REs. See the [Bibliography](#) for more information on these books.

Notes

- [1] A *meta-meaning* is the meaning of a term or expression on a higher level of abstraction. For example, the *literal* meaning of *regular expression* is an ordinary expression that conforms to accepted usage. The *meta-meaning* is drastically different, as discussed at length in this chapter.
- [2] Since [sed](#), [awk](#), and [grep](#) process single lines, there will usually not be a newline to match. In those cases where there is a newline in a multiple line expression, the dot will match the newline.

```
1 #!/bin/bash
2
3 sed -e 'N;s/.*/[&]/' << EOF # Here Document
4 line1
5 line2
6 EOF
7 # OUTPUT:
8 # [line1
9 # line2]
10
11
12
13 echo
14
15 awk '{ $0=$1 "\n" $2; if (/line.1/) {print}}' << EOF
16 line 1
17 line 2
18 EOF
19 # OUTPUT:
20 # line
```

```
21 # 1
22
23
24 # Thanks, S.C.
25
26 exit 0
```

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18.2. Globbing

Bash itself cannot recognize Regular Expressions. Inside scripts, it is commands and utilities -- such as [sed](#) and [awk](#) -- that interpret RE's.

Bash *does* carry out *filename expansion* [1] -- a process known as *globbing* -- but this does *not* use the standard RE set. Instead, globbing recognizes and expands *wild cards*. Globbing interprets the standard wild card characters [2] -- `*` and `?`, character lists in square brackets, and certain other special characters (such as `^` for negating the sense of a match). There are important limitations on wild card characters in globbing, however. Strings containing `*` will not match filenames that start with a dot, as, for example, [.bashrc](#). [3] Likewise, the `?` has a different meaning in globbing than as part of an RE.

```
bash$ ls -l
total 2
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 a.1
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 b.1
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 c.1
-rw-rw-r-- 1 bozo bozo 466 Aug 6 17:48 t2.sh
-rw-rw-r-- 1 bozo bozo 758 Jul 30 09:02 test1.txt

bash$ ls -l t?.sh
-rw-rw-r-- 1 bozo bozo 466 Aug 6 17:48 t2.sh

bash$ ls -l [ab]*
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 a.1
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 b.1

bash$ ls -l [a-c]*
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 a.1
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 b.1
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 c.1

bash$ ls -l [^ab]*
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 c.1
-rw-rw-r-- 1 bozo bozo 466 Aug 6 17:48 t2.sh
-rw-rw-r-- 1 bozo bozo 758 Jul 30 09:02 test1.txt


bash$ ls -l {b*,c*,*est*}
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 b.1
-rw-rw-r-- 1 bozo bozo 0 Aug 6 18:42 c.1
-rw-rw-r-- 1 bozo bozo 758 Jul 30 09:02 test1.txt
```


Bash performs filename expansion on unquoted command-line arguments. The [echo](#) command demonstrates this.

```
bash$ echo *
a.1 b.1 c.1 t2.sh test1.txt

bash$ echo t*
t2.sh test1.txt

bash$ echo t?.sh
t2.sh
```

 It is possible to modify the way Bash interprets special characters in globbing. A `set -f` command disables globbing, and the `nocaseglob` and `nullglob` options to [shopt](#) change globbing behavior. See also [Example 11-5](#).

 Filenames with embedded [whitespace](#) can cause *globbing* to choke. [David Wheeler](#) shows how to avoid many such pitfalls.

```
1 IFS="$(printf '\n\t')" # Remove space.
2
3 # Correct glob use:
4 # Always use for-loop, prefix glob, check if exists file.
5 for file in /* ; do # Use /* ... NEVER bare *
6   if [ -e "$file" ] ; then # Check whether file exists.
7     COMMAND ... "$file" ...
8   fi
9 done
10
11 # This example taken from David Wheeler's site, with permission.
```

Notes

- [1] *Filename expansion* means expanding filename patterns or templates containing special characters. For example, `example.???` might expand to `example.001` and/or `example.txt`.
- [2] A *wild card* character, analogous to a wild card in poker, can represent (almost) any other character.
- [3] Filename expansion *can* match dotfiles, but only if the pattern explicitly includes the dot as a literal character.

```
1 ~/[.]bashrc # Will not expand to ~/.bashrc
2 ~/?bashrc # Neither will this.
3 # Wild cards and metacharacters will NOT
4 #+ expand to a dot in globbing.
5
6 ~/[.]bashrc # Will expand to ~/.bashrc
7 ~/.ba?hrc # Likewise.
8 ~/.bashr* # Likewise.
9
10 # Setting the "dotglob" option turns this off.
11
12 # Thanks, S.C.
```

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Chapter 19. Here Documents

Here and now, boys.

--Aldous Huxley, Island

A *here document* is a special-purpose code block. It uses a form of [I/O redirection](#) to feed a command list to an interactive program or a command, such as [ftp](#), [cat](#), or the *ex* text editor.

```
1 COMMAND <<InputComesFromHERE
2 ...
3 ...
4 ...
5 InputComesFromHERE
```

A *limit string* delineates (frames) the command list. The special symbol << precedes the limit string. This has the effect of redirecting the output of a command block into the `stdin` of the program or command. It is similar to **interactive-program < command-file**, where `command-file` contains

```
1 command #1
2 command #2
3 ...
```

The *here document* equivalent looks like this:

```
1 interactive-program <<LimitString
2 command #1
3 command #2
4 ...
5 LimitString
```

Choose a *limit string* sufficiently unusual that it will not occur anywhere in the command list and confuse matters.

Note that *here documents* may sometimes be used to good effect with non-interactive utilities and commands, such as, for example, [wall](#).

Example 19-1. *broadcast*: Sends message to everyone logged in

```
1 #!/bin/bash
2
3 wall <<zzz23EndOfMessagezzz23
4 E-mail your noontime orders for pizza to the system administrator.
5     (Add an extra dollar for anchovy or mushroom topping.)
6 # Additional message text goes here.
7 # Note: 'wall' prints comment lines.
8 zzz23EndOfMessagezzz23
9
10 # Could have been done more efficiently by
11 #     wall <message-file
12 # However, embedding the message template in a script
13 #+ is a quick-and-dirty one-off solution.
14
15 exit
```

Even such unlikely candidates as the *vi* text editor lend themselves to *here documents*.

Example 19-2. *dummyfile*: Creates a 2-line dummy file

```
1 #!/bin/bash
2
3 # Noninteractive use of 'vi' to edit a file.
4 # Emulates 'sed'.
5
6 E_BADARGS=85
7
8 if [ -z "$1" ]
9 then
10  echo "Usage: `basename $0` filename"
11  exit $E_BADARGS
12 fi
13
14 TARGETFILE=$1
15
16 # Insert 2 lines in file, then save.
17 #-----Begin here document-----#
18 vi $TARGETFILE <<x23LimitStringx23
19 i
20 This is line 1 of the example file.
21 This is line 2 of the example file.
22 ^[
23 ZZ
24 x23LimitStringx23
25 #-----End here document-----#
26
27 # Note that ^[ above is a literal escape
28 #+ typed by Control-V <Esc>.
29
30 # Bram Moolenaar points out that this may not work with 'vim'
31 #+ because of possible problems with terminal interaction.
32
33 exit
```

The above script could just as effectively have been implemented with **ex**, rather than **vi**. *Here documents* containing a list of **ex** commands are common enough to form their own category, known as *ex scripts*.

```
1 #!/bin/bash
2 # Replace all instances of "Smith" with "Jones"
3 #+ in files with a ".txt" filename suffix.
4
5 ORIGINAL=Smith
6 REPLACEMENT=Jones
7
8 for word in $(fgrep -l $ORIGINAL *.txt)
9 do
10  # -----
11  ex $word <<EOF
12  :%s/$ORIGINAL/$REPLACEMENT/g
13  :wq
14 EOF
15 # :%s is the "ex" substitution command.
16 # :wq is write-and-quit.
17 # -----
18 done
```

Analogous to "ex scripts" are *cat scripts*.

Example 19-3. Multi-line message using *cat*

```

1 #!/bin/bash
2
3 # 'echo' is fine for printing single line messages,
4 #+ but somewhat problematic for for message blocks.
5 # A 'cat' here document overcomes this limitation.
6
7 cat <<End-of-message
8 -----
9 This is line 1 of the message.
10 This is line 2 of the message.
11 This is line 3 of the message.
12 This is line 4 of the message.
13 This is the last line of the message.
14 -----
15 End-of-message
16
17 # Replacing line 7, above, with
18 #+ cat > $Newfile <<End-of-message
19 #+ ^^^^^^^^^^^
20 #+ writes the output to the file $Newfile, rather than to stdout.
21
22 exit 0
23
24
25 #-----
26 # Code below disabled, due to "exit 0" above.
27
28 # S.C. points out that the following also works.
29 echo "-----"
30 This is line 1 of the message.
31 This is line 2 of the message.
32 This is line 3 of the message.
33 This is line 4 of the message.
34 This is the last line of the message.
35 -----"
36 # However, text may not include double quotes unless they are escaped.

```

The `-` option to mark a here document limit string (`<<-LimitString`) suppresses leading tabs (but not spaces) in the output. This may be useful in making a script more readable.

Example 19-4. Multi-line message, with tabs suppressed

```

1 #!/bin/bash
2 # Same as previous example, but...
3
4 # The - option to a here document <<-
5 #+ suppresses leading tabs in the body of the document,
6 #+ but *not* spaces.
7
8 cat <<-ENDOFMESSAGE
9     This is line 1 of the message.
10    This is line 2 of the message.
11    This is line 3 of the message.
12    This is line 4 of the message.
13    This is the last line of the message.
14 ENDOFMESSAGE
15 # The output of the script will be flush left.
16 # Leading tab in each line will not show.
17
18 # Above 5 lines of "message" prefaced by a tab, not spaces.
19 # Spaces not affected by <<- .
20

```

```
21 # Note that this option has no effect on *embedded* tabs.
22
23 exit 0
```

A *here document* supports parameter and command substitution. It is therefore possible to pass different parameters to the body of the here document, changing its output accordingly.

Example 19-5. Here document with replaceable parameters

```
1 #!/bin/bash
2 # Another 'cat' here document, using parameter substitution.
3
4 # Try it with no command-line parameters, ./scriptname
5 # Try it with one command-line parameter, ./scriptname Mortimer
6 # Try it with one two-word quoted command-line parameter,
7 # ./scriptname "Mortimer Jones"
8
9 CMDLINEPARAM=1 # Expect at least command-line parameter.
10
11 if [ $# -ge $CMDLINEPARAM ]
12 then
13     NAME=$1 # If more than one command-line param,
14             #+ then just take the first.
15 else
16     NAME="John Doe" # Default, if no command-line parameter.
17 fi
18
19 RESPONDENT="the author of this fine script"
20
21
22 cat <<Endofmessage
23
24 Hello, there, $NAME.
25 Greetings to you, $NAME, from $RESPONDENT.
26
27 # This comment shows up in the output (why?).
28
29 Endofmessage
30
31 # Note that the blank lines show up in the output.
32 # So does the comment.
33
34 exit
```

This is a useful script containing a *here document* with parameter substitution.

Example 19-6. Upload a file pair to *Sunsite* incoming directory

```
1 #!/bin/bash
2 # upload.sh
3
4 # Upload file pair (Filename.lsm, Filename.tar.gz)
5 #+ to incoming directory at Sunsite/UNC (ibiblio.org).
6 # Filename.tar.gz is the tarball itself.
7 # Filename.lsm is the descriptor file.
8 # Sunsite requires "lsm" file, otherwise will bounce contributions.
9
```

```

10
11 E_ARGERROR=85
12
13 if [ -z "$1" ]
14 then
15     echo "Usage: `basename $0` Filename-to-upload"
16     exit $E_ARGERROR
17 fi
18
19
20 Filename=`basename $1`           # Strips pathname out of file name.
21
22 Server="ibiblio.org"
23 Directory="/incoming/Linux"
24 # These need not be hard-coded into script,
25 #+ but may instead be changed to command-line argument.
26
27 Password="your.e-mail.address"   # Change above to suit.
28
29 ftp -n $Server <<End-Of-Session
30 # -n option disables auto-logon
31
32 user anonymous "$Password"       # If this doesn't work, then try:
33                                   # quote user anonymous "$Password"
34 binary
35 bell                             # Ring 'bell' after each file transfer.
36 cd $Directory
37 put "$Filename.lsm"
38 put "$Filename.tar.gz"
39 bye
40 End-Of-Session
41
42 exit 0

```

Quoting or escaping the "limit string" at the head of a here document disables parameter substitution within its body. The reason for this is that *quoting/escaping the limit string* effectively [escapes](#) the \$, `, and \ [special characters](#), and causes them to be interpreted literally. (Thank you, Allen Halsey, for pointing this out.)

Example 19-7. Parameter substitution turned off

```

1 #!/bin/bash
2 # A 'cat' here-document, but with parameter substitution disabled.
3
4 NAME="John Doe"
5 RESPONDENT="the author of this fine script"
6
7 cat <<'Endofmessage'
8
9 Hello, there, $NAME.
10 Greetings to you, $NAME, from $RESPONDENT.
11
12 Endofmessage
13
14 # No parameter substitution when the "limit string" is quoted or escaped.
15 # Either of the following at the head of the here document would have
16 #+ the same effect.
17 # cat <<"Endofmessage"
18 # cat <<\Endofmessage
19
20
21

```

```

22 #   And, likewise:
23
24 cat <<"SpecialCharTest"
25
26 Directory listing would follow
27 if limit string were not quoted.
28 `ls -l`
29
30 Arithmetic expansion would take place
31 if limit string were not quoted.
32  $$(5 + 3)$ 
33
34 A a single backslash would echo
35 if limit string were not quoted.
36 \\
37
38 SpecialCharTest
39
40
41 exit

```

Disabling parameter substitution permits outputting literal text. Generating scripts or even program code is one use for this.

Example 19-8. A script that generates another script

```

1 #!/bin/bash
2 # generate-script.sh
3 # Based on an idea by Albert Reiner.
4
5 OUTFILE=generated.sh      # Name of the file to generate.
6
7
8 # -----
9 # 'Here document containing the body of the generated script.
10 (
11 cat <<'EOF'
12 #!/bin/bash
13
14 echo "This is a generated shell script."
15 # Note that since we are inside a subshell,
16 #+ we can't access variables in the "outside" script.
17
18 echo "Generated file will be named: $OUTFILE"
19 # Above line will not work as normally expected
20 #+ because parameter expansion has been disabled.
21 # Instead, the result is literal output.
22
23 a=7
24 b=3
25
26 let "c = $a * $b"
27 echo "c = $c"
28
29 exit 0
30 EOF
31 ) > $OUTFILE
32 # -----
33
34 # Quoting the 'limit string' prevents variable expansion
35 #+ within the body of the above 'here document.'
36 # This permits outputting literal strings in the output file.

```



```
37
38 if [ -f "$OUTFILE" ]
39 then
40   chmod 755 $OUTFILE
41   # Make the generated file executable.
42 else
43   echo "Problem in creating file: \"$OUTFILE\""
44 fi
45
46 # This method also works for generating
47 #+ C programs, Perl programs, Python programs, Makefiles,
48 #+ and the like.
49
50 exit 0
```

It is possible to set a variable from the output of a here document. This is actually a devious form of [command substitution](#).

```
1 variable=$(cat <<SETVAR
2 This variable
3 runs over multiple lines.
4 SETVAR
5 )
6
7 echo "$variable"
```

A here document can supply input to a function in the same script.

Example 19-9. Here documents and functions

```
1 #!/bin/bash
2 # here-function.sh
3
4 GetPersonalData ()
5 {
6   read firstname
7   read lastname
8   read address
9   read city
10  read state
11  read zipcode
12 } # This certainly appears to be an interactive function, but . . .
13
14
15 # Supply input to the above function.
16 GetPersonalData <<RECORD001
17 Bozo
18 Bozeman
19 2726 Nondescript Dr.
20 Bozeman
21 MT
22 21226
23 RECORD001
24
25
26 echo
27 echo "$firstname $lastname"
28 echo "$address"
29 echo "$city, $state $zipcode"
30 echo
31
```


It is possible to use `:` as a dummy command accepting output from a here document. This, in effect, creates an "anonymous" here document.

Example 19-10. "Anonymous" Here Document

```

1 #!/bin/bash
2
3 : <<TESTVARIABLES
4 ${HOSTNAME?}${USER?}${MAIL?} # Print error message if one of the variables not set.
5 TESTVARIABLES
6
7 exit $?

```

 A variation of the above technique permits "commenting out" blocks of code.

Example 19-11. Commenting out a block of code

```


1 #!/bin/bash
2 # commentblock.sh
3
4 : <<COMMENTBLOCK
5 echo "This line will not echo."
6 This is a comment line missing the "#" prefix.
7 This is another comment line missing the "#" prefix.
8
9 &*@!!+=
10 The above line will cause no error message,
11 because the Bash interpreter will ignore it.
12 COMMENTBLOCK
13
14 echo "Exit value of above \"COMMENTBLOCK\" is $?." # 0
15 # No error shown.
16 echo
17
18
19 # The above technique also comes in useful for commenting out
20 #+ a block of working code for debugging purposes.
21 # This saves having to put a "#" at the beginning of each line,
22 #+ then having to go back and delete each "#" later.
23 # Note that the use of of colon, above, is optional.
24
25 echo "Just before commented-out code block."
26 # The lines of code between the double-dashed lines will not execute.
27 # =====
28 : <<DEBUGXXX
29 for file in *
30 do
31 cat "$file"
32 done
33 DEBUGXXX
34 # =====
35 echo "Just after commented-out code block."
36
37 exit 0
38

```

```

39
40
41 #####
42 # Note, however, that if a bracketed variable is contained within
43 #+ the commented-out code block,
44 #+ then this could cause problems.
45 # for example:
46
47
48 #!/bin/bash
49
50 : <<COMMENTBLOCK
51 echo "This line will not echo."
52 &*@!!+=
53 ${foo_bar_bazz?}
54 $(rm -rf /tmp/foobar/)
55 $(touch my_build_directory/cups/Makefile)
56 COMMENTBLOCK
57
58
59 $ sh commented-bad.sh
60 commented-bad.sh: line 3: foo_bar_bazz: parameter null or not set
61
62 # The remedy for this is to strong-quote the 'COMMENTBLOCK' in line 49, above.
63
64 : <<'COMMENTBLOCK'
65
66 # Thank you, Kurt Pfeifle, for pointing this out.

```

 Yet another twist of this nifty trick makes "self-documenting" scripts possible.

Example 19-12. A self-documenting script

```

1 #!/bin/bash
2 # self-document.sh: self-documenting script
3 # Modification of "colm.sh".
4
5 DOC_REQUEST=70
6
7 if [ "$1" = "-h" -o "$1" = "--help" ]      # Request help.
8 then
9     echo; echo "Usage: $0 [directory-name]"; echo
10    sed --silent -e '/DOCUMENTATIONXX$/,/^DOCUMENTATIONXX$/p' "$0" |
11    sed -e '/DOCUMENTATIONXX$/d'; exit $DOC_REQUEST; fi
12
13
14 : <<DOCUMENTATIONXX
15 List the statistics of a specified directory in tabular format.
16 -----
17 The command-line parameter gives the directory to be listed.
18 If no directory specified or directory specified cannot be read,
19 then list the current working directory.
20
21 DOCUMENTATIONXX
22
23 if [ -z "$1" -o ! -r "$1" ]
24 then
25     directory=.
26 else
27     directory="$1"
28 fi

```

```

29
30 echo "Listing of "$directory":"; echo
31 (printf "PERMISSIONS LINKS OWNER GROUP SIZE MONTH DAY HH:MM PROG-NAME\n" \
32 ; ls -l "$directory" | sed 1d) | column -t
33
34 exit 0

```

Using a [cat script](#) is an alternate way of accomplishing this.

```

1 DOC_REQUEST=70
2
3 if [ "$1" = "-h" -o "$1" = "--help" ]      # Request help.
4 then                                       # Use a "cat script" . . .
5     cat <<DOCUMENTATIONXX
6 List the statistics of a specified directory in tabular format.
7 -----
8 The command-line parameter gives the directory to be listed.
9 If no directory specified or directory specified cannot be read,
10 then list the current working directory.
11
12 DOCUMENTATIONXX
13 exit $DOC_REQUEST
14 fi

```

See also [Example A-28](#), [Example A-40](#), [Example A-41](#), and [Example A-42](#) for more examples of self-documenting scripts.



Here documents create temporary files, but these files are deleted after opening and are not accessible to any other process.

```

bash$ bash -c 'lsof -a -p $$ -d0' << EOF
> EOF
lsof      1213 bozo      0r   REG      3,5      0 30386 /tmp/t1213-0-sh (deleted)

```



Some utilities will not work inside a *here document*.



The closing *limit string*, on the final line of a here document, must start in the *first* character position. There can be *no leading whitespace*. Trailing whitespace after the limit string likewise causes unexpected behavior. The whitespace prevents the limit string from being recognized. [\[1\]](#)

```

1 #!/bin/bash
2
3 echo "-----"
4
5 cat <<LimitString
6 echo "This is line 1 of the message inside the here document."
7 echo "This is line 2 of the message inside the here document."
8 echo "This is the final line of the message inside the here document."
9     LimitString
10 #^^^Indented limit string. Error! This script will not behave as expected.
11
12 echo "-----"
13
14 # These comments are outside the 'here document',
15 #+ and should not echo.
16
17 echo "Outside the here document."
18
19 exit 0
20

```

```
21 echo "This line had better not echo." # Follows an 'exit' command.
```



Some people very cleverly use a single ! as a limit string. But, that's not necessarily a good idea.

```
1 # This works.
2 cat <<!
3 Hello!
4 ! Three more exclamations !!!
5 !
6
7
8 # But . . .
9 cat <<!
10 Hello!
11 Single exclamation point follows!
12 !
13 !
14 # Crashes with an error message.
15
16
17 # However, the following will work.
18 cat <<EOF
19 Hello!
20 Single exclamation point follows!
21 !
22 EOF
23 # It's safer to use a multi-character limit string.
```

For those tasks too complex for a *here document*, consider using the *expect* scripting language, which was specifically designed for feeding input into interactive programs.

19.1. Here Strings

A *here string* can be considered as a stripped-down form of a *here document*. It consists of nothing more than **COMMAND <<< \$WORD**, where \$WORD is expanded and fed to the `stdin` of **COMMAND**.

As a simple example, consider this alternative to the [echo-grep](#) construction.

```
1 # Instead of:
2 if echo "$VAR" | grep -q txt # if [[ $VAR = *txt* ]]
3 # etc.
4
5 # Try:
6 if grep -q "txt" <<< "$VAR"
7 then # ^^^
8     echo "$VAR contains the substring sequence \"txt\""
9 fi
10 # Thank you, Sebastian Kaminski, for the suggestion.
```

Or, in combination with [read](#):

```
1 String="This is a string of words."
2
3 read -r -a Words <<< "$String"
4 # The -a option to "read"
5 #+ assigns the resulting values to successive members of an array.
6
7 echo "First word in String is:  ${Words[0]}" # This
8 echo "Second word in String is: ${Words[1]}" # is
9 echo "Third word in String is:  ${Words[2]}" # a
10 echo "Fourth word in String is: ${Words[3]}" # string
11 echo "Fifth word in String is:  ${Words[4]}" # of
12 echo "Sixth word in String is:  ${Words[5]}" # words.
13 echo "Seventh word in String is: ${Words[6]}" # (null)
14 # Past end of $String.
15
16 # Thank you, Francisco Lobo, for the suggestion.
```

It is, of course, possible to feed the output of a *here string* into the `stdin` of a [loop](#).

```
1 # As Seamus points out . . .
2
3 ArrayVar=( element0 element1 element2 {A..D} )
4
5 while read element ; do
6     echo "$element" 1>&2
7 done <<< $(echo ${ArrayVar[*]})
8
9 # element0 element1 element2 A B C D
```

Example 19-13. Prepending a line to a file

```
1 #!/bin/bash
2 # prepend.sh: Add text at beginning of file.
3 #
4 # Example contributed by Kenny Stauffer,
5 #+ and slightly modified by document author.
```

```

6
7
8 E_NOSUCHFILE=85
9
10 read -p "File: " file # -p arg to 'read' displays prompt.
11 if [ ! -e "$file" ]
12 then # Bail out if no such file.
13     echo "File $file not found."
14     exit $E_NOSUCHFILE
15 fi
16
17 read -p "Title: " title
18 cat - $file <<<$title > $file.new
19
20 echo "Modified file is $file.new"
21
22 exit # Ends script execution.
23
24 from 'man bash':
25 Here Strings
26     A variant of here documents, the format is:
27
28         <<<word
29
30     The word is expanded and supplied to the command on its standard input.
31
32
33 Of course, the following also works:
34 sed -e '1i\
35     Title: ' $file

```

Example 19-14. Parsing a mailbox

```

1 #!/bin/bash
2 # Script by Francisco Lobo,
3 #+ and slightly modified and commented by ABS Guide author.
4 # Used in ABS Guide with permission. (Thank you!)
5
6 # This script will not run under Bash versions -lt 3.0.
7
8
9 E_MISSING_ARG=87
10 if [ -z "$1" ]
11 then
12     echo "Usage: $0 mailbox-file"
13     exit $E_MISSING_ARG
14 fi
15
16 mbox_grep() # Parse mailbox file.
17 {
18     declare -i body=0 match=0
19     declare -a date sender
20     declare mail header value
21
22
23     while IFS= read -r mail
24 #         ^^^^ Reset $IFS.
25 # Otherwise "read" will strip leading & trailing space from its input.
26
27 do
28     if [[ $mail =~ ^From ]] # Match "From" field in message.
29     then

```



```

30         (( body = 0 ))           # "Zero out" variables.
31         (( match = 0 ))
32         unset date
33
34     elif (( body ))
35     then
36         (( match ))
37         # echo "$mail"
38         # Uncomment above line if you want entire body
39         #+ of message to display.
40
41     elif [[ $mail ]]; then
42         IFS=: read -r header value <<< "$mail"
43         #             ^^^ "here string"
44
45         case "$header" in
46         [Ff][Rr][Oo][Mm] ) [[ $value =~ "$2" ]] && (( match++ )) ;;
47         # Match "From" line.
48         [Dd][Aa][Tt][Ee] ) read -r -a date <<< "$value" ;;
49         #             ^^^
50         # Match "Date" line.
51         [Rr][Ee][Cc][Ee][Ii][Vv][Ee][Dd] ) read -r -a sender <<< "$value" ;;
52         #             ^^^
53         # Match IP Address (may be spoofed).
54         esac
55
56     else
57         (( body++ ))
58         (( match )) &&
59         echo "MESSAGE ${date:+of: ${date[*]} }"
60         #     Entire $date array           ^
61         echo "IP address of sender: ${sender[1]}"
62         #     Second field of "Received" line ^
63
64     fi
65
66
67     done < "$1" # Redirect stdout of file into loop.
68 }
69
70
71 mbox_grep "$1" # Send mailbox file to function.
72
73 exit $?
74
75 # Exercises:
76 # -----
77 # 1) Break the single function, above, into multiple functions,
78 #+   for the sake of readability.
79 # 2) Add additional parsing to the script, checking for various keywords.
80
81
82
83 $ mailbox_grep.sh scam_mail
84 MESSAGE of Thu, 5 Jan 2006 08:00:56 -0500 (EST)
85 IP address of sender: 196.3.62.4

```

Exercise: Find other uses for *here strings*, such as, for example, [feeding input to dc](#).

Notes

[1] Except, as Dennis Benzinger points out, if [using <<- to suppress tabs](#).

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I/O Redirection

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Chapter 20. I/O Redirection

There are always three default *files* [1] open, `stdin` (the keyboard), `stdout` (the screen), and `stderr` (error messages output to the screen). These, and any other open files, can be redirected. Redirection simply means capturing output from a file, command, program, script, or even code block within a script (see [Example 3-1](#) and [Example 3-2](#)) and sending it as input to another file, command, program, or script.

Each open file gets assigned a file descriptor. [2] The file descriptors for `stdin`, `stdout`, and `stderr` are 0, 1, and 2, respectively. For opening additional files, there remain descriptors 3 to 9. It is sometimes useful to assign one of these additional file descriptors to `stdin`, `stdout`, or `stderr` as a temporary duplicate link. [3] This simplifies restoration to normal after complex redirection and reshuffling (see [Example 20-1](#)).

```
1  COMMAND_OUTPUT >
2      # Redirect stdout to a file.
3      # Creates the file if not present, otherwise overwrites it.
4
5      ls -lR > dir-tree.list
6      # Creates a file containing a listing of the directory tree.
7
8  : > filename
9      # The > truncates file "filename" to zero length.
10     # If file not present, creates zero-length file (same effect as 'touch').
11     # The : serves as a dummy placeholder, producing no output.
12
13  > filename
14     # The > truncates file "filename" to zero length.
15     # If file not present, creates zero-length file (same effect as 'touch').
16     # (Same result as ": >", above, but this does not work with some shells.)
17
18  COMMAND_OUTPUT >>
19     # Redirect stdout to a file.
20     # Creates the file if not present, otherwise appends to it.
21
22
23     # Single-line redirection commands (affect only the line they are on):
24     # -----
25
26  1>filename
27     # Redirect stdout to file "filename."
28  1>>filename
29     # Redirect and append stdout to file "filename."
30  2>filename
31     # Redirect stderr to file "filename."
32  2>>filename
33     # Redirect and append stderr to file "filename."
34  &>filename
35     # Redirect both stdout and stderr to file "filename."
36     # This operator is now functional, as of Bash 4, final release.
37
38  M>N
39     # "M" is a file descriptor, which defaults to 1, if not explicitly set.
40     # "N" is a filename.
41     # File descriptor "M" is redirect to file "N."
42  M>&N
43     # "M" is a file descriptor, which defaults to 1, if not set.
44     # "N" is another file descriptor.
45
46     #=====
47
48     # Redirecting stdout, one line at a time.
```

```

49     LOGFILE=script.log
50
51     echo "This statement is sent to the log file, \"\$LOGFILE\"." 1>\$LOGFILE
52     echo "This statement is appended to \"\$LOGFILE\"." 1>>\$LOGFILE
53     echo "This statement is also appended to \"\$LOGFILE\"." 1>>\$LOGFILE
54     echo "This statement is echoed to stdout, and will not appear in \"\$LOGFILE\"."
55     # These redirection commands automatically "reset" after each line.
56
57
58
59     # Redirecting stderr, one line at a time.
60     ERRORFILE=script.errors
61
62     bad_command1 2>\$ERRORFILE      # Error message sent to \$ERRORFILE.
63     bad_command2 2>>\$ERRORFILE    # Error message appended to \$ERRORFILE.
64     bad_command3                  # Error message echoed to stderr,
65                                   #+ and does not appear in \$ERRORFILE.
66     # These redirection commands also automatically "reset" after each line.
67     #=====

```

```

1     2>&1
2     # Redirects stderr to stdout.
3     # Error messages get sent to same place as standard output.
4     >>filename 2>&1
5         bad_command >>filename 2>&1
6         # Appends both stdout and stderr to the file "filename" ...
7     2>&1 | [command(s)]
8         bad_command 2>&1 | awk '{print $5}' # found
9         # Sends stderr through a pipe.
10        # |& was added to Bash 4 as an abbreviation for 2>&1 |.
11
12    i>&j
13    # Redirects file descriptor i to j.
14    # All output of file pointed to by i gets sent to file pointed to by j.
15
16    >&j
17    # Redirects, by default, file descriptor 1 (stdout) to j.
18    # All stdout gets sent to file pointed to by j.

```

```

1     0< FILENAME
2     < FILENAME
3     # Accept input from a file.
4     # Companion command to ">", and often used in combination with it.
5     #
6     # grep search-word <filename
7
8
9     [j]<>filename
10    # Open file "filename" for reading and writing,
11    #+ and assign file descriptor "j" to it.
12    # If "filename" does not exist, create it.
13    # If file descriptor "j" is not specified, default to fd 0, stdin.
14    #
15    # An application of this is writing at a specified place in a file.
16    echo 1234567890 > File # Write string to "File".
17    exec 3<> File # Open "File" and assign fd 3 to it.
18    read -n 4 <&3 # Read only 4 characters.
19    echo -n . >&3 # Write a decimal point there.
20    exec 3>&- # Close fd 3.
21    cat File # ==> 1234.67890
22    # Random access, by golly.
23
24
25
26    |

```

```

27     # Pipe.
28     # General purpose process and command chaining tool.
29     # Similar to ">", but more general in effect.
30     # Useful for chaining commands, scripts, files, and programs together.
31     cat *.txt | sort | uniq > result-file
32     # Sorts the output of all the .txt files and deletes duplicate lines,
33     # finally saves results to "result-file".

```

Multiple instances of input and output redirection and/or pipes can be combined in a single command line.

```

1  command < input-file > output-file
2  # Or the equivalent:
3  < input-file command > output-file # Although this is non-standard.
4
5  command1 | command2 | command3 > output-file

```

See [Example 16-31](#) and [Example A-14](#).

Multiple output streams may be redirected to one file.

```

1  ls -yz >> command.log 2>&1
2  # Capture result of illegal options "yz" in file "command.log."
3  # Because stderr is redirected to the file,
4  #+ any error messages will also be there.
5
6  # Note, however, that the following does *not* give the same result.
7  ls -yz 2>&1 >> command.log
8  # Outputs an error message, but does not write to file.
9  # More precisely, the command output (in this case, null)
10 #+ writes to the file, but the error message goes only to stdout.
11
12 # If redirecting both stdout and stderr,
13 #+ the order of the commands makes a difference.

```

Closing File Descriptors

`n<&-`

Close input file descriptor *n*.

`0<&-`, `<&-`

Close stdin.

`n>&-`

Close output file descriptor *n*.

`1>&-`, `>&-`

Close stdout.

Child processes inherit open file descriptors. This is why pipes work. To prevent an fd from being inherited, close it.

```

1  # Redirecting only stderr to a pipe.
2
3  exec 3>&1
4  ls -l 2>&1 >&3 3>&- | grep bad 3>&- # Save current "value" of stdout.
5  #           ^^^^  ^^^^ # Close fd 3 for 'grep' (but not 'ls').
6  exec 3>&- # Now close it for the remainder of the script.
7
8  # Thanks, S.C.

```

For a more detailed introduction to I/O redirection see [Appendix F](#).


20.1. Using `exec`

An `exec <filename` command redirects `stdin` to a file. From that point on, all `stdin` comes from that file, rather than its normal source (usually keyboard input). This provides a method of reading a file line by line and possibly parsing each line of input using [sed](#) and/or [awk](#).

Example 20-1. Redirecting `stdin` using `exec`

```
1 #!/bin/bash
2 # Redirecting stdin using 'exec'.
3
4
5 exec 6<&0          # Link file descriptor #6 with stdin.
6                  # Saves stdin.
7
8 exec < data-file  # stdin replaced by file "data-file"
9
10 read a1          # Reads first line of file "data-file".
11 read a2          # Reads second line of file "data-file."
12
13 echo
14 echo "Following lines read from file."
15 echo "-----"
16 echo $a1
17 echo $a2
18
19 echo; echo; echo
20
21 exec 0<&6 6<&-
22 # Now restore stdin from fd #6, where it had been saved,
23 #+ and close fd #6 ( 6<&- ) to free it for other processes to use.
24 #
25 # <&6 6<&- also works.
26
27 echo -n "Enter data  "
28 read b1 # Now "read" functions as expected, reading from normal stdin.
29 echo "Input read from stdin."
30 echo "-----"
31 echo "b1 = $b1"
32
33 echo
34
35 exit 0
```

Similarly, an `exec >filename` command redirects `stdout` to a designated file. This sends all command output that would normally go to `stdout` to that file.

 **exec N > filename** affects the entire script or *current shell*. Redirection in the [PID](#) of the script or shell from that point on has changed. However . . .

N > filename affects only the newly-forked process, not the entire script or shell.

Thank you, Ahmed Darwish, for pointing this out.

Example 20-2. Redirecting `stdout` using `exec`

```

1 #!/bin/bash
2 # reassign-stdout.sh
3
4 LOGFILE=logfile.txt
5
6 exec 6>&1          # Link file descriptor #6 with stdout.
7                  # Saves stdout.
8
9 exec > $LOGFILE   # stdout replaced with file "logfile.txt".
10
11 # ----- #
12 # All output from commands in this block sent to file $LOGFILE.
13
14 echo -n "Logfile: "
15 date
16 echo "-----"
17 echo
18
19 echo "Output of \"ls -al\" command"
20 echo
21 ls -al
22 echo; echo
23 echo "Output of \"df\" command"
24 echo
25 df
26
27 # ----- #
28
29 exec 1>&6 6>&-    # Restore stdout and close file descriptor #6.
30
31 echo
32 echo "== stdout now restored to default == "
33 echo
34 ls -al
35 echo
36
37 exit 0

```

Example 20-3. Redirecting both `stdin` and `stdout` in the same script with `exec`

```

1 #!/bin/bash
2 # upperconv.sh
3 # Converts a specified input file to uppercase.
4
5 E_FILE_ACCESS=70
6 E_WRONG_ARGS=71
7
8 if [ ! -r "$1" ]      # Is specified input file readable?
9 then
10  echo "Can't read from input file!"
11  echo "Usage: $0 input-file output-file"
12  exit $E_FILE_ACCESS
13 fi
14                # Will exit with same error
15                #+ even if input file ($1) not specified (why?).
16
17 if [ -z "$2" ]
18 then
19  echo "Need to specify output file."
20  echo "Usage: $0 input-file output-file"
21  exit $E_WRONG_ARGS
22 fi
23
24

```



```

23
24 exec 4<&0
25 exec < $1          # Will read from input file.
26
27 exec 7>&1
28 exec > $2          # Will write to output file.
29                   # Assumes output file writable (add check?).
30
31 # -----
32     cat - | tr a-z A-Z  # Uppercase conversion.
33 #   ^^^^^             # Reads from stdin.
34 #   ^^^^^^^^^^^      # Writes to stdout.
35 # However, both stdin and stdout were redirected.
36 # Note that the 'cat' can be omitted.
37 # -----
38
39 exec 1>&7 7>&-      # Restore stout.
40 exec 0<&4 4<&-      # Restore stdin.
41
42 # After restoration, the following line prints to stdout as expected.
43 echo "File \"$1\" written to \"$2\" as uppercase conversion."
44
45 exit 0

```

I/O redirection is a clever way of avoiding the dreaded [inaccessible variables within a subshell](#) problem.

Example 20-4. Avoiding a subshell

```

1 #!/bin/bash
2 # avoid-subshell.sh
3 # Suggested by Matthew Walker.
4
5 Lines=0
6
7 echo
8
9 cat myfile.txt | while read line;
10     do {
11         echo $line
12         (( Lines++ )); # Incremented values of this variable
13                       #+ inaccessible outside loop.
14                       # Subshell problem.
15     }
16     done
17
18 echo "Number of lines read = $Lines" # 0
19                                     # Wrong!
20
21 echo "-----"
22
23
24 exec 3<> myfile.txt
25 while read line <&3
26 do {
27     echo "$line"
28     (( Lines++ )); # Incremented values of this variable
29                   #+ accessible outside loop.
30                   # No subshell, no problem.
31 }
32 done
33 exec 3>&-
34
35 echo "Number of lines read = $Lines" # 8

```

```
36
37 echo
38
39 exit 0
40
41 # Lines below not seen by script.
42
43 $ cat myfile.txt
44
45 Line 1.
46 Line 2.
47 Line 3.
48 Line 4.
49 Line 5.
50 Line 6.
51 Line 7.
52 Line 8.
```

Notes

- [1] By convention in UNIX and Linux, data streams and peripherals ([device files](#)) are treated as files, in a fashion analogous to ordinary files.
- [2] A *file descriptor* is simply a number that the operating system assigns to an open file to keep track of it. Consider it a simplified type of file pointer. It is analogous to a *file handle* in C.
- [3] Using *file descriptor 5* might cause problems. When Bash creates a child process, as with [exec](#), the child inherits fd 5 (see Chet Ramey's archived e-mail, [SUBJECT: RE: File descriptor 5 is held open](#)). Best leave this particular fd alone.

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20.2. Redirecting Code Blocks

Blocks of code, such as [while](#), [until](#), and [for](#) loops, even [if/then](#) test blocks can also incorporate redirection of `stdin`. Even a function may use this form of redirection (see [Example 24-11](#)). The `<` operator at the end of the code block accomplishes this.

Example 20-5. Redirected *while* loop

```
1 #!/bin/bash
2 # redir2.sh
3
4 if [ -z "$1" ]
5 then
6     Filename=names.data          # Default, if no filename specified.
7 else
8     Filename=$1
9 fi
10 #+ Filename=${1:-names.data}
11 # can replace the above test (parameter substitution).
12
13 count=0
14
15 echo
16
17 while [ "$name" != Smith ] # Why is variable $name in quotes?
18 do
19     read name                # Reads from $Filename, rather than stdin.
20     echo $name
21     let "count += 1"
22 done <"$Filename"          # Redirects stdin to file $Filename.
23 #     ^^^^^^^^^^^^^^^
24
25 echo; echo "$count names read"; echo
26
27 exit 0
28
29 # Note that in some older shell scripting languages,
30 #+ the redirected loop would run as a subshell.
31 # Therefore, $count would return 0, the initialized value outside the loop.
32 # Bash and ksh avoid starting a subshell *whenever possible*,
33 #+ so that this script, for example, runs correctly.
34 # (Thanks to Heiner Steven for pointing this out.)
35
36 # However . . .
37 # Bash *can* sometimes start a subshell in a PIPED "while-read" loop,
38 #+ as distinct from a REDIRECTED "while" loop.
39
40 abc=hi
41 echo -e "1\n2\n3" | while read l
42     do abc="$l"
43     echo $abc
44     done
45 echo $abc
46
47 # Thanks, Bruno de Oliveira Schneider, for demonstrating this
48 #+ with the above snippet of code.
49 # And, thanks, Brian Onn, for correcting an annotation error.
```

Example 20-6. Alternate form of redirected *while* loop

```
1 #!/bin/bash
2
3 # This is an alternate form of the preceding script.
4
5 # Suggested by Heiner Steven
6 ## as a workaround in those situations when a redirect loop
7 ## runs as a subshell, and therefore variables inside the loop
8 ## +do not keep their values upon loop termination.
9
10
11 if [ -z "$1" ]
12 then
13     Filename=names.data      # Default, if no filename specified.
14 else
15     Filename=$1
16 fi
17
18
19 exec 3<&0                    # Save stdin to file descriptor 3.
20 exec 0<"$Filename"         # Redirect standard input.
21
22 count=0
23 echo
24
25
26 while [ "$name" != Smith ]
27 do
28     read name                # Reads from redirected stdin ($Filename).
29     echo $name
30     let "count += 1"
31 done                         # Loop reads from file $Filename
32                             #+ because of line 20.
33
34 # The original version of this script terminated the "while" loop with
35 ## done <"$Filename"
36 # Exercise:
37 # Why is this unnecessary?
38
39
40 exec 0<&3                    # Restore old stdin.
41 exec 3<&-                    # Close temporary fd 3.
42
43 echo; echo "$count names read"; echo
44
45 exit 0
```

Example 20-7. Redirected *until* loop

```
1 #!/bin/bash
2 # Same as previous example, but with "until" loop.
3
4 if [ -z "$1" ]
5 then
6     Filename=names.data      # Default, if no filename specified.
7 else
8     Filename=$1
9 fi
10
11 # while [ "$name" != Smith ]
12 until [ "$name" = Smith ]    # Change != to =.
```

```

13 do
14     read name                # Reads from $Filename, rather than stdin.
15     echo $name
16 done <"$Filename"          # Redirects stdin to file $Filename.
17 #     ^^^^^^^^^^^^^^^
18
19 # Same results as with "while" loop in previous example.
20
21 exit 0

```

Example 20-8. Redirected *for* loop

```

1 #!/bin/bash
2
3 if [ -z "$1" ]
4 then
5     Filename=names.data      # Default, if no filename specified.
6 else
7     Filename=$1
8 fi
9
10 line_count=`wc $Filename | awk '{ print $1 }'`
11 #         Number of lines in target file.
12 #
13 # Very contrived and kludgy, nevertheless shows that
14 #+ it's possible to redirect stdin within a "for" loop...
15 #+ if you're clever enough.
16 #
17 # More concise is      line_count=$(wc -l < "$Filename")
18
19
20 for name in `seq $line_count` # Recall that "seq" prints sequence of numbers.
21 # while [ "$name" != Smith ] -- more complicated than a "while" loop --
22 do
23     read name                # Reads from $Filename, rather than stdin.
24     echo $name
25     if [ "$name" = Smith ]   # Need all this extra baggage here.
26     then
27         break
28     fi
29 done <"$Filename"          # Redirects stdin to file $Filename.
30 #     ^^^^^^^^^^^^^^^
31
32 exit 0

```

We can modify the previous example to also redirect the output of the loop.

Example 20-9. Redirected *for* loop (both *stdin* and *stdout* redirected)

```

1 #!/bin/bash
2
3 if [ -z "$1" ]
4 then
5     Filename=names.data      # Default, if no filename specified.
6 else
7     Filename=$1
8 fi
9
10 Savefile=$Filename.new      # Filename to save results in.

```

```

11 FinalName=Jonah                # Name to terminate "read" on.
12
13 line_count=`wc $Filename | awk '{ print $1 }'` # Number of lines in target file.
14
15
16 for name in `seq $line_count`
17 do
18   read name
19   echo "$name"
20   if [ "$name" = "$FinalName" ]
21   then
22     break
23   fi
24 done < "$Filename" > "$Savefile"   # Redirects stdin to file $Filename,
25 #   ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^ and saves it to backup file.
26
27 exit 0

```

Example 20-10. Redirected *if/then* test

```

1 #!/bin/bash
2
3 if [ -z "$1" ]
4 then
5   Filename=names.data  # Default, if no filename specified.
6 else
7   Filename=$1
8 fi
9
10 TRUE=1
11
12 if [ "$TRUE" ]          # if true    and    if :    also work.
13 then
14   read name
15   echo $name
16 fi <"$Filename"
17 #   ^^^^^^^^^^^^^^^^^
18
19 # Reads only first line of file.
20 # An "if/then" test has no way of iterating unless embedded in a loop.
21
22 exit 0

```

Example 20-11. Data file *names.data* for above examples

```

1 Aristotle
2 Arrhenius
3 Belisarius
4 Capablanca
5 Dickens
6 Euler
7 Goethe
8 Hegel
9 Jonah
10 Laplace
11 Maroczy
12 Purcell
13 Schmidt
14 Schopenhauer

```

```
15 Semmelweiss
16 Smith
17 Steinmetz
18 Tukhashevsky
19 Turing
20 Venn
21 Warshawski
22 Znosko-Borowski
23
24 # This is a data file for
25 #+ "redir2.sh", "redir3.sh", "redir4.sh", "redir4a.sh", "redir5.sh".
```

Redirecting the `stdout` of a code block has the effect of saving its output to a file. See [Example 3-2](#).

[Here documents](#) are a special case of redirected code blocks. That being the case, it should be possible to feed the output of a *here document* into the `stdin` for a *while loop*.

```
1 # This example by Albert Siersema
2 # Used with permission (thanks!).
3
4 function doesOutput()
5 # Could be an external command too, of course.
6 # Here we show you can use a function as well.
7 {
8   ls -al *.jpg | awk '{print $5,$9}'
9 }
10
11
12 nr=0          # We want the while loop to be able to manipulate these and
13 totalSize=0  #+ to be able to see the changes after the 'while' finished.
14
15 while read fileSize fileName ; do
16   echo "$fileName is $fileSize bytes"
17   let nr++
18   totalSize=$((totalSize+fileSize)) # Or: "let totalSize+=fileSize"
19 done<<EOF
20 $(doesOutput)
21 EOF
22
23 echo "$nr files totaling $totalSize bytes"
```

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20.3. Applications

Clever use of I/O redirection permits parsing and stitching together snippets of command output (see [Example 15-7](#)). This permits generating report and log files.

Example 20-12. Logging events

```
1 #!/bin/bash
2 # logevents.sh
3 # Author: Stephane Chazelas.
4 # Used in ABS Guide with permission.
5
6 # Event logging to a file.
7 # Must be run as root (for write access in /var/log).
8
9 ROOT_UID=0      # Only users with $UID 0 have root privileges.
10 E_NOTROOT=67   # Non-root exit error.
11
12
13 if [ "$UID" -ne "$ROOT_UID" ]
14 then
15     echo "Must be root to run this script."
16     exit $E_NOTROOT
17 fi
18
19
20 FD_DEBUG1=3
21 FD_DEBUG2=4
22 FD_DEBUG3=5
23
24 # === Uncomment one of the two lines below to activate script. ===
25 # LOG_EVENTS=1
26 # LOG_VARS=1
27
28
29 log() # Writes time and date to log file.
30 {
31 echo "$(date) $*" >&7      # This *appends* the date to the file.
32 #     ^^^^^^^^ command substitution
33                               # See below.
34 }
35
36
37
38 case $LOG_LEVEL in
39 1) exec 3>&2          4> /dev/null 5> /dev/null;;
40 2) exec 3>&2          4>&2      5> /dev/null;;
41 3) exec 3>&2          4>&2      5>&2;;
42 *) exec 3> /dev/null 4> /dev/null 5> /dev/null;;
43 esac
44
45 FD_LOGVARS=6
46 if [[ $LOG_VARS ]]
47 then exec 6>> /var/log/vars.log
48 else exec 6> /dev/null          # Bury output.
49 fi
50
51 FD_LOGEVENTS=7
52 if [[ $LOG_EVENTS ]]
53 then
54     # exec 7 >(exec gawk '{print strftime(), $0}' >> /var/log/event.log)
55     # Above line fails in versions of Bash more recent than 2.04. Why?
```

```
56  exec 7>> /var/log/event.log          # Append to "event.log".
57  log                                   # Write time and date.
58  else exec 7> /dev/null               # Bury output.
59  fi
60
61  echo "DEBUG3: beginning" >&${FD_DEBUG3}
62
63  ls -l >&5 2>&4                          # command1 >&5 2>&4
64
65  echo "Done"                            # command2
66
67  echo "sending mail" >&${FD_LOGEVENTS}
68  # Writes "sending mail" to file descriptor #7.
69
70
71  exit 0
```

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Chapter 21. Subshells

Running a shell script launches a new process, a *subshell*.

Definition: A *subshell* is a [child process](#) launched by a shell (or *shell script*).

A subshell is a separate instance of the command processor -- the *shell* that gives you the prompt at the console or in an *xterm* window. Just as your commands are interpreted at the command-line prompt, similarly does a script [batch-process](#) a list of commands. Each shell script running is, in effect, a subprocess (*child process*) of the [parent](#) shell.

A shell script can itself launch subprocesses. These *subshells* let the script do parallel processing, in effect executing multiple subtasks simultaneously.

```
1 #!/bin/bash
2 # subshell-test.sh
3
4 (
5 # Inside parentheses, and therefore a subshell . . .
6 while [ 1 ] # Endless loop.
7 do
8   echo "Subshell running . . ."
9 done
10 )
11
12 # Script will run forever,
13 #+ or at least until terminated by a Ctl-C.
14
15 exit $? # End of script (but will never get here).
16
17
18
19 Now, run the script:
20 sh subshell-test.sh
21
22 And, while the script is running, from a different xterm:
23 ps -ef | grep subshell-test.sh
24
25 UID      PID    PPID  C  STIME TTY      TIME    CMD
26 500      2698   2502  0  14:26 pts/4    00:00:00 sh subshell-test.sh
27 500      2699   2698  21 14:26 pts/4    00:00:24 sh subshell-test.sh
28
29          ^^^^
30
31 Analysis:
32 PID 2698, the script, launched PID 2699, the subshell.
33
34 Note: The "UID ..." line would be filtered out by the "grep" command,
35 but is shown here for illustrative purposes.
```

In general, an [external command](#) in a script [forks off](#) a subprocess, [1] whereas a Bash [builtin](#) does not. For this reason, builtins execute more quickly and use fewer system resources than their external command equivalents.

Command List within Parentheses

(command1; command2; command3; ...)

A command list embedded between *parentheses* runs as a subshell.

Variables in a subshell are *not* visible outside the block of code in the subshell. They are not accessible to the [parent process](#), to the shell that launched the subshell. These are, in effect, variables [local](#) to the *child process*.

Example 21-1. Variable scope in a subshell

```
1 #!/bin/bash
2 # subshell.sh
3
4 echo
5
6 echo "We are outside the subshell."
7 echo "Subshell level OUTSIDE subshell = $BASH_SUBSHELL"
8 # Bash, version 3, adds the new          $BASH_SUBSHELL variable.
9 echo; echo
10
11 outer_variable=Outer
12 global_variable=
13 # Define global variable for "storage" of
14 #+ value of subshell variable.
15
16 (
17 echo "We are inside the subshell."
18 echo "Subshell level INSIDE subshell = $BASH_SUBSHELL"
19 inner_variable=Inner
20
21 echo "From inside subshell, \"inner_variable\" = $inner_variable"
22 echo "From inside subshell, \"outer\" = $outer_variable"
23
24 global_variable="$inner_variable"    # Will this allow "exporting"
25                                     #+ a subshell variable?
26 )
27
28 echo; echo
29 echo "We are outside the subshell."
30 echo "Subshell level OUTSIDE subshell = $BASH_SUBSHELL"
31 echo
32
33 if [ -z "$inner_variable" ]
34 then
35     echo "inner_variable undefined in main body of shell"
36 else
37     echo "inner_variable defined in main body of shell"
38 fi
39
40 echo "From main body of shell, \"inner_variable\" = $inner_variable"
41 # $inner_variable will show as blank (uninitialized)
42 #+ because variables defined in a subshell are "local variables".
43 # Is there a remedy for this?
44 echo "global_variable = \"$global_variable\"    # Why doesn't this work?"
45
46 echo
47
48 # =====
49
50 # Additionally ...
51
52 echo "-----"; echo
53
54 var=41                                     # Global variable.
55
56 ( let "var+=1"; echo "\$var INSIDE subshell = $var" ) # 42
57
58 echo "\$var OUTSIDE subshell = $var"          # 41
59 # Variable operations inside a subshell, even to a GLOBAL variable
```


```

60 #+ do not affect the value of the variable outside the subshell!
61
62
63 exit 0
64
65 # Question:
66 # -----
67 # Once having exited a subshell,
68 #+ is there any way to reenter that very same subshell
69 #+ to modify or access the subshell variables?

```

See also [\\$BASHPID](#) and [Example 34-2](#).

Definition: The *scope* of a variable is the context in which it has meaning, in which it has a *value* that can be referenced. For example, the scope of a [local variable](#) lies only within the function, block of code, or subshell within which it is defined, while the scope of a *global* variable is the entire script in which it appears.

 While the [\\$BASH_SUBSHELL](#) internal variable indicates the nesting level of a subshell, the [\\$SHLVL](#) variable *shows no change* within a subshell.

```

1 echo " \$BASH_SUBSHELL outside subshell      = $BASH_SUBSHELL"          # 0
2   ( echo " \$BASH_SUBSHELL inside subshell    = $BASH_SUBSHELL" )      # 1
3   ( ( echo " \$BASH_SUBSHELL inside nested subshell = $BASH_SUBSHELL" ) ) # 2
4 # ^ ^                                     *** nested ***                ^ ^
5
6 echo
7
8 echo " \$SHLVL outside subshell = $SHLVL"          # 3
9 ( echo " \$SHLVL inside subshell = $SHLVL" )      # 3 (No change!)

```

Directory changes made in a subshell do not carry over to the parent shell.

Example 21-2. List User Profiles

```

1 #!/bin/bash
2 # allprofs.sh: Print all user profiles.
3
4 # This script written by Heiner Steven, and modified by the document author.
5
6 FILE=.bashrc # File containing user profile,
7             #+ was ".profile" in original script.
8
9 for home in `awk -F: '{print $6}' /etc/passwd`
10 do
11   [ -d "$home" ] || continue # If no home directory, go to next.
12   [ -r "$home" ] || continue # If not readable, go to next.
13   (cd $home; [ -e $FILE ] && less $FILE)
14 done
15
16 # When script terminates, there is no need to 'cd' back to original directory,
17 #+ because 'cd $home' takes place in a subshell.
18
19 exit 0

```

A subshell may be used to set up a "dedicated environment" for a command group.

```

1 COMMAND1
2 COMMAND2
3 COMMAND3
4 (
5   IFS=:
6   PATH=/bin
7   unset TERMINFO
8   set -C
9   shift 5
10  COMMAND4
11  COMMAND5
12  exit 3 # Only exits the subshell!
13 )
14 # The parent shell has not been affected, and the environment is preserved.
15 COMMAND6
16 COMMAND7

```

As seen here, the [exit](#) command only terminates the subshell in which it is running, *not* the parent shell or script.

One application of such a "dedicated environment" is testing whether a variable is defined.

```

1 if (set -u; : $variable) 2> /dev/null
2 then
3   echo "Variable is set."
4 fi      # Variable has been set in current script,
5         #+ or is an an internal Bash variable,
6         #+ or is present in environment (has been exported).
7
8 # Could also be written [[ ${variable-x} != x || ${variable-y} != y ]]
9 # or                [[ ${variable-x} != x$variable ]]
10 # or                [[ ${variable+x} = x ]]
11 # or                [[ ${variable-x} != x ]]

```

Another application is checking for a lock file:

```

1 if (set -C; : > lock_file) 2> /dev/null
2 then
3   : # lock_file didn't exist: no user running the script
4 else
5   echo "Another user is already running that script."
6 exit 65
7 fi
8
9 # Code snippet by Stéphane Chazelas,
10 #+ with modifications by Paulo Marcel Coelho Aragao.

```

+

Processes may execute in parallel within different subshells. This permits breaking a complex task into subcomponents processed concurrently.

Example 21-3. Running parallel processes in subshells

```

1 (cat list1 list2 list3 | sort | uniq > list123) &
2 (cat list4 list5 list6 | sort | uniq > list456) &
3 # Merges and sorts both sets of lists simultaneously.
4 # Running in background ensures parallel execution.
5 #
6 # Same effect as
7 # cat list1 list2 list3 | sort | uniq > list123 &
8 # cat list4 list5 list6 | sort | uniq > list456 &
9
10 wait # Don't execute the next command until subshells finish.

```

```
11
12 diff list123 list456
```

Redirecting I/O to a subshell uses the "|" pipe operator, as in `ls -al | (command)`.

 A code block between [curly brackets](#) does *not* launch a subshell.

```
{ command1; command2; command3; . . . commandN; }
```

```
1 var1=23
2 echo "$var1" # 23
3
4 { var1=76; }
5 echo "$var1" # 76
```

Notes

[1] An external command invoked with an [exec](#) does *not* (usually) fork off a subprocess / subshell.

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Chapter 22. Restricted Shells

Disabled commands in restricted shells

. Running a script or portion of a script in *restricted mode* disables certain commands that would otherwise be available. This is a security measure intended to limit the privileges of the script user and to minimize possible damage from running the script.

The following commands and actions are disabled:

- Using `cd` to change the working directory.
 - Changing the values of the `$PATH`, `$SHELL`, `$BASH_ENV`, or `$ENV` [environmental variables](#).
 - Reading or changing the `$SHELLOPTS`, shell environmental options.
 - Output redirection.
 - Invoking commands containing one or more `/`'s.
 - Invoking [exec](#) to substitute a different process for the shell.
 - Various other commands that would enable monkeying with or attempting to subvert the script for an unintended purpose.
 - Getting out of restricted mode within the script.
-

Example 22-1. Running a script in restricted mode

```
1 #!/bin/bash
2
3 # Starting the script with "#!/bin/bash -r"
4 #+ runs entire script in restricted mode.
5
6 echo
7
8 echo "Changing directory."
9 cd /usr/local
10 echo "Now in `pwd`"
11 echo "Coming back home."
12 cd
13 echo "Now in `pwd`"
14 echo
15
16 # Everything up to here in normal, unrestricted mode.
17
18 set -r
19 # set --restricted has same effect.
20 echo "==> Now in restricted mode. <=="
```

```
21
22 echo
23 echo
24
25 echo "Attempting directory change in restricted mode."
26 cd ..
27 echo "Still in `pwd`"
28
29 echo
30 echo
31
32 echo "\$SHELL = $SHELL"
33 echo "Attempting to change shell in restricted mode."
34 SHELL="/bin/ash"
35 echo
36 echo "\$SHELL= $SHELL"
37
```

```
38 echo
39 echo
40
41 echo "Attempting to redirect output in restricted mode."
42 ls -l /usr/bin > bin.files
43 ls -l bin.files    # Try to list attempted file creation effort.
44
45 echo
46
47 exit 0
```

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Chapter 23. Process Substitution

[Piping](#) the `stdout` of a command into the `stdin` of another is a powerful technique. But, what if you need to pipe the `stdout` of *multiple* commands? This is where *process substitution* comes in.

Process substitution feeds the output of a [process](#) (or processes) into the `stdin` of another process.

Template

Command list enclosed within parentheses

`>(command_list)`

`<(command_list)`

Process substitution uses `/dev/fd/<n>` files to send the results of the process(es) within parentheses to another process. [\[1\]](#)



There is *no* space between the the "<" or ">" and the parentheses. Space there would give an error message.

```
bash$ echo >(true)
/dev/fd/63

bash$ echo <(true)
/dev/fd/63

bash$ echo >(true) <(true)
/dev/fd/63 /dev/fd/62

bash$ wc <(cat /usr/share/dict/linux.words)
483523 483523 4992010 /dev/fd/63

bash$ grep script /usr/share/dict/linux.words | wc
262 262 3601

bash$ wc <(grep script /usr/share/dict/linux.words)
262 262 3601 /dev/fd/63
```



Bash creates a pipe with two [file descriptors](#), `--fIn` and `fOut--`. The `stdin` of `true` connects to `fOut` (`dup2(fOut, 0)`), then Bash passes a `/dev/fd/fIn` argument to `echo`. On systems lacking `/dev/fd/<n>` files, Bash may use temporary files. (Thanks, S.C.)

Process substitution can compare the output of two different commands, or even the output of different options to the same command.

```
bash$ comm <(ls -l) <(ls -al)
total 12
-rw-rw-r-- 1 bozo bozo 78 Mar 10 12:58 File0
-rw-rw-r-- 1 bozo bozo 42 Mar 10 12:58 File2
-rw-rw-r-- 1 bozo bozo 103 Mar 10 12:58 t2.sh
total 20
drwxrwxrwx 2 bozo bozo 4096 Mar 10 18:10 .
drwx----- 72 bozo bozo 4096 Mar 10 17:58 ..
-rw-rw-r-- 1 bozo bozo 78 Mar 10 12:58 File0
-rw-rw-r-- 1 bozo bozo 42 Mar 10 12:58 File2
-rw-rw-r-- 1 bozo bozo 103 Mar 10 12:58 t2.sh
```

Process substitution can compare the contents of two directories -- to see which filenames are in one, but not the other.

```
1 diff <(ls $first_directory) <(ls $second_directory)
```

Some other usages and uses of process substitution:

```
1 read -a list <<( od -Ad -w24 -t u2 /dev/urandom )
2 # Read a list of random numbers from /dev/urandom,
3 #+ process with "od"
4 #+ and feed into stdin of "read" . . .
5
6 # From "insertion-sort.bash" example script.
7 # Courtesy of JuanJo Ciarlante.
```

```
1 PORT=6881 # bittorrent
2
3 # Scan the port to make sure nothing nefarious is going on.
4 netcat -l $PORT | tee>(md5sum ->mydata-orig.md5) |
5 gzip | tee>(md5sum - | sed 's/-$/mydata.lz2/'>mydata-gz.md5)>mydata.gz
6
7 # Check the decompression:
8 gzip -d<mydata.gz | md5sum -c mydata-orig.md5)
9 # The MD5sum of the original checks stdin and detects compression issues.
10
11 # Bill Davidsen contributed this example
12 #+ (with light edits by the ABS Guide author).
```

```
1 cat <(ls -l)
2 # Same as      ls -l | cat
3
4 sort -k 9 <(ls -l /bin) <(ls -l /usr/bin) <(ls -l /usr/X11R6/bin)
5 # Lists all the files in the 3 main 'bin' directories, and sorts by filename.
6 # Note that three (count 'em) distinct commands are fed to 'sort'.
7
8
9 diff <(command1) <(command2) # Gives difference in command output.
10
11 tar cf >(bzip2 -c > file.tar.bz2) $directory_name
12 # Calls "tar cf /dev/fd/?? $directory_name", and "bzip2 -c > file.tar.bz2".
13 #
14 # Because of the /dev/fd/<n> system feature,
15 # the pipe between both commands does not need to be named.
16 #
17 # This can be emulated.
18 #
19 bzip2 -c < pipe > file.tar.bz2&
20 tar cf pipe $directory_name
21 rm pipe
22 #      or
23 exec 3>&1
24 tar cf /dev/fd/4 $directory_name 4>&1 >&3 3>&- | bzip2 -c > file.tar.bz2 3>&-
25 exec 3>&-
26
27
28 # Thanks, Stéphane Chazelas
```

Here is a method of circumventing the problem of an [echo piped to a while-read loop](#) running in a subshell.

Example 23-1. Code block redirection without forking

```
1 #!/bin/bash
```

```

2 # wr-ps.bash: while-read loop with process substitution.
3
4 # This example contributed by Tomas Pospisek.
5 # (Heavily edited by the ABS Guide author.)
6
7 echo
8
9 echo "random input" | while read i
10 do
11     global=3D": Not available outside the loop."
12     # ... because it runs in a subshell.
13 done
14
15 echo "\$global (from outside the subprocess) = $global"
16 # $global (from outside the subprocess) =
17
18 echo; echo "--"; echo
19
20 while read i
21 do
22     echo $i
23     global=3D": Available outside the loop."
24     # ... because it does NOT run in a subshell.
25 done <<( echo "random input" )
26 #     ^ ^
27
28 echo "\$global (using process substitution) = $global"
29 # Random input
30 # $global (using process substitution) = 3D: Available outside the loop.
31
32
33 echo; echo "#####"; echo
34
35
36
37 # And likewise . . .
38
39 declare -a inloop
40 index=0
41 cat $0 | while read line
42 do
43     inloop[$index]="$line"
44     ((index++))
45     # It runs in a subshell, so ...
46 done
47 echo "OUTPUT = "
48 echo ${inloop[*]}           # ... nothing echoes.
49
50
51 echo; echo "--"; echo
52
53
54 declare -a outloop
55 index=0
56 while read line
57 do
58     outloop[$index]="$line"
59     ((index++))
60     # It does NOT run in a subshell, so ...
61 done <<( cat $0 )
62 echo "OUTPUT = "
63 echo ${outloop[*]}         # ... the entire script echoes.
64
65 exit $?

```

This is a similar example.

Example 23-2. Redirecting the output of *process substitution* into a loop.

```
1 #!/bin/bash
2 # psub.bash
3
4 # As inspired by Diego Molina (thanks!).
5
6 declare -a array0
7 while read
8 do
9     array0[${#array0[@]}]=$REPLY
10 done <<( sed -e 's/bash/CRASH-BANG!/' $0 | grep bin | awk '{print $1}' )
11 # Sets the default 'read' variable, $REPLY, by process substitution,
12 #+ then copies it into an array.
13
14 echo "${array0[@]}"
15
16 exit $?
17
18 # ===== #
19
20 bash psub.bash
21
22 #!/bin/CRASH-BANG! done #!/bin/CRASH-BANG!
```

A reader sent in the following interesting example of process substitution.

```
1 # Script fragment taken from SuSE distribution:
2
3 # -----#
4 while read des what mask iface; do
5 # Some commands ...
6 done <<(route -n)
7 #   ^ ^ First < is redirection, second is process substitution.
8
9 # To test it, let's make it do something.
10 while read des what mask iface; do
11     echo $des $what $mask $iface
12 done <<(route -n)
13
14 # Output:
15 # Kernel IP routing table
16 # Destination Gateway Genmask Flags Metric Ref Use Iface
17 # 127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo
18 # -----#
19
20 # As Stéphane Chazelas points out,
21 #+ an easier-to-understand equivalent is:
22 route -n |
23     while read des what mask iface; do # Variables set from output of pipe.
24         echo $des $what $mask $iface
25     done # This yields the same output as above.
26         # However, as Ulrich Gayer points out . . .
27         #+ this simplified equivalent uses a subshell for the while loop,
28         #+ and therefore the variables disappear when the pipe terminates.
29
30 # -----#
31
32 # However, Filip Moritz comments that there is a subtle difference
33 #+ between the above two examples, as the following shows.
34
```

```
35 (  
36 route -n | while read x; do ((y++)); done  
37 echo $y # $y is still unset  
38  
39 while read x; do ((y++)); done <<(route -n)  
40 echo $y # $y has the number of lines of output of route -n  
41 )  
42  
43 More generally spoken  
44 (  
45 : | x=x  
46 # seems to start a subshell like  
47 : | ( x=x )  
48 # while  
49 x=x <<(:)  
50 # does not  
51 )  
52  
53 # This is useful, when parsing csv and the like.  
54 # That is, in effect, what the original SuSE code fragment does.
```

Notes

- [1] This has the same effect as a [named pipe](#) (temp file), and, in fact, named pipes were at one time used in process substitution.

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Functions

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Chapter 24. Functions

Like "real" programming languages, Bash has functions, though in a somewhat limited implementation. A function is a subroutine, a [code block](#) that implements a set of operations, a "black box" that performs a specified task. Wherever there is repetitive code, when a task repeats with only slight variations in procedure, then consider using a function.

```
function function_name {  
  command...  
}
```


or

```
function_name () {  
  command...  
}
```

This second form will cheer the hearts of C programmers (and is more [portable](#)).

As in C, the function's opening bracket may optionally appear on the second line.

```
function_name ()  
{  
  command...  
}
```

 A function may be "compacted" into a single line.

```
1 fun () { echo "This is a function"; echo; }  
2 #
```

In this case, however, a *semicolon* must follow the final command in the function.

```
1 fun () { echo "This is a function"; echo } # Error!  
2 #  
3  
4 fun2 () { echo "Even a single-command function? Yes!"; }  
5 #
```

Functions are called, *triggered*, simply by invoking their names. A *function call* is equivalent to a *command*.

Example 24-1. Simple functions

```
1 #!/bin/bash  
2 # ex59.sh: Exercising functions (simple).  
3  
4 JUST_A_SECOND=1  
5  
6 funky ()  
7 { # This is about as simple as functions get.  
8   echo "This is a funky function."  
9   echo "Now exiting funky function."  
10 } # Function declaration must precede call.  
11  
12  
13 fun ()
```

```

14 { # A somewhat more complex function.
15   i=0
16   REPEATS=30
17
18   echo
19   echo "And now the fun really begins."
20   echo
21
22   sleep $JUST_A_SECOND    # Hey, wait a second!
23   while [ $i -lt $REPEATS ]
24   do
25     echo "-----FUNCTIONS----->"
26     echo "<-----ARE-----"
27     echo "<-----FUN----->"
28     echo
29     let "i+=1"
30   done
31 }
32
33 # Now, call the functions.
34
35 funky
36 fun
37
38 exit $?

```

The function definition must precede the first call to it. There is no method of "declaring" the function, as, for example, in C.

```

1 f1
2 # Will give an error message, since function "f1" not yet defined.
3
4 declare -f f1      # This doesn't help either.
5 f1                # Still an error message.
6
7 # However...
8
9
10 f1 ()
11 {
12   echo "Calling function \"f2\" from within function \"f1\"."
13   f2
14 }
15
16 f2 ()
17 {
18   echo "Function \"f2\"."
19 }
20
21 f1 # Function "f2" is not actually called until this point,
22    #+ although it is referenced before its definition.
23    # This is permissible.
24
25    # Thanks, S.C.

```

 Functions may not be empty!

```

1 #!/bin/bash
2 # empty-function.sh
3
4 empty ()
5 {
6 }
7

```

```

8 exit 0 # Will not exit here!
9
10 # $ sh empty-function.sh
11 # empty-function.sh: line 6: syntax error near unexpected token `}'
12 # empty-function.sh: line 6: `}'
13
14 # $ echo $?
15 # 2
16
17
18 # Note that a function containing only comments is empty.
19
20 func ()
21 {
22     # Comment 1.
23     # Comment 2.
24     # This is still an empty function.
25     # Thank you, Mark Bova, for pointing this out.
26 }
27 # Results in same error message as above.
28
29
30 # However ...
31
32 not_quite_empty ()
33 {
34     illegal_command
35 } # A script containing this function will *not* bomb
36    #+ as long as the function is not called.
37
38 not_empty ()
39 {
40     :
41 } # Contains a : (null command), and this is okay.
42
43
44 # Thank you, Dominick Geyer and Thiemo Kellner.

```

It is even possible to nest a function within another function, although this is not very useful.

```

1 f1 ()
2 {
3
4     f2 () # nested
5     {
6         echo "Function \"f2\", inside \"f1\"."
7     }
8
9 }
10
11 f2 # Gives an error message.
12    # Even a preceding "declare -f f2" wouldn't help.
13
14 echo
15
16 f1 # Does nothing, since calling "f1" does not automatically call "f2".
17 f2 # Now, it's all right to call "f2",
18    #+ since its definition has been made visible by calling "f1".
19
20    # Thanks, S.C.

```

Function declarations can appear in unlikely places, even where a command would otherwise go.

```

1 ls -l | foo() { echo "foo"; } # Permissible, but useless.
2
3

```

```

4
5 if [ "$USER" = bozo ]
6 then
7   bozo_greet () # Function definition embedded in an if/then construct.
8   {
9     echo "Hello, Bozo."
10  }
11 fi
12
13 bozo_greet      # Works only for Bozo, and other users get an error.
14
15
16
17 # Something like this might be useful in some contexts.
18 NO_EXIT=1      # Will enable function definition below.
19
20 [[ $NO_EXIT -eq 1 ]] && exit() { true; } # Function definition in an "and-list".
21 # If $NO_EXIT is 1, declares "exit ()".
22 # This disables the "exit" builtin by aliasing it to "true".
23
24 exit # Invokes "exit ()" function, not "exit" builtin.
25
26
27
28 # Or, similarly:
29 filename=file1
30
31 [ -f "$filename" ] &&
32 foo () { rm -f "$filename"; echo "File "$filename" deleted."; } ||
33 foo () { echo "File "$filename" not found."; touch bar; }
34
35 foo
36
37 # Thanks, S.C. and Christopher Head

```

Function names can take strange forms.

```

1  _(){ for i in {1..10}; do echo -n "$FUNCNAME"; done; echo; }
2  # ^^
3  #      This doesn't always work. Why not?
4
5  # Now, let's invoke the function.
6  -      # _____
7  #      ^^^^^^^^^^ 10 underscores (10 x function name)!
8  # A "naked" underscore is an acceptable function name.
9
10
11 # In fact, a colon is likewise an acceptable function name.
12
13 :(){ echo ":"; }; :
14
15 # Of what use is this?
16 # It's a devious way to obfuscate the code in a script.

```

See also [Example A-56](#)



What happens when different versions of the same function appear in a script?

```

1 # As Yan Chen points out,
2 # when a function is defined multiple times,
3 # the final version is what is invoked.
4 # This is not, however, particularly useful.
5
6 func ()
7 {
8   echo "First version of func ()."
9 }

```

```
10
11 func ()
12 {
13     echo "Second version of func ()."
14 }
15
16 func    # Second version of func ().
17
18 exit $?
19
20 # It is even possible to use functions to override
21 #+ or preempt system commands.
22 # Of course, this is *not* advisable.
```


24.1. Complex Functions and Function Complexities

Functions may process arguments passed to them and return an [exit status](#) to the script for further processing.


```
1 function_name $arg1 $arg2
```

The function refers to the passed arguments by position (as if they were [positional parameters](#)), that is, \$1, \$2, and so forth.

Example 24-2. Function Taking Parameters

```
1 #!/bin/bash
2 # Functions and parameters
3
4 DEFAULT=default                # Default param value.
5
6 func2 () {
7     if [ -z "$1" ]             # Is parameter #1 zero length?
8     then
9         echo "-Parameter #1 is zero length.-" # Or no parameter passed.
10    else
11        echo "-Parameter #1 is \"$1\".-"
12    fi
13
14    variable=${1-$DEFAULT}      # What does
15    echo "variable = $variable" #+ parameter substitution show?
16                                # -----
17                                # It distinguishes between
18                                #+ no param and a null param.
19
20    if [ "$2" ]
21    then
22        echo "-Parameter #2 is \"$2\".-"
23    fi
24
25    return 0
26 }
27
28 echo
29
30 echo "Nothing passed."
31 func2                                # Called with no params
32 echo
33
34
35 echo "Zero-length parameter passed."
36 func2 ""                             # Called with zero-length param
37 echo
38
39 echo "Null parameter passed."
40 func2 "$uninitialized_param"        # Called with uninitialized param
41 echo
42
43 echo "One parameter passed."
44 func2 first                          # Called with one param
45 echo
46
47 echo "Two parameters passed."
48 func2 first second                  # Called with two params
```

```
49 echo
50
51 echo "\"\" \"second\" passed."
52 func2 "" second      # Called with zero-length first parameter
53 echo                 # and ASCII string as a second one.
54
55 exit 0
```

 The [shift](#) command works on arguments passed to functions (see [Example 36-18](#)).

But, what about command-line arguments passed to the script? Does a function see them? Well, let's clear up the confusion.

Example 24-3. Functions and command-line args passed to the script

```
1 #!/bin/bash
2 # func-cmdlinearg.sh
3 # Call this script with a command-line argument,
4 #+ something like $0 arg1.
5
6
7 func ()
8
9 {
10 echo "$1"    # Echoes first arg passed to the function.
11 }           # Does a command-line arg qualify?
12
13 echo "First call to function: no arg passed."
14 echo "See if command-line arg is seen."
15 func
16 # No! Command-line arg not seen.
17
18 echo "=====
19 echo
20 echo "Second call to function: command-line arg passed explicitly."
21 func $1
22 # Now it's seen!
23
24 exit 0
```

In contrast to certain other programming languages, shell scripts normally pass only value parameters to functions. Variable names (which are actually *pointers*), if passed as parameters to functions, will be treated as string literals. *Functions interpret their arguments literally.*

[Indirect variable references](#) (see [Example 37-2](#)) provide a clumsy sort of mechanism for passing variable pointers to functions.

Example 24-4. Passing an indirect reference to a function

```
1 #!/bin/bash
2 # ind-func.sh: Passing an indirect reference to a function.
3
4 echo_var ()
5 {
6 echo "$1"
7 }
```



```

8
9 message=Hello
10 Hello=Goodbye
11
12 echo_var "$message"          # Hello
13 # Now, let's pass an indirect reference to the function.
14 echo_var "${!message}"      # Goodbye
15
16 echo "-----"
17
18 # What happens if we change the contents of "hello" variable?
19 Hello="Hello, again!"
20 echo_var "$message"          # Hello
21 echo_var "${!message}"      # Hello, again!
22
23 exit 0

```

The next logical question is whether parameters can be dereferenced *after* being passed to a function.

Example 24-5. Dereferencing a parameter passed to a function

```

1 #!/bin/bash
2 # dereference.sh
3 # Dereferencing parameter passed to a function.
4 # Script by Bruce W. Clare.
5
6 dereference ()
7 {
8     y=\ "$1"    # Name of variable (not value!).
9     echo $y     # $Junk
10
11     x=`eval "expr \ "$y\" "`
12     echo $1=$x
13     eval "$1=\"Some Different Text \"" # Assign new value.
14 }
15
16 Junk="Some Text"
17 echo $Junk "before"    # Some Text before
18
19 dereference Junk
20 echo $Junk "after"     # Some Different Text after
21
22 exit 0

```

Example 24-6. Again, dereferencing a parameter passed to a function

```

1 #!/bin/bash
2 # ref-params.sh: Dereferencing a parameter passed to a function.
3 # (Complex Example)
4
5 ITERATIONS=3 # How many times to get input.
6 icount=1
7
8 my_read () {
9     # Called with my_read varname,
10    #+ outputs the previous value between brackets as the default value,
11    #+ then asks for a new value.
12
13    local local_var

```

```

14
15 echo -n "Enter a value "
16 eval 'echo -n "[${$1}] "' # Previous value.
17 # eval echo -n "[\${$1}] " # Easier to understand,
18 #+ but loses trailing space in user prompt.
19 read local_var
20 [ -n "$local_var" ] && eval $1=\${local_var}
21
22 # "And-list": if "local_var" then set "$1" to its value.
23 }
24
25 echo
26
27 while [ "$icount" -le "$ITERATIONS" ]
28 do
29 my_read var
30 echo "Entry #${icount} = $var"
31 let "icount += 1"
32 echo
33 done
34
35
36 # Thanks to Stephane Chazelas for providing this instructive example.
37
38 exit 0

```

Exit and Return

exit status

Functions return a value, called an *exit status*. This is analogous to the [exit status](#) returned by a command. The exit status may be explicitly specified by a **return** statement, otherwise it is the exit status of the last command in the function (0 if successful, and a non-zero error code if not). This [exit status](#) may be used in the script by referencing it as [\\$?](#). This mechanism effectively permits script functions to have a "return value" similar to C functions.

return

Terminates a function. A **return** command [\[1\]](#) optionally takes an *integer* argument, which is returned to the calling script as the "exit status" of the function, and this exit status is assigned to the variable [\\$?](#).

Example 24-7. Maximum of two numbers

```


1 #!/bin/bash
2 # max.sh: Maximum of two integers.
3
4 E_PARAM_ERR=250 # If less than 2 params passed to function.
5 EQUAL=251 # Return value if both params equal.
6 # Error values out of range of any
7 #+ params that might be fed to the function.
8
9 max2 () # Returns larger of two numbers.
10 { # Note: numbers compared must be less than 250.
11 if [ -z "$2" ]
12 then
13 return $E_PARAM_ERR
14 fi
15
16 if [ "$1" -eq "$2" ]
17 then
18 return $EQUAL

```

```

19 else
20   if [ "$1" -gt "$2" ]
21   then
22     return $1
23   else
24     return $2
25   fi
26 fi
27 }
28
29 max2 33 34
30 return_val=$?
31
32 if [ "$return_val" -eq $E_PARAM_ERR ]
33 then
34   echo "Need to pass two parameters to the function."
35 elif [ "$return_val" -eq $EQUAL ]
36 then
37   echo "The two numbers are equal."
38 else
39   echo "The larger of the two numbers is $return_val."
40 fi
41
42
43 exit 0
44
45 # Exercise (easy):
46 # -----
47 # Convert this to an interactive script,
48 #+ that is, have the script ask for input (two numbers).

```

 For a function to return a string or array, use a dedicated variable.

```

1 count_lines_in_etc_passwd()
2 {
3   [[ -r /etc/passwd ]] && REPLY=$(echo $(wc -l < /etc/passwd))
4   # If /etc/passwd is readable, set REPLY to line count.
5   # Returns both a parameter value and status information.
6   # The 'echo' seems unnecessary, but . . .
7   #+ it removes excess whitespace from the output.
8 }
9
10 if count_lines_in_etc_passwd
11 then
12   echo "There are $REPLY lines in /etc/passwd."
13 else
14   echo "Cannot count lines in /etc/passwd."
15 fi
16
17 # Thanks, S.C.

```

Example 24-8. Converting numbers to Roman numerals

```

1 #!/bin/bash
2
3 # Arabic number to Roman numeral conversion
4 # Range: 0 - 200
5 # It's crude, but it works.
6
7 # Extending the range and otherwise improving the script is left as an exercise.
8
9 # Usage: roman number-to-convert

```

```

10
11 LIMIT=200
12 E_ARG_ERR=65
13 E_OUT_OF_RANGE=66
14
15 if [ -z "$1" ]
16 then
17     echo "Usage: `basename $0` number-to-convert"
18     exit $E_ARG_ERR
19 fi
20
21 num=$1
22 if [ "$num" -gt $LIMIT ]
23 then
24     echo "Out of range!"
25     exit $E_OUT_OF_RANGE
26 fi
27
28 to_roman ()    # Must declare function before first call to it.
29 {
30     number=$1
31     factor=$2
32     rchar=$3
33     let "remainder = number - factor"
34     while [ "$remainder" -ge 0 ]
35     do
36         echo -n $rchar
37         let "number -= factor"
38         let "remainder = number - factor"
39     done
40
41     return $number
42     # Exercises:
43     # -----
44     # 1) Explain how this function works.
45     #     Hint: division by successive subtraction.
46     # 2) Extend to range of the function.
47     #     Hint: use "echo" and command-substitution capture.
48 }
49
50
51 to_roman $num 100 C
52 num=$?
53 to_roman $num 90 LXXXX
54 num=$?
55 to_roman $num 50 L
56 num=$?
57 to_roman $num 40 XL
58 num=$?
59 to_roman $num 10 X
60 num=$?
61 to_roman $num 9 IX
62 num=$?
63 to_roman $num 5 V
64 num=$?
65 to_roman $num 4 IV
66 num=$?
67 to_roman $num 1 I
68 # Successive calls to conversion function!
69 # Is this really necessary??? Can it be simplified?
70
71 echo
72
73 exit

```

See also [Example 11-29](#).

! The largest positive integer a function can return is 255. The **return** command is closely tied to the concept of [exit status](#), which accounts for this particular limitation. Fortunately, there are various [workarounds](#) for those situations requiring a large integer return value from a function.

Example 24-9. Testing large return values in a function

```
1 #!/bin/bash
2 # return-test.sh
3
4 # The largest positive value a function can return is 255.
5
6 return_test ()      # Returns whatever passed to it.
7 {
8     return $1
9 }
10
11 return_test 27      # o.k.
12 echo $?            # Returns 27.
13
14 return_test 255     # Still o.k.
15 echo $?            # Returns 255.
16
17 return_test 257     # Error!
18 echo $?            # Returns 1 (return code for miscellaneous error).
19
20 # =====
21 return_test -151896 # Do large negative numbers work?
22 echo $?            # Will this return -151896?
23                   # No! It returns 168.
24 # Version of Bash before 2.05b permitted
25 #+ large negative integer return values.
26 # It happened to be a useful feature.
27 # Newer versions of Bash unfortunately plug this loophole.
28 # This may break older scripts.
29 # Caution!
30 # =====
31
32 exit 0
```

A workaround for obtaining large integer "return values" is to simply assign the "return value" to a global variable.

```
1 Return_Val= # Global variable to hold oversize return value of function.
2
3 alt_return_test ()
4 {
5     fvar=$1
6     Return_Val=$fvar
7     return # Returns 0 (success).
8 }
9
10 alt_return_test 1
11 echo $? # 0
12 echo "return value = $Return_Val" # 1
13
14 alt_return_test 256
15 echo "return value = $Return_Val" # 256
16
17 alt_return_test 257
```

```

18 echo "return value = $Return_Val"      # 257
19
20 alt_return_test 25701
21 echo "return value = $Return_Val"      #25701

```

A more elegant method is to have the function **echo** its "return value to stdout," and then capture it by [command substitution](#). See the [discussion of this](#) in [Section 36.7](#).

Example 24-10. Comparing two large integers

```

1 #!/bin/bash
2 # max2.sh: Maximum of two LARGE integers.
3
4 # This is the previous "max.sh" example,
5 #+ modified to permit comparing large integers.
6
7 EQUAL=0                # Return value if both params equal.
8 E_PARAM_ERR=-99999    # Not enough params passed to function.
9 #           ^^^^^^    Out of range of any params that might be passed.
10
11 max2 ()                # "Returns" larger of two numbers.
12 {
13 if [ -z "$2" ]
14 then
15     echo $E_PARAM_ERR
16     return
17 fi
18
19 if [ "$1" -eq "$2" ]
20 then
21     echo $EQUAL
22     return
23 else
24     if [ "$1" -gt "$2" ]
25     then
26         retval=$1
27     else
28         retval=$2
29     fi
30 fi
31
32 echo $retval          # Echoes (to stdout), rather than returning value.
33                      # Why?
34 }
35
36
37 return_val=$(max2 33001 33997)
38 #           ^^^^^          Function name
39 #           ^^^^^ ^^^^^    Params passed
40 # This is actually a form of command substitution:
41 #+ treating a function as if it were a command,
42 #+ and assigning the stdout of the function to the variable "return_val."
43
44
45 # ===== OUTPUT =====
46 if [ "$return_val" -eq "$E_PARAM_ERR" ]
47 then
48     echo "Error in parameters passed to comparison function!"
49 elif [ "$return_val" -eq "$EQUAL" ]
50 then
51     echo "The two numbers are equal."
52 else
53     echo "The larger of the two numbers is $return_val."

```

```

54 fi
55 # =====
56
57 exit 0
58
59 # Exercises:
60 # -----
61 # 1) Find a more elegant way of testing
62 #+ the parameters passed to the function.
63 # 2) Simplify the if/then structure at "OUTPUT."
64 # 3) Rewrite the script to take input from command-line parameters.

```

Here is another example of capturing a function "return value." Understanding it requires some knowledge of [awk](#).

```

1 month_length () # Takes month number as an argument.
2 {               # Returns number of days in month.
3 monthD="31 28 31 30 31 30 31 31 30 31 30 31" # Declare as local?
4 echo "$monthD" | awk '{ print $'"${1}"' }' # Tricky.
5 #                                     ^^^^^^^^^
6 # Parameter passed to function ($1 -- month number), then to awk.
7 # Awk sees this as "print $1 . . . print $12" (depending on month number)
8 # Template for passing a parameter to embedded awk script:
9 #                                     $"${script_parameter}"'
10
11 # Here's a slightly simpler awk construct:
12 # echo $monthD | awk -v month=$1 '{print $(month)}'
13 # Uses the -v awk option, which assigns a variable value
14 #+ prior to execution of the awk program block.
15 # Thank you, Rich.
16
17 # Needs error checking for correct parameter range (1-12)
18 #+ and for February in leap year.
19 }
20
21 # -----
22 # Usage example:
23 month=4 # April, for example (4th month).
24 days_in=$(month_length $month)
25 echo $days_in # 30
26 # -----

```

See also [Example A-7](#) and [Example A-37](#).

Exercise: Using what we have just learned, extend the previous [Roman numerals example](#) to accept arbitrarily large input.

Redirection

Redirecting the stdin of a function

A function is essentially a [code block](#), which means its `stdin` can be redirected (as in [Example 3-1](#)).

Example 24-11. Real name from username

```

1 #!/bin/bash
2 # realname.sh
3 #
4 # From username, gets "real name" from /etc/passwd.
5
6
7 ARGCOUNT=1 # Expect one arg.

```

```

8 E_WRONGARGS=85
9
10 file=/etc/passwd
11 pattern=$1
12
13 if [ $# -ne "$ARGCOUNT" ]
14 then
15     echo "Usage: `basename $0` USERNAME"
16     exit $E_WRONGARGS
17 fi
18
19 file_excerpt ()      # Scan file for pattern,
20 {                    #+ then print relevant portion of line.
21     while read line # "while" does not necessarily need [ condition ]
22     do
23         echo "$line" | grep $1 | awk -F":" '{ print $5 }'
24         # Have awk use ":" delimiter.
25     done
26 } <$file # Redirect into function's stdin.
27
28 file_excerpt $pattern
29
30 # Yes, this entire script could be reduced to
31 #     grep PATTERN /etc/passwd | awk -F":" '{ print $5 }'
32 # or
33 #     awk -F: '/PATTERN/ {print $5}'
34 # or
35 #     awk -F: '($1 == "username") { print $5 }' # real name from username
36 # However, it might not be as instructive.
37
38 exit 0

```

There is an alternate, and perhaps less confusing method of redirecting a function's `stdin`. This involves redirecting the `stdin` to an embedded bracketed code block within the function.

```

1 # Instead of:
2 Function ()
3 {
4     ...
5 } < file
6
7 # Try this:
8 Function ()
9 {
10 {
11     ...
12 } < file
13 }
14
15 # Similarly,
16
17 Function () # This works.
18 {
19 {
20     echo $*
21 } | tr a b
22 }
23
24 Function () # This doesn't work.
25 {
26     echo $*
27 } | tr a b # A nested code block is mandatory here.
28
29
30 # Thanks, S.C.

```




Emmanuel Rouat's [sample bashrc file](#) contains some instructive examples of functions.

Notes

[1] The **return** command is a Bash [builtin](#).

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Local Variables

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24.2. Local Variables


What makes a variable *local*?

local variables

A variable declared as *local* is one that is visible only within the [block of code](#) in which it appears. It has local [scope](#). In a function, a *local variable* has meaning only within that function block. [\[1\]](#)

Example 24-12. Local variable visibility

```
1 #!/bin/bash
2 # ex62.sh: Global and local variables inside a function.
3
4 func ()
5 {
6     local loc_var=23          # Declared as local variable.
7     echo                    # Uses the 'local' builtin.
8     echo "\"loc_var\" in function = $loc_var"
9     global_var=999          # Not declared as local.
10                                # Therefore, defaults to global.
11     echo "\"global_var\" in function = $global_var"
12 }
13
14 func
15
16 # Now, to see if local variable "loc_var" exists outside the function.
17
18 echo
19 echo "\"loc_var\" outside function = $loc_var"
20                                # $loc_var outside function =
21                                # No, $loc_var not visible globally.
22 echo "\"global_var\" outside function = $global_var"
23                                # $global_var outside function = 999
24                                # $global_var is visible globally.
25 echo
26
27 exit 0
28 # In contrast to C, a Bash variable declared inside a function
29 #+ is local ONLY if declared as such.
```

 Before a function is called, *all* variables declared within the function are invisible outside the body of the function, not just those explicitly declared as *local*.

```
1 #!/bin/bash
2
3 func ()
4 {
5     global_var=37          # Visible only within the function block
6                             #+ before the function has been called.
7 }                          # END OF FUNCTION
8
9 echo "global_var = $global_var" # global_var =
10                                # Function "func" has not yet been called,
11                                #+ so $global_var is not visible here.
12
13 func
14 echo "global_var = $global_var" # global_var = 37
15                                # Has been set by function call.
```



As Evgeniy Ivanov points out, when declaring and setting a local variable in a single command, apparently the order of operations is *first set the variable, and only afterwards restrict it to local scope*. This is reflected in the [return value](#).

```
1 #!/bin/bash
2
3 echo "=="OUTSIDE Function (global)=="
4 t=$(exit 1)
5 echo $?      # 1
6              # As expected.
7 echo
8
9 function0 ()
10 {
11
12 echo "=="INSIDE Function=="
13 echo "Global"
14 t0=$(exit 1)
15 echo $?      # 1
16              # As expected.
17
18 echo
19 echo "Local declared & assigned in same command."
20 local t1=$(exit 1)
21 echo $?      # 0
22              # Unexpected!
23 # Apparently, the variable assignment takes place before
24 #+ the local declaration.
25 #+ The return value is for the latter.
26
27 echo
28 echo "Local declared, then assigned (separate commands)."
```

24.2.1. Local variables and recursion.

Recursion is an interesting and sometimes useful form of *self-reference*. [Herbert Mayer](#) defines it as "... expressing an algorithm by using a simpler version of that same algorithm ..."

Consider a definition defined in terms of itself, [\[2\]](#) an expression implicit in its own expression, [\[3\]](#) *a snake swallowing its own tail*, [\[4\]](#) or ... a function that calls itself. [\[5\]](#)

Example 24-13. Demonstration of a simple recursive function

```
1 #!/bin/bash
2 # recursion-demo.sh
3 # Demonstration of recursion.
```

```

4
5 RECURSIONS=9 # How many times to recurse.
6 r_count=0 # Must be global. Why?
7
8 recurse ()
9 {
10  var="$1"
11
12  while [ "$var" -ge 0 ]
13  do
14    echo "Recursion count = "$r_count"  ++  \ $var = "$var"
15    (( var-- )); (( r_count++ ))
16    recurse "$var" # Function calls itself (recurses)
17  done #+ until what condition is met?
18 }
19
20 recurse $RECURSIONS
21
22 exit $?

```

Example 24-14. Another simple demonstration

```

1 #!/bin/bash
2 # recursion-def.sh
3 # A script that defines "recursion" in a rather graphic way.
4
5 RECURSIONS=10
6 r_count=0
7 sp=" "
8
9 define_recursion ()
10 {
11  ((r_count++))
12  sp="$sp" " "
13  echo -n "$sp"
14  echo "\"The act of recurring ... \"" # Per 1913 Webster's dictionary.
15
16  while [ $r_count -le $RECURSIONS ]
17  do
18    define_recursion
19  done
20 }
21
22 echo
23 echo "Recursion: "
24 define_recursion
25 echo
26
27 exit $?

```

Local variables are a useful tool for writing recursive code, but this practice generally involves a great deal of computational overhead and is definitely *not* recommended in a shell script. [\[6\]](#)

Example 24-15. Recursion, using a local variable

```

1 #!/bin/bash
2

```

```

3 #          factorial
4 #          -----
5
6
7 # Does bash permit recursion?
8 # Well, yes, but...
9 # It's so slow that you gotta have rocks in your head to try it.
10
11
12 MAX_ARG=5
13 E_WRONG_ARGS=85
14 E_RANGE_ERR=86
15
16
17 if [ -z "$1" ]
18 then
19     echo "Usage: `basename $0` number"
20     exit $E_WRONG_ARGS
21 fi
22
23 if [ "$1" -gt $MAX_ARG ]
24 then
25     echo "Out of range ($MAX_ARG is maximum)."

```

Also see [Example A-15](#) for an example of recursion in a script. Be aware that recursion is resource-intensive and executes slowly, and is therefore generally not appropriate in a script.

Notes

- [1] However, as Thomas Braunberger points out, a local variable declared in a function *is also visible to functions called by the parent function*.

```

1 #!/bin/bash
2
3 function1 ()
4 {

```

```

5  local funclvar=20
6
7  echo "Within function1, \${funclvar} = $funclvar."
8
9  function2
10 }
11
12 function2 ()
13 {
14  echo "Within function2, \${funclvar} = $funclvar."
15 }
16
17 function1
18
19 exit 0
20
21
22 # Output of the script:
23
24 # Within function1, $funclvar = 20.
25 # Within function2, $funclvar = 20.

```

This is documented in the Bash manual:

"Local can only be used within a function; it makes the variable name have a visible scope restricted to that function *and its children*." [emphasis added] *The ABS Guide author considers this behavior to be a bug.*

- [2] Otherwise known as *redundancy*.
- [3] Otherwise known as *tautology*.
- [4] Otherwise known as a *metaphor*.
- [5] Otherwise known as a *recursive function*.
- [6] Too many levels of recursion may crash a script with a segfault.

```

1  #!/bin/bash
2
3  #  Warning: Running this script could possibly lock up your system!
4  #  If you're lucky, it will segfault before using up all available memory.
5
6  recursive_function ()
7  {
8  echo "$1"      # Makes the function do something, and hastens the segfault.
9  (( $1 < $2 )) && recursive_function $(( $1 + 1 )) $2;
10 #  As long as 1st parameter is less than 2nd,
11 #+ increment 1st and recurse.
12 }
13
14 recursive_function 1 50000 # Recurse 50,000 levels!
15 #  Most likely segfaults (depending on stack size, set by ulimit -m).
16
17 #  Recursion this deep might cause even a C program to segfault,
18 #+ by using up all the memory allotted to the stack.
19
20
21 echo "This will probably not print."
22 exit 0 # This script will not exit normally.
23
24 #  Thanks, Stéphane Chazelas.

```


24.3. Recursion Without Local Variables

A function may recursively call itself even without use of local variables.

Example 24-16. *The Fibonacci Sequence*

```
1 #!/bin/bash
2 # fibo.sh : Fibonacci sequence (recursive)
3 # Author: M. Cooper
4 # License: GPL3
5
6 # -----algorithm-----
7 # Fibo(0) = 0
8 # Fibo(1) = 1
9 # else
10 #   Fibo(j) = Fibo(j-1) + Fibo(j-2)
11 # -----
12
13 MAXTERM=15      # Number of terms (+1) to generate.
14 MINIDX=2        # If idx is less than 2, then Fibo(idx) = idx.
15
16 Fibonacci ()
17 {
18   idx=$1 # Doesn't need to be local. Why not?
19   if [ "$idx" -lt "$MINIDX" ]
20   then
21     echo "$idx" # First two terms are 0 1 ... see above.
22   else
23     (( --idx )) # j-1
24     term1=$( Fibonacci $idx ) # Fibo(j-1)
25
26     (( --idx )) # j-2
27     term2=$( Fibonacci $idx ) # Fibo(j-2)
28
29     echo $(( term1 + term2 ))
30   fi
31   # An ugly, ugly kludge.
32   # The more elegant implementation of recursive fibo in C
33   #+ is a straightforward translation of the algorithm in lines 7 - 10.
34 }
35
36 for i in $(seq 0 $MAXTERM)
37 do # Calculate $MAXTERM+1 terms.
38   FIBO=$(Fibonacci $i)
39   echo -n "$FIBO "
40 done
41 # 0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610
42 # Takes a while, doesn't it? Recursion in a script is slow.
43
44 echo
45
46 exit 0
```

Example 24-17. *The Towers of Hanoi*

```
1 #! /bin/bash
2 #
```

```

3 # The Towers Of Hanoi
4 # Bash script
5 # Copyright (C) 2000 Amit Singh. All Rights Reserved.
6 # http://hanoi.kernelthread.com
7 #
8 # Tested under Bash version 2.05b.0(13)-release.
9 # Also works under Bash version 3.x.
10 #
11 # Used in "Advanced Bash Scripting Guide"
12 #+ with permission of script author.
13 # Slightly modified and commented by ABS author.
14 #
15 #=====#
16 # The Tower of Hanoi is a mathematical puzzle attributed to
17 #+ Edouard Lucas, a nineteenth-century French mathematician.
18 #
19 # There are three vertical posts set in a base.
20 # The first post has a set of annular rings stacked on it.
21 # These rings are disks with a hole drilled out of the center,
22 #+ so they can slip over the posts and rest flat.
23 # The rings have different diameters, and they stack in ascending
24 #+ order, according to size.
25 # The smallest ring is on top, and the largest on the bottom.
26 #
27 # The task is to transfer the stack of rings
28 #+ to one of the other posts.
29 # You can move only one ring at a time to another post.
30 # You are permitted to move rings back to the original post.
31 # You may place a smaller ring atop a larger one,
32 #+ but *not* vice versa.
33 # Again, it is forbidden to place a larger ring atop a smaller one.
34 #
35 # For a small number of rings, only a few moves are required.
36 #+ For each additional ring,
37 #+ the required number of moves approximately doubles,
38 #+ and the "strategy" becomes increasingly complicated.
39 #
40 # For more information, see http://hanoi.kernelthread.com
41 #+ or pp. 186-92 of _The Armchair Universe_ by A.K. Dewdney.
42 #
43 #
44 #           ...           ...           ...
45 #           | |           | |           | |
46 #         _|_|_         | |           | |
47 #        |_____|         | |           | |
48 #       |_____|         | |           | |
49 #      |_____|         | |           | |
50 #     |_____|         | |           | |
51 #    |_____|         | |           | |
52 # .-----#
53 # |*****|
54 #           #1           #2           #3
55 #
56 #=====#
57
58
59 E_NOPARAM=66 # No parameter passed to script.
60 E_BADPARAM=67 # Illegal number of disks passed to script.
61 Moves=      # Global variable holding number of moves.
62             # Modification to original script.
63
64 dohanoi() { # Recursive function.
65     case $1 in
66     0)
67         ;;
68     *)

```

```

69     dohanoi "$(($1-1))" $2 $4 $3
70     echo move $2 "-->" $3
71     ((Moves++))          # Modification to original script.
72     dohanoi "$(($1-1))" $4 $3 $2
73     ;;
74     esac
75 }
76
77 case $# in
78     1) case $((($1>0)) in      # Must have at least one disk.
79         1) # Nested case statement.
80             dohanoi $1 1 3 2
81             echo "Total moves = $Moves"    # 2^n - 1, where n = # of disks.
82             exit 0;
83         ;;
84         *)
85             echo "$0: illegal value for number of disks";
86             exit $E_BADPARAM;
87         ;;
88     esac
89     ;;
90     *)
91         echo "usage: $0 N"
92         echo "      Where \"N\" is the number of disks."
93         exit $E_NOPARAM;
94     ;;
95 esac
96
97 # Exercises:
98 # -----
99 # 1) Would commands beyond this point ever be executed?
100 #    Why not? (Easy)
101 # 2) Explain the workings of the workings of the "dohanoi" function.
102 #    (Difficult -- see the Dewdney reference, above.)

```

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Chapter 25. Aliases

A Bash *alias* is essentially nothing more than a keyboard shortcut, an abbreviation, a means of avoiding typing a long command sequence. If, for example, we include **alias ll="ls -l | more"** in the [~/.bashrc file](#), then each **ll** typed at the command-line will automatically be replaced by a **ls -l | more**. This can save a great deal of typing at the command-line and avoid having to remember complex combinations of commands and options. Setting **alias rm="rm -i"** (interactive mode delete) may save a good deal of grief, since it can prevent inadvertently deleting important files.

In a script, aliases have very limited usefulness. It would be nice if aliases could assume some of the functionality of the C preprocessor, such as macro expansion, but unfortunately Bash does not expand arguments within the alias body. [2] Moreover, a script fails to expand an alias itself within "compound constructs," such as [if/then](#) statements, loops, and functions. An added limitation is that an alias will not expand recursively. Almost invariably, whatever we would like an alias to do could be accomplished much more effectively with a [function](#).

Example 25-1. Aliases within a script

```
1 #!/bin/bash
2 # alias.sh
3
4 shopt -s expand_aliases
5 # Must set this option, else script will not expand aliases.
6
7
8 # First, some fun.
9 alias Jesse_James='echo "\"Alias Jesse James\" was a 1959 comedy starring Bob Hope."'
10 Jesse_James
11
12 echo; echo; echo;
13
14 alias ll="ls -l"
15 # May use either single (') or double (") quotes to define an alias.
16
17 echo "Trying aliased \"ll\":"
18 ll /usr/X11R6/bin/mk*    #* Alias works.
19
20 echo
21
22 directory=/usr/X11R6/bin/
23 prefix=mk*    # See if wild card causes problems.
24 echo "Variables \"directory\" + \"prefix\" = $directory$prefix"
25 echo
26
27 alias lll="ls -l $directory$prefix"
28
29 echo "Trying aliased \"lll\":"
30 lll    # Long listing of all files in /usr/X11R6/bin stating with mk.
31 # An alias can handle concatenated variables -- including wild card -- o.k.
32
33
34
35
36 TRUE=1
37
38 echo
39
40 if [ TRUE ]
```

```

41 then
42   alias rr="ls -l"
43   echo "Trying aliased \"rr\" within if/then statement:"
44   rr /usr/X11R6/bin/mk*   /* Error message results!
45   # Aliases not expanded within compound statements.
46   echo "However, previously expanded alias still recognized:"
47   ll /usr/X11R6/bin/mk*
48 fi
49
50 echo
51
52 count=0
53 while [ $count -lt 3 ]
54 do
55   alias rrr="ls -l"
56   echo "Trying aliased \"rrr\" within \"while\" loop:"
57   rrr /usr/X11R6/bin/mk*   /* Alias will not expand here either.
58                           # alias.sh: line 57: rrr: command not found
59   let count+=1
60 done
61
62 echo; echo
63
64 alias xyz='cat $0'   # Script lists itself.
65                   # Note strong quotes.
66 xyz
67 # This seems to work,
68 #+ although the Bash documentation suggests that it shouldn't.
69 #
70 # However, as Steve Jacobson points out,
71 #+ the "$0" parameter expands immediately upon declaration of the alias.
72
73 exit 0

```

The **unalias** command removes a previously set *alias*.

Example 25-2. *unalias*: Setting and unsetting an alias

```

1 #!/bin/bash
2 # unalias.sh
3
4 shopt -s expand_aliases # Enables alias expansion.
5
6 alias llm='ls -al | more'
7 llm
8
9 echo
10
11 unalias llm           # Unset alias.
12 llm
13 # Error message results, since 'llm' no longer recognized.
14
15 exit 0

```

```

bash$ ./unalias.sh
total 6
drwxrwxr-x   2 bozo   bozo   3072 Feb  6 14:04 .
drwxr-xr-x  40 bozo   bozo   2048 Feb  6 14:04 ..
-rwxr-xr-x   1 bozo   bozo    199 Feb  6 14:04 unalias.sh

./unalias.sh: llm: command not found

```

Notes

- [1] ... as the first word of a command string. Obviously, an alias is only meaningful at the *beginning* of a command.
- [2] However, aliases do seem to expand positional parameters.

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List Constructs

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Chapter 26. List Constructs

The *and list* and *or list* constructs provide a means of processing a number of commands consecutively. These can effectively replace complex nested [if/then](#) or even [case](#) statements.

Chaining together commands

and list

```
1 command-1 && command-2 && command-3 && ... command-n
```

Each command executes in turn, provided that the previous command has given a return value of *true* (zero). At the first *false* (non-zero) return, the command chain terminates (the first command returning *false* is the last one to execute).

An interesting use of a two-condition *and list* from an early version of YongYe's [Tetris game script](#):

```
1 equation()
2
3 { # core algorithm used for doubling and halving the coordinates
4   [[ ${cdx} ]] && ((y=cy+(ccy-cdy){2}2))
5   eval ${1}+=\"${x} ${y} \"
6 }
```

Example 26-1. Using an *and list* to test for command-line arguments

```
1 #!/bin/bash
2 # and list
3
4 if [ ! -z "$1" ] && echo "Argument #1 = $1" && [ ! -z "$2" ] && \
5 #           ^^           ^^           ^^
6 echo "Argument #2 = $2"
7 then
8   echo "At least 2 arguments passed to script."
9   # All the chained commands return true.
10 else
11   echo "Fewer than 2 arguments passed to script."
12   # At least one of the chained commands returns false.
13 fi
14 # Note that "if [ !-z $1 ]" works, but its alleged equivalent,
15 #   "if [ -n $1 ]" does not.
16 #   However, quoting fixes this.
17 #   if "[ -n \"$1\" ]" works.
18 #           ^ ^ Careful!
19 # It is always best to QUOTE the variables being tested.
20
21
22 # This accomplishes the same thing, using "pure" if/then statements.
23 if [ ! -z "$1" ]
24 then
25   echo "Argument #1 = $1"
26 fi
27 if [ ! -z "$2" ]
28 then
29   echo "Argument #2 = $2"
30   echo "At least 2 arguments passed to script."
31 else
32   echo "Fewer than 2 arguments passed to script."
33 fi
```

```
34 # It's longer and more ponderous than using an "and list".
35
36
37 exit $?
```

Example 26-2. Another command-line arg test using an *and list*

```
1 #!/bin/bash
2
3 ARGS=1          # Number of arguments expected.
4 E_BADARGS=85   # Exit value if incorrect number of args passed.
5
6 test $# -ne $ARGS && \
7 #   ^^^^^^^^^^^^^ condition #1
8 echo "Usage: `basename $0` $ARGS argument(s)" && exit $E_BADARGS
9 #
10 # If condition #1 tests true (wrong number of args passed to script),
11 #+ then the rest of the line executes, and script terminates.
12
13 # Line below executes only if the above test fails.
14 echo "Correct number of arguments passed to this script."
15
16 exit 0
17
18 # To check exit value, do a "echo $?" after script termination.
```

Of course, an *and list* can also *set* variables to a default value.

```
1 arg1=${@} && [ -z "$arg1" ] && arg1=DEFAULT
2
3           # Set $arg1 to command-line arguments, if any.
4           # But . . . set to DEFAULT if not specified on command-line.
```

or list

```
1 command-1 || command-2 || command-3 || ... command-n
```

Each command executes in turn for as long as the previous command returns false. At the first true return, the command chain terminates (the first command returning true is the last one to execute). This is obviously the inverse of the "and list".


Example 26-3. Using *or lists* in combination with an *and list*

```
1 #!/bin/bash
2
3 # delete.sh, a not-so-cunning file deletion utility.
4 # Usage: delete filename
5
6 E_BADARGS=85
7
8 if [ -z "$1" ]
9 then
10  echo "Usage: `basename $0` filename"
11  exit $E_BADARGS # No arg? Bail out.
12 else
13  file=$1          # Set filename.
14 fi
15
```

```

16
17 [ ! -f "$file" ] && echo "File \"$file\" not found. \
18 Cowardly refusing to delete a nonexistent file."
19 # AND LIST, to give error message if file not present.
20 # Note echo message continuing on to a second line after an escape.
21
22 [ ! -f "$file" ] || (rm -f $file; echo "File \"$file\" deleted.")
23 # OR LIST, to delete file if present.
24
25 # Note logic inversion above.
26 # AND LIST executes on true, OR LIST on false.
27
28 exit $?

```

 If the first command in an *or list* returns true, it *will* execute.

```

1 # ==> The following snippets from the /etc/rc.d/init.d/single
2 #+=> script by Miquel van Smoorenburg
3 #+=> illustrate use of "and" and "or" lists.
4 # ==> "Arrowed" comments added by document author.
5
6 [ -x /usr/bin/clear ] && /usr/bin/clear
7 # ==> If /usr/bin/clear exists, then invoke it.
8 # ==> Checking for the existence of a command before calling it
9 #+=> avoids error messages and other awkward consequences.
10
11 # ==> . . .
12
13 # If they want to run something in single user mode, might as well run it...
14 for i in /etc/rc1.d/S[0-9][0-9]* ; do
15     # Check if the script is there.
16     [ -x "$i" ] || continue
17     # ==> If corresponding file in $PWD *not* found,
18     #+=> then "continue" by jumping to the top of the loop.
19
20     # Reject backup files and files generated by rpm.
21     case "$i" in
22         *.rpmsave|*.rpmorig|*.rpmnew|*~|*.orig)
23             continue;;
24     esac
25     [ "$i" = "/etc/rc1.d/S00single" ] && continue
26     # ==> Set script name, but don't execute it yet.
27     $i start
28 done
29
30 # ==> . . .

```

 The [exit status](#) of an **and list** or an **or list** is the exit status of the last command executed.

Clever combinations of *and* and *or* lists are possible, but the logic may easily become convoluted and require close attention to [operator precedence rules](#), and possibly extensive debugging.

```

1 false && true || echo false      # false
2
3 # Same result as
4 ( false && true ) || echo false  # false
5 # But NOT
6 false && ( true || echo false )  # (nothing echoed)
7
8 # Note left-to-right grouping and evaluation of statements.
9
10 # It's usually best to avoid such complexities.
11
12 # Thanks, S.C.

```

See [Example A-7](#) and [Example 7-4](#) for illustrations of using **and** / **or** **list** constructs to test variables.

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Chapter 27. Arrays

Newer versions of Bash support one-dimensional arrays. Array elements may be initialized with the **variable[xx]** notation. Alternatively, a script may introduce the entire array by an explicit **declare -a variable** statement. To dereference (retrieve the contents of) an array element, use *curly bracket* notation, that is, **\${element [xx]}**.

Example 27-1. Simple array usage

```
1 #!/bin/bash
2
3
4 area[11]=23
5 area[13]=37
6 area[51]=UFOs
7
8 # Array members need not be consecutive or contiguous.
9
10 # Some members of the array can be left uninitialized.
11 # Gaps in the array are okay.
12 # In fact, arrays with sparse data ("sparse arrays")
13 #+ are useful in spreadsheet-processing software.
14
15
16 echo -n "area[11] = "
17 echo ${area[11]} # {curly brackets} needed.
18
19 echo -n "area[13] = "
20 echo ${area[13]}
21
22 echo "Contents of area[51] are ${area[51]}."
23
24 # Contents of uninitialized array variable print blank (null variable).
25 echo -n "area[43] = "
26 echo ${area[43]}
27 echo "(area[43] unassigned)"
28
29 echo
30
31 # Sum of two array variables assigned to third
32 area[5]=`expr ${area[11]} + ${area[13]}`
33 echo "area[5] = area[11] + area[13]"
34 echo -n "area[5] = "
35 echo ${area[5]}
36
37 area[6]=`expr ${area[11]} + ${area[51]}`
38 echo "area[6] = area[11] + area[51]"
39 echo -n "area[6] = "
40 echo ${area[6]}
41 # This fails because adding an integer to a string is not permitted.
42
43 echo; echo; echo
44
45 # -----
46 # Another array, "area2".
47 # Another way of assigning array variables...
48 # array_name=( XXX YYZ ZZZ ... )
49
50 area2=( zero one two three four )
```

```

51
52 echo -n "area2[0] = "
53 echo ${area2[0]}
54 # Aha, zero-based indexing (first element of array is [0], not [1]).
55
56 echo -n "area2[1] = "
57 echo ${area2[1]}      # [1] is second element of array.
58 # -----
59
60 echo; echo; echo
61
62 # -----
63 # Yet another array, "area3".
64 # Yet another way of assigning array variables...
65 # array_name=( [xx]=XXX [yy]=YYY ...)
66
67 area3=( [17]=seventeen [24]=twenty-four)
68
69 echo -n "area3[17] = "
70 echo ${area3[17]}
71
72 echo -n "area3[24] = "
73 echo ${area3[24]}
74 # -----
75
76 exit 0

```

As we have seen, a convenient way of initializing an entire array is the `array=(element1 element2 ... elementN)` notation.

```

1 base64_charset=( {A..Z} {a..z} {0..9} + / = )
2                 # Using extended brace expansion
3                 #+ to initialize the elements of the array.
4                 # Excerpted from vladz's "base64.sh" script
5                 #+ in the "Contributed Scripts" appendix.

```

Bash permits array operations on variables, even if the variables are not explicitly declared as arrays.

```

1 string=abcABC123ABCabc
2 echo ${string[@]}           # abcABC123ABCabc
3 echo ${string[*]}          # abcABC123ABCabc
4 echo ${string[0]}           # abcABC123ABCabc
5 echo ${string[1]}           # No output!
6                             # Why?
7 echo ${#string[@]}          # 1
8                             # One element in the array.
9                             # The string itself.
10
11 # Thank you, Michael Zick, for pointing this out.

```

Once again this demonstrates that [Bash variables are untyped](#).

Example 27-2. Formatting a poem

```

1 #!/bin/bash
2 # poem.sh: Pretty-prints one of the ABS Guide author's favorite poems.
3
4 # Lines of the poem (single stanza).
5 Line[1]="I do not know which to prefer,"

```



```

22                                     # (Alternate notation)
23
24 echo ${#array[1]}                   # 3
25                                     # Length of second element of array.
26                                     # Arrays in Bash have zero-based indexing.
27
28 echo ${#array[*]}                   # 6
29                                     # Number of elements in array.
30 echo ${#array[@]}                   # 6
31                                     # Number of elements in array.
32
33 echo "-----"
34
35 array2=( [0]="first element" [1]="second element" [3]="fourth element" )
36 #           ^         ^         ^         ^         ^         ^         ^         ^
37 # Quoting permits embedding whitespace within individual array elements.
38
39 echo ${array2[0]}                    # first element
40 echo ${array2[1]}                    # second element
41 echo ${array2[2]}                    #
42                                     # Skipped in initialization, and therefore null.
43 echo ${array2[3]}                    # fourth element
44 echo ${#array2[0]}                   # 13      (length of first element)
45 echo ${#array2[*]}                   # 3       (number of elements in array)
46
47 exit

```

Many of the standard [string operations](#) work on arrays.

Example 27-4. String operations on arrays

```

1 #!/bin/bash
2 # array-strops.sh: String operations on arrays.
3
4 # Script by Michael Zick.
5 # Used in ABS Guide with permission.
6 # Fixups: 05 May 08, 04 Aug 08.
7
8 # In general, any string operation using the ${name ... } notation
9 #+ can be applied to all string elements in an array,
10 #+ with the ${name[@] ... } or ${name[*] ...} notation.
11
12
13 arrayZ=( one two three four five five )
14
15 echo
16
17 # Trailing Substring Extraction
18 echo ${arrayZ[@]:0}                  # one two three four five five
19 #           ^                          All elements.
20
21 echo ${arrayZ[@]:1}                  # two three four five five
22 #           ^                          All elements following element[0].
23
24 echo ${arrayZ[@]:1:2}                # two three
25 #           ^                          Only the two elements after element[0].
26
27 echo "-----"
28
29
30 # Substring Removal
31

```



```

32 # Removes shortest match from front of string(s).
33
34 echo ${arrayZ[@]#f*r} # one two three five five
35 #           ^         # Applied to all elements of the array.
36 #           # Matches "four" and removes it.
37
38 # Longest match from front of string(s)
39 echo ${arrayZ[@]##t*e} # one two four five five
40 #           ^^        # Applied to all elements of the array.
41 #           # Matches "three" and removes it.
42
43 # Shortest match from back of string(s)
44 echo ${arrayZ[@]%h*e} # one two t four five five
45 #           ^         # Applied to all elements of the array.
46 #           # Matches "hree" and removes it.
47
48 # Longest match from back of string(s)
49 echo ${arrayZ[@]%%t*e} # one two four five five
50 #           ^^        # Applied to all elements of the array.
51 #           # Matches "three" and removes it.
52
53 echo "-----"
54
55
56 # Substring Replacement
57
58 # Replace first occurrence of substring with replacement.
59 echo ${arrayZ[@]/fiv/XYZ} # one two three four XYZe XYZe
60 #           ^         # Applied to all elements of the array.
61
62 # Replace all occurrences of substring.
63 echo ${arrayZ[@]//iv/YY} # one two three four fYYe fYYe
64 #           # Applied to all elements of the array.
65
66 # Delete all occurrences of substring.
67 # Not specifying a replacement defaults to 'delete' ...
68 echo ${arrayZ[@]//fi/} # one two three four ve ve
69 #           ^^        # Applied to all elements of the array.
70
71 # Replace front-end occurrences of substring.
72 echo ${arrayZ[@]#fi/XY} # one two three four XYve XYve
73 #           ^         # Applied to all elements of the array.
74
75 # Replace back-end occurrences of substring.
76 echo ${arrayZ[@]%/ve/ZZ} # one two three four fiZZ fiZZ
77 #           ^         # Applied to all elements of the array.
78
79 echo ${arrayZ[@]%/o/XX} # one twXX three four five five
80 #           ^         # Why?
81
82 echo "-----"
83
84
85 replacement() {
86     echo -n "!!!"
87 }
88
89 echo ${arrayZ[@]%/e/${replacement}}
90 #           ^  ^^^^^^^^^^^^^^^^^^^
91 # on!!! two thre!!! four fiv!!! fiv!!!
92 # The stdout of replacement() is the replacement string.
93 # Q.E.D: The replacement action is, in effect, an 'assignment.'
94
95 echo "-----"
96
97 # Accessing the "for-each":

```

```

98 echo ${arrayZ[@]//*/$(replacement optional_arguments)}
99 #           ^^ ^^^^^^^^^^^^^^^^^^^
100 # !!! !!! !!! !!! !!! !!!
101
102 # Now, if Bash would only pass the matched string
103 #+ to the function being called . . .
104
105 echo
106
107 exit 0
108
109 # Before reaching for a Big Hammer -- Perl, Python, or all the rest --
110 # recall:
111 #   $( ... ) is command substitution.
112 #   A function runs as a sub-process.
113 #   A function writes its output (if echo-ed) to stdout.
114 #   Assignment, in conjunction with "echo" and command substitution,
115 #+ can read a function's stdout.
116 #   The name[@] notation specifies (the equivalent of) a "for-each"
117 #+ operation.
118 #   Bash is more powerful than you think!

```

[Command substitution](#) can construct the individual elements of an array.

Example 27-5. Loading the contents of a script into an array

```

1 #!/bin/bash
2 # script-array.sh: Loads this script into an array.
3 # Inspired by an e-mail from Chris Martin (thanks!).
4
5 script_contents=( $(cat "$0") ) # Stores contents of this script ($0)
6                               #+ in an array.
7
8 for element in $(seq 0 $($#{script_contents[@]} - 1))
9 do
10     # ${script_contents[@]}
11     #+ gives number of elements in the array.
12     #
13     # Question:
14     # Why is seq 0 necessary?
15     # Try changing it to seq 1.
16     echo -n "${script_contents[$element]}"
17     # List each field of this script on a single line.
18     # echo -n "${script_contents[element]}" also works because of ${ ... }.
19     echo -n " -- " # Use " -- " as a field separator.
20 done
21 echo
22
23 exit 0
24
25 # Exercise:
26 # -----
27 # Modify this script so it lists itself
28 #+ in its original format,
29 #+ complete with whitespace, line breaks, etc.

```

In an array context, some Bash [builtins](#) have a slightly altered meaning. For example, [unset](#) deletes array elements, or even an entire array.

Example 27-6. Some special properties of arrays

```
1 #!/bin/bash
2
3 declare -a colors
4 # All subsequent commands in this script will treat
5 #+ the variable "colors" as an array.
6
7 echo "Enter your favorite colors (separated from each other by a space)."
```

As seen in the previous example, either `${array_name[@]}` or `${array_name[*]}` refers to *all* the elements of the array. Similarly, to get a count of the number of elements in an array, use either `${#array_name[@]}` or `${#array_name[*]}`. `${#array_name}` is the length (number of characters) of `${array_name[0]}`, the first element of the array.

Example 27-7. Of empty arrays and empty elements

```
1 #!/bin/bash
2 # empty-array.sh
3
4 # Thanks to Stephane Chazelas for the original example,
5 #+ and to Michael Zick and Omair Eshkenazi, for extending it.
6 # And to Nathan Coulter for clarifications and corrections.
7
8
9 # An empty array is not the same as an array with empty elements.
10
11 array0=( first second third )
12 array1=( ' ' ) # "array1" consists of one empty element.
13 array2=( ) # No elements . . . "array2" is empty.
14 array3=( ) # What about this array?
15
16
17 echo
18 ListArray()
19 {
20 echo
21 echo "Elements in array0: ${array0[@]}"
22 echo "Elements in array1: ${array1[@]}"
23 echo "Elements in array2: ${array2[@]}"
24 echo "Elements in array3: ${array3[@]}"
25 echo
26 echo "Length of first element in array0 = ${#array0}"
27 echo "Length of first element in array1 = ${#array1}"
28 echo "Length of first element in array2 = ${#array2}"
29 echo "Length of first element in array3 = ${#array3}"
30 echo
31 echo "Number of elements in array0 = ${#array0[*]}" # 3
32 echo "Number of elements in array1 = ${#array1[*]}" # 1 (Surprise!)
33 echo "Number of elements in array2 = ${#array2[*]}" # 0
34 echo "Number of elements in array3 = ${#array3[*]}" # 0
35 }
36
37 # =====
38
39 ListArray
40
41 # Try extending those arrays.
42
43 # Adding an element to an array.
44 array0=( "${array0[@]}" "new1" )
45 array1=( "${array1[@]}" "new1" )
46 array2=( "${array2[@]}" "new1" )
47 array3=( "${array3[@]}" "new1" )
48
49 ListArray
50
51 # or
52 array0[${#array0[*]}]="new2"
```

```

53 array1[${#array1[*]}]="new2"
54 array2[${#array2[*]}]="new2"
55 array3[${#array3[*]}]="new2"
56
57 ListArray
58
59 # When extended as above, arrays are 'stacks' ...
60 # Above is the 'push' ...
61 # The stack 'height' is:
62 height=${#array2[@]}
63 echo
64 echo "Stack height for array2 = $height"
65
66 # The 'pop' is:
67 unset array2[${#array2[@]}-1] # Arrays are zero-based,
68 height=${#array2[@]}          #+ which means first element has index 0.
69 echo
70 echo "POP"
71 echo "New stack height for array2 = $height"
72
73 ListArray
74
75 # List only 2nd and 3rd elements of array0.
76 from=1                # Zero-based numbering.
77 to=2
78 array3=( ${array0[@]:1:2} )
79 echo
80 echo "Elements in array3:  ${array3[@]}"
81
82 # Works like a string (array of characters).
83 # Try some other "string" forms.
84
85 # Replacement:
86 array4=( ${array0[@]/second/2nd} )
87 echo
88 echo "Elements in array4:  ${array4[@]}"
89
90 # Replace all matching wildcarded string.
91 array5=( ${array0[@]/new?/old} )
92 echo
93 echo "Elements in array5:  ${array5[@]}"
94
95 # Just when you are getting the feel for this . . .
96 array6=( ${array0[@]#*new} )
97 echo # This one might surprise you.
98 echo "Elements in array6:  ${array6[@]}"
99
100 array7=( ${array0[@]#new1} )
101 echo # After array6 this should not be a surprise.
102 echo "Elements in array7:  ${array7[@]}"
103
104 # Which looks a lot like . . .
105 array8=( ${array0[@]/new1/} )
106 echo
107 echo "Elements in array8:  ${array8[@]}"
108
109 # So what can one say about this?
110
111 # The string operations are performed on
112 #+ each of the elements in var[@] in succession.
113 # Therefore : Bash supports string vector operations.
114 # If the result is a zero length string,
115 #+ that element disappears in the resulting assignment.
116 # However, if the expansion is in quotes, the null elements remain.
117
118 # Michael Zick: Question, are those strings hard or soft quotes?

```

```

119 # Nathan Coulter: There is no such thing as "soft quotes."
120 #!   What's really happening is that
121 #!+  the pattern matching happens after
122 #!+  all the other expansions of [word]
123 #!+  in cases like ${parameter#word}.
124
125
126 zap='new*'
127 array9=( ${array0[@]/$zap/} )
128 echo
129 echo "Number of elements in array9: ${#array9[@]}"
130 array9=( "${array0[@]/$zap/}" )
131 echo "Elements in array9: ${array9[@]}"
132 # This time the null elements remain.
133 echo "Number of elements in array9: ${#array9[@]}"
134
135
136 # Just when you thought you were still in Kansas . . .
137 array10=( ${array0[@]#$zap} )
138 echo
139 echo "Elements in array10: ${array10[@]}"
140 # But, the asterisk in zap won't be interpreted if quoted.
141 array10=( ${array0[@]#"$zap"} )
142 echo
143 echo "Elements in array10: ${array10[@]}"
144 # Well, maybe we are still in Kansas . . .
145 # (Revisions to above code block by Nathan Coulter.)
146
147
148 # Compare array7 with array10.
149 # Compare array8 with array9.
150
151 # Reiterating: No such thing as soft quotes!
152 # Nathan Coulter explains:
153 # Pattern matching of 'word' in ${parameter#word} is done after
154 #+ parameter expansion and *before* quote removal.
155 # In the normal case, pattern matching is done *after* quote removal.
156
157 exit

```

The relationship of `${array_name[@]}` and `${array_name[*]}` is analogous to that between [\\$@](#) and [\\$*](#). This powerful array notation has a number of uses.

```

1 # Copying an array.
2 array2=( "${array1[@]}" )
3 # or
4 array2="${array1[@]}"
5 #
6 # However, this fails with "sparse" arrays,
7 #+ arrays with holes (missing elements) in them,
8 #+ as Jochen DeSmet points out.
9 # -----
10 array1[0]=0
11 # array1[1] not assigned
12 array1[2]=2
13 array2=( "${array1[@]}" )      # Copy it?
14
15 echo ${array2[0]}           # 0
16 echo ${array2[2]}           # (null), should be 2
17 # -----
18
19
20
21 # Adding an element to an array.

```

```

22 array=( "${array[@]}" "new element" )
23 # or
24 array[${#array[*]}]="new element"
25
26 # Thanks, S.C.

```

i The `array=(element1 element2 ... elementN)` initialization operation, with the help of [command substitution](#), makes it possible to load the contents of a text file into an array.

```

1 #!/bin/bash
2
3 filename=sample_file
4
5 #           cat sample_file
6 #
7 #           1 a b c
8 #           2 d e fg
9
10
11 declare -a array1
12
13 array1=( `cat "$filename"` )           # Loads contents
14 #           List file to stdout           #+ of $filename into array1.
15 #
16 # array1=( `cat "$filename" | tr '\n' ' '` )
17 #           change linefeeds in file to spaces.
18 # Not necessary because Bash does word splitting,
19 #+ changing linefeeds to spaces.
20
21 echo ${array1[@]}           # List the array.
22 #           1 a b c 2 d e fg
23 #
24 # Each whitespace-separated "word" in the file
25 #+ has been assigned to an element of the array.
26
27 element_count=${#array1[*]}
28 echo $element_count           # 8

```

Clever scripting makes it possible to add array operations.

Example 27-8. Initializing arrays

```

1 #! /bin/bash
2 # array-assign.bash
3
4 # Array operations are Bash-specific,
5 #+ hence the ".bash" in the script name.
6
7 # Copyright (c) Michael S. Zick, 2003, All rights reserved.
8 # License: Unrestricted reuse in any form, for any purpose.
9 # Version: $ID$
10 #
11 # Clarification and additional comments by William Park.
12
13 # Based on an example provided by Stephane Chazelas
14 #+ which appeared in an earlier version of the
15 #+ Advanced Bash Scripting Guide.
16
17 # Output format of the 'times' command:
18 # User CPU <space> System CPU
19 # User CPU of dead children <space> System CPU of dead children
20

```

```

21 # Bash has two versions of assigning all elements of an array
22 #+ to a new array variable.
23 # Both drop 'null reference' elements
24 #+ in Bash versions 2.04 and later.
25 # An additional array assignment that maintains the relationship of
26 #+ [subscript]=value for arrays may be added to newer versions.
27
28 # Constructs a large array using an internal command,
29 #+ but anything creating an array of several thousand elements
30 #+ will do just fine.
31
32 declare -a bigOne=( /dev/* ) # All the files in /dev . . .
33 echo
34 echo 'Conditions: Unquoted, default IFS, All-Elements-Of'
35 echo "Number of elements in array is ${#bigOne[@]}"
36
37 # set -vx
38
39
40
41 echo
42 echo '- - testing: =( ${array[@]} ) - -'
43 times
44 declare -a bigTwo=( ${bigOne[@]} )
45 # Note parens:      ^           ^
46 times
47
48
49 echo
50 echo '- - testing:=${array[@]} - -'
51 times
52 declare -a bigThree=${bigOne[@]}
53 # No parentheses this time.
54 times
55
56 # Comparing the numbers shows that the second form, pointed out
57 #+ by Stephane Chazelas, is faster.
58 #
59 # As William Park explains:
60 #+ The bigTwo array assigned element by element (because of parentheses),
61 #+ whereas bigThree assigned as a single string.
62 # So, in essence, you have:
63 #           bigTwo=( [0]="..." [1]="..." [2]="..." ... )
64 #           bigThree=( [0]="... .." )
65 #
66 # Verify this by: echo ${bigTwo[0]}
67 #                 echo ${bigThree[0]}
68
69
70 # I will continue to use the first form in my example descriptions
71 #+ because I think it is a better illustration of what is happening.
72
73 # The reusable portions of my examples will actual contain
74 #+ the second form where appropriate because of the speedup.
75
76 # MSZ: Sorry about that earlier oversight folks.
77
78
79 # Note:
80 # ----
81 # The "declare -a" statements in lines 32 and 44
82 #+ are not strictly necessary, since it is implicit
83 #+ in the Array=( ... ) assignment form.
84 # However, eliminating these declarations slows down
85 #+ the execution of the following sections of the script.
86 # Try it, and see.

```




Adding a superfluous **declare -a** statement to an array declaration may speed up execution of subsequent operations on the array.

Example 27-9. Copying and concatenating arrays

```
1 #! /bin/bash
2 # CopyArray.sh
3 #
4 # This script written by Michael Zick.
5 # Used here with permission.
6
7 # How-To "Pass by Name & Return by Name"
8 #+ or "Building your own assignment statement".
9
10
11 CpArray_Mac() {
12
13 # Assignment Command Statement Builder
14
15     echo -n 'eval '
16     echo -n "$2"           # Destination name
17     echo -n '= ( ${'
18     echo -n "$1"         # Source name
19     echo -n '[@] } )'
20
21 # That could all be a single command.
22 # Matter of style only.
23 }
24
25 declare -f CopyArray      # Function "Pointer"
26 CopyArray=CpArray_Mac    # Statement Builder
27
28 Hype()
29 {
30
31 # Hype the array named $1.
32 # (Splice it together with array containing "Really Rocks".)
33 # Return in array named $2.
34
35     local -a TMP
36     local -a hype=( Really Rocks )
37
38     ${CopyArray $1 TMP}
39     TMP=( ${TMP[@]} ${hype[@]} )
40     ${CopyArray TMP $2}
41 }
42
43 declare -a before=( Advanced Bash Scripting )
44 declare -a after
45
46 echo "Array Before = ${before[@]}"
47
48 Hype before after
49
50 echo "Array After = ${after[@]}"
51
52 # Too much hype?
53
54 echo "What ${after[@]:3:2}?"
55
```

```

56 declare -a modest=( ${after[@]:2:1} ${after[@]:3:2} )
57 #          ---- substring extraction ----
58
59 echo "Array Modest = ${modest[@]}"
60
61 # What happened to 'before' ?
62
63 echo "Array Before = ${before[@]}"
64
65 exit 0

```

Example 27-10. More on concatenating arrays

```

1  #! /bin/bash
2  # array-append.bash
3
4  # Copyright (c) Michael S. Zick, 2003, All rights reserved.
5  # License: Unrestricted reuse in any form, for any purpose.
6  # Version: $ID$
7  #
8  # Slightly modified in formatting by M.C.
9
10
11 # Array operations are Bash-specific.
12 # Legacy UNIX /bin/sh lacks equivalents.
13
14
15 # Pipe the output of this script to 'more'
16 #+ so it doesn't scroll off the terminal.
17 # Or, redirect output to a file.
18
19
20 declare -a array1=( zero1 one1 two1 )
21 # Subscript packed.
22 declare -a array2=( [0]=zero2 [2]=two2 [3]=three2 )
23 # Subscript sparse -- [1] is not defined.
24
25 echo
26 echo '- Confirm that the array is really subscript sparse. -'
27 echo "Number of elements: 4"          # Hard-coded for illustration.
28 for (( i = 0 ; i < 4 ; i++ ))
29 do
30     echo "Element [$i]: ${array2[$i]}"
31 done
32 # See also the more general code example in basics-reviewed.bash.
33
34
35 declare -a dest
36
37 # Combine (append) two arrays into a third array.
38 echo
39 echo 'Conditions: Unquoted, default IFS, All-Elements-Of operator'
40 echo '- Undefined elements not present, subscripts not maintained. -'
41 # # The undefined elements do not exist; they are not being dropped.
42
43 dest=( ${array1[@]} ${array2[@]} )
44 # dest=${array1[@]}${array2[@]}      # Strange results, possibly a bug.
45
46 # Now, list the result.
47 echo
48 echo '- - Testing Array Append - -'
49 cnt=${#dest[@]}

```

```

50
51 echo "Number of elements: $cnt"
52 for (( i = 0 ; i < cnt ; i++ ))
53 do
54     echo "Element [$i]: ${dest[$i]}"
55 done
56
57 # Assign an array to a single array element (twice).
58 dest[0]=${array1[@]}
59 dest[1]=${array2[@]}
60
61 # List the result.
62 echo
63 echo '- - Testing modified array - -'
64 cnt=${#dest[@]}
65
66 echo "Number of elements: $cnt"
67 for (( i = 0 ; i < cnt ; i++ ))
68 do
69     echo "Element [$i]: ${dest[$i]}"
70 done
71
72 # Examine the modified second element.
73 echo
74 echo '- - Reassign and list second element - -'
75
76 declare -a subArray=${dest[1]}
77 cnt=${#subArray[@]}
78
79 echo "Number of elements: $cnt"
80 for (( i = 0 ; i < cnt ; i++ ))
81 do
82     echo "Element [$i]: ${subArray[$i]}"
83 done
84
85 # The assignment of an entire array to a single element
86 #+ of another array using the '=${ ... }' array assignment
87 #+ has converted the array being assigned into a string,
88 #+ with the elements separated by a space (the first character of IFS).
89
90 # If the original elements didn't contain whitespace . . .
91 # If the original array isn't subscript sparse . . .
92 # Then we could get the original array structure back again.
93
94 # Restore from the modified second element.
95 echo
96 echo '- - Listing restored element - -'
97
98 declare -a subArray=( ${dest[1]} )
99 cnt=${#subArray[@]}
100
101 echo "Number of elements: $cnt"
102 for (( i = 0 ; i < cnt ; i++ ))
103 do
104     echo "Element [$i]: ${subArray[$i]}"
105 done
106 echo '- - Do not depend on this behavior. - -'
107 echo '- - This behavior is subject to change - -'
108 echo '- - in versions of Bash newer than version 2.05b - -'
109
110 # MSZ: Sorry about any earlier confusion folks.
111
112 exit 0

```

Arrays permit deploying old familiar algorithms as shell scripts. Whether this is necessarily a good idea is left for the reader to decide.

Example 27-11. The Bubble Sort

```
1 #!/bin/bash
2 # bubble.sh: Bubble sort, of sorts.
3
4 # Recall the algorithm for a bubble sort. In this particular version...
5
6 # With each successive pass through the array to be sorted,
7 #+ compare two adjacent elements, and swap them if out of order.
8 # At the end of the first pass, the "heaviest" element has sunk to bottom.
9 # At the end of the second pass, the next "heaviest" one has sunk next to bottom.
10 # And so forth.
11 # This means that each successive pass needs to traverse less of the array.
12 # You will therefore notice a speeding up in the printing of the later passes.
13
14
15 exchange()
16 {
17     # Swaps two members of the array.
18     local temp=${Countries[$1]} # Temporary storage
19                                 #+ for element getting swapped out.
20     Countries[$1]=${Countries[$2]}
21     Countries[$2]=$temp
22
23     return
24 }
25
26 declare -a Countries # Declare array,
27                     #+ optional here since it's initialized below.
28
29 # Is it permissible to split an array variable over multiple lines
30 #+ using an escape (\)?
31 # Yes.
32
33 Countries=(Netherlands Ukraine Zaire Turkey Russia Yemen Syria \
34 Brazil Argentina Nicaragua Japan Mexico Venezuela Greece England \
35 Israel Peru Canada Oman Denmark Wales France Kenya \
36 Xanadu Qatar Liechtenstein Hungary)
37
38 # "Xanadu" is the mythical place where, according to Coleridge,
39 #+ Kubla Khan did a pleasure dome decree.
40
41
42 clear # Clear the screen to start with.
43
44 echo "0: ${Countries[*]}" # List entire array at pass 0.
45
46 number_of_elements=${#Countries[@]}
47 let "comparisons = $number_of_elements - 1"
48
49 count=1 # Pass number.
50
51 while [ "$comparisons" -gt 0 ] # Beginning of outer loop
52 do
53
54     index=0 # Reset index to start of array after each pass.
55
56     while [ "$index" -lt "$comparisons" ] # Beginning of inner loop
57     do
```

```

58     if [ ${Countries[$index]} \> ${Countries[`expr $index + 1`] } ]
59     # If out of order...
60     # Recalling that \> is ASCII comparison operator
61     #+ within single brackets.
62
63     # if [[ ${Countries[$index]} > ${Countries[`expr $index + 1`] } ]]
64     #+ also works.
65     then
66         exchange $index `expr $index + 1` # Swap.
67     fi
68     let "index += 1" # Or, index+=1 on Bash, ver. 3.1 or newer.
69 done # End of inner loop
70
71 # -----
72 # Paulo Marcel Coelho Aragao suggests for-loops as a simpler alternative.
73 #
74 # for (( last = $number_of_elements - 1 ; last > 0 ; last-- ))
75 ##           Fix by C.Y. Hunt           ^ (Thanks!)
76 # do
77 #     for (( i = 0 ; i < last ; i++ ))
78 #     do
79 #         [ "${Countries[$i]}" > "${Countries[$((i+1))]}" ] \
80 #         && exchange $i $((i+1))
81 #     done
82 # done
83 # -----
84
85
86 let "comparisons -= 1" # Since "heaviest" element bubbles to bottom,
87     #+ we need do one less comparison each pass.
88
89 echo
90 echo "$count: ${Countries[@]}" # Print resultant array at end of each pass.
91 echo
92 let "count += 1" # Increment pass count.
93
94 done # End of outer loop
95 # All done.
96
97 exit 0

```

--

Is it possible to nest arrays within arrays?

```

1 #!/bin/bash
2 # "Nested" array.
3
4 # Michael Zick provided this example,
5 #+ with corrections and clarifications by William Park.
6
7 AnArray=( $(ls --inode --ignore-backups --almost-all \
8     --directory --full-time --color=none --time=status \
9     --sort=time -l ${PWD} ) ) # Commands and options.
10
11 # Spaces are significant . . . and don't quote anything in the above.
12
13 SubArray=( ${AnArray[@]:11:1} ${AnArray[@]:6:5} )
14 # This array has six elements:
15 #+     SubArray=( [0]=${AnArray[11]} [1]=${AnArray[6]} [2]=${AnArray[7]}
16 #     [3]=${AnArray[8]} [4]=${AnArray[9]} [5]=${AnArray[10]} )
17 #
18 # Arrays in Bash are (circularly) linked lists

```

```

19 #+ of type string (char *).
20 # So, this isn't actually a nested array,
21 #+ but it's functionally similar.
22
23 echo "Current directory and date of last status change:"
24 echo "${SubArray[@]}"
25
26 exit 0

```

--

Embedded arrays in combination with [indirect references](#) create some fascinating possibilities

Example 27-12. Embedded arrays and indirect references

```

1 #!/bin/bash
2 # embedded-arrays.sh
3 # Embedded arrays and indirect references.
4
5 # This script by Dennis Leeuw.
6 # Used with permission.
7 # Modified by document author.
8
9
10 ARRAY1=(
11     VAR1_1=value11
12     VAR1_2=value12
13     VAR1_3=value13
14 )
15
16 ARRAY2=(
17     VARIABLE="test"
18     STRING="VAR1=value1 VAR2=value2 VAR3=value3"
19     ARRAY21=${ARRAY1[*]}
20 ) # Embed ARRAY1 within this second array.
21
22 function print () {
23     OLD_IFS="$IFS"
24     IFS=$'\n' # To print each array element
25               #+ on a separate line.
26     TEST1="ARRAY2[*]"
27     local ${!TEST1} # See what happens if you delete this line.
28     # Indirect reference.
29     # This makes the components of $TEST1
30     #+ accessible to this function.
31
32
33     # Let's see what we've got so far.
34     echo
35     echo "\$TEST1 = $TEST1" # Just the name of the variable.
36     echo; echo
37     echo "${!TEST1} = ${!TEST1}" # Contents of the variable.
38                                 # That's what an indirect
39                                 #+ reference does.
40
41     echo
42     echo "-----"; echo
43     echo
44
45     # Print variable
46     echo "Variable VARIABLE: $VARIABLE"
47
48     # Print a string element

```

```

49     IFS="$OLD_IFS"
50     TEST2="STRING[*]"
51     local ${!TEST2}      # Indirect reference (as above).
52     echo "String element VAR2: $VAR2 from STRING"
53
54     # Print an array element
55     TEST2="ARRAY21[*]"
56     local ${!TEST2}      # Indirect reference (as above).
57     echo "Array element VAR1_1: $VAR1_1 from ARRAY21"
58 }
59
60 print
61 echo
62
63 exit 0
64
65 #   As the author of the script notes,
66 #+ "you can easily expand it to create named-hashes in bash."
67 #   (Difficult) exercise for the reader: implement this.

```

--

Arrays enable implementing a shell script version of the *Sieve of Eratosthenes*. Of course, a resource-intensive application of this nature should really be written in a compiled language, such as C. It runs excruciatingly slowly as a script.

Example 27-13. The Sieve of Eratosthenes

```

1 #!/bin/bash
2 # sieve.sh (ex68.sh)
3
4 # Sieve of Eratosthenes
5 # Ancient algorithm for finding prime numbers.
6
7 # This runs a couple of orders of magnitude slower
8 #+ than the equivalent program written in C.
9
10 LOWER_LIMIT=1      # Starting with 1.
11 UPPER_LIMIT=1000   # Up to 1000.
12 # (You may set this higher . . . if you have time on your hands.)
13
14 PRIME=1
15 NON_PRIME=0
16
17 let SPLIT=UPPER_LIMIT/2
18 # Optimization:
19 # Need to test numbers only halfway to upper limit. Why?
20
21
22 declare -a Primes
23 # Primes[] is an array.
24
25
26 initialize ()
27 {
28 # Initialize the array.
29
30 i=$LOWER_LIMIT
31 until [ "$i" -gt "$UPPER_LIMIT" ]
32 do
33     Primes[i]=$PRIME

```

```

34  let "i += 1"
35 done
36 # Assume all array members guilty (prime)
37 #+ until proven innocent.
38 }
39
40 print_primes ()
41 {
42 # Print out the members of the Primes[] array tagged as prime.
43
44 i=$LOWER_LIMIT
45
46 until [ "$i" -gt "$UPPER_LIMIT" ]
47 do
48
49  if [ "${Primes[i]}" -eq "$PRIME" ]
50  then
51    printf "%8d" $i
52    # 8 spaces per number gives nice, even columns.
53  fi
54
55  let "i += 1"
56
57 done
58
59 }
60
61 sift () # Sift out the non-primes.
62 {
63
64 let i=$LOWER_LIMIT+1
65 # Let's start with 2.
66
67 until [ "$i" -gt "$UPPER_LIMIT" ]
68 do
69
70 if [ "${Primes[i]}" -eq "$PRIME" ]
71 # Don't bother sieving numbers already sieved (tagged as non-prime).
72 then
73
74  t=$i
75
76  while [ "$t" -le "$UPPER_LIMIT" ]
77  do
78    let "t += $i "
79    Primes[t]=$NON_PRIME
80    # Tag as non-prime all multiples.
81  done
82
83 fi
84
85  let "i += 1"
86 done
87
88
89 }
90
91
92 # =====
93 # main ()
94 # Invoke the functions sequentially.
95 initialize
96 sift
97 print_primes
98 # This is what they call structured programming.
99 # =====

```



```

100
101 echo
102
103 exit 0
104
105
106
107 # ----- #
108 # Code below line will not execute, because of 'exit.'
109
110 # This improved version of the Sieve, by Stephane Chazelas,
111 #+ executes somewhat faster.
112
113 # Must invoke with command-line argument (limit of primes).
114
115 UPPER_LIMIT=$1          # From command-line.
116 let SPLIT=UPPER_LIMIT/2 # Halfway to max number.
117
118 Primes=( '' $(seq $UPPER_LIMIT) )
119
120 i=1
121 until (( ( i += 1 ) > SPLIT )) # Need check only halfway.
122 do
123     if [[ -n ${Primes[i]} ]]
124     then
125         t=$i
126         until (( ( t += i ) > UPPER_LIMIT ))
127         do
128             Primes[t]=
129         done
130     fi
131 done
132 echo ${Primes[*]}
133
134 exit $?

```

Example 27-14. The Sieve of Eratosthenes, Optimized

```

1 #!/bin/bash
2 # Optimized Sieve of Eratosthenes
3 # Script by Jared Martin, with very minor changes by ABS Guide author.
4 # Used in ABS Guide with permission (thanks!).
5
6 # Based on script in Advanced Bash Scripting Guide.
7 # http://tldp.org/LDP/abs/html/arrays.html#PRIMES0 (ex68.sh).
8
9 # http://www.cs.hmc.edu/~oneill/papers/Sieve-JFP.pdf (reference)
10 # Check results against http://primes.utm.edu/lists/small/1000.txt
11
12 # Necessary but not sufficient would be, e.g.,
13 #     ((${sieve 7919 | wc -w} == 1000)) && echo "7919 is the 1000th prime"
14
15 UPPER_LIMIT=${1:? "Need an upper limit of primes to search."}
16
17 Primes=( '' $(seq $UPPER_LIMIT) )
18
19 typeset -i i t
20 Primes[i=1]='' # 1 is not a prime.
21 until (( ( i += 1 ) > (UPPER_LIMIT/i) )) # Need check only ith-way.
22     do # Why?
23         if ((${Primes[t=i*(i-1), i]})
24         # Obscure, but instructive, use of arithmetic expansion in subscript.

```

```

25     then
26         until ( ( t += i ) > ${UPPER_LIMIT} )
27             do Primes[t]=; done
28     fi
29 done
30
31 # echo ${Primes[*]}
32 echo # Change to original script for pretty-printing (80-col. display).
33 printf "%8d" ${Primes[*]}
34 echo; echo
35
36 exit $?

```

Compare these array-based prime number generators with alternatives that do not use arrays, [Example A-15](#), and [Example 16-46](#).

--

Arrays lend themselves, to some extent, to emulating data structures for which Bash has no native support.

Example 27-15. Emulating a push-down stack

```

1 #!/bin/bash
2 # stack.sh: push-down stack simulation
3
4 # Similar to the CPU stack, a push-down stack stores data items
5 #+ sequentially, but releases them in reverse order, last-in first-out.
6
7
8 BP=100          # Base Pointer of stack array.
9                # Begin at element 100.
10
11 SP=$BP        # Stack Pointer.
12              # Initialize it to "base" (bottom) of stack.
13
14 Data=         # Contents of stack location.
15              # Must use global variable,
16              #+ because of limitation on function return range.
17
18
19              # 100    Base pointer      <-- Base Pointer
20              # 99    First data item
21              # 98    Second data item
22              # ...   More data
23              #      Last data item     <-- Stack pointer
24
25
26 declare -a stack
27
28
29 push()        # Push item on stack.
30 {
31 if [ -z "$1" ] # Nothing to push?
32 then
33     return
34 fi
35
36 let "SP -= 1" # Bump stack pointer.
37 stack[$SP]=$1
38
39 return

```

```

40 }
41
42 pop()                # Pop item off stack.
43 {
44 Data=                # Empty out data item.
45
46 if [ "$SP" -eq "$BP" ] # Stack empty?
47 then
48     return
49 fi                    # This also keeps SP from getting past 100,
50                    #+ i.e., prevents a runaway stack.
51
52 Data=${stack[$SP]}
53 let "SP += 1"        # Bump stack pointer.
54 return
55 }
56
57 status_report()      # Find out what's happening.
58 {
59 echo "-----"
60 echo "REPORT"
61 echo "Stack Pointer = $SP"
62 echo "Just popped \"'$Data'\" off the stack."
63 echo "-----"
64 echo
65 }
66
67
68 # =====
69 # Now, for some fun.
70
71 echo
72
73 # See if you can pop anything off empty stack.
74 pop
75 status_report
76
77 echo
78
79 push garbage
80 pop
81 status_report        # Garbage in, garbage out.
82
83 value1=23;          push $value1
84 value2=skidoo;     push $value2
85 value3=LAST;       push $value3
86
87 pop                 # LAST
88 status_report
89 pop                 # skidoo
90 status_report
91 pop                 # 23
92 status_report        # Last-in, first-out!
93
94 # Notice how the stack pointer decrements with each push,
95 #+ and increments with each pop.
96
97 echo
98
99 exit 0
100
101 # =====
102
103
104 # Exercises:
105 # -----

```

```

106
107 # 1) Modify the "push()" function to permit pushing
108 #   + multiple element on the stack with a single function call.
109
110 # 2) Modify the "pop()" function to permit popping
111 #   + multiple element from the stack with a single function call.
112
113 # 3) Add error checking to the critical functions.
114 #     That is, return an error code, depending on
115 #     + successful or unsuccessful completion of the operation,
116 #     + and take appropriate action.
117
118 # 4) Using this script as a starting point,
119 #     + write a stack-based 4-function calculator.

```

--

Fancy manipulation of array "subscripts" may require intermediate variables. For projects involving this, again consider using a more powerful programming language, such as Perl or C.

Example 27-16. Complex array application: *Exploring a weird mathematical series*

```

1 #!/bin/bash
2
3 # Douglas Hofstadter's notorious "Q-series":
4
5 # Q(1) = Q(2) = 1
6 # Q(n) = Q(n - Q(n-1)) + Q(n - Q(n-2)), for n>2
7
8 # This is a "chaotic" integer series with strange
9 #+ and unpredictable behavior.
10 # The first 20 terms of the series are:
11 # 1 1 2 3 3 4 5 5 6 6 6 8 8 8 10 9 10 11 11 12
12
13 # See Hofstadter's book, _Goedel, Escher, Bach: An Eternal Golden Braid_,
14 #+ p. 137, ff.
15
16
17 LIMIT=100      # Number of terms to calculate.
18 LINEWIDTH=20  # Number of terms printed per line.
19
20 Q[1]=1         # First two terms of series are 1.
21 Q[2]=1
22
23 echo
24 echo "Q-series [${LIMIT} terms]:"
25 echo -n "${Q[1]} "      # Output first two terms.
26 echo -n "${Q[2]} "
27
28 for ((n=3; n <= $LIMIT; n++)) # C-like loop expression.
29 do # Q[n] = Q[n - Q[n-1]] + Q[n - Q[n-2]] for n>2
30 # Need to break the expression into intermediate terms,
31 #+ since Bash doesn't handle complex array arithmetic very well.
32
33     let "n1 = $n - 1"      # n-1
34     let "n2 = $n - 2"      # n-2
35
36     t0=`expr $n - ${Q[n1]}` # n - Q[n-1]
37     t1=`expr $n - ${Q[n2]}` # n - Q[n-2]
38
39     T0=${Q[t0]}            # Q[n - Q[n-1]]
40     T1=${Q[t1]}            # Q[n - Q[n-2]]

```

```

41
42 Q[n]=`expr $T0 + $T1`      # Q[n - Q[n-1]] + Q[n - Q[n-2]]
43 echo -n "${Q[n]} "
44
45 if [ `expr $n % $LINEWIDTH` -eq 0 ]      # Format output.
46 then      #      ^ modulo
47     echo # Break lines into neat chunks.
48 fi
49
50 done
51
52 echo
53
54 exit 0
55
56 # This is an iterative implementation of the Q-series.
57 # The more intuitive recursive implementation is left as an exercise.
58 # Warning: calculating this series recursively takes a VERY long time
59 #+ via a script. C/C++ would be orders of magnitude faster.

```

--

Bash supports only one-dimensional arrays, though a little trickery permits simulating multi-dimensional ones.

Example 27-17. Simulating a two-dimensional array, then tilting it

```

1 #!/bin/bash
2 # twodim.sh: Simulating a two-dimensional array.
3
4 # A one-dimensional array consists of a single row.
5 # A two-dimensional array stores rows sequentially.
6
7 Rows=5
8 Columns=5
9 # 5 X 5 Array.
10
11 declare -a alpha      # char alpha [Rows] [Columns];
12                      # Unnecessary declaration. Why?
13
14 load_alpha ()
15 {
16     local rc=0
17     local index
18
19     for i in A B C D E F G H I J K L M N O P Q R S T U V W X Y
20     do      # Use different symbols if you like.
21         local row=`expr $rc / $Columns`
22         local column=`expr $rc % $Rows`
23         let "index = $row * $Rows + $column"
24         alpha[$index]=$i
25     # alpha[$row][$column]
26     let "rc += 1"
27     done
28
29     # Simpler would be
30     #+ declare -a alpha=( A B C D E F G H I J K L M N O P Q R S T U V W X Y )
31     #+ but this somehow lacks the "flavor" of a two-dimensional array.
32 }
33
34 print_alpha ()

```

```

35 {
36 local row=0
37 local index
38
39 echo
40
41 while [ "$row" -lt "$Rows" ] # Print out in "row major" order:
42 do #+ columns vary,
43 #+ while row (outer loop) remains the same.
44     local column=0
45
46     echo -n "          " # Lines up "square" array with rotated one.
47
48     while [ "$column" -lt "$Columns" ]
49     do
50         let "index = $row * $Rows + $column"
51         echo -n "${alpha[index]} " # alpha[$row][$column]
52         let "column += 1"
53     done
54
55     let "row += 1"
56     echo
57
58 done
59
60 # The simpler equivalent is
61 #     echo ${alpha[*]} | xargs -n $Columns
62
63 echo
64 }
65
66 filter () # Filter out negative array indices.
67 {
68
69 echo -n " " # Provides the tilt.
70 # Explain how.
71
72 if [[ "$1" -ge 0 && "$1" -lt "$Rows" && "$2" -ge 0 && "$2" -lt "$Columns" ]]
73 then
74     let "index = $1 * $Rows + $2"
75     # Now, print it rotated.
76     echo -n "${alpha[index]}"
77     #         alpha[$row][$column]
78 fi
79
80 }
81
82
83
84
85 rotate () # Rotate the array 45 degrees --
86 { #+ "balance" it on its lower lefthand corner.
87 local row
88 local column
89
90 for (( row = Rows; row > -Rows; row-- ))
91 do # Step through the array backwards. Why?
92
93     for (( column = 0; column < Columns; column++ ))
94     do
95
96         if [ "$row" -ge 0 ]
97         then
98             let "t1 = $column - $row"
99             let "t2 = $column"
100         else

```

```

101     let "t1 = $column"
102     let "t2 = $column + $row"
103     fi
104
105     filter $t1 $t2    # Filter out negative array indices.
106                       # What happens if you don't do this?
107 done
108
109 echo; echo
110
111 done
112
113 # Array rotation inspired by examples (pp. 143-146) in
114 #+ "Advanced C Programming on the IBM PC," by Herbert Mayer
115 #+ (see bibliography).
116 # This just goes to show that much of what can be done in C
117 #+ can also be done in shell scripting.
118
119 }
120
121
122 #----- Now, let the show begin. -----#
123 load_alpha    # Load the array.
124 print_alpha   # Print it out.
125 rotate       # Rotate it 45 degrees counterclockwise.
126 #-----#
127
128 exit 0
129
130 # This is a rather contrived, not to mention inelegant simulation.
131
132 # Exercises:
133 # -----
134 # 1) Rewrite the array loading and printing functions
135 #    in a more intuitive and less kludgy fashion.
136 #
137 # 2) Figure out how the array rotation functions work.
138 #    Hint: think about the implications of backwards-indexing an array.
139 #
140 # 3) Rewrite this script to handle a non-square array,
141 #    such as a 6 X 4 one.
142 #    Try to minimize "distortion" when the array is rotated.

```

A two-dimensional array is essentially equivalent to a one-dimensional one, but with additional addressing modes for referencing and manipulating the individual elements by *row* and *column* position.

For an even more elaborate example of simulating a two-dimensional array, see [Example A-10](#).

--

For more interesting scripts using arrays, see:

- [Example 12-3](#)
- [Example 16-46](#)
- [Example A-22](#)
- [Example A-44](#)
- [Example A-41](#)
- [Example A-42](#)

Chapter 28. Indirect References

We have seen that [referencing a variable](#), `$var`, fetches its *value*. But, what about the *value of a value*? What about `$$var`?

The actual notation is `\$$var`, usually preceded by an [eval](#) (and sometimes an [echo](#)). This is called an *indirect reference*.

Example 28-1. Indirect Variable References

```
1 #!/bin/bash
2 # ind-ref.sh: Indirect variable referencing.
3 # Accessing the contents of the contents of a variable.
4
5 # First, let's fool around a little.
6
7 var=23
8
9 echo "\$var = $var"           # $var = 23
10 # So far, everything as expected. But ...
11
12 echo "\$\$var = $$var"       # $$var = 4570var
13 # Not useful ...
14 # \$$ expanded to PID of the script
15 # -- refer to the entry on the $$ variable --
16 #+ and "var" is echoed as plain text.
17 # (Thank you, Jakob Bohm, for pointing this out.)
18
19 echo "\\$\$var = \$$var"     # \$$var = $23
20 # As expected. The first $ is escaped and pasted on to
21 #+ the value of var ($var = 23 ).
22 # Meaningful, but still not useful.
23
24 # Now, let's start over and do it the right way.
25
26 # ===== #
27
28
29 a=letter_of_alphabet        # Variable "a" holds the name of another variable.
30 letter_of_alphabet=z
31
32 echo
33
34 # Direct reference.
35 echo "a = $a"               # a = letter_of_alphabet
36
37 # Indirect reference.
38 eval a=\$$a
39 # ^^          Forcing an eval(uation), and ...
40 # ^          Escaping the first $ ...
41 # -----
42 # The 'eval' forces an update of $a, sets it to the updated value of \$$a.
43 # So, we see why 'eval' so often shows up in indirect reference notation.
44 # -----
45 echo "Now a = $a"          # Now a = z
46
47 echo
48
49
50 # Now, let's try changing the second-order reference.
```

```

51
52 t=table_cell_3
53 table_cell_3=24
54 echo "\"table_cell_3\" = $table_cell_3"           # "table_cell_3" = 24
55 echo -n "dereferenced \"t\" = "; eval echo \$$t   # dereferenced "t" = 24
56 # In this simple case, the following also works (why?).
57 #     eval t=\$$t; echo "\"t\" = $t"
58
59 echo
60
61 t=table_cell_3
62 NEW_VAL=387
63 table_cell_3=$NEW_VAL
64 echo "Changing value of \"table_cell_3\" to $NEW_VAL."
65 echo "\"table_cell_3\" now $table_cell_3"
66 echo -n "dereferenced \"t\" now "; eval echo \$$t
67 # "eval" takes the two arguments "echo" and "\$$t" (set equal to $table_cell_3)
68
69
70 echo
71
72 # (Thanks, Stephane Chazelas, for clearing up the above behavior.)
73
74
75 # A more straightforward method is the ${!t} notation, discussed in the
76 #+ "Bash, version 2" section.
77 # See also ex78.sh.
78
79 exit 0

```

Indirect referencing in Bash is a multi-step process. First, take the name of a variable: `varname`. Then, reference it: `$varname`. Then, reference the reference: `$$varname`. Then, *escape* the first `$`: `\$$varname`. Finally, force a reevaluation of the expression and assign it: **`eval newvar=\$$varname`**.

Of what practical use is indirect referencing of variables? It gives Bash a little of the functionality of [pointers](#) in C, for instance, in [table lookup](#). And, it also has some other very interesting applications. . . .

Nils Radtke shows how to build "dynamic" variable names and evaluate their contents. This can be useful when [sourcing](#) configuration files.

```

1 #!/bin/bash
2
3
4 # -----
5 # This could be "sourced" from a separate file.
6 isdnMyProviderRemoteNet=172.16.0.100
7 isdnYourProviderRemoteNet=10.0.0.10
8 isdnOnlineService="MyProvider"
9 # -----
10
11
12 remoteNet=$(eval "echo \$$ (echo isdn${isdnOnlineService}RemoteNet) ")
13 remoteNet=$(eval "echo \$$ (echo isdnMyProviderRemoteNet) ")
14 remoteNet=$(eval "echo \$$isdnMyProviderRemoteNet")
15 remoteNet=$(eval "echo $$isdnMyProviderRemoteNet")
16
17 echo "$remoteNet"      # 172.16.0.100
18
19 # =====
20
21 # And, it gets even better.

```

```

22
23 # Consider the following snippet given a variable named getSparc,
24 #+ but no such variable getIa64:
25
26 chkMirrorArchs () {
27     arch="$1";
28     if [ "$(eval "echo \${$(echo get$(echo -ne $arch |
29         sed 's/\(.\).*\/\1/g' | tr 'a-z' 'A-Z'; echo $arch |
30         sed 's/^\(.*\)\/\1/g'}):-false}")" = true ]
31     then
32         return 0;
33     else
34         return 1;
35     fi;
36 }
37
38 getSparc="true"
39 unset getIa64
40 chkMirrorArchs sparc
41 echo $?          # 0
42                 # True
43
44 chkMirrorArchs Ia64
45 echo $?          # 1
46                 # False
47
48 # Notes:
49 # -----
50 # Even the to-be-substituted variable name part is built explicitly.
51 # The parameters to the chkMirrorArchs calls are all lower case.
52 # The variable name is composed of two parts: "get" and "Sparc" . . .

```


Example 28-2. Passing an indirect reference to *awk*

```

1 #!/bin/bash
2
3 # Another version of the "column totaler" script
4 #+ that adds up a specified column (of numbers) in the target file.
5 # This one uses indirect references.
6
7 ARGS=2
8 E_WRONGARGS=85
9
10 if [ $# -ne "$ARGS" ] # Check for proper number of command-line args.
11 then
12     echo "Usage: `basename $0` filename column-number"
13     exit $E_WRONGARGS
14 fi
15
16 filename=$1          # Name of file to operate on.
17 column_number=$2    # Which column to total up.
18
19 #===== Same as original script, up to this point =====#
20
21
22 # A multi-line awk script is invoked by
23 #   awk "
24 #   ...
25 #   ...
26 #   ...
27 #   "
28
29
30 # Begin awk script.

```

```
31 # -----
32 awk "
33
34 { total += \${column_number} # Indirect reference
35 }
36 END {
37     print total
38 }
39
40     "$filename"
41 # Note that awk doesn't need an eval preceding \$.
42 # -----
43 # End awk script.
44
45 # Indirect variable reference avoids the hassles
46 #+ of referencing a shell variable within the embedded awk script.
47 # Thanks, Stephane Chazelas.
48
49
50 exit $?
```

 This method of indirect referencing is a bit tricky. If the second order variable changes its value, then the first order variable must be properly dereferenced (as in the above example). Fortunately, the `${!variable}` notation introduced with [version 2](#) of Bash (see [Example 37-2](#) and [Example A-22](#)) makes indirect referencing more intuitive.

Bash does not support pointer arithmetic, and this severely limits the usefulness of indirect referencing. In fact, indirect referencing in a scripting language is, at best, something of an afterthought.

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/dev and /proc

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Chapter 29. /dev and /proc

A Linux or UNIX filesystem typically has the `/dev` and `/proc` special-purpose directories.

29.1. /dev

The `/dev` directory contains entries for the *physical devices* that may or may not be present in the hardware. [1] Appropriately enough, these are called *device files*. As an example, the hard drive partitions containing the mounted filesystem(s) have entries in `/dev`, as `df` shows.

```
bash$ df
Filesystem            1k-blocks    Used Available Use%
Mounted on
/dev/hda6              495876      222748    247527   48% /
/dev/hda1              50755       3887     44248    9% /boot
/dev/hda8             367013      13262    334803    4% /home
/dev/hda5             1714416    1123624    503704   70% /usr
```

Among other things, the `/dev` directory contains *loopback* devices, such as `/dev/loop0`. A loopback device is a gimmick that allows an ordinary file to be accessed as if it were a block device. [2] This permits mounting an entire filesystem within a single large file. See [Example 17-8](#) and [Example 17-7](#).

A few of the pseudo-devices in `/dev` have other specialized uses, such as [/dev/null](#), [/dev/zero](#), [/dev/urandom](#), `/dev/sda1` (hard drive partition), `/dev/udp` (*User Datagram Packet* port), and [/dev/tcp](#).

For instance:

To manually [mount](#) a USB flash drive, append the following line to [/etc/fstab](#). [3]

```
1 /dev/sda1 /mnt/flashdrive auto noauto,user,noatime 0 0
```

(See also [Example A-23](#).)

Checking whether a disk is in the CD-burner (soft-linked to `/dev/hdc`):

```
1 head -1 /dev/hdc
2
3
4 # head: cannot open '/dev/hdc' for reading: No medium found
5 # (No disc in the drive.)
6
7 # head: error reading '/dev/hdc': Input/output error
8 # (There is a disk in the drive, but it can't be read;
9 #+ possibly it's an unrecorded CDR blank.)
10
11 # Stream of characters and assorted gibberish
12 # (There is a pre-recorded disk in the drive,
13 #+ and this is raw output -- a stream of ASCII and binary data.)
14 # Here we see the wisdom of using 'head' to limit the output
15 #+ to manageable proportions, rather than 'cat' or something similar.
16
17
18 # Now, it's just a matter of checking/parsing the output and taking
19 #+ appropriate action.
```

When executing a command on a `/dev/tcp/$host/$port` pseudo-device file, Bash opens a TCP connection to the associated *socket*.

A *socket* is a communications node associated with a specific I/O port. (This is analogous to a *hardware socket*, or *receptacle*, for a connecting cable.) It permits data transfer between hardware devices on the same

machine, between machines on the same network, between machines across different networks, and, of course, between machines at different locations on the Internet.

The following examples assume an active Internet connection.

Getting the time from `nist.gov`:

```
bash$ cat </dev/tcp/time.nist.gov/13
53082 04-03-18 04:26:54 68 0 0 502.3 UTC(NIST) *
```

[Mark contributed this example.]

Generalizing the above into a script:

```
1 #!/bin/bash
2 # This script must run with root permissions.
3
4 URL="time.nist.gov/13"
5
6 Time=$(cat </dev/tcp/"$URL")
7 UTC=$(echo "$Time" | awk '{print$3}') # Third field is UTC (GMT) time.
8 # Exercise: modify this for different time zones.
9
10 echo "UTC Time = "$UTC"
```

Downloading a URL:

```
bash$ exec 5<>/dev/tcp/www.net.cn/80
bash$ echo -e "GET / HTTP/1.0\n" >&5
bash$ cat <&5
```

[Thanks, Mark and Mihai Maties.]

Example 29-1. Using `/dev/tcp` for troubleshooting

```
1 #!/bin/bash
2 # dev-tcp.sh: /dev/tcp redirection to check Internet connection.
3
4 # Script by Troy Engel.
5 # Used with permission.
6
7 TCP_HOST=news-15.net # A known spam-friendly ISP.
8 TCP_PORT=80 # Port 80 is http.
9
10 # Try to connect. (Somewhat similar to a 'ping' . . .)
11 echo "HEAD / HTTP/1.0" >/dev/tcp/${TCP_HOST}/${TCP_PORT}
12 MYEXIT=$?
13
14 : <<EXPLANATION
15 If bash was compiled with --enable-net-redirections, it has the capability of
16 using a special character device for both TCP and UDP redirections. These
17 redirections are used identically as STDIN/STDOUT/STDERR. The device entries
18 are 30,36 for /dev/tcp:
19
20 mknod /dev/tcp c 30 36
21
22 >From the bash reference:
23 /dev/tcp/host/port
24 If host is a valid hostname or Internet address, and port is an integer
25 port number or service name, Bash attempts to open a TCP connection to the
26 corresponding socket.
27 EXPLANATION
```



```

28
29
30 if [ "$MYEXIT" = "X0" ]; then
31     echo "Connection successful. Exit code: $MYEXIT"
32 else
33     echo "Connection unsuccessful. Exit code: $MYEXIT"
34 fi
35
36 exit $MYEXIT

```

Example 29-2. Playing music

```

1 #!/bin/bash
2 # music.sh
3
4 # Music without external files
5
6 # Author: Antonio Macchi
7 # Used in ABS Guide with permission.
8
9
10 # /dev/dsp default = 8000 frames per second, 8 bits per frame (1 byte),
11 #+ 1 channel (mono)
12
13 duration=2000          # If 8000 bytes = 1 second, then 2000 = 1/4 second.
14 volume=${'\xc0'}      # Max volume = \xff (or \x00).
15 mute=${'\x80'}        # No volume = \x80 (the middle).
16
17 function mknote ()    # $1=Note Hz in bytes (e.g. A = 440Hz ::
18 {                    #+ 8000 fps / 440 = 16 :: A = 16 bytes per second)
19     for t in `seq 0 $duration`
20     do
21         test $(( $t % $1 )) = 0 && echo -n $volume || echo -n $mute
22     done
23 }
24
25 e=`mknote 49`
26 g=`mknote 41`
27 a=`mknote 36`
28 b=`mknote 32`
29 c=`mknote 30`
30 cis=`mknote 29`
31 d=`mknote 27`
32 e2=`mknote 24`
33 n=`mknote 32767`
34 # European notation.
35
36 echo -n "$g$e2$d$c$d$c$a$g$n$g$e$n$g$e2$d$c$c$b$c$cis$n$cis$d \
37 $n$g$e2$d$c$d$c$a$g$n$g$e$n$g$a$d$c$b$a$b$c" > /dev/dsp
38 # dsp = Digital Signal Processor
39
40 exit          # A "bonny" example of an elegant shell script!

```

Notes

- [1] The entries in `/dev` provide mount points for physical and virtual devices. These entries use very little drive space.

Some devices, such as `/dev/null`, `/dev/zero`, and `/dev/urandom` are virtual. They are not actual physical devices and exist only in software.

- [2] A *block device* reads and/or writes data in chunks, or *blocks*, in contrast to a *character device*, which accesses data in *character* units. Examples of block devices are hard drives, CDROM drives, and flash drives. Examples of character devices are keyboards, modems, sound cards.
- [3] Of course, the mount point `/mnt/flashdrive` must exist. If not, then, as *root*, **mkdir /mnt/flashdrive**.

To actually mount the drive, use the following command: **mount /mnt/flashdrive**

Newer Linux distros automount flash drives in the `/media` directory without user intervention.

29.2. /proc

The /proc directory is actually a pseudo-filesystem. The files in /proc mirror currently running system and kernel [processes](#) and contain information and statistics about them.

```
bash$ cat /proc/devices
Character devices:
 1 mem
 2 pty
 3 tty
 4 ttyS
 5 cua
 7 vcs
10 misc
14 sound
29 fb
36 netlink
128 ptm
136 pts
162 raw
254 pcmcia

Block devices:
 1 ramdisk
 2 fd
 3 ide0
 9 md

bash$ cat /proc/interrupts
          CPU0
 0:         84505          XT-PIC  timer
 1:          3375          XT-PIC  keyboard
 2:             0          XT-PIC  cascade
 5:             1          XT-PIC  soundblaster
 8:             1          XT-PIC  rtc
12:          4231          XT-PIC  PS/2 Mouse
14:       109373          XT-PIC  ide0
NMI:             0
ERR:             0

bash$ cat /proc/partitions
major minor #blocks name          rio rmerge rsect ruse wio wmerge wsect wuse running use aveq
 3      0    3007872 hda 4472 22260 114520 94240 3551 18703 50384 549710 0 111550 644030
 3      1         52416 hda1 27 395 844 960 4 2 14 180 0 800 1140
 3      2             1 hda2 0 0 0 0 0 0 0 0 0 0 0 0
 3      4    165280 hda4 10 0 20 210 0 0 0 0 0 210 210
...

bash$ cat /proc/loadavg
0.13 0.42 0.27 2/44 1119

bash$ cat /proc/apm
1.16 1.2 0x03 0x01 0xff 0x80 -1% -1 ?
```

```

bash$ cat /proc/acpi/battery/BAT0/info
present:                yes
design capacity:         43200 mWh
last full capacity:    36640 mWh
battery technology:     rechargeable
design voltage:          10800 mV
design capacity warning: 1832 mWh
design capacity low:     200 mWh
capacity granularity 1: 1 mWh
capacity granularity 2: 1 mWh
model number:           IBM-02K6897
serial number:           1133
battery type:           LION
OEM info:                Panasonic

```

```

bash$ fgrep Mem /proc/meminfo
MemTotal:                515216 kB
MemFree:                 266248 kB

```

Shell scripts may extract data from certain of the files in /proc. [\[1\]](#)

```

1 FS=iso                  # ISO filesystem support in kernel?
2
3 grep $FS /proc/filesystems # iso9660

```

```

1 kernel_version=$( awk '{ print $3 }' /proc/version )

```

```

1 CPU=$( awk '/model name/ {print $5}' < /proc/cpuinfo )
2
3 if [ "$CPU" = "Pentium(R)" ]
4 then
5     run_some_commands
6     ...
7 else
8     run_other_commands
9     ...
10 fi
11
12
13
14 cpu_speed=$( fgrep "cpu MHz" /proc/cpuinfo | awk '{print $4}' )
15 # Current operating speed (in MHz) of the cpu on your machine.
16 # On a laptop this may vary, depending on use of battery
17 #+ or AC power.

```

```

1 #!/bin/bash
2 # get-commandline.sh
3 # Get the command-line parameters of a process.
4
5 OPTION=cmdline
6
7 # Identify PID.
8 pid=$( echo $(pidof "$1") | awk '{ print $1 }' )
9 # Get only first          ^^^^^^^^^^^^^^^^^^^^^ of multiple instances.
10
11 echo
12 echo "Process ID of (first instance of) \"$1\" = $pid"
13 echo -n "Command-line arguments: "
14 cat /proc/"$pid"/"$OPTION" | xargs -0 echo
15 #   Formats output:          ^^^^^^^^^^^^^^^^^
16 #   (Thanks, Han Holl, for the fixup!)

```

```

17
18 echo; echo
19
20
21 # For example:
22 # sh get-commandline.sh xterm

```

+

```

1 devfile="/proc/bus/usb/devices"
2 text="Spd"
3 USB1="Spd=12"
4 USB2="Spd=480"
5
6
7 bus_speed=$(fgrep -m 1 "$text" $devfile | awk '{print $9}')
8 #          ^^^ Stop after first match.
9
10 if [ "$bus_speed" = "$USB1" ]
11 then
12     echo "USB 1.1 port found."
13     # Do something appropriate for USB 1.1.
14 fi

```



It is even possible to control certain peripherals with commands sent to the `/proc` directory.

```
root# echo on > /proc/acpi/ibm/light
```

This turns on the *Thinklight* in certain models of IBM/Lenovo Thinkpads. (May not work on all Linux distros.)

Of course, caution is advised when writing to `/proc`.

The `/proc` directory contains subdirectories with unusual numerical names. Every one of these names maps to the [process ID](#) of a currently running process. Within each of these subdirectories, there are a number of files that hold useful information about the corresponding process. The `stat` and `status` files keep running statistics on the process, the `cmdline` file holds the command-line arguments the process was invoked with, and the `exe` file is a symbolic link to the complete path name of the invoking process. There are a few more such files, but these seem to be the most interesting from a scripting standpoint.

Example 29-3. Finding the process associated with a PID

```

1 #!/bin/bash
2 # pid-identifier.sh:
3 # Gives complete path name to process associated with pid.
4
5 ARGNO=1 # Number of arguments the script expects.
6 E_WRONGARGS=65
7 E_BADPID=66
8 E_NOSUCHPROCESS=67
9 E_NOPERMISSION=68
10 PROCFILE=exe
11
12 if [ $# -ne $ARGNO ]
13 then
14     echo "Usage: `basename $0` PID-number" >&2 # Error message >stderr.
15     exit $E_WRONGARGS
16 fi
17
18 pidno=$( ps ax | grep $1 | awk '{ print $1 }' | grep $1 )
19 # Checks for pid in "ps" listing, field #1.
20 # Then makes sure it is the actual process, not the process invoked by this script.

```


```

21 # The last "grep $1" filters out this possibility.
22 #
23 #   pidno=$( ps ax | awk '{ print $1 }' | grep $1 )
24 #   also works, as Teemu Huovila, points out.
25
26 if [ -z "$pidno" ] # If, after all the filtering, the result is a zero-length string,
27 then             #+ no running process corresponds to the pid given.
28   echo "No such process running."
29   exit $E_NOSUCHPROCESS
30 fi
31
32 # Alternatively:
33 #   if ! ps $1 > /dev/null 2>&1
34 #   then             # no running process corresponds to the pid given.
35 #     echo "No such process running."
36 #     exit $E_NOSUCHPROCESS
37 #   fi
38
39 # To simplify the entire process, use "pidof".
40
41
42 if [ ! -r "/proc/$1/$PROCFILE" ] # Check for read permission.
43 then
44   echo "Process $1 running, but..."
45   echo "Can't get read permission on /proc/$1/$PROCFILE."
46   exit $E_NOPERMISSION # Ordinary user can't access some files in /proc.
47 fi
48
49 # The last two tests may be replaced by:
50 #   if ! kill -0 $1 > /dev/null 2>&1 # '0' is not a signal, but
51 #                                   # this will test whether it is possible
52 #                                   # to send a signal to the process.
53 #   then echo "PID doesn't exist or you're not its owner" >&2
54 #   exit $E_BADPID
55 #   fi
56
57
58
59 exe_file=$( ls -l /proc/$1 | grep "exe" | awk '{ print $11 }' )
60 # Or     exe_file=$( ls -l /proc/$1/exe | awk '{print $11}' )
61 #
62 # /proc/pid-number/exe is a symbolic link
63 #+ to the complete path name of the invoking process.
64
65 if [ -e "$exe_file" ] # If /proc/pid-number/exe exists,
66 then                 #+ then the corresponding process exists.
67   echo "Process #$1 invoked by $exe_file."
68 else
69   echo "No such process running."
70 fi
71
72
73 # This elaborate script can *almost* be replaced by
74 #   ps ax | grep $1 | awk '{ print $5 }'
75 # However, this will not work...
76 #+ because the fifth field of 'ps' is argv[0] of the process,
77 #+ not the executable file path.
78 #
79 # However, either of the following would work.
80 #   find /proc/$1/exe -printf '%l\n'
81 #   lsof -aFn -p $1 -d txt | sed -ne 's/^n//p'
82
83 # Additional commentary by Stephane Chazelas.
84
85 exit 0

```

Example 29-4. On-line connect status

```
1 #!/bin/bash
2 # connect-stat.sh
3 # Note that this script may need modification
4 #+ to work with a wireless connection.
5
6 PROCNAME=pppd          # ppp daemon
7 PROCFILENAME=status    # Where to look.
8 NOTCONNECTED=85
9 INTERVAL=2             # Update every 2 seconds.
10
11 pidno=$( ps ax | grep -v "ps ax" | grep -v grep | grep $PROCNAME |
12 awk '{ print $1 }' )
13
14 # Finding the process number of 'pppd', the 'ppp daemon'.
15 # Have to filter out the process lines generated by the search itself.
16 #
17 # However, as Oleg Philon points out,
18 #+ this could have been considerably simplified by using "pidof".
19 # pidno=$( pidof $PROCNAME )
20 #
21 # Moral of the story:
22 #+ When a command sequence gets too complex, look for a shortcut.
23
24
25 if [ -z "$pidno" ]     # If no pid, then process is not running.
26 then
27     echo "Not connected."
28     # exit $NOTCONNECTED
29 else
30     echo "Connected."; echo
31 fi
32
33 while [ true ]        # Endless loop, script can be improved here.
34 do
35
36     if [ ! -e "/proc/$pidno/$PROCFILENAME" ]
37     # While process running, then "status" file exists.
38     then
39         echo "Disconnected."
40         # exit $NOTCONNECTED
41     fi
42
43     netstat -s | grep "packets received" # Get some connect statistics.
44     netstat -s | grep "packets delivered"
45
46
47     sleep $INTERVAL
48     echo; echo
49
50 done
51
52 exit 0
53
54 # As it stands, this script must be terminated with a Control-C.
55
56 # Exercises:
57 # -----
58 # Improve the script so it exits on a "q" keystroke.
59 # Make the script more user-friendly in other ways.
60 # Fix the script to work with wireless/DSL connections.
```

 In general, it is dangerous to *write* to the files in `/proc`, as this can corrupt the filesystem or crash the machine.

Notes

[1] Certain system commands, such as [procinfo](#), [free](#), [vmstat](#), [lsdev](#), and [uptime](#) do this as well.

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Chapter 30. Network Programming

The Net's a cross between an elephant and a white elephant sale: it never forgets, and it's always crap.

--Nemo

A Linux system has quite a number of tools for accessing, manipulating, and troubleshooting network connections. We can incorporate some of these tools into scripts -- scripts that expand our knowledge of networking, useful scripts that can facilitate the administration of a network.

Here is a simple CGI script that demonstrates connecting to a remote server.

Example 30-1. Print the server environment

```
1 #!/bin/bash
2 # test-cgi.sh
3 # by Michael Zick
4 # Used with permission
5
6 # May have to change the location for your site.
7 # (At the ISP's servers, Bash may not be in the usual place.)
8 # Other places: /usr/bin or /usr/local/bin
9 # Might even try it without any path in sha-bang.
10
11 # Disable filename globbing.
12 set -f
13
14 # Header tells browser what to expect.
15 echo Content-type: text/plain
16 echo
17
18 echo CGI/1.0 test script report:
19 echo
20
21 echo environment settings:
22 set
23 echo
24
25 echo whereis bash?
26 whereis bash
27 echo
28
29
30 echo who are we?
31 echo ${BASH_VERSINFO[*]}
32 echo
33
34 echo argc is $#. argv is "$*".
35 echo
36
37 # CGI/1.0 expected environment variables.
38
39 echo SERVER_SOFTWARE = $SERVER_SOFTWARE
40 echo SERVER_NAME = $SERVER_NAME
41 echo GATEWAY_INTERFACE = $GATEWAY_INTERFACE
42 echo SERVER_PROTOCOL = $SERVER_PROTOCOL
43 echo SERVER_PORT = $SERVER_PORT
44 echo REQUEST_METHOD = $REQUEST_METHOD
45 echo HTTP_ACCEPT = "$HTTP_ACCEPT"
```

```

46 echo PATH_INFO = "$PATH_INFO"
47 echo PATH_TRANSLATED = "$PATH_TRANSLATED"
48 echo SCRIPT_NAME = "$SCRIPT_NAME"
49 echo QUERY_STRING = "$QUERY_STRING"
50 echo REMOTE_HOST = $REMOTE_HOST
51 echo REMOTE_ADDR = $REMOTE_ADDR
52 echo REMOTE_USER = $REMOTE_USER
53 echo AUTH_TYPE = $AUTH_TYPE
54 echo CONTENT_TYPE = $CONTENT_TYPE
55 echo CONTENT_LENGTH = $CONTENT_LENGTH
56
57 exit 0
58
59 # Here document to give short instructions.
60 :<<-'_test_CGI_'
61
62 1) Drop this in your http://domain.name/cgi-bin directory.
63 2) Then, open http://domain.name/cgi-bin/test-cgi.sh.
64
65 _test_CGI_

```

For security purposes, it may be helpful to identify the IP addresses a computer is accessing.

Example 30-2. IP addresses

```

1 #!/bin/bash
2 # ip-addresses.sh
3 # List the IP addresses your computer is connected to.
4
5 # Inspired by Greg Bledsoe's ddos.sh script,
6 # Linux Journal, 09 March 2011.
7 # URL:
8 # http://www.linuxjournal.com/content/back-dead-simple-bash-complex-ddos
9 # Greg licensed his script under the GPL2,
10 #+ and as a derivative, this script is likewise GPL2.
11
12 connection_type=TCP # Also try UDP.
13 field=2 # Which field of the output we're interested in.
14 no_match=LISTEN # Filter out records containing this. Why?
15 lsof_args=-ni # -i lists Internet-associated files.
16 # -n preserves numerical IP addresses.
17 # What happens without the -n option? Try it.
18 router="[0-9][0-9][0-9][0-9][0-9]->"
19 # Delete the router info.
20
21 lsof "$lsof_args" | grep $connection_type | grep -v "$no_match" |
22 awk '{print $9}' | cut -d : -f $field | sort | uniq |
23 sed s/"^$router"//
24
25 # Bledsoe's script assigns the output of a filtered IP list,
26 # (similar to lines 19-22, above) to a variable.
27 # He checks for multiple connections to a single IP address,
28 # then uses:
29 #
30 # iptables -I INPUT -s $ip -p tcp -j REJECT --reject-with tcp-reset
31 #
32 # ... within a 60-second delay loop to bounce packets from DDOS attacks.
33
34
35 # Exercise:
36 # -----
37 # Use the 'iptables' command to extend this script

```

More examples of network programming:

1. [Getting the time from *nist.gov*](#)
2. [Downloading a URL](#)
3. [A GRE tunnel](#)
4. [Checking if an Internet server is up](#)
5. [Example 16-41](#)
6. [Example A-28](#)
7. [Example A-29](#)
8. [Example 29-1](#)

See also the [networking commands](#) in the [System and Administrative Commands](#) chapter and the [communications commands](#) in the [External Filters, Programs and Commands](#) chapter.

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Chapter 31. Of Zeros and Nulls

Faultily faultless, icily regular, splendidly null

Dead perfection; no more.

--Alfred Lord Tennyson

`/dev/zero ... /dev/null`

Uses of `/dev/null`

Think of `/dev/null` as a *black hole*. It is essentially the equivalent of a write-only file. Everything written to it disappears. Attempts to read or output from it result in nothing. All the same, `/dev/null` can be quite useful from both the command-line and in scripts.

Suppressing `stdout`.

```
1 cat $filename >/dev/null
2 # Contents of the file will not list to stdout.
```

Suppressing `stderr` (from [Example 16-3](#)).

```
1 rm $badname 2>/dev/null
2 #           So error messages [stderr] deep-sixed.
```

Suppressing output from *both* `stdout` and `stderr`.

```
1 cat $filename 2>/dev/null >/dev/null
2 # If "$filename" does not exist, there will be no error message output.
3 # If "$filename" does exist, the contents of the file will not list to stdout.
4 # Therefore, no output at all will result from the above line of code.
5 #
6 # This can be useful in situations where the return code from a command
7 #+ needs to be tested, but no output is desired.
8 #
9 # cat $filename &>/dev/null
10 #      also works, as Baris Cicek points out.
```

Deleting contents of a file, but preserving the file itself, with all attendant permissions (from [Example 2-1](#) and [Example 2-3](#)):

```
1 cat /dev/null > /var/log/messages
2 # : > /var/log/messages has same effect, but does not spawn a new process.
3
4 cat /dev/null > /var/log/wtmp
```

Automatically emptying the contents of a logfile (especially good for dealing with those nasty "cookies" sent by commercial Web sites):

Example 31-1. Hiding the cookie jar

```
1 # Obsolete Netscape browser.
2 # Same principle applies to newer browsers.
3
4 if [ -f ~/.netscape/cookies ] # Remove, if exists.
5 then
6   rm -f ~/.netscape/cookies
7 fi
8
9 ln -s /dev/null ~/.netscape/cookies
```

```
10 # All cookies now get sent to a black hole, rather than saved to disk.
```

Uses of /dev/zero

Like /dev/null, /dev/zero is a pseudo-device file, but it actually produces a stream of nulls (*binary zeros*, not the [ASCII](#) kind). Output written to /dev/zero disappears, and it is fairly difficult to actually read the nulls emitted there, though it can be done with [od](#) or a hex editor. The chief use of /dev/zero is creating an initialized dummy file of predetermined length intended as a temporary swap file.

Example 31-2. Setting up a swapfile using /dev/zero

```
1 #!/bin/bash
2 # Creating a swap file.
3
4 # A swap file provides a temporary storage cache
5 #+ which helps speed up certain filesystem operations.
6
7 ROOT_UID=0          # Root has $UID 0.
8 E_WRONG_USER=85     # Not root?
9
10 FILE=/swap
11 BLOCKSIZE=1024
12 MINBLOCKS=40
13 SUCCESS=0
14
15
16 # This script must be run as root.
17 if [ "$UID" -ne "$ROOT_UID" ]
18 then
19     echo; echo "You must be root to run this script."; echo
20     exit $E_WRONG_USER
21 fi
22
23
24 blocks=${1:-$MINBLOCKS}          # Set to default of 40 blocks,
25                                 #+ if nothing specified on command-line.
26 # This is the equivalent of the command block below.
27 # -----
28 # if [ -n "$1" ]
29 # then
30 #     blocks=$1
31 # else
32 #     blocks=$MINBLOCKS
33 # fi
34 # -----
35
36
37 if [ "$blocks" -lt $MINBLOCKS ]
38 then
39     blocks=$MINBLOCKS          # Must be at least 40 blocks long.
40 fi
41
42
43 #####
44 echo "Creating swap file of size $blocks blocks (KB)."
```

```
45 dd if=/dev/zero of=$FILE bs=$BLOCKSIZE count=$blocks # Zero out file.
46 mkswap $FILE $blocks          # Designate it a swap file.
47 swapon $FILE                  # Activate swap file.
48 retcode=$?                    # Everything worked?
49 # Note that if one or more of these commands fails,
50 #+ then it could cause nasty problems.
51 #####
```

```

52
53 # Exercise:
54 # Rewrite the above block of code so that if it does not execute
55 #+ successfully, then:
56 #     1) an error message is echoed to stderr,
57 #     2) all temporary files are cleaned up, and
58 #     3) the script exits in an orderly fashion with an
59 #+     appropriate error code.
60
61 echo "Swap file created and activated."
62
63 exit $retcode

```

Another application of `/dev/zero` is to "zero out" a file of a designated size for a special purpose, such as mounting a filesystem on a [loopback device](#) (see [Example 17-8](#)) or "securely" deleting a file (see [Example 16-61](#)).

Example 31-3. Creating a ramdisk

```

1 #!/bin/bash
2 # ramdisk.sh
3
4 # A "ramdisk" is a segment of system RAM memory
5 #+ which acts as if it were a filesystem.
6 # Its advantage is very fast access (read/write time).
7 # Disadvantages: volatility, loss of data on reboot or powerdown,
8 #+     less RAM available to system.
9 #
10 # Of what use is a ramdisk?
11 # Keeping a large dataset, such as a table or dictionary on ramdisk,
12 #+ speeds up data lookup, since memory access is much faster than disk access.
13
14
15 E_NON_ROOT_USER=70           # Must run as root.
16 ROOTUSER_NAME=root
17
18 MOUNTPT=/mnt/ramdisk        # Create with mkdir /mnt/ramdisk.
19 SIZE=2000                   # 2K blocks (change as appropriate)
20 BLOCKSIZE=1024              # 1K (1024 byte) block size
21 DEVICE=/dev/ram0            # First ram device
22
23 username=`id -nu`
24 if [ "$username" != "$ROOTUSER_NAME" ]
25 then
26     echo "Must be root to run \"`basename $0`\"."
27     exit $E_NON_ROOT_USER
28 fi
29
30 if [ ! -d "$MOUNTPT" ]      # Test whether mount point already there,
31 then                        #+ so no error if this script is run
32     mkdir $MOUNTPT         #+ multiple times.
33 fi
34
35 #####
36 dd if=/dev/zero of=$DEVICE count=$SIZE bs=$BLOCKSIZE # Zero out RAM device.
37                                                         # Why is this necessary?
38 mke2fs $DEVICE           # Create an ext2 filesystem on it.
39 mount $DEVICE $MOUNTPT   # Mount it.
40 chmod 777 $MOUNTPT       # Enables ordinary user to access ramdisk.
41                           # However, must be root to unmount it.
42 #####
43 # Need to test whether above commands succeed. Could cause problems otherwise.
44 # Exercise: modify this script to make it safer.

```

```
45
46 echo "\"$MOUNTPT\" now available for use."
47 # The ramdisk is now accessible for storing files, even by an ordinary user.
48
49 # Caution, the ramdisk is volatile, and its contents will disappear
50 #+ on reboot or power loss.
51 # Copy anything you want saved to a regular directory.
52
53 # After reboot, run this script to again set up ramdisk.
54 # Remounting /mnt/ramdisk without the other steps will not work.
55
56 # Suitably modified, this script can be invoked in /etc/rc.d/rc.local,
57 #+ to set up ramdisk automatically at bootup.
58 # That may be appropriate on, for example, a database server.
59
60 exit 0
```

In addition to all the above, `/dev/zero` is needed by ELF (*Executable and Linking Format*) UNIX/Linux binaries.

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Debugging

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Chapter 32. Debugging

Debugging is twice as hard as writing the code in the first place. Therefore, if you write the code as cleverly as possible, you are, by definition, not smart enough to debug it.

--Brian Kernighan

The Bash shell contains no built-in debugger, and only bare-bones debugging-specific commands and constructs. Syntax errors or outright typos in the script generate cryptic error messages that are often of no help in debugging a non-functional script.

Example 32-1. A buggy script

```
1 #!/bin/bash
2 # ex74.sh
3
4 # This is a buggy script.
5 # Where, oh where is the error?
6
7 a=37
8
9 if [ $a -gt 27 ]
10 then
11     echo $a
12 fi
13
14 exit $?    # 0! Why?
```

Output from script:

```
./ex74.sh: [37: command not found
```

What's wrong with the above script? Hint: after the *if*.

Example 32-2. Missing [keyword](#)

```
1 #!/bin/bash
2 # missing-keyword.sh
3 # What error message will this script generate? And why?
4
5 for a in 1 2 3
6 do
7     echo "$a"
8 # done    # Required keyword 'done' commented out in line 8.
9
10 exit 0    # Will not exit here!
11
12 # === #
13
14 # From command line, after script terminates:
15     echo $?    # 2
```

Output from script:

```
missing-keyword.sh: line 10: syntax error: unexpected end of file
```

Note that the error message does *not* necessarily reference the line in which the error occurs, but the line where the Bash interpreter finally becomes aware of the error.

Error messages may disregard comment lines in a script when reporting the line number of a syntax error.

What if the script executes, but does not work as expected? This is the all too familiar logic error.

Example 32-3. *test24*: another buggy script

```
1 #!/bin/bash
2
3 # This script is supposed to delete all filenames in current directory
4 #+ containing embedded spaces.
5 # It doesn't work.
6 # Why not?
7
8
9 badname=`ls | grep ' '`
10
11 # Try this:
12 # echo "$badname"
13
14 rm "$badname"
15
16 exit 0
```

Try to find out what's wrong with [Example 32-3](#) by uncommenting the **echo "\$badname"** line. Echo statements are useful for seeing whether what you expect is actually what you get.

In this particular case, **rm "\$badname"** will not give the desired results because `$badname` should not be quoted. Placing it in quotes ensures that **rm** has only one argument (it will match only one filename). A partial fix is to remove the quotes from `$badname` and to reset `$IFS` to contain only a newline, **IFS=\$'\n'**. However, there are simpler ways of going about it.


```
1 # Correct methods of deleting filenames containing spaces.
2 rm *\ *
3 rm *" "*
4 rm *' '*
5 # Thank you. S.C.
```

Summarizing the symptoms of a buggy script,

1. It bombs with a "syntax error" message, or
2. It runs, but does not work as expected (logic error).
3. It runs, works as expected, but has nasty side effects (logic bomb).

Tools for debugging non-working scripts include

1. Inserting [echo](#) statements at critical points in the script to trace the variables, and otherwise give a snapshot of what is going on.

 Even better is an **echo** that echoes only when *debug* is on.

```
1 ### debecho (debug-echo), by Stefano Falsetto ###
2 ### Will echo passed parameters only if DEBUG is set to a value. ###
3 debecho () {
4     if [ ! -z "$DEBUG" ]; then
```

```

5     echo "$1" >&2
6     #         ^^^ to stderr
7     fi
8 }
9
10  DEBUG=on
11  Whatever=whatnot
12  debecho $Whatever # whatnot
13
14  DEBUG=
15  Whatever=notwhat
16  debecho $Whatever # (Will not echo.)

```

2. Using the [tee](#) filter to check processes or data flows at critical points.
3. Setting option flags `-n -v -x`

sh -n scriptname checks for syntax errors without actually running the script. This is the equivalent of inserting **set -n** or **set -o noexec** into the script. Note that certain types of syntax errors can slip past this check.

sh -v scriptname echoes each command before executing it. This is the equivalent of inserting **set -v** or **set -o verbose** in the script.

The `-n` and `-v` flags work well together. **sh -nv scriptname** gives a verbose syntax check.

sh -x scriptname echoes the result each command, but in an abbreviated manner. This is the equivalent of inserting **set -x** or **set -o xtrace** in the script.

Inserting **set -u** or **set -o nounset** in the script runs it, but gives an unbound variable error message and aborts the script.

```

1 set -u # Or set -o nounset
2
3 # Setting a variable to null will not trigger the error/abort.
4 # unset_var=
5
6 echo $unset_var # Unset (and undeclared) variable.
7
8 echo "Should not echo!"
9
10 # sh t2.sh
11 # t2.sh: line 6: unset_var: unbound variable

```

4. Using an "assert" function to test a variable or condition at critical points in a script. (This is an idea borrowed from C.)

Example 32-4. Testing a condition with an *assert*

```

1 #!/bin/bash
2 # assert.sh
3
4 #####
5 assert () # If condition false,
6 { #+ exit from script
7 #+ with appropriate error message.
8     E_PARAM_ERR=98
9     E_ASSERT_FAILED=99
10
11
12 if [ -z "$2" ] # Not enough parameters passed

```

```

13  then                                     #+ to assert() function.
14      return $E_PARAM_ERR                 # No damage done.
15  fi
16
17  lineno=$2
18
19  if [ ! $1 ]
20  then
21      echo "Assertion failed: \"$1\""
22      echo "File \"$0\", line $lineno"     # Give name of file and line number.
23      exit $E_ASSERT_FAILED
24  # else
25  #   return
26  #   and continue executing the script.
27  fi
28 } # Insert a similar assert() function into a script you need to debug.
29 #####
30
31
32 a=5
33 b=4
34 condition="$a -lt $b"                   # Error message and exit from script.
35                                         # Try setting "condition" to something else
36                                         #+ and see what happens.
37
38 assert "$condition" $LINENO
39 # The remainder of the script executes only if the "assert" does not fail.
40
41
42 # Some commands.
43 # Some more commands . . .
44 echo "This statement echoes only if the \"assert\" does not fail."
45 # . . .
46 # More commands . . .
47
48 exit $?

```

5. Using the [\\$LINENO](#) variable and the [caller](#) builtin.
6. Trapping at exit.

The [exit](#) command in a script triggers a signal 0, terminating the process, that is, the script itself. [1] It is often useful to trap the *exit*, forcing a "printout" of variables, for example. The *trap* must be the first command in the script.

Trapping signals

trap

Specifies an action on receipt of a signal; also useful for debugging.

A *signal* is a message sent to a process, either by the kernel or another process, telling it to take some specified action (usually to terminate). For example, hitting a [Control-C](#) sends a user interrupt, an INT signal, to a running program.

A simple instance:

```

1 trap '' 2
2 # Ignore interrupt 2 (Control-C), with no action specified.
3
4 trap 'echo "Control-C disabled."' 2

```

Example 32-5. Trapping at exit

```
1 #!/bin/bash
2 # Hunting variables with a trap.
3
4 trap 'echo Variable Listing --- a = $a b = $b' EXIT
5 # EXIT is the name of the signal generated upon exit from a script.
6 #
7 # The command specified by the "trap" doesn't execute until
8 #+ the appropriate signal is sent.
9
10 echo "This prints before the \"trap\" --"
11 echo "even though the script sees the \"trap\" first."
12 echo
13
14 a=39
15
16 b=36
17
18 exit 0
19 # Note that commenting out the 'exit' command makes no difference,
20 #+ since the script exits in any case after running out of commands.
```

Example 32-6. Cleaning up after Control-C

```
1 #!/bin/bash
2 # logon.sh: A quick 'n dirty script to check whether you are on-line yet.
3
4 umask 177 # Make sure temp files are not world readable.
5
6
7 TRUE=1
8 LOGFILE=/var/log/messages
9 # Note that $LOGFILE must be readable
10 #+ (as root, chmod 644 /var/log/messages).
11 TEMPFILE=temp.$$
12 # Create a "unique" temp file name, using process id of the script.
13 # Using 'mktemp' is an alternative.
14 # For example:
15 # TEMPFILE=`mktemp temp.XXXXXX`
16 KEYWORD=address
17 # At logon, the line "remote IP address xxx.xxx.xxx.xxx"
18 # appended to /var/log/messages.
19 ONLINE=22
20 USER_INTERRUPT=13
21 CHECK_LINES=100
22 # How many lines in log file to check.
23
24 trap 'rm -f $TEMPFILE; exit $USER_INTERRUPT' TERM INT
25 # Cleans up the temp file if script interrupted by control-c.
26
27 echo
28
29 while [ $TRUE ] #Endless loop.
30 do
31 tail -n $CHECK_LINES $LOGFILE> $TEMPFILE
32 # Saves last 100 lines of system log file as temp file.
33 # Necessary, since newer kernels generate many log messages at log on.
```

```

34 search=`grep $KEYWORD $TEMPFILE`
35 # Checks for presence of the "IP address" phrase,
36 #+ indicating a successful logon.
37
38 if [ ! -z "$search" ] # Quotes necessary because of possible spaces.
39 then
40     echo "On-line"
41     rm -f $TEMPFILE      # Clean up temp file.
42     exit $ONLINE
43 else
44     echo -n "."          # The -n option to echo suppresses newline,
45                         #+ so you get continuous rows of dots.
46 fi
47
48 sleep 1
49 done
50
51
52 # Note: if you change the KEYWORD variable to "Exit",
53 #+ this script can be used while on-line
54 #+ to check for an unexpected logoff.
55
56 # Exercise: Change the script, per the above note,
57 #           and prettify it.
58
59 exit 0
60
61
62 # Nick Drage suggests an alternate method:
63
64 while true
65 do ifconfig ppp0 | grep UP 1> /dev/null && echo "connected" && exit 0
66 echo -n "." # Prints dots (.....) until connected.
67 sleep 2
68 done
69
70 # Problem: Hitting Control-C to terminate this process may be insufficient.
71 #+         (Dots may keep on echoing.)
72 # Exercise: Fix this.
73
74
75
76 # Stephane Chazelas has yet another alternative:
77
78 CHECK_INTERVAL=1
79
80 while ! tail -n 1 "$LOGFILE" | grep -q "$KEYWORD"
81 do echo -n .
82     sleep $CHECK_INTERVAL
83 done
84 echo "On-line"
85
86 # Exercise: Discuss the relative strengths and weaknesses
87 #           of each of these various approaches.

```

Example 32-7. A Simple Implementation of a Progress Bar

```

1 #! /bin/bash
2 # progress-bar2.sh
3 # Author: Graham Ewart (with reformatting by ABS Guide author).
4 # Used in ABS Guide with permission (thanks!).
5

```

```

6 # Invoke this script with bash. It doesn't work with sh.
7
8 interval=1
9 long_interval=10
10
11 {
12     trap "exit" SIGUSR1
13     sleep $interval; sleep $interval
14     while true
15     do
16         echo -n '.'      # Use dots.
17         sleep $interval
18     done; } &          # Start a progress bar as a background process.
19
20 pid=$!
21 trap "echo !; kill -USR1 $pid; wait $pid"  EXIT      # To handle ^C.
22
23 echo -n 'Long-running process '
24 sleep $long_interval
25 echo ' Finished!'
26
27 kill -USR1 $pid
28 wait $pid          # Stop the progress bar.
29 trap EXIT
30
31 exit $?

```



The **DEBUG** argument to **trap** causes a specified action to execute after every command in a script. This permits tracing variables, for example.

Example 32-8. Tracing a variable

```

1 #!/bin/bash
2
3 trap 'echo "VARIABLE-TRACE> \$variable = \"\$variable\"" DEBUG
4 # Echoes the value of $variable after every command.
5
6 variable=29; line=$LINENO
7
8 echo "  Just initialized \$variable to $variable in line number $line."
9
10 let "variable *= 3"; line=$LINENO
11 echo "  Just multiplied \$variable by 3 in line number $line."
12
13 exit 0
14
15 # The "trap 'command1 . . . command2 . . .' DEBUG" construct is
16 #+ more appropriate in the context of a complex script,
17 #+ where inserting multiple "echo $variable" statements might be
18 #+ awkward and time-consuming.
19
20 # Thanks, Stephane Chazelas for the pointer.
21
22
23 Output of script:
24
25 VARIABLE-TRACE> $variable = ""
26 VARIABLE-TRACE> $variable = "29"
27   Just initialized $variable to 29.
28 VARIABLE-TRACE> $variable = "29"
29 VARIABLE-TRACE> $variable = "87"
30   Just multiplied $variable by 3.
31 VARIABLE-TRACE> $variable = "87"

```

Of course, the **trap** command has other uses aside from debugging, such as disabling certain keystrokes within a script (see [Example A-43](#)).

Example 32-9. Running multiple processes (on an SMP box)

```
1 #!/bin/bash
2 # parent.sh
3 # Running multiple processes on an SMP box.
4 # Author: Tedman Eng
5
6 # This is the first of two scripts,
7 ## both of which must be present in the current working directory.
8
9
10
11
12 LIMIT=$1          # Total number of process to start
13 NUMPROC=4        # Number of concurrent threads (forks?)
14 PROCID=1         # Starting Process ID
15 echo "My PID is $$"
16
17 function start_thread() {
18     if [ $PROCID -le $LIMIT ] ; then
19         ./child.sh $PROCID&
20         let "PROCID++"
21     else
22         echo "Limit reached."
23         wait
24         exit
25     fi
26 }
27
28 while [ "$NUMPROC" -gt 0 ]; do
29     start_thread;
30     let "NUMPROC--"
31 done
32
33
34 while true
35 do
36
37 trap "start_thread" SIGRTMIN
38
39 done
40
41 exit 0
42
43
44
45 # ===== Second script follows =====
46
47
48 #!/bin/bash
49 # child.sh
50 # Running multiple processes on an SMP box.
51 # This script is called by parent.sh.
52 # Author: Tedman Eng
53
54 temp=$RANDOM
55 index=$1
56 shift
57 let "temp %= 5"
```



```


58 let "temp += 4"
59 echo "Starting $index Time:$temp" "$@"
60 sleep ${temp}
61 echo "Ending $index"
62 kill -s SIGRTMIN $PPID
63
64 exit 0
65
66
67 # ===== SCRIPT AUTHOR'S NOTES ===== #
68 # It's not completely bug free.
69 # I ran it with limit = 500 and after the first few hundred iterations,
70 #+ one of the concurrent threads disappeared!
71 # Not sure if this is collisions from trap signals or something else.
72 # Once the trap is received, there's a brief moment while executing the
73 #+ trap handler but before the next trap is set. During this time, it may
74 #+ be possible to miss a trap signal, thus miss spawning a child process.
75
76 # No doubt someone may spot the bug and will be writing
77 #+ . . . in the future.
78
79
80
81 # ===== #
82
83
84
85 # -----#
86
87
88
89 #####
90 # The following is the original script written by Vernia Damiano.
91 # Unfortunately, it doesn't work properly.
92 #####
93
94 #!/bin/bash
95
96 # Must call script with at least one integer parameter
97 #+ (number of concurrent processes).
98 # All other parameters are passed through to the processes started.
99
100
101 INDICE=8          # Total number of process to start
102 TEMPO=5          # Maximum sleep time per process
103 E_BADARGS=65     # No arg(s) passed to script.
104
105 if [ $# -eq 0 ] # Check for at least one argument passed to script.
106 then
107     echo "Usage: `basename $0` number_of_processes [passed params]"
108     exit $E_BADARGS
109 fi
110
111 NUMPROC=$1      # Number of concurrent process
112 shift
113 PARAMETRI=( "$@" ) # Parameters of each process
114
115 function avvia() {
116     local temp
117     local index
118     temp=$RANDOM
119     index=$1
120     shift
121     let "temp %= $TEMPO"
122     let "temp += 1"
123     echo "Starting $index Time:$temp" "$@"

```

```

124     sleep ${temp}
125     echo "Ending $index"
126     kill -s SIGRTMIN $$
127 }
128
129 function parti() {
130     if [ $INDICE -gt 0 ] ; then
131         avvia $INDICE "${PARAMETRI[@]}" &
132         let "INDICE--"
133     else
134         trap : SIGRTMIN
135     fi
136 }
137
138 trap parti SIGRTMIN
139
140 while [ "$NUMPROC" -gt 0 ]; do
141     parti;
142     let "NUMPROC--"
143 done
144
145 wait
146 trap - SIGRTMIN
147
148 exit $?
149
150 : <<SCRIPT_AUTHOR_COMMENTS
151 I had the need to run a program, with specified options, on a number of
152 different files, using a SMP machine. So I thought [I'd] keep running
153 a specified number of processes and start a new one each time . . . one
154 of these terminates.
155
156 The "wait" instruction does not help, since it waits for a given process
157 or *all* process started in background. So I wrote [this] bash script
158 that can do the job, using the "trap" instruction.
159 --Vernia Damiano
160 SCRIPT_AUTHOR_COMMENTS

```

 **trap ' ' SIGNAL** (two adjacent apostrophes) disables SIGNAL for the remainder of the script. **trap SIGNAL** restores the functioning of SIGNAL once more. This is useful to protect a critical portion of a script from an undesirable interrupt.

```

1  trap ' ' 2 # Signal 2 is Control-C, now disabled.
2  command
3  command
4  command
5  trap 2    # Reenables Control-C
6

```

[Version 3](#) of Bash adds the following [internal variables](#) for use by the debugger.

1. \$BASH_ARGC

Number of command-line arguments passed to script, similar to [\\$#](#).

2. \$BASH_ARGV

Final command-line parameter passed to script, equivalent [\\${!#}](#).

3. \$BASH_COMMAND

Command currently executing.

4. `$BASH_EXECUTION_STRING`

The *option string* following the `-c` [option](#) to Bash.

5. `$BASH_LINENO`

In a [function](#), indicates the line number of the function call.

6. `$BASH_REMATCH`

Array variable associated with `=~` [conditional regex matching](#).

7.

`$BASH_SOURCE`

This is the name of the script, usually the same as `$0`.

8. [`\$BASH_SUBSHELL`](#)

Notes

[1] By convention, *signal 0* is assigned to [exit](#).

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Chapter 33. Options

Options are settings that change shell and/or script behavior.

The `set` command enables options within a script. At the point in the script where you want the options to take effect, use `set -o option-name` or, in short form, `set -option-abbrev`. These two forms are equivalent.

```
1    #!/bin/bash
2
3    set -o verbose
4    # Echoes all commands before executing.
5
```

```
1    #!/bin/bash
2
3    set -v
4    # Exact same effect as above.
5
```



To *disable* an option within a script, use `set +o option-name` or `set +option-abbrev`.

```
1    #!/bin/bash
2
3    set -o verbose
4    # Command echoing on.
5    command
6    ...
7    command
8
9    set +o verbose
10   # Command echoing off.
11   command
12   # Not echoed.
13
14
15   set -v
16   # Command echoing on.
17   command
18   ...
19   command
20
21   set +v
22   # Command echoing off.
23   command
24
25   exit 0
26
```

An alternate method of enabling options in a script is to specify them immediately following the `#!` script header.

```
1    #!/bin/bash -x
2    #
3    # Body of script follows.
4
```

It is also possible to enable script options from the command line. Some options that will not work with `set` are available this way. Among these are `-i`, force script to run interactive.

bash -v script-name

bash -o verbose script-name

The following is a listing of some useful options. They may be specified in either abbreviated form (preceded by a single dash) or by complete name (preceded by a *double* dash or by -o).

Table 33-1. Bash options

Abbreviation	Name	Effect
-B	brace expansion	Enable brace expansion (default setting = on)
+B	brace expansion	Disable brace expansion
-C	noclobber	Prevent overwriting of files by redirection (may be overridden by >)
-D	(none)	List double-quoted strings prefixed by \$, but do not execute commands in script
-a	allexport	Export all defined variables
-b	notify	Notify when jobs running in background terminate (not of much use in a script)
-c ...	(none)	Read commands from ...
checkjobs		Informs user of any open jobs upon shell exit. Introduced in version 4 of Bash, and still "experimental." Usage: shopt -s checkjobs (<i>Caution</i> : may hang!)
-e	errexit	Abort script at first error, when a command exits with non-zero status (except in until or while loops , if-tests , list constructs)
-f	noglob	Filename expansion (globbing) disabled
globstar	globbing star-match	Enables the ** globbing operator (version 4+ of Bash). Usage: shopt -s globstar
-i	interactive	Script runs in <i>interactive</i> mode
-n	noexec	Read commands in script, but do not execute them (syntax check)
-o Option-Name	(none)	Invoke the <i>Option-Name</i> option
-o posix	POSIX	Change the behavior of Bash, or invoked script, to conform to POSIX standard.
-o pipefail	pipe failure	Causes a pipeline to return the exit status of the last command in the pipe that returned a non-zero return value.
-p	privileged	Script runs as "suid" (caution!)
-r	restricted	Script runs in <i>restricted</i> mode (see Chapter 22).
-s	stdin	Read commands from <code>stdin</code>
-t	(none)	Exit after first command
-u	nounset	Attempt to use undefined variable outputs error message, and forces an exit
-v	verbose	Print each command to <code>stdout</code> before executing it
-x	xtrace	Similar to -v, but expands commands
-	(none)	End of options flag. All other arguments are positional parameters .
--	(none)	

	Unset positional parameters. If arguments given (<code>-- arg1 arg2</code>), positional parameters set to arguments.
--	--

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Chapter 34. Gotchas

Turandot: Gli enigmi sono tre, la morte una!

Caleph: No, no! Gli enigmi sono tre, una la vita!

--Puccini

Here are some (non-recommended!) scripting practices that will bring excitement into an otherwise dull life.

- Assigning reserved words or characters to variable names.

```
1 case=value0      # Causes problems.
2 23skidoo=value1  # Also problems.
3 # Variable names starting with a digit are reserved by the shell.
4 # Try _23skidoo=value1. Starting variables with an underscore is okay.
5
6 # However . . . using just an underscore will not work.
7 _=25
8 echo $_          # $_ is a special variable set to last arg of last command.
9 # But . . . _ is a valid function name!
10
11 xyz(!*=value2   # Causes severe problems.
12 # As of version 3 of Bash, periods are not allowed within variable names.
```

- Using a hyphen or other reserved characters in a variable name (or function name).

```
1 var-1=23
2 # Use 'var_1' instead.
3
4 function-whatever () # Error
5 # Use 'function_whatever ()' instead.
6
7
8 # As of version 3 of Bash, periods are not allowed within function names.
9 function.whatever () # Error
10 # Use 'functionWhatever ()' instead.
```

- Using the same name for a variable and a function. This can make a script difficult to understand.

```
1 do_something ()
2 {
3     echo "This function does something with \"\$1\"."
4 }
5
6 do_something=do_something
7
8 do_something do_something
9
10 # All this is legal, but highly confusing.
```

- Using [whitespace](#) inappropriately. In contrast to other programming languages, Bash can be quite finicky about whitespace.

```
1 var1 = 23      # 'var1=23' is correct.
2 # On line above, Bash attempts to execute command "var1"
3 # with the arguments "=" and "23".
4
5 let c = $a - $b # Instead: let c=$a-$b or let "c = $a - $b"
6
7 if [ $a -le 5 ] # if [ $a -le 5 ] is correct.
8 #             ^^ if [ "$a" -le 5 ] is even better.
```

```
9 # [[ $a -le 5 ]] also works.
```

Not terminating with a [semicolon](#) the final command in a [code block within curly brackets](#).

```
1 { ls -l; df; echo "Done." }
2 # bash: syntax error: unexpected end of file
3
4 { ls -l; df; echo "Done."; }
5 # ^ ### Final command needs semicolon.
```

Assuming uninitialized variables (variables before a value is assigned to them) are "zeroed out". An uninitialized variable has a value of *null*, *not* zero.

```
1 #!/bin/bash
2
3 echo "uninitialized_var = $uninitialized_var"
4 # uninitialized_var =
5
6 # However . . .
7 # if $BASH_VERSION ≥ 4.2; then
8
9 if [[ ! -v uninitialized_var ]]
10 then
11     uninitialized_var=0 # Initialize it to zero!
12 fi
13
14
```

Mixing up = and -eq in a test. Remember, = is for comparing literal variables and -eq for integers.

```
1 if [ "$a" = 273 ] # Is $a an integer or string?
2 if [ "$a" -eq 273 ] # If $a is an integer.
3
4 # Sometimes you can interchange -eq and = without adverse consequences.
5 # However . . .
6
7
8 a=273.0 # Not an integer.
9
10 if [ "$a" = 273 ]
11 then
12     echo "Comparison works."
13 else
14     echo "Comparison does not work."
15 fi # Comparison does not work.
16
17 # Same with a=" 273" and a="0273".
18
19
20 # Likewise, problems trying to use "-eq" with non-integer values.
21
22 if [ "$a" -eq 273.0 ]
23 then
24     echo "a = $a"
25 fi # Aborts with an error message.
26 # test.sh: [: 273.0: integer expression expected
```

Misusing [string comparison](#) operators.

Example 34-1. Numerical and string comparison are not equivalent

```
1 #!/bin/bash
2 # bad-op.sh: Trying to use a string comparison on integers.
3
4 echo
5 number=1
6
7 # The following while-loop has two errors:
8 #+ one blatant, and the other subtle.
9
10 while [ "$number" < 5 ]      # Wrong! Should be: while [ "$number" -lt 5 ]
11 do
12     echo -n "$number "
13     let "number += 1"
14 done
15 # Attempt to run this bombs with the error message:
16 #+ bad-op.sh: line 10: 5: No such file or directory
17 # Within single brackets, "<" must be escaped,
18 #+ and even then, it's still wrong for comparing integers.
19
20 echo "-----"
21
22 while [ "$number" \< 5 ]      # 1 2 3 4
23 do                             #
24     echo -n "$number "        # It *seems* to work, but . . .
25     let "number += 1"        #+ it actually does an ASCII comparison,
26 done                          #+ rather than a numerical one.
27
28 echo; echo "-----"
29
30 # This can cause problems. For example:
31
32 lesser=5
33 greater=105
34
35 if [ "$greater" \< "$lesser" ]
36 then
37     echo "$greater is less than $lesser"
38 fi                             # 105 is less than 5
39 # In fact, "105" actually is less than "5"
40 #+ in a string comparison (ASCII sort order).
41
42 echo
43
44 exit 0
```

- Attempting to use [let](#) to set string variables.

```
1 let "a = hello, you"
2 echo "$a" # 0
```

- Sometimes variables within "test" brackets ([]) need to be quoted (double quotes). Failure to do so may cause unexpected behavior. See [Example 7-6](#), [Example 20-5](#), and [Example 9-6](#).
- Quoting a variable containing whitespace [prevents splitting](#). Sometimes this produces [unintended consequences](#).
- Commands issued from a script may fail to execute because the script owner lacks execute permission for them. If a user cannot invoke a command from the command-line, then putting it into a script will likewise fail. Try changing the attributes of the command in question, perhaps even setting the `suid` bit

(as *root*, of course).

- Attempting to use `-` as a redirection operator (which it is not) will usually result in an unpleasant surprise.

```
1 command1 2> - | command2
2 # Trying to redirect error output of command1 into a pipe . . .
3 # . . . will not work.
4
5 command1 2>& - | command2 # Also futile.
6
7 Thanks, S.C.
```

- Using Bash [version 2+](#) functionality may cause a bailout with error messages. Older Linux machines may have version 1.XX of Bash as the default installation.

```
1 #!/bin/bash
2
3 minimum_version=2
4 # Since Chet Ramey is constantly adding features to Bash,
5 # you may set $minimum_version to 2.XX, 3.XX, or whatever is appropriate.
6 E_BAD_VERSION=80
7
8 if [ "$BASH_VERSION" \<< "$minimum_version" ]
9 then
10  echo "This script works only with Bash, version $minimum or greater."
11  echo "Upgrade strongly recommended."
12  exit $E_BAD_VERSION
13 fi
14
15 ...
```

- Using Bash-specific functionality in a [Bourne shell](#) script (`#!/bin/sh`) on a non-Linux machine [may cause unexpected behavior](#). A Linux system usually aliases `sh` to `bash`, but this does not necessarily hold true for a generic UNIX machine.

- Using undocumented features in Bash turns out to be a dangerous practice. In previous releases of this book there were several scripts that depended on the "feature" that, although the maximum value of an [exit](#) or [return](#) value was 255, that limit did not apply to *negative* integers. Unfortunately, in version 2.05b and later, that loophole disappeared. See [Example 24-9](#).

- In certain contexts, a misleading [exit status](#) may be returned. This may occur when [setting a local variable within a function](#) or when [assigning an arithmetic value to a variable](#).

- The [exit status of an arithmetic expression](#) is *not* equivalent to an *error code*.

```
1 var=1 && ((--var)) && echo $var
2 #           ^^^^^^^^^ Here the and-list terminates with exit status 1.
3 #           $var doesn't echo!
4 echo $?    # 1
```

- A script with DOS-type newlines (`\r\n`) will fail to execute, since `#!/bin/bash\r\n` is *not* recognized, *not* the same as the expected `#!/bin/bash\n`. The fix is to convert the script to UNIX-style newlines.

```
1 #!/bin/bash
2
3 echo "Here"
4
5 unix2dos $0 # Script changes itself to DOS format.
6 chmod 755 $0 # Change back to execute permission.
```

```

7           # The 'unix2dos' command removes execute permission.
8
9 ./ $0     # Script tries to run itself again.
10          # But it won't work as a DOS file.
11
12 echo "There"
13
14 exit 0

```

- A shell script headed by **#!/bin/sh** will not run in full Bash-compatibility mode. Some Bash-specific functions might be disabled. Scripts that need complete access to all the Bash-specific extensions should start with **#!/bin/bash**.
- [Putting whitespace in front of the terminating limit string](#) of a [here document](#) will cause unexpected behavior in a script.
- Putting more than one *echo* statement in a function [whose output is captured](#).

```

1 add2 ()
2 {
3   echo "Whatever ... " # Delete this line!
4   let "retval = $1 + $2"
5   echo $retval
6 }
7
8   num1=12
9   num2=43
10  echo "Sum of $num1 and $num2 = $(add2 $num1 $num2)"
11
12 #   Sum of 12 and 43 = Whatever ...
13 #   55
14
15 #           The "echoes" concatenate.

```

This [will not work](#).

- A script may not **export** variables back to its [parent process](#), the shell, or to the environment. Just as we learned in biology, a child process can inherit from a parent, but not vice versa.

```

1 WHATEVER=/home/bozo
2 export WHATEVER
3 exit 0

```

```
bash$ echo $WHATEVER
```

```
bash$
```

Sure enough, back at the command prompt, \$WHATEVER remains unset.

- Setting and manipulating variables in a [subshell](#), then attempting to use those same variables outside the scope of the subshell will result an unpleasant surprise.

Example 34-2. Subshell Pitfalls

```

1 #!/bin/bash
2 # Pitfalls of variables in a subshell.
3
4 outer_variable=outer
5 echo
6 echo "outer_variable = $outer_variable"
7 echo
8
9 (
10 # Begin subshell

```

```

11
12 echo "outer_variable inside subshell = $outer_variable"
13 inner_variable=inner # Set
14 echo "inner_variable inside subshell = $inner_variable"
15 outer_variable=inner # Will value change globally?
16 echo "outer_variable inside subshell = $outer_variable"
17
18 # Will 'exporting' make a difference?
19 #     export inner_variable
20 #     export outer_variable
21 # Try it and see.
22
23 # End subshell
24 )
25
26 echo
27 echo "inner_variable outside subshell = $inner_variable" # Unset.
28 echo "outer_variable outside subshell = $outer_variable" # Unchanged.
29 echo
30
31 exit 0
32
33 # What happens if you uncomment lines 19 and 20?
34 # Does it make a difference?

```

- **Piping** `echo` output to a `read` may produce unexpected results. In this scenario, the `read` acts as if it were running in a subshell. Instead, use the `set` command (as in [Example 15-18](#)).

Example 34-3. Piping the output of `echo` to a `read`

```

1 #!/bin/bash
2 # badread.sh:
3 # Attempting to use 'echo and 'read'
4 #+ to assign variables non-interactively.
5
6 # shopt -s lastpipe
7
8 a=aaa
9 b=bbb
10 c=ccc
11
12 echo "one two three" | read a b c
13 # Try to reassign a, b, and c.
14
15 echo
16 echo "a = $a" # a = aaa
17 echo "b = $b" # b = bbb
18 echo "c = $c" # c = ccc
19 # Reassignment failed.
20
21 ### However . . .
22 ## Uncommenting line 6:
23 # shopt -s lastpipe
24 ##+ fixes the problem!
25 ### This is a new feature in Bash, version 4.2.
26
27 # -----
28
29 # Try the following alternative.
30
31 var=`echo "one two three"`
32 set -- $var

```

```

33 a=$1; b=$2; c=$3
34
35 echo "-----"
36 echo "a = $a" # a = one
37 echo "b = $b" # b = two
38 echo "c = $c" # c = three
39 # Reassignment succeeded.
40
41 # -----
42
43 # Note also that an echo to a 'read' works within a subshell.
44 # However, the value of the variable changes only within the subshell.
45
46 a=aaa # Starting all over again.
47 b=bbb
48 c=ccc
49
50 echo; echo
51 echo "one two three" | ( read a b c;
52 echo "Inside subshell: "; echo "a = $a"; echo "b = $b"; echo "c = $c" )
53 # a = one
54 # b = two
55 # c = three
56 echo "-----"
57 echo "Outside subshell: "
58 echo "a = $a" # a = aaa
59 echo "b = $b" # b = bbb
60 echo "c = $c" # c = ccc
61 echo
62
63 exit 0

```

In fact, as Anthony Richardson points out, piping to *any* loop can cause a similar problem.

```

1 # Loop piping troubles.
2 # This example by Anthony Richardson,
3 #+ with addendum by Wilbert Berendsen.
4
5
6 foundone=false
7 find $HOME -type f -atime +30 -size 100k |
8 while true
9 do
10     read f
11     echo "$f is over 100KB and has not been accessed in over 30 days"
12     echo "Consider moving the file to archives."
13     foundone=true
14     # -----
15     echo "Subshell level = $BASH_SUBSHELL"
16     # Subshell level = 1
17     # Yes, we're inside a subshell.
18     # -----
19 done
20
21 # foundone will always be false here since it is
22 #+ set to true inside a subshell
23 if [ $foundone = false ]
24 then
25     echo "No files need archiving."
26 fi
27
28 # =====Now, here is the correct way:=====
29
30 foundone=false

```

```

31 for f in $(find $HOME -type f -atime +30 -size 100k) # No pipe here.
32 do
33     echo "$f is over 100KB and has not been accessed in over 30 days"
34     echo "Consider moving the file to archives."
35     foundone=true
36 done
37
38 if [ $foundone = false ]
39 then
40     echo "No files need archiving."
41 fi
42
43 # =====And here is another alternative=====
44
45 # Places the part of the script that reads the variables
46 #+ within a code block, so they share the same subshell.
47 # Thank you, W.B.
48
49 find $HOME -type f -atime +30 -size 100k | {
50     foundone=false
51     while read f
52     do
53         echo "$f is over 100KB and has not been accessed in over 30 days"
54         echo "Consider moving the file to archives."
55         foundone=true
56     done
57
58     if ! $foundone
59     then
60         echo "No files need archiving."
61     fi
62 }

```

A lookalike problem occurs when trying to write the stdout of a `tail -f` piped to `grep`.

```

1 tail -f /var/log/messages | grep "$ERROR_MSG" >> error.log
2 # The "error.log" file will not have anything written to it.
3 # As Samuli Kaipiainen points out, this results from grep
4 #+ buffering its output.
5 # The fix is to add the "--line-buffered" parameter to grep.

```

-
- Using "suid" commands within scripts is risky, as it may compromise system security. [\[1\]](#)
-
- Using shell scripts for CGI programming may be problematic. Shell script variables are not "typesafe," and this can cause undesirable behavior as far as CGI is concerned. Moreover, it is difficult to "cracker-proof" shell scripts.
- Bash does not handle the [double slash \(//\) string](#) correctly.
-
- Bash scripts written for Linux or BSD systems may need fixups to run on a commercial UNIX machine. Such scripts often employ the GNU set of commands and filters, which have greater functionality than their generic UNIX counterparts. This is particularly true of such text processing utilities as `tr`.
-
- Sadly, updates to Bash itself have broken older scripts that [used to work perfectly fine](#). Let us recall [how risky it is to use undocumented Bash features](#).

Danger is near thee --

Beware, beware, beware, beware.

Many brave hearts are asleep in the deep.

So beware --

Beware.

--A.J. Lamb and H.W. Petrie

Notes

[1] Setting the [suid](#) permission on the script itself has no effect in Linux and most other UNIX flavors.

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Chapter 35. Scripting With Style

Get into the habit of writing shell scripts in a structured and systematic manner. Even on-the-fly and "written on the back of an envelope" scripts will benefit if you take a few minutes to plan and organize your thoughts before sitting down and coding.

Herewith are a few stylistic guidelines. This is not (necessarily) intended as an *Official Shell Scripting Stylesheet*.

35.1. Unofficial Shell Scripting Stylesheet

- Comment your code. This makes it easier for others to understand (and appreciate), and easier for you to maintain.

```
1 PASS="$PASS${MATRIX:$((($RANDOM%${#MATRIX})):1)}"
2 # It made perfect sense when you wrote it last year,
3 #+ but now it's a complete mystery.
4 # (From Antek Sawicki's "pw.sh" script.)
```

Add descriptive headers to your scripts and functions.

```
1 #!/bin/bash
2
3 #*****#
4 #                               #
5 #           xyz.sh                #
6 #           written by Bozo Bozeman #
7 #           July 05, 2001          #
8 #                               #
9 #           Clean up project files. #
10 #*****#
11 E_BADDIR=85                      # No such directory.
12 projectdir=/home/bozo/projects   # Directory to clean up.
13
14 # ----- #
15 # cleanup_pfiles ()                #
16 # Removes all files in designated directory. #
17 # Parameter: $target_directory    #
18 # Returns: 0 on success, $E_BADDIR if something went wrong. #
19 # ----- #
20 cleanup_pfiles ()
21 {
22     if [ ! -d "$1" ] # Test if target directory exists.
23     then
24         echo "$1 is not a directory."
25         return $E_BADDIR
26     fi
27
28     rm -f "$1"/*
29     return 0 # Success.
30 }
31
32 cleanup_pfiles $projectdir
33
34 exit $?
```

- Avoid using "magic numbers," [\[1\]](#) that is, "hard-wired" literal constants. Use meaningful variable names instead. This makes the script easier to understand and permits making changes and updates without breaking the application.

```
1 if [ -f /var/log/messages ]
2 then
3     ...
4 fi
5 # A year later, you decide to change the script to check /var/log/syslog.
6 # It is now necessary to manually change the script, instance by instance,
7 #+ and hope nothing breaks.
8
9 # A better way:
10 LOGFILE=/var/log/messages # Only line that needs to be changed.
11 if [ -f "$LOGFILE" ]
12 then
13     ...
```

- Choose descriptive names for variables and functions.

```

1 fl=`ls -al $dirname`           # Cryptic.
2 file_listing=`ls -al $dirname` # Better.
3
4
5 MAXVAL=10 # All caps used for a script constant.
6 while [ "$index" -le "$MAXVAL" ]
7 ...
8
9
10 E_NOTFOUND=95                 # Uppercase for an errorcode,
11                               #+ and name prefixed with E_.
12 if [ ! -e "$filename" ]
13 then
14   echo "File $filename not found."
15   exit $E_NOTFOUND
16 fi
17
18
19 MAIL_DIRECTORY=/var/spool/mail/bozo # Uppercase for an environmental
20 export MAIL_DIRECTORY              #+ variable.
21
22
23 GetAnswer ()                  # Mixed case works well for a
24 {                              #+ function name, especially
25   prompt=$1                    #+ when it improves legibility.
26   echo -n $prompt
27   read answer
28   return $answer
29 }
30
31 GetAnswer "What is your favorite number? "
32 favorite_number=$?
33 echo $favorite_number
34
35
36 _uservariable=23              # Permissible, but not recommended.
37 # It's better for user-defined variables not to start with an underscore.
38 # Leave that for system variables.

```

- Use [exit codes](#) in a systematic and meaningful way.

```

1 E_WRONG_ARGS=95
2 ...
3 ...
4 exit $E_WRONG_ARGS

```

See also [Appendix E](#).

Ender suggests using the [exit codes in /usr/include/sysexits.h](#) in shell scripts, though these are primarily intended for C and C++ programming.

- Use standardized parameter flags for script invocation. *Ender* proposes the following set of flags.

```

1 -a      All: Return all information (including hidden file info).
2 -b      Brief: Short version, usually for other scripts.
3 -c      Copy, concatenate, etc.
4 -d      Daily: Use information from the whole day, and not merely
5          information for a specific instance/user.
6 -e      Extended/Elaborate: (often does not include hidden file info).
7 -h      Help: Verbose usage w/descs, aux info, discussion, help.
8          See also -V.
9 -l      Log output of script.
10 -m     Manual: Launch man-page for base command.

```

```
11 -n      Numbers: Numerical data only.
12 -r      Recursive: All files in a directory (and/or all sub-dirs).
13 -s      Setup & File Maintenance: Config files for this script.
14 -u      Usage: List of invocation flags for the script.
15 -v      Verbose: Human readable output, more or less formatted.
16 -V      Version / License / Copy(right|left) / Contribs (email too).
```

See also [Section G.1](#).

- Break complex scripts into simpler modules. Use functions where appropriate. See [Example 37-4](#).
- Don't use a complex construct where a simpler one will do.

```
1 COMMAND
2 if [ $? -eq 0 ]
3 ...
4 # Redundant and non-intuitive.
5
6 if COMMAND
7 ...
8 # More concise (if perhaps not quite as legible).
```

... reading the UNIX source code to the Bourne shell (/bin/sh). I was shocked at how much simple algorithms could be made cryptic, and therefore useless, by a poor choice of code style. I asked myself, "Could someone be proud of this code?"

--Landon Noll

Notes

- [1] In this context, "magic numbers" have an entirely different meaning than the [magic numbers](#) used to designate file types.

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Chapter 36. Miscellany

Nobody really knows what the Bourne shell's grammar is. Even examination of the source code is little help.

--Tom Duff

36.1. Interactive and non-interactive shells and scripts

An *interactive* shell reads commands from user input on a `tty`. Among other things, such a shell reads startup files on activation, displays a prompt, and enables job control by default. The user can *interact* with the shell.

A shell running a script is always a non-interactive shell. All the same, the script can still access its `tty`. It is even possible to emulate an interactive shell in a script.

```
1 #!/bin/bash
2 MY_PROMPT='$ '
3 while :
4 do
5     echo -n "$MY_PROMPT"
6     read line
7     eval "$line"
8 done
9
10 exit 0
11
12 # This example script, and much of the above explanation supplied by
13 # Stéphane Chazelas (thanks again).
```

Let us consider an *interactive* script to be one that requires input from the user, usually with [read](#) statements (see [Example 15-3](#)). "Real life" is actually a bit messier than that. For now, assume an interactive script is bound to a `tty`, a script that a user has invoked from the console or an *xterm*.

Init and startup scripts are necessarily non-interactive, since they must run without human intervention. Many administrative and system maintenance scripts are likewise non-interactive. Unvarying repetitive tasks cry out for automation by non-interactive scripts.

Non-interactive scripts can run in the background, but interactive ones hang, waiting for input that never comes. Handle that difficulty by having an **expect** script or embedded [here document](#) feed input to an interactive script running as a background job. In the simplest case, redirect a file to supply input to a **read** statement (**read variable <file**). These particular workarounds make possible general purpose scripts that run in either interactive or non-interactive modes.

If a script needs to test whether it is running in an interactive shell, it is simply a matter of finding whether the *prompt* variable, `$PS1` is set. (If the user is being prompted for input, then the script needs to display a prompt.)


```
1 if [ -z $PS1 ] # no prompt?
2 ### if [ -v PS1 ] # On Bash 4.2+ ...
3 then
4     # non-interactive
5     ...
6 else
7     # interactive
8     ...
9 fi
```

Alternatively, the script can test for the presence of option "i" in the `$-` flag.

```
1 case $- in
2  *i*) # interactive shell
3 ;;
4  *) # non-interactive shell
5 ;;
6 # (Courtesy of "UNIX F.A.Q.," 1993)
```

However, John Lange describes an alternative method, using the [-t test operator](#).

```
1 # Test for a terminal!
2
3 fd=0 # stdin
4
5 # As we recall, the -t test option checks whether the stdin, [ -t 0 ],
6 #+ or stdout, [ -t 1 ], in a given script is running in a terminal.
7 if [ -t "$fd" ]
8 then
9     echo interactive
10 else
11     echo non-interactive
12 fi
13
14
15 # But, as John points out:
16 #     if [ -t 0 ] works ... when you're logged in locally
17 #     but fails when you invoke the command remotely via ssh.
18 #     So for a true test you also have to test for a socket.
19
20 if [[ -t "$fd" || -p /dev/stdin ]]
21 then
22     echo interactive
23 else
24     echo non-interactive
25 fi
```

 Scripts may be forced to run in interactive mode with the `-i` option or with a `#!/bin/bash -i` header. Be aware that this can cause erratic script behavior or show error messages even when no error is present.

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36.2. Shell Wrappers

A *wrapper* is a shell script that embeds a system command or utility, that accepts and passes a set of parameters to that command. [1] Wrapping a script around a complex command-line simplifies invoking it. This is especially useful with [sed](#) and [awk](#).

A `sed` or `awk` script would normally be invoked from the command-line by a `sed -e 'commands'` or `awk 'commands'`. Embedding such a script in a Bash script permits calling it more simply, and makes it *reusable*. This also enables combining the functionality of `sed` and `awk`, for example [piping](#) the output of a set of `sed` commands to `awk`. As a saved executable file, you can then repeatedly invoke it in its original form or modified, without the inconvenience of retyping it on the command-line.

Example 36-1. *shell wrapper*

```
1 #!/bin/bash
2
3 # This simple script removes blank lines from a file.
4 # No argument checking.
5 #
6 # You might wish to add something like:
7 #
8 # E_NOARGS=85
9 # if [ -z "$1" ]
10 # then
11 #   echo "Usage: `basename $0` target-file"
12 #   exit $E_NOARGS
13 # fi
14
15
16
17 sed -e /^$/d "$1"
18 # Same as
19 #   sed -e '/^$/d' filename
20 # invoked from the command-line.
21
22 # The '-e' means an "editing" command follows (optional here).
23 # '^' indicates the beginning of line, '$' the end.
24 # This matches lines with nothing between the beginning and the end --
25 #+ blank lines.
26 # The 'd' is the delete command.
27
28 # Quoting the command-line arg permits
29 #+ whitespace and special characters in the filename.
30
31 # Note that this script doesn't actually change the target file.
32 # If you need to do that, redirect its output.
33
34 exit
```

Example 36-2. A slightly more complex *shell wrapper*

```
1 #!/bin/bash
2
3 # subst.sh: a script that substitutes one pattern for
4 #+ another in a file,
5 #+ i.e., "sh subst.sh Smith Jones letter.txt".
```

```

6 #           Jones replaces Smith.
7
8 ARGS=3      # Script requires 3 arguments.
9 E_BADARGS=85 # Wrong number of arguments passed to script.
10
11 if [ $# -ne "$ARGS" ]
12 then
13     echo "Usage: `basename $0` old-pattern new-pattern filename"
14     exit $E_BADARGS
15 fi
16
17 old_pattern=$1
18 new_pattern=$2
19
20 if [ -f "$3" ]
21 then
22     file_name=$3
23 else
24     echo "File \"$3\" does not exist."
25     exit $E_BADARGS
26 fi
27
28
29 # -----
30 # Here is where the heavy work gets done.
31 sed -e "s/$old_pattern/$new_pattern/g" $file_name
32 # -----
33
34 # 's' is, of course, the substitute command in sed,
35 #+ and /pattern/ invokes address matching.
36 # The 'g,' or global flag causes substitution for EVERY
37 #+ occurrence of $old_pattern on each line, not just the first.
38 # Read the 'sed' docs for an in-depth explanation.
39
40 exit $? # Redirect the output of this script to write to a file.

```

Example 36-3. A generic *shell wrapper* that writes to a logfile

```

1 #!/bin/bash
2 # logging-wrapper.sh
3 # Generic shell wrapper that performs an operation
4 #+ and logs it.
5
6 DEFAULT_LOGFILE=logfile.txt
7
8 # Set the following two variables.
9 OPERATION=
10 #     Can be a complex chain of commands,
11 #+     for example an awk script or a pipe . . .
12
13 LOGFILE=
14 if [ -z "$LOGFILE" ]
15 then # If not set, default to ...
16     LOGFILE="$DEFAULT_LOGFILE"
17 fi
18
19 #     Command-line arguments, if any, for the operation.
20 OPTIONS="$@"
21
22
23 # Log it.
24 echo "`date` + `whoami` + $OPERATION \"$@\" " >> $LOGFILE

```

```
25 # Now, do it.
26 exec $OPERATION "$@"
27
28 # It's necessary to do the logging before the operation.
29 # Why?
```

Example 36-4. A *shell wrapper* around an awk script

```
1 #!/bin/bash
2 # pr-ascii.sh: Prints a table of ASCII characters.
3
4 START=33 # Range of printable ASCII characters (decimal).
5 END=127 # Will not work for unprintable characters (> 127).
6
7 echo " Decimal Hex Character" # Header.
8 echo " ----- ---"
9
10 for ((i=START; i<=END; i++))
11 do
12 echo $i | awk '{printf(" %3d %2x %c\n", $1, $1, $1)}'
13 # The Bash printf builtin will not work in this context:
14 # printf "%c" "$i"
15 done
16
17 exit 0
18
19
20 # Decimal Hex Character
21 # ----- ---
22 # 33 21 !
23 # 34 22 "
24 # 35 23 #
25 # 36 24 $
26 #
27 # . . .
28 #
29 # 122 7a z
30 # 123 7b {
31 # 124 7c |
32 # 125 7d }
33
34
35 # Redirect the output of this script to a file
36 #+ or pipe it to "more": sh pr-asc.sh | more
```

Example 36-5. A *shell wrapper* around another awk script

```
1 #!/bin/bash
2
3 # Adds up a specified column (of numbers) in the target file.
4 # Floating-point (decimal) numbers okay, because awk can handle them.
5
6 ARGS=2
7 E_WRONGARGS=85
8
9 if [ $# -ne "$ARGS" ] # Check for proper number of command-line args.
10 then
11 echo "Usage: `basename $0` filename column-number"
12 exit $E_WRONGARGS
```

```

13 fi
14
15 filename=$1
16 column_number=$2
17
18 # Passing shell variables to the awk part of the script is a bit tricky.
19 # One method is to strong-quote the Bash-script variable
20 #+ within the awk script.
21 #     '$BASH_SCRIPT_VAR'
22 #     ^             ^
23 # This is done in the embedded awk script below.
24 # See the awk documentation for more details.
25
26 # A multi-line awk script is here invoked by
27 # awk '
28 # ...
29 # ...
30 # ...
31 # '
32
33
34 # Begin awk script.
35 # -----
36 awk '
37
38 { total += "${column_number}"
39 }
40 END {
41     print total
42 }
43
44 ' "$filename"
45 # -----
46 # End awk script.
47
48
49 # It may not be safe to pass shell variables to an embedded awk script,
50 #+ so Stephane Chazelas proposes the following alternative:
51 # -----
52 # awk -v column_number="$column_number" '
53 # { total += $column_number
54 # }
55 # END {
56 #     print total
57 # }' "$filename"
58 # -----
59
60
61 exit 0

```

For those scripts needing a single do-it-all tool, a Swiss army knife, there is *Perl*. Perl combines the capabilities of [sed](#) and [awk](#), and throws in a large subset of **C**, to boot. It is modular and contains support for everything ranging from object-oriented programming up to and including the kitchen sink. Short Perl scripts lend themselves to embedding within shell scripts, and there may be some substance to the claim that Perl can totally replace shell scripting (though the author of the *ABS Guide* remains skeptical).

Example 36-6. Perl embedded in a *Bash* script

```

1 #!/bin/bash
2
3 # Shell commands may precede the Perl script.

```



```

4 echo "This precedes the embedded Perl script within \"\$0\"."
5 echo "=====
6
7 perl -e 'print "This line prints from an embedded Perl script.\n";'
8 # Like sed, Perl also uses the "-e" option.
9
10 echo "=====
11 echo "However, the script may also contain shell and system commands."
12
13 exit 0

```

It is even possible to combine a Bash script and Perl script within the same file. Depending on how the script is invoked, either the Bash part or the Perl part will execute.

Example 36-7. Bash and Perl scripts combined

```

1 #!/bin/bash
2 # bashandperl.sh
3
4 echo "Greetings from the Bash part of the script, $0."
5 # More Bash commands may follow here.
6
7 exit
8 # End of Bash part of the script.
9
10 # =====
11
12 #!/usr/bin/perl
13 # This part of the script must be invoked with
14 # perl -x bashandperl.sh
15
16 print "Greetings from the Perl part of the script, $0.\n";
17 # Perl doesn't seem to like "echo" ...
18 # More Perl commands may follow here.
19
20 # End of Perl part of the script.

```

```

bash$ bash bashandperl.sh
Greetings from the Bash part of the script.

```

```

bash$ perl -x bashandperl.sh
Greetings from the Perl part of the script.

```

It is, of course, possible to embed even more exotic scripting languages within shell wrappers. *Python*, for example ...

Example 36-8. Python embedded in a *Bash* script

```

1 #!/bin/bash
2 # ex56py.sh
3
4 # Shell commands may precede the Python script.
5 echo "This precedes the embedded Python script within \"\$0\"."
6 echo "=====
7

```

```
8 python -c 'print "This line prints from an embedded Python script.\n";'
9 # Unlike sed and perl, Python uses the "-c" option.
10 python -c 'k = raw_input( "Hit a key to exit to outer script. " )'
11
12 echo "=====
13 echo "However, the script may also contain shell and system commands."
14
15 exit 0
```

Wrapping a script around *mplayer* and the Google's translation server, you can create something that talks back to you.

Example 36-9. A script that speaks

```
1 #!/bin/bash
2 #   Courtesy of:
3 #   http://elinux.org/RPi_Text_to_Speech_(Speech_Synthesis)
4
5 #   You must be on-line for this script to work,
6 #+  so you can access the Google translation server.
7 #   Of course, mplayer must be present on your computer.
8
9 speak()
10 {
11     local IFS=+
12     # Invoke mplayer, then connect to Google translation server.
13     /usr/bin/mplayer -ao alsa -really-quiet -noconsolecontrols \
14     "http://translate.google.com/translate_tts?tl=en&q=\"$*"
15     # Google translates, but can also speak.
16 }
17
18 LINES=4
19
20 spk=$(tail -$LINES $0) # Tail end of same script!
21 speak "$spk"
22 exit
23 # Browns. Nice talking to you.
```

One interesting example of a complex shell wrapper is Martin Matusiak's [undvd script](#), which provides an easy-to-use command-line interface to the complex [mencoder](#) utility. Another example is Itzhak Rehberg's [Ext3Undel](#), a set of scripts to recover deleted file on an *ext3* filesystem.

Notes

- [1] Quite a number of Linux utilities are, in fact, shell wrappers. Some examples are `/usr/bin/pdf2ps`, `/usr/bin/batch`, and `/usr/bin/xmkmf`.

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36.3. Tests and Comparisons: Alternatives

For tests, the `[[]]` construct may be more appropriate than `[]`. Likewise, [arithmetic comparisons](#) might benefit from the `(())` construct.

```
1 a=8
2
3 # All of the comparisons below are equivalent.
4 test "$a" -lt 16 && echo "yes, $a < 16"           # "and list"
5 /bin/test "$a" -lt 16 && echo "yes, $a < 16"
6 [ "$a" -lt 16 ] && echo "yes, $a < 16"
7 [[ $a -lt 16 ]] && echo "yes, $a < 16"           # Quoting variables within
8 (( a < 16 )) && echo "yes, $a < 16"             # [[ ]] and (( )) not necessary.
9
10 city="New York"
11 # Again, all of the comparisons below are equivalent.
12 test "$city" \< Paris && echo "Yes, Paris is greater than $city"
13                                     # Greater ASCII order.
14 /bin/test "$city" \< Paris && echo "Yes, Paris is greater than $city"
15 [ "$city" \< Paris ] && echo "Yes, Paris is greater than $city"
16 [[ $city < Paris ]] && echo "Yes, Paris is greater than $city"
17                                     # Need not quote $city.
18
19 # Thank you, S.C.
```

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36.4. Recursion: a script calling itself

Can a script [recursively](#) call itself? Indeed.

Example 36-10. A (useless) script that recursively calls itself

```
1 #!/bin/bash
2 # recurse.sh
3
4 # Can a script recursively call itself?
5 # Yes, but is this of any practical use?
6 # (See the following.)
7
8 RANGE=10
9 MAXVAL=9
10
11 i=$RANDOM
12 let "i %= $RANGE" # Generate a random number between 0 and $RANGE - 1.
13
14 if [ "$i" -lt "$MAXVAL" ]
15 then
16     echo "i = $i"
17     ./$0          # Script recursively spawns a new instance of itself.
18 fi              # Each child script does the same, until
19                #+ a generated $i equals $MAXVAL.
20
21 # Using a "while" loop instead of an "if/then" test causes problems.
22 # Explain why.
23
24 exit 0
25
26 # Note:
27 # ----
28 # This script must have execute permission for it to work properly.
29 # This is the case even if it is invoked by an "sh" command.
30 # Explain why.
```

Example 36-11. A (useful) script that recursively calls itself

```
1 #!/bin/bash
2 # pb.sh: phone book
3
4 # Written by Rick Boivie, and used with permission.
5 # Modifications by ABS Guide author.
6
7 MINARGS=1      # Script needs at least one argument.
8 DATAFILE=./phonebook
9               # A data file in current working directory
10              #+ named "phonebook" must exist.
11 PROGRAMME=$0
12 E_NOARGS=70   # No arguments error.
13
14 if [ $# -lt $MINARGS ]; then
15     echo "Usage: \"$PROGRAMME\" data-to-look-up"
16     exit $E_NOARGS
17 fi
18
```

```

19
20 if [ $# -eq $MINARGS ]; then
21     grep $1 "$DATAFILE"
22     # 'grep' prints an error message if $DATAFILE not present.
23 else
24     ( shift; "$PROGNAME" $* ) | grep $1
25     # Script recursively calls itself.
26 fi
27
28 exit 0          # Script exits here.
29                # Therefore, it's o.k. to put
30                #+ non-hashmarked comments and data after this point.
31
32 # -----
33 Sample "phonebook" datafile:
34
35 John Doe        1555 Main St., Baltimore, MD 21228      (410) 222-3333
36 Mary Moe       9899 Jones Blvd., Warren, NH 03787      (603) 898-3232
37 Richard Roe    856 E. 7th St., New York, NY 10009      (212) 333-4567
38 Sam Roe        956 E. 8th St., New York, NY 10009      (212) 444-5678
39 Zoe Zenobia    4481 N. Baker St., San Francisco, SF 94338      (415) 501-1631
40 # -----
41
42 $bash pb.sh Roe
43 Richard Roe    856 E. 7th St., New York, NY 10009      (212) 333-4567
44 Sam Roe        956 E. 8th St., New York, NY 10009      (212) 444-5678
45
46 $bash pb.sh Roe Sam
47 Sam Roe        956 E. 8th St., New York, NY 10009      (212) 444-5678
48
49 # When more than one argument is passed to this script,
50 #+ it prints *only* the line(s) containing all the arguments.

```

Example 36-12. Another (useful) script that recursively calls itself

```

1 #!/bin/bash
2 # usrmnt.sh, written by Anthony Richardson
3 # Used in ABS Guide with permission.
4
5 # usage:      usrmnt.sh
6 # description: mount device, invoking user must be listed in the
7 #              MNTUSERS group in the /etc/sudoers file.
8
9 # -----
10 # This is a usermount script that reruns itself using sudo.
11 # A user with the proper permissions only has to type
12
13 #   usermount /dev/fd0 /mnt/floppy
14
15 # instead of
16
17 #   sudo usermount /dev/fd0 /mnt/floppy
18
19 # I use this same technique for all of my
20 #+ sudo scripts, because I find it convenient.
21 # -----
22
23 # If SUDO_COMMAND variable is not set we are not being run through
24 #+ sudo, so rerun ourselves. Pass the user's real and group id . . .
25
26 if [ -z "$SUDO_COMMAND" ]
27 then

```

```
28  mntusr=$(id -u) grpusr=$(id -g) sudo $0 $*
29  exit 0
30 fi
31
32 # We will only get here if we are being run by sudo.
33 /bin/mount $* -o uid=$mntusr,gid=$grpusr
34
35 exit 0
36
37 # Additional notes (from the author of this script):
38 # -----
39
40 # 1) Linux allows the "users" option in the /etc/fstab
41 #    file so that any user can mount removable media.
42 #    But, on a server, I like to allow only a few
43 #    individuals access to removable media.
44 #    I find using sudo gives me more control.
45
46 # 2) I also find sudo to be more convenient than
47 #    accomplishing this task through groups.
48
49 # 3) This method gives anyone with proper permissions
50 #    root access to the mount command, so be careful
51 #    about who you allow access.
52 #    You can get finer control over which access can be mounted
53 #    by using this same technique in separate mntfloppy, mntcdrom,
54 #    and mntsamba scripts.
```



Too many levels of recursion can exhaust the script's stack space, causing a segfault.

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"Colorizing" Scripts

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36.5. "Colorizing" Scripts

The ANSI [\[1\]](#) escape sequences set screen attributes, such as bold text, and color of foreground and background. [DOS batch files](#) commonly used ANSI escape codes for *color* output, and so can Bash scripts.

Example 36-13. A "colorized" address database

```
1 #!/bin/bash
2 # ex30a.sh: "Colorized" version of ex30.sh.
3 #           Crude address database
4
5
6 clear                               # Clear the screen.
7
8 echo -n "                            "
9 echo -e '\E[37;44m'\033[1mContact List\033[0m"
10                                     # White on blue background
11 echo; echo
12 echo -e "\033[1mChoose one of the following persons:\033[0m"
13                                     # Bold
14 tput sgr0                            # Reset attributes.
15 echo "(Enter only the first letter of name.)"
16 echo
17 echo -en '\E[47;34m'\033[1mE\033[0m" # Blue
18 tput sgr0                            # Reset colors to "normal."
19 echo "vans, Roland"                  # "[E]vans, Roland"
20 echo -en '\E[47;35m'\033[1mJ\033[0m" # Magenta
21 tput sgr0
22 echo "ambalaya, Mildred"
23 echo -en '\E[47;32m'\033[1mS\033[0m" # Green
24 tput sgr0
25 echo "mith, Julie"
26 echo -en '\E[47;31m'\033[1mZ\033[0m" # Red
27 tput sgr0
28 echo "ane, Morris"
29 echo
30
31 read person
32
33 case "$person" in
34 # Note variable is quoted.
35
36   "E" | "e" )
37   # Accept upper or lowercase input.
38   echo
39   echo "Roland Evans"
40   echo "4321 Flash Dr."
41   echo "Hardscrabble, CO 80753"
42   echo "(303) 734-9874"
43   echo "(303) 734-9892 fax"
44   echo "revans@zzy.net"
45   echo "Business partner & old friend"
46   ;;
47
48   "J" | "j" )
49   echo
50   echo "Mildred Jambalaya"
51   echo "249 E. 7th St., Apt. 19"
52   echo "New York, NY 10009"
53   echo "(212) 533-2814"
54   echo "(212) 533-9972 fax"
```

```

55 echo "milliej@loisaida.com"
56 echo "Girlfriend"
57 echo "Birthday: Feb. 11"
58 ;;
59
60 # Add info for Smith & Zane later.
61
62     * )
63 # Default option.
64 # Empty input (hitting RETURN) fits here, too.
65 echo
66 echo "Not yet in database."
67 ;;
68
69 esac
70
71 tput sgr0                # Reset colors to "normal."
72
73 echo
74
75 exit 0

```

Example 36-14. Drawing a box

```

1 #!/bin/bash
2 # Draw-box.sh: Drawing a box using ASCII characters.
3
4 # Script by Stefano Palmeri, with minor editing by document author.
5 # Minor edits suggested by Jim Angstadt.
6 # Used in the ABS Guide with permission.
7
8
9 #####
10 ### draw_box function doc ###
11
12 # The "draw_box" function lets the user
13 #+ draw a box in a terminal.
14 #
15 # Usage: draw_box ROW COLUMN HEIGHT WIDTH [COLOR]
16 # ROW and COLUMN represent the position
17 #+ of the upper left angle of the box you're going to draw.
18 # ROW and COLUMN must be greater than 0
19 #+ and less than current terminal dimension.
20 # HEIGHT is the number of rows of the box, and must be > 0.
21 # HEIGHT + ROW must be <= than current terminal height.
22 # WIDTH is the number of columns of the box and must be > 0.
23 # WIDTH + COLUMN must be <= than current terminal width.
24 #
25 # E.g.: If your terminal dimension is 20x80,
26 # draw_box 2 3 10 45 is good
27 # draw_box 2 3 19 45 has bad HEIGHT value (19+2 > 20)
28 # draw_box 2 3 18 78 has bad WIDTH value (78+3 > 80)
29 #
30 # COLOR is the color of the box frame.
31 # This is the 5th argument and is optional.
32 # 0=black 1=red 2=green 3=tan 4=blue 5=purple 6=cyan 7=white.
33 # If you pass the function bad arguments,
34 #+ it will just exit with code 65,
35 #+ and no messages will be printed on stderr.
36 #
37 # Clear the terminal before you start to draw a box.
38 # The clear command is not contained within the function.

```

```

39 # This allows the user to draw multiple boxes, even overlapping ones.
40
41 ### end of draw_box function doc ###
42 #####
43
44 draw_box(){
45
46 #=====#
47 HORZ="-"
48 VERT="|"
49 CORNER_CHAR="+"
50
51 MINARGS=4
52 E_BADARGS=65
53 #=====#
54
55
56 if [ $# -lt "$MINARGS" ]; then          # If args are less than 4, exit.
57     exit $E_BADARGS
58 fi
59
60 # Looking for non digit chars in arguments.
61 # Probably it could be done better (exercise for the reader?).
62 if echo $@ | tr -d [:blank:] | tr -d [:digit:] | grep . &> /dev/null; then
63     exit $E_BADARGS
64 fi
65
66 BOX_HEIGHT=`expr $3 - 1`    # -1 correction needed because angle char "+"
67 BOX_WIDTH=`expr $4 - 1`    #+ is a part of both box height and width.
68 T_ROWS=`tput lines`        # Define current terminal dimension
69 T_COLS=`tput cols`         #+ in rows and columns.
70
71 if [ $1 -lt 1 ] || [ $1 -gt $T_ROWS ]; then    # Start checking if arguments
72     exit $E_BADARGS                            #+ are correct.
73 fi
74 if [ $2 -lt 1 ] || [ $2 -gt $T_COLS ]; then
75     exit $E_BADARGS
76 fi
77 if [ `expr $1 + $BOX_HEIGHT + 1` -gt $T_ROWS ]; then
78     exit $E_BADARGS
79 fi
80 if [ `expr $2 + $BOX_WIDTH + 1` -gt $T_COLS ]; then
81     exit $E_BADARGS
82 fi
83 if [ $3 -lt 1 ] || [ $4 -lt 1 ]; then
84     exit $E_BADARGS
85 fi
86                                     # End checking arguments.
87
87 plot_char(){                          # Function within a function.
88     echo -e "\E[${1}];${2}H"$3
89 }
90
91 echo -ne "\E[3${5}m"                   # Set box frame color, if defined.
92
93 # start drawing the box
94
95 count=1                                # Draw vertical lines using
96 for (( r=$1; count<=$BOX_HEIGHT; r++)); do    #+ plot_char function.
97     plot_char $r $2 $VERT
98     let count=count+1
99 done
100
101 count=1
102 c=`expr $2 + $BOX_WIDTH`
103 for (( r=$1; count<=$BOX_HEIGHT; r++)); do
104     plot_char $r $c $VERT

```

```

105  let count=count+1
106 done
107
108 count=1                                # Draw horizontal lines using
109 for (( c=$2; count<=$BOX_WIDTH; c++)); do    #+ plot_char function.
110  plot_char $1 $c $HORZ
111  let count=count+1
112 done
113
114 count=1
115 r=`expr $1 + $BOX_HEIGHT`
116 for (( c=$2; count<=$BOX_WIDTH; c++)); do
117  plot_char $r $c $HORZ
118  let count=count+1
119 done
120
121 plot_char $1 $2 $CORNER_CHAR                # Draw box angles.
122 plot_char $1 `expr $2 + $BOX_WIDTH` $CORNER_CHAR
123 plot_char `expr $1 + $BOX_HEIGHT` $2 $CORNER_CHAR
124 plot_char `expr $1 + $BOX_HEIGHT` `expr $2 + $BOX_WIDTH` $CORNER_CHAR
125
126 echo -ne "\E[0m"                            # Restore old colors.
127
128 P_ROWS=`expr $T_ROWS - 1`                    # Put the prompt at bottom of the terminal.
129
130 echo -e "\E[${P_ROWS}];1H"
131 }
132
133
134 # Now, let's try drawing a box.
135 clear                                        # Clear the terminal.
136 R=2      # Row
137 C=3      # Column
138 H=10     # Height
139 W=45     # Width
140 col=1    # Color (red)
141 draw_box $R $C $H $W $col    # Draw the box.
142
143 exit 0
144
145 # Exercise:
146 # -----
147 # Add the option of printing text within the drawn box.

```

The simplest, and perhaps most useful ANSI escape sequence is bold text, `\033[1m ... \033[0m`. The `\033` represents an [escape](#), the `"[1"` turns on the bold attribute, while the `"[0"` switches it off. The `"m"` terminates each term of the escape sequence.

```
bash$ echo -e "\033[1mThis is bold text.\033[0m"
```

A similar escape sequence switches on the underline attribute (on an *rxvt* and an *aterm*).

```
bash$ echo -e "\033[4mThis is underlined text.\033[0m"
```


 With an `echo`, the `-e` option enables the escape sequences.

Other escape sequences change the text and/or background color.


```
bash$ echo -e '\E[34;47mThis prints in blue.'; tput sgr0
```

```
bash$ echo -e '\E[33;44m"yellow text on blue background"; tput sgr0
```

```
bash$ echo -e '\E[1;33;44m'"BOLD yellow text on blue background"; tput sgr0
```

 It's usually advisable to set the *bold* attribute for light-colored foreground text.

The **tput sgr0** restores the terminal settings to normal. Omitting this lets all subsequent output from that particular terminal remain blue.

 Since **tput sgr0** fails to restore terminal settings under certain circumstances, **echo -ne \E[0m** may be a better choice.

Use the following template for writing colored text on a colored background.

```
echo -e '\E[COLOR1;COLOR2mSome text goes here.'
```

The "\E[" begins the escape sequence. The semicolon-separated numbers "COLOR1" and "COLOR2" specify a foreground and a background color, according to the table below. (The order of the numbers does not matter, since the foreground and background numbers fall in non-overlapping ranges.) The "m" terminates the escape sequence, and the text begins immediately after that.

Note also that [single quotes](#) enclose the remainder of the command sequence following the **echo -e**.

The numbers in the following table work for an *rxvt* terminal. Results may vary for other terminal emulators.

Table 36-1. Numbers representing colors in Escape Sequences

Color	Foreground	Background
black	30	40
red	31	41
green	32	42
yellow	33	43
blue	34	44
magenta	35	45
cyan	36	46
white	37	47

Example 36-15. Echoing colored text

```
1 #!/bin/bash
2 # color-echo.sh: Echoing text messages in color.
3
4 # Modify this script for your own purposes.
5 # It's easier than hand-coding color.
6
7 black='\E[30;47m'
8 red='\E[31;47m'
9 green='\E[32;47m'
10 yellow='\E[33;47m'
11 blue='\E[34;47m'
12 magenta='\E[35;47m'
```

```

13 cyan='\E[36;47m'
14 white='\E[37;47m'
15
16
17 alias Reset="tput sgr0"      # Reset text attributes to normal
18                             #+ without clearing screen.
19
20
21 cecho ()                    # Color-echo.
22                             # Argument $1 = message
23                             # Argument $2 = color
24 {
25 local default_msg="No message passed."
26                             # Doesn't really need to be a local variable.
27
28 message=${1:-$default_msg}  # Defaults to default message.
29 color=${2:-$black}         # Defaults to black, if not specified.
30
31 echo -e "$color"
32 echo "$message"
33 Reset                        # Reset to normal.
34
35 return
36 }
37
38
39 # Now, let's try it out.
40 # -----
41 cecho "Feeling blue..." $blue
42 cecho "Magenta looks more like purple." $magenta
43 cecho "Green with envy." $green
44 cecho "Seeing red?" $red
45 cecho "Cyan, more familiarly known as aqua." $cyan
46 cecho "No color passed (defaults to black)."
47     # Missing $color argument.
48 cecho "\"Empty\" color passed (defaults to black)." ""
49     # Empty $color argument.
50 cecho
51     # Missing $message and $color arguments.
52 cecho "" ""
53     # Empty $message and $color arguments.
54 # -----
55
56 echo
57
58 exit 0
59
60 # Exercises:
61 # -----
62 # 1) Add the "bold" attribute to the 'cecho ()' function.
63 # 2) Add options for colored backgrounds.

```

Example 36-16. A "horserace" game

```

1 #!/bin/bash
2 # horserace.sh: Very simple horserace simulation.
3 # Author: Stefano Palmeri
4 # Used with permission.
5
6 #####
7 # Goals of the script:
8 # playing with escape sequences and terminal colors.

```

```

9 #
10 # Exercise:
11 # Edit the script to make it run less randomly,
12 #+ set up a fake betting shop . . .
13 # Um . . . um . . . it's starting to remind me of a movie . . .
14 #
15 # The script gives each horse a random handicap.
16 # The odds are calculated upon horse handicap
17 #+ and are expressed in European(?) style.
18 # E.g., odds=3.75 means that if you bet $1 and win,
19 #+ you receive $3.75.
20 #
21 # The script has been tested with a GNU/Linux OS,
22 #+ using xterm and rxvt, and konsole.
23 # On a machine with an AMD 900 MHz processor,
24 #+ the average race time is 75 seconds.
25 # On faster computers the race time would be lower.
26 # So, if you want more suspense, reset the USLEEP_ARG variable.
27 #
28 # Script by Stefano Palmeri.
29 #####
30
31 E_RUNERR=65
32
33 # Check if md5sum and bc are installed.
34 if ! which bc &> /dev/null; then
35     echo bc is not installed.
36     echo "Can't run . . . "
37     exit $E_RUNERR
38 fi
39 if ! which md5sum &> /dev/null; then
40     echo md5sum is not installed.
41     echo "Can't run . . . "
42     exit $E_RUNERR
43 fi
44
45 # Set the following variable to slow down script execution.
46 # It will be passed as the argument for usleep (man usleep)
47 #+ and is expressed in microseconds (500000 = half a second).
48 USLEEP_ARG=0
49
50 # Clean up the temp directory, restore terminal cursor and
51 #+ terminal colors -- if script interrupted by Ctl-C.
52 trap 'echo -en "\E[?25h"; echo -en "\E[0m"; stty echo;\
53 tput cup 20 0; rm -fr $HORSE_RACE_TMP_DIR' TERM EXIT
54 # See the chapter on debugging for an explanation of 'trap.'
55
56 # Set a unique (paranoid) name for the temp directory the script needs.
57 HORSE_RACE_TMP_DIR=$HOME/.horserace-`date +%s`-`head -c10 /dev/urandom \
58 | md5sum | head -c30`
59
60 # Create the temp directory and move right in.
61 mkdir $HORSE_RACE_TMP_DIR
62 cd $HORSE_RACE_TMP_DIR
63
64
65 # This function moves the cursor to line $1 column $2 and then prints $3.
66 # E.g.: "move_and_echo 5 10 linux" is equivalent to
67 #+ "tput cup 4 9; echo linux", but with one command instead of two.
68 # Note: "tput cup" defines 0 0 the upper left angle of the terminal,
69 #+ echo defines 1 1 the upper left angle of the terminal.
70 move_and_echo() {
71     echo -ne "\E[${1}];${2}H"$3"
72 }
73
74 # Function to generate a pseudo-random number between 1 and 9.

```

```

75 random_1_9 ()
76 {
77     head -c10 /dev/urandom | md5sum | tr -d [a-z] | tr -d 0 | cut -c1
78 }
79
80 # Two functions that simulate "movement," when drawing the horses.
81 draw_horse_one() {
82     echo -n " "//$MOVE_HORSE//
83 }
84 draw_horse_two(){
85     echo -n " "\\\$MOVE_HORSE\\\\"
86 }
87
88
89 # Define current terminal dimension.
90 N_COLS=`tput cols`
91 N_LINES=`tput lines`
92
93 # Need at least a 20-LINES X 80-COLUMNS terminal. Check it.
94 if [ $N_COLS -lt 80 ] || [ $N_LINES -lt 20 ]; then
95     echo "`basename $0` needs a 80-cols X 20-lines terminal."
96     echo "Your terminal is ${N_COLS}-cols X ${N_LINES}-lines."
97     exit $E_RUNERR
98 fi
99
100
101 # Start drawing the race field.
102
103 # Need a string of 80 chars. See below.
104 BLANK80=`seq -s "" 100 | head -c80`
105
106 clear
107
108 # Set foreground and background colors to white.
109 echo -ne '\E[37;47m'
110
111 # Move the cursor on the upper left angle of the terminal.
112 tput cup 0 0
113
114 # Draw six white lines.
115 for n in `seq 5`; do
116     echo $BLANK80 # Use the 80 chars string to colorize the terminal.
117 done
118
119 # Sets foreground color to black.
120 echo -ne '\E[30m'
121
122 move_and_echo 3 1 "START 1"
123 move_and_echo 3 75 FINISH
124 move_and_echo 1 5 "|"
125 move_and_echo 1 80 "|"
126 move_and_echo 2 5 "|"
127 move_and_echo 2 80 "|"
128 move_and_echo 4 5 "| 2"
129 move_and_echo 4 80 "|"
130 move_and_echo 5 5 "V 3"
131 move_and_echo 5 80 "V"
132
133 # Set foreground color to red.
134 echo -ne '\E[31m'
135
136 # Some ASCII art.
137 move_and_echo 1 8 "..@@@...@@@@@...@@@@@.@...@...@@@@..."
138 move_and_echo 2 8 ".@...@...@.....@...@...@.@"
139 move_and_echo 3 8 ".@@@@@...@.....@...@@@@@.@@@@..."
140 move_and_echo 4 8 ".@...@...@.....@...@...@.@"

```



```

141 move_and_echo 5 8 ".@...@...@.....@...@...@...@...@"
142 move_and_echo 1 43 "#####.....#####.....#####....."
143 move_and_echo 2 43 "@...@...@...@...@...@...@...@...@"
144 move_and_echo 3 43 "#####.....#####.....#####....."
145 move_and_echo 4 43 "@...@...@...@...@...@...@...@...@"
146 move_and_echo 5 43 "@...@...@...@...@...@...@...@...@"
147
148
149 # Set foreground and background colors to green.
150 echo -ne '\E[32;42m'
151
152 # Draw eleven green lines.
153 tput cup 5 0
154 for n in `seq 11`; do
155     echo $BLANK80
156 done
157
158 # Set foreground color to black.
159 echo -ne '\E[30m'
160 tput cup 5 0
161
162 # Draw the fences.
163 echo "+++++\
164 +++++"
165
166 tput cup 15 0
167 echo "+++++\
168 +++++"
169
170 # Set foreground and background colors to white.
171 echo -ne '\E[37;47m'
172
173 # Draw three white lines.
174 for n in `seq 3`; do
175     echo $BLANK80
176 done
177
178 # Set foreground color to black.
179 echo -ne '\E[30m'
180
181 # Create 9 files to stores handicaps.
182 for n in `seq 10 7 68`; do
183     touch $n
184 done
185
186 # Set the first type of "horse" the script will draw.
187 HORSE_TYPE=2
188
189 # Create position-file and odds-file for every "horse".
190 #+ In these files, store the current position of the horse,
191 #+ the type and the odds.
192 for HN in `seq 9`; do
193     touch horse_${HN}_position
194     touch odds_${HN}
195     echo \-1 > horse_${HN}_position
196     echo $HORSE_TYPE >> horse_${HN}_position
197     # Define a random handicap for horse.
198     HANDICAP=`random_1_9`
199     # Check if the random_1_9 function returned a good value.
200     while ! echo $HANDICAP | grep [1-9] &> /dev/null; do
201         HANDICAP=`random_1_9`
202     done
203     # Define last handicap position for horse.
204     LHP=`expr $HANDICAP \* 7 + 3`
205     for FILE in `seq 10 7 $LHP`; do
206         echo $HN >> $FILE

```

```

207     done
208
209     # Calculate odds.
210     case $HANDICAP in
211         1) ODDS=`echo $HANDICAP \* 0.25 + 1.25 | bc`
212             echo $ODDS > odds_{$HN}
213         ;;
214         2 | 3) ODDS=`echo $HANDICAP \* 0.40 + 1.25 | bc`
215             echo $ODDS > odds_{$HN}
216         ;;
217         4 | 5 | 6) ODDS=`echo $HANDICAP \* 0.55 + 1.25 | bc`
218             echo $ODDS > odds_{$HN}
219         ;;
220         7 | 8) ODDS=`echo $HANDICAP \* 0.75 + 1.25 | bc`
221             echo $ODDS > odds_{$HN}
222         ;;
223         9) ODDS=`echo $HANDICAP \* 0.90 + 1.25 | bc`
224             echo $ODDS > odds_{$HN}
225     esac
226
227
228 done
229
230
231 # Print odds.
232 print_odds() {
233     tput cup 6 0
234     echo -ne '\E[30;42m'
235     for HN in `seq 9`; do
236         echo "#$HN odds->" `cat odds_{$HN}`
237     done
238 }
239
240 # Draw the horses at starting line.
241 draw_horses() {
242     tput cup 6 0
243     echo -ne '\E[30;42m'
244     for HN in `seq 9`; do
245         echo /\$HN/\ "
246     done
247 }
248
249 print_odds
250
251 echo -ne '\E[47m'
252 # Wait for a enter key press to start the race.
253 # The escape sequence '\E[?25l' disables the cursor.
254 tput cup 17 0
255 echo -e '\E[?25l'Press [enter] key to start the race...
256 read -s
257
258 # Disable normal echoing in the terminal.
259 # This avoids key presses that might "contaminate" the screen
260 #+ during the race.
261 stty -echo
262
263 # -----
264 # Start the race.
265
266 draw_horses
267 echo -ne '\E[37;47m'
268 move_and_echo 18 1 $BLANK80
269 echo -ne '\E[30m'
270 move_and_echo 18 1 Starting...
271 sleep 1
272

```

```

273 # Set the column of the finish line.
274 WINNING_POS=74
275
276 # Define the time the race started.
277 START_TIME=`date +%s`
278
279 # COL variable needed by following "while" construct.
280 COL=0
281
282 while [ $COL -lt $WINNING_POS ]; do
283
284     MOVE_HORSE=0
285
286     # Check if the random_1_9 function has returned a good value.
287     while ! echo $MOVE_HORSE | grep [1-9] &> /dev/null; do
288         MOVE_HORSE=`random_1_9`
289     done
290
291     # Define old type and position of the "randomized horse".
292     HORSE_TYPE=`cat horse_${MOVE_HORSE}_position | tail -n 1`
293     COL=$(expr `cat horse_${MOVE_HORSE}_position | head -n 1`)
294
295     ADD_POS=1
296     # Check if the current position is an handicap position.
297     if seq 10 7 68 | grep -w $COL &> /dev/null; then
298         if grep -w $MOVE_HORSE $COL &> /dev/null; then
299             ADD_POS=0
300             grep -v -w $MOVE_HORSE $COL > ${COL}_new
301             rm -f $COL
302             mv -f ${COL}_new $COL
303         else ADD_POS=1
304         fi
305     else ADD_POS=1
306     fi
307     COL=$(expr $COL + $ADD_POS)
308     echo $COL > horse_${MOVE_HORSE}_position # Store new position.
309
310     # Choose the type of horse to draw.
311     case $HORSE_TYPE in
312         1) HORSE_TYPE=2; DRAW_HORSE=draw_horse_two
313         ;;
314         2) HORSE_TYPE=1; DRAW_HORSE=draw_horse_one
315     esac
316     echo $HORSE_TYPE >> horse_${MOVE_HORSE}_position
317     # Store current type.
318
319     # Set foreground color to black and background to green.
320     echo -ne '\E[30;42m'
321
322     # Move the cursor to new horse position.
323     tput cup `expr $MOVE_HORSE + 5` \
324     `cat horse_${MOVE_HORSE}_position | head -n 1`
325
326     # Draw the horse.
327     $DRAW_HORSE
328     usleep $USLEEP_ARG
329
330     # When all horses have gone beyond field line 15, reprint odds.
331     touch fieldline15
332     if [ $COL = 15 ]; then
333         echo $MOVE_HORSE >> fieldline15
334     fi
335     if [ `wc -l fieldline15 | cut -f1 -d " " = 9 ]; then
336         print_odds
337         : > fieldline15
338     fi


```

```

339
340     # Define the leading horse.
341     HIGHEST_POS=`cat *position | sort -n | tail -1`
342
343     # Set background color to white.
344     echo -ne '\E[47m'
345     tput cup 17 0
346     echo -n Current leader: `grep -w $HIGHEST_POS *position | cut -c7`\
347     "
348
349 done
350
351 # Define the time the race finished.
352 FINISH_TIME=`date +%s`
353
354 # Set background color to green and enable blinking text.
355 echo -ne '\E[30;42m'
356 echo -en '\E[5m'
357
358 # Make the winning horse blink.
359 tput cup `expr $MOVE_HORSE + 5` \
360 `cat horse_${MOVE_HORSE}_position | head -n 1`
361 $DRAW_HORSE
362
363 # Disable blinking text.
364 echo -en '\E[25m'
365
366 # Set foreground and background color to white.
367 echo -ne '\E[37;47m'
368 move_and_echo 18 1 $BLANK80
369
370 # Set foreground color to black.
371 echo -ne '\E[30m'
372
373 # Make winner blink.
374 tput cup 17 0
375 echo -e "\E[5mWINNER: $MOVE_HORSE\E[25m"" Odds: `cat odds_${MOVE_HORSE}`""
376 " Race time: `expr $FINISH_TIME - $START_TIME` secs"
377
378 # Restore cursor and old colors.
379 echo -en "\E[?25h"
380 echo -en "\E[0m"
381
382 # Restore echoing.
383 stty echo
384
385 # Remove race temp directory.
386 rm -rf $HORSE_RACE_TMP_DIR
387
388 tput cup 19 0
389
390 exit 0

```

See also [Example A-21](#), [Example A-44](#), [Example A-52](#), and [Example A-40](#).

 There is, however, a major problem with all this. *ANSI escape sequences are emphatically non-portable*. What works fine on some terminal emulators (or the console) may work differently, or not at all, on others. A "colorized" script that looks stunning on the script author's machine may produce unreadable output on someone else's. This somewhat compromises the usefulness of colorizing scripts, and possibly relegates this technique to the status of a gimmick. Colorized scripts are probably inappropriate in a commercial setting, i.e., your supervisor might disapprove.

Alister's [ansi-color](#) utility (based on [Moshe Jacobson's color utility](#)) considerably simplifies using ANSI escape sequences. It substitutes a clean and logical syntax for the clumsy constructs just discussed.

Henry/teikedvl has likewise created a utility (<http://scriptechocolor.sourceforge.net/>) to simplify creation of colorized scripts.

Notes

- [1] ANSI is, of course, the acronym for the American National Standards Institute. This august body establishes and maintains various technical and industrial standards.

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Optimizations

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36.6. Optimizations

Most shell scripts are quick 'n dirty solutions to non-complex problems. As such, optimizing them for speed is not much of an issue. Consider the case, though, where a script carries out an important task, does it well, but runs too slowly. Rewriting it in a compiled language may not be a palatable option. The simplest fix would be to rewrite the parts of the script that slow it down. Is it possible to apply principles of code optimization even to a lowly shell script?

Check the loops in the script. Time consumed by repetitive operations adds up quickly. If at all possible, remove time-consuming operations from within loops.

Use [builtin](#) commands in preference to system commands. Builtins execute faster and usually do not launch a subshell when invoked.

Avoid unnecessary commands, particularly in a [pipe](#).

```
1 cat "$file" | grep "$word"
2
3 grep "$word" "$file"
4
5 # The above command-lines have an identical effect,
6 #+ but the second runs faster since it launches one fewer subprocess.
```

The [cat](#) command seems especially prone to overuse in scripts.


Disabling certain Bash options can speed up scripts.

As Erik Brandsberg points out:

If you don't need [Unicode](#) support, you can get potentially a 2x or more improvement in speed by simply setting the **LC_ALL** variable.

```
1 export LC_ALL=C
2
3 [specifies the locale as ANSI C,
4 thereby disabling Unicode support]
5
6 [In an example script ...]
7
8 Without [Unicode support]:
9 erik@erik-desktop:~/capture$ time ./cap-ngrep.sh
10 live2.pcap > out.txt
11
12 real    0m20.483s
13 user    1m34.470s
14 sys     0m12.869s
15
16 With [Unicode support]:
17 erik@erik-desktop:~/capture$ time ./cap-ngrep.sh
18 live2.pcap > out.txt
19
20 real    0m50.232s
21 user    3m51.118s
22 sys     0m11.221s
23
24 A large part of the overhead that is optimized is, I believe,
```


```
25 regex match using [[ string =~ REGEX ]],
26 but it may help with other portions of the code as well.
27 I hadn't [seen it] mentioned that this optimization helped
28 with Bash, but I had seen it helped with "grep,"
29 so why not try?
```

 Certain operators, notably [expr](#), are very inefficient and might be replaced by [double parentheses](#) arithmetic expansion. See [Example A-59](#).

```
1 Math tests
2
3 math via $(( ))
4 real          0m0.294s
5 user          0m0.288s
6 sys          0m0.008s
7
8 math via expr:
9 real          1m17.879s  # Much slower!
10 user         0m3.600s
11 sys          0m8.765s
12
13 math via let:
14 real          0m0.364s
15 user          0m0.372s
16 sys          0m0.000s
```

[Condition testing](#) constructs in scripts deserve close scrutiny. Substitute [case](#) for [if-then](#) constructs and combine tests when possible, to minimize script execution time. Again, refer to [Example A-59](#).

```
1 Test using "case" construct:
2 real          0m0.329s
3 user          0m0.320s
4 sys          0m0.000s
5
6
7 Test with if [], no quotes:
8 real          0m0.438s
9 user          0m0.432s
10 sys          0m0.008s
11
12
13 Test with if [], quotes:
14 real          0m0.476s
15 user          0m0.452s
16 sys          0m0.024s
17
18
19 Test with if [], using -eq:
20 real          0m0.457s
21 user          0m0.456s
22 sys          0m0.000s
```

 Erik Brandsberg recommends using [associative arrays](#) in preference to conventional numeric-indexed arrays in most cases. When overwriting values in a numeric array, there is a significant performance penalty vs. associative arrays. Running a test script confirms this. See [Example A-60](#).

```
1 Assignment tests
2
3 Assigning a simple variable
4 real          0m0.418s
5 user          0m0.416s
6 sys          0m0.004s
```



```

7
8 Assigning a numeric index array entry
9 real          0m0.582s
10 user         0m0.564s
11 sys          0m0.016s
12
13 Overwriting a numeric index array entry
14 real          0m21.931s
15 user         0m21.913s
16 sys          0m0.016s
17
18 Linear reading of numeric index array
19 real          0m0.422s
20 user         0m0.416s
21 sys          0m0.004s
22
23 Assigning an associative array entry
24 real          0m1.800s
25 user         0m1.796s
26 sys          0m0.004s
27
28 Overwriting an associative array entry
29 real          0m1.798s
30 user         0m1.784s
31 sys          0m0.012s
32
33 Linear reading an associative array entry
34 real          0m0.420s
35 user         0m0.420s
36 sys          0m0.000s
37
38 Assigning a random number to a simple variable
39 real          0m0.402s
40 user         0m0.388s
41 sys          0m0.016s
42
43 Assigning a sparse numeric index array entry randomly into 64k cells
44 real          0m12.678s
45 user         0m12.649s
46 sys          0m0.028s
47
48 Reading sparse numeric index array entry
49 real          0m0.087s
50 user         0m0.084s
51 sys          0m0.000s
52
53 Assigning a sparse associative array entry randomly into 64k cells
54 real          0m0.698s
55 user         0m0.696s
56 sys          0m0.004s
57
58 Reading sparse associative index array entry
59 real          0m0.083s
60 user         0m0.084s
61 sys          0m0.000s

```

Use the [time](#) and [times](#) tools to profile computation-intensive commands. Consider rewriting time-critical code sections in C, or even in assembler.

Try to minimize file I/O. Bash is not particularly efficient at handling files, so consider using more appropriate tools for this within the script, such as [awk](#) or [Perl](#).

Write your scripts in a modular and coherent form, [\[1\]](#) so they can be reorganized and tightened up as necessary. Some of the optimization techniques applicable to high-level languages may work for scripts, but others, such as *loop unrolling*, are mostly irrelevant. Above all, use common sense.

For an excellent demonstration of how optimization can dramatically reduce the execution time of a script, see [Example 16-47](#).

Notes

[1] This usually means liberal use of [functions](#).

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36.7. Assorted Tips

36.7.1. Ideas for more powerful scripts

- You have a problem that you want to solve by writing a Bash script. Unfortunately, you don't know quite where to start. One method is to plunge right in and code those parts of the script that come easily, and write the hard parts as *pseudo-code*.

```
1 #!/bin/bash
2
3 ARGCOUNT=1                # Need name as argument.
4 E_WRONGARGS=65
5
6 if [ number-of-arguments is-not-equal-to "$ARGCOUNT" ]
7 #   ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
8 #   Can't figure out how to code this . . .
9 #+ . . . so write it in pseudo-code.
10
11 then
12     echo "Usage: name-of-script name"
13 #     ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
14     exit $E_WRONGARGS
15 fi
16
17 . . .
18
19 exit 0
20
21
22 # Later on, substitute working code for the pseudo-code.
23
24 # Line 6 becomes:
25 if [ $# -ne "$ARGCOUNT" ]
26
27 # Line 12 becomes:
28     echo "Usage: `basename $0` name"
```

For an example of using pseudo-code, see the [Square Root](#) exercise.

- To keep a record of which user scripts have run during a particular session or over a number of sessions, add the following lines to each script you want to keep track of. This will keep a continuing file record of the script names and invocation times.

```
1 # Append (>>) following to end of each script tracked.
2
3 whoami>> $SAVE_FILE        # User invoking the script.
4 echo $0>> $SAVE_FILE      # Script name.
5 date>> $SAVE_FILE         # Date and time.
6 echo>> $SAVE_FILE        # Blank line as separator.
7
8 # Of course, SAVE_FILE defined and exported as environmental variable in ~/.bashrc
9 #+ (something like ~/.scripts-run)
```

The >> operator *appends* lines to a file. What if you wish to *prepend* a line to an existing file, that is, to paste it in at the beginning?

```
1 file=data.txt
2 title="***This is the title line of data text file***"
3
4 echo $title | cat - $file >$file.new
```

```

5 # "cat -" concatenates stdout to $file.
6 # End result is
7 #+ to write a new file with $title appended at *beginning*.

```

This is a simplified variant of the [Example 19-13](#) script given earlier. And, of course, [sed](#) can also do this.

- A shell script may act as an embedded command inside another shell script, a *Tcl* or *wish* script, or even a [Makefile](#). It can be invoked as an external shell command in a C program using the `system()` call, i.e., `system("script_name");`.
- Setting a variable to the contents of an embedded *sed* or *awk* script increases the readability of the surrounding [shell wrapper](#). See [Example A-1](#) and [Example 15-20](#).
- Put together files containing your favorite and most useful definitions and functions. As necessary, "include" one or more of these "library files" in scripts with either the [dot](#) (`.`) or [source](#) command.

```

1 # SCRIPT LIBRARY
2 # -----
3
4 # Note:
5 # No "#!" here.
6 # No "live code" either.
7
8
9 # Useful variable definitions
10
11 ROOT_UID=0           # Root has $UID 0.
12 E_NOTROOT=101       # Not root user error.
13 MAXRETVAL=255       # Maximum (positive) return value of a function.
14 SUCCESS=0
15 FAILURE=-1
16
17
18
19 # Functions
20
21 Usage ()             # "Usage:" message.
22 {
23     if [ -z "$1" ]   # No arg passed.
24     then
25         msg=filename
26     else
27         msg=$@
28     fi
29
30     echo "Usage: `basename $0` "$msg"
31 }
32
33
34 Check_if_root ()    # Check if root running script.
35 {                  # From "ex39.sh" example.
36     if [ "$UID" -ne "$ROOT_UID" ]
37     then
38         echo "Must be root to run this script."
39         exit $E_NOTROOT
40     fi
41 }
42
43
44 CreateTempfileName () # Creates a "unique" temp filename.
45 {                    # From "ex51.sh" example.
46     prefix=temp
47     suffix=`eval date +%s`

```

```

48 Tempfilename=$prefix.$suffix
49 }
50
51
52 isalpha2 ()          # Tests whether *entire string* is alphabetic.
53 {                  # From "isalpha.sh" example.
54   [ $# -eq 1 ] || return $FAILURE
55
56   case $1 in
57     *[^a-zA-Z]*|") return $FAILURE;;
58     *) return $SUCCESS;;
59   esac             # Thanks, S.C.
60 }
61
62
63 abs ()              # Absolute value.
64 {                  # Caution: Max return value = 255.
65   E_ARGERR=-999999
66
67   if [ -z "$1" ]   # Need arg passed.
68   then
69     return $E_ARGERR # Obvious error value returned.
70   fi
71
72   if [ "$1" -ge 0 ] # If non-negative,
73   then              #
74     absval=$1      # stays as-is.
75   else              # Otherwise,
76     let "absval = (( 0 - $1 ))" # change sign.
77   fi
78
79   return $absval
80 }
81
82
83 tolower ()         # Converts string(s) passed as argument(s)
84 {                 #+ to lowercase.
85
86   if [ -z "$1" ]   # If no argument(s) passed,
87   then              #+ send error message
88     echo "(null)"  #+ (C-style void-pointer error message)
89     return          #+ and return from function.
90   fi
91
92   echo "$@" | tr A-Z a-z
93   # Translate all passed arguments ($@).
94
95   return
96
97 # Use command substitution to set a variable to function output.
98 # For example:
99 #   oldvar="A seT of miXed-caSe LEtTerS"
100 #   newvar=`tolower "$oldvar"`
101 #   echo "$newvar" # a set of mixed-case letters
102 #
103 # Exercise: Rewrite this function to change lowercase passed argument(s)
104 #           to uppercase ... toupper() [easy].
105 }

```

• Use special-purpose comment headers to increase clarity and legibility in scripts.

```

1 ## Caution.
2 rm -rf *.zzy ## The "-rf" options to "rm" are very dangerous,
3               ##+ especially with wild cards.
4

```

```

5 #+ Line continuation.
6 # This is line 1
7 #+ of a multi-line comment,
8 #+ and this is the final line.
9
10 #* Note.
11
12 #o List item.
13
14 #> Another point of view.
15 while [ "$var1" != "end" ]      #> while test "$var1" != "end"

```

• Dotan Barak contributes template code for a *progress bar* in a script.

Example 36-17. A Progress Bar

```

1 #!/bin/bash
2 # progress-bar.sh
3
4 # Author: Dotan Barak (very minor revisions by ABS Guide author).
5 # Used in ABS Guide with permission (thanks!).
6
7
8 BAR_WIDTH=50
9 BAR_CHAR_START="["
10 BAR_CHAR_END="]"
11 BAR_CHAR_EMPTY="."
12 BAR_CHAR_FULL="="
13 BRACKET_CHARS=2
14 LIMIT=100
15
16 print_progress_bar()
17 {
18     # Calculate how many characters will be full.
19     let "full_limit = ((( $1 - $BRACKET_CHARS ) * $2) / $LIMIT)"
20
21     # Calculate how many characters will be empty.
22     let "empty_limit = ( $1 - $BRACKET_CHARS ) - ${full_limit}"
23
24     # Prepare the bar.
25     bar_line="${BAR_CHAR_START}"
26     for ((j=0; j<full_limit; j++)); do
27         bar_line="${bar_line}${BAR_CHAR_FULL}"
28     done
29
30     for ((j=0; j<empty_limit; j++)); do
31         bar_line="${bar_line}${BAR_CHAR_EMPTY}"
32     done
33
34     bar_line="${bar_line}${BAR_CHAR_END}"
35
36     printf "%3d%% %s" $2 ${bar_line}
37 }
38
39 # Here is a sample of code that uses it.
40 MAX_PERCENT=100
41 for ((i=0; i<=MAX_PERCENT; i++)); do
42     #
43     usleep 10000
44     # ... Or run some other commands ...
45     #
46     print_progress_bar ${BAR_WIDTH} ${i}
47     echo -en "\r"

```

```
48 done
49
50 echo ""
51
52 exit
```

- A particularly clever use of [if-test](#) constructs is for comment blocks.

```
1 #!/bin/bash
2
3 COMMENT_BLOCK=
4 # Try setting the above variable to some value
5 #+ for an unpleasant surprise.
6
7 if [ $COMMENT_BLOCK ]; then
8
9 Comment block --
10 =====
11 This is a comment line.
12 This is another comment line.
13 This is yet another comment line.
14 =====
15
16 echo "This will not echo."
17
18 Comment blocks are error-free! Whee!
19
20 fi
21
22 echo "No more comments, please."
23
24 exit 0
```

- Compare this with [using here documents to comment out code blocks](#).

- Using the [\\$? exit status variable](#), a script may test if a parameter contains only digits, so it can be treated as an integer.

```
1 #!/bin/bash
2
3 SUCCESS=0
4 E_BADINPUT=85
5
6 test "$1" -ne 0 -o "$1" -eq 0 2>/dev/null
7 # An integer is either equal to 0 or not equal to 0.
8 # 2>/dev/null suppresses error message.
9
10 if [ $? -ne "$SUCCESS" ]
11 then
12     echo "Usage: `basename $0` integer-input"
13     exit $E_BADINPUT
14 fi
15
16 let "sum = $1 + 25" # Would give error if $1 not integer.
17 echo "Sum = $sum"
18
19 # Any variable, not just a command-line parameter, can be tested this way.
20
21 exit 0
```

- The 0 - 255 range for function return values is a severe limitation. Global variables and other workarounds are often problematic. An alternative method for a function to communicate a value back to the main body of the script is to have the function write to stdout (usually with [echo](#)) the

"return value," and assign this to a variable. This is actually a variant of [command substitution](#).

Example 36-18. Return value trickery

```
1 #!/bin/bash
2 # multiplication.sh
3
4 multiply ()                # Multiplies params passed.
5 {                          # Will accept a variable number of args.
6
7     local product=1
8
9     until [ -z "$1" ]      # Until uses up arguments passed...
10    do
11        let "product *= $1"
12        shift
13    done
14
15    echo $product           # Will not echo to stdout,
16 }                          #+ since this will be assigned to a variable.
17
18 mult1=15383; mult2=25211
19 val1=`multiply $mult1 $mult2`
20 # Assigns stdout (echo) of function to the variable val1.
21 echo "$mult1 X $mult2 = $val1"          # 387820813
22
23 mult1=25; mult2=5; mult3=20
24 val2=`multiply $mult1 $mult2 $mult3`
25 echo "$mult1 X $mult2 X $mult3 = $val2" # 2500
26
27 mult1=188; mult2=37; mult3=25; mult4=47
28 val3=`multiply $mult1 $mult2 $mult3 $mult4`
29 echo "$mult1 X $mult2 X $mult3 X $mult4 = $val3" # 8173300
30
31 exit 0
```

The same technique also works for alphanumeric strings. This means that a function can "return" a non-numeric value.

```
1 capitalize_ichar ()        # Capitalizes initial character
2 {                          #+ of argument string(s) passed.
3
4     string0="$@"           # Accepts multiple arguments.
5
6     firstchar=${string0:0:1} # First character.
7     string1=${string0:1}    # Rest of string(s).
8
9     FirstChar=`echo "$firstchar" | tr a-z A-Z`
10                    # Capitalize first character.
11
12     echo "$FirstChar$string1" # Output to stdout.
13
14 }
15
16 newstring=`capitalize_ichar "every sentence should start with a capital letter."`
17 echo "$newstring"         # Every sentence should start with a capital letter.
```


It is even possible for a function to "return" multiple values with this method.

Example 36-19. Even more return value trickery

```

1 #!/bin/bash
2 # sum-product.sh
3 # A function may "return" more than one value.
4
5 sum_and_product () # Calculates both sum and product of passed args.
6 {
7     echo $(( $1 + $2 )) $(( $1 * $2 ))
8 # Echoes to stdout each calculated value, separated by space.
9 }
10
11 echo
12 echo "Enter first number "
13 read first
14
15 echo
16 echo "Enter second number "
17 read second
18 echo
19
20 retval=`sum_and_product $first $second` # Assigns output of function.
21 sum=`echo "$retval" | awk '{print $1}'` # Assigns first field.
22 product=`echo "$retval" | awk '{print $2}'` # Assigns second field.
23
24 echo "$first + $second = $sum"
25 echo "$first * $second = $product"
26 echo
27
28 exit 0

```

 There can be only **one** *echo* statement in the function for this to work. If you alter the previous example:

```

1 sum_and_product ()
2 {
3     echo "This is the sum_and_product function." # This messes things up!
4     echo $(( $1 + $2 )) $(( $1 * $2 ))
5 }
6 ...
7 retval=`sum_and_product $first $second` # Assigns output of function.
8 # Now, this will not work correctly.

```

Next in our bag of tricks are techniques for passing an [array](#) to a [function](#), then "returning" an array back to the main body of the script.

Passing an array involves loading the space-separated elements of the array into a variable with [command substitution](#). Getting an array back as the "return value" from a function uses the previously mentioned strategem of [echoing](#) the array in the function, then invoking command substitution and the (...) operator to assign it to an array.

Example 36-20. Passing and returning arrays

```

1 #!/bin/bash
2 # array-function.sh: Passing an array to a function and ...
3 # "returning" an array from a function
4
5
6 Pass_Array ()
7 {
8     local passed_array # Local variable!
9     passed_array=( `echo "$1"` )

```

```

10 echo "${passed_array[@]}"
11 # List all the elements of the new array
12 #+ declared and set within the function.
13 }
14
15
16 original_array=( element1 element2 element3 element4 element5 )
17
18 echo
19 echo "original_array = ${original_array[@]}"
20 # List all elements of original array.
21
22
23 # This is the trick that permits passing an array to a function.
24 # *****
25 argument=`echo ${original_array[@]}`
26 # *****
27 # Pack a variable
28 #+ with all the space-separated elements of the original array.
29 #
30 # Attempting to just pass the array itself will not work.
31
32
33 # This is the trick that allows grabbing an array as a "return value".
34 # *****
35 returned_array=( `Pass_Array "$argument"` )
36 # *****
37 # Assign 'echoed' output of function to array variable.
38
39 echo "returned_array = ${returned_array[@]}"
40
41 echo "=====
42
43 # Now, try it again,
44 #+ attempting to access (list) the array from outside the function.
45 Pass_Array "$argument"
46
47 # The function itself lists the array, but ...
48 #+ accessing the array from outside the function is forbidden.
49 echo "Passed array (within function) = ${passed_array[@]}"
50 # NULL VALUE since the array is a variable local to the function.
51
52 echo
53
54 #####
55
56 # And here is an even more explicit example:
57
58 ret_array ()
59 {
60     for element in {11..20}
61     do
62         echo "$element " # Echo individual elements
63     done #+ of what will be assembled into an array.
64 }
65
66 arr=( $(ret_array) ) # Assemble into array.
67
68 echo "Capturing array \"arr\" from function ret_array () ..."
69 echo "Third element of array \"arr\" is ${arr[2]}." # 13 (zero-indexed)
70 echo -n "Entire array is: "
71 echo ${arr[@]} # 11 12 13 14 15 16 17 18 19 20
72
73 echo
74
75 exit 0

```

```
76
77 # Nathan Coulter points out that passing arrays with elements containing
78 #+ whitespace breaks this example.
```

For a more elaborate example of passing arrays to functions, see [Example A-10](#).

- Using the [double-parentheses construct](#), it is possible to use C-style syntax for setting and incrementing/decrementing variables and in [for](#) and [while](#) loops. See [Example 11-13](#) and [Example 11-18](#).
- Setting the [path](#) and [umask](#) at the beginning of a script makes it more [portable](#) -- more likely to run on a "foreign" machine whose user may have bollixed up the \$PATH and **umask**.

```
1 #!/bin/bash
2 PATH=/bin:/usr/bin:/usr/local/bin ; export PATH
3 umask 022 # Files that the script creates will have 755 permission.
4
5 # Thanks to Ian D. Allen, for this tip.
```

A useful scripting technique is to *repeatedly* feed the output of a filter (by piping) back to the *same* filter, but with a different set of arguments and/or options. Especially suitable for this are [tr](#) and [grep](#).

```
1 # From "wstrings.sh" example.
2
3 wlist=`strings "$1" | tr A-Z a-z | tr '[:space:]' Z | \
4 tr -cs '[:alpha:]' Z | tr -s '\173-\377' Z | tr Z ' '`
```

Example 36-21. Fun with anagrams

```
1 #!/bin/bash
2 # agram.sh: Playing games with anagrams.
3
4 # Find anagrams of...
5 LETTERSET=etaoinshrdlu
6 FILTER='.....' # How many letters minimum?
7 # 1234567
8
9 anagram "$LETTERSET" | # Find all anagrams of the letterset...
10 grep "$FILTER" | # With at least 7 letters,
11 grep '^is' | # starting with 'is'
12 grep -v 's$' | # no plurals
13 grep -v 'ed$' # no past tense verbs
14 # Possible to add many combinations of conditions and filters.
15
16 # Uses "anagram" utility
17 #+ that is part of the author's "yaw1" word list package.
18 # http://ibiblio.org/pub/Linux/libs/yaw1-0.3.2.tar.gz
19 # http://bash.deta.in/yaw1-0.3.2.tar.gz
20
21 exit 0 # End of code.
22
23
24 bash$ sh agram.sh
25 islander
26 isolate
27 isolead
28 isothermal
29
30
31
```

```

32 # Exercises:
33 # -----
34 # Modify this script to take the LETTERSET as a command-line parameter.
35 # Parameterize the filters in lines 11 - 13 (as with $FILTER),
36 #+ so that they can be specified by passing arguments to a function.
37
38 # For a slightly different approach to anagramming,
39 #+ see the agram2.sh script.

```

See also [Example 29-4](#), [Example 16-25](#), and [Example A-9](#).

- Use "[anonymous here documents](#)" to comment out blocks of code, to save having to individually comment out each line with a #. See [Example 19-11](#).

- Running a script on a machine that relies on a command that might not be installed is dangerous. Use [whatis](#) to avoid potential problems with this.

```

1  CMD=command1          # First choice.
2  PlanB=command2       # Fallback option.
3
4  command_test=$(whatis "$CMD" | grep 'nothing appropriate')
5  # If 'command1' not found on system, 'whatis' will return
6  #+ "command1: nothing appropriate."
7  #
8  # A safer alternative is:
9  #     command_test=$(whereis "$CMD" | grep \/)
10 # But then the sense of the following test would have to be reversed,
11 #+ since the $command_test variable holds content only if
12 #+ the $CMD exists on the system.
13 #     (Thanks, bojster.)
14
15
16 if [[ -z "$command_test" ]] # Check whether command present.
17 then
18     $CMD option1 option2    # Run command1 with options.
19 else
20     $PlanB                 #+ run command2.
21 fi

```

- An [if-grep test](#) may not return expected results in an error case, when text is output to stderr, rather than stdout.

```

1 if ls -l nonexistent_filename | grep -q 'No such file or directory'
2 then echo "File \"nonexistent_filename\" does not exist."
3 fi

```

[Redirecting](#) stderr to stdout fixes this.

```

1 if ls -l nonexistent_filename 2>&1 | grep -q 'No such file or directory'
2 #
3 then echo "File \"nonexistent_filename\" does not exist."
4 fi
5
6 # Thanks, Chris Martin, for pointing this out.

```

- If you absolutely must access a subshell variable outside the subshell, here's a way to do it.

```

1 TMPFILE=tmpfile          # Create a temp file to store the variable.
2
3 ( # Inside the subshell ...
4 inner_variable=Inner
5 echo $inner_variable
6 echo $inner_variable >>$TMPFILE # Append to temp file.

```

```

7 )
8
9     # Outside the subshell ...
10
11 echo; echo "-----"; echo
12 echo $inner_variable           # Null, as expected.
13 echo "-----"; echo
14
15 # Now ...
16 read inner_variable <$TMPFILE  # Read back shell variable.
17 rm -f "$TMPFILE"              # Get rid of temp file.
18 echo "$inner_variable"         # It's an ugly kludge, but it works.

```

- The [run-parts](#) command is handy for running a set of command scripts in a particular sequence, especially in combination with [cron](#) or [at](#).

- For doing multiple revisions on a complex script, use the *rcs* Revision Control System package.

Among other benefits of this is automatically updated ID header tags. The **co** command in *rcs* does a parameter replacement of certain reserved key words, for example, replacing # *\$Id\$* in a script with something like:

```
1 # $Id: hello-world.sh,v 1.1 2004/10/16 02:43:05 bozo Exp $
```

36.7.2. Widgets

It would be nice to be able to invoke X-Windows widgets from a shell script. There happen to exist several packages that purport to do so, namely *Xscript*, *Xmenu*, and *widtools*. The first two of these no longer seem to be maintained. Fortunately, it is still possible to obtain *widtools* [here](#).

- ⚠ The *widtools* (widget tools) package requires the *XForms* library to be installed. Additionally, the [Makefile](#) needs some judicious editing before the package will build on a typical Linux system. Finally, three of the six widgets offered do not work (and, in fact, segfault).

The *dialog* family of tools offers a method of calling "dialog" widgets from a shell script. The original *dialog* utility works in a text console, but its successors, *gdialog*, *Xdialog*, and *kdialog* use X-Windows-based widget sets.

Example 36-22. Widgets invoked from a shell script

```

1 #!/bin/bash
2 # dialog.sh: Using 'gdialog' widgets.
3
4 # Must have 'gdialog' installed on your system to run this script.
5 # Or, you can replace all instance of 'gdialog' below with 'kdialog' ...
6 # Version 1.1 (corrected 04/05/05)
7
8 # This script was inspired by the following article.
9 #     "Scripting for X Productivity," by Marco Fioretti,
10 #     LINUX JOURNAL, Issue 113, September 2003, pp. 86-9.
11 # Thank you, all you good people at LJ.
12
13
14 # Input error in dialog box.
15 E_INPUT=85
16 # Dimensions of display, input widgets.

```

```

17 HEIGHT=50
18 WIDTH=60
19
20 # Output file name (constructed out of script name).
21 OUTFILE=$0.output
22
23 # Display this script in a text widget.
24 gdialog --title "Displaying: $0" --textbox $0 $HEIGHT $WIDTH
25
26
27
28 # Now, we'll try saving input in a file.
29 echo -n "VARIABLE=" > $OUTFILE
30 gdialog --title "User Input" --inputbox "Enter variable, please:" \
31 $HEIGHT $WIDTH 2>> $OUTFILE
32
33
34 if [ "$?" -eq 0 ]
35 # It's good practice to check exit status.
36 then
37     echo "Executed \"dialog box\" without errors."
38 else
39     echo "Error(s) in \"dialog box\" execution."
40         # Or, clicked on "Cancel", instead of "OK" button.
41     rm $OUTFILE
42     exit $_INPUT
43 fi
44
45
46
47 # Now, we'll retrieve and display the saved variable.
48 . $OUTFILE # 'Source' the saved file.
49 echo "The variable input in the \"input box\" was: \"$VARIABLE\""
50
51
52 rm $OUTFILE # Clean up by removing the temp file.
53             # Some applications may need to retain this file.
54
55 exit $?
56
57 # Exercise: Rewrite this script using the 'zenity' widget set.

```

The [xmessage](#) command is a simple method of popping up a message/query window. For example:

```
1 xmessage Fatal error in script! -button exit
```

The latest entry in the widget sweepstakes is [zenity](#). This utility pops up *GTK+* dialog widgets-and-windows, and it works very nicely within a script.

```

1 get_info ()
2 {
3     zenity --entry          # Pops up query window . . .
4                             #+ and prints user entry to stdout.
5
6                             # Also try the --calendar and --scale options.
7 }
8
9 answer=$( get_info ) # Capture stdout in $answer variable.
10
11 echo "User entered: \"$answer\""

```

For other methods of scripting with widgets, try *Tk* or *wish* (*Tcl* derivatives), *PerlTk* (*Perl* with *Tk* extensions), *tksh* (*ksh* with *Tk* extensions), *XForms4Perl* (*Perl* with *XForms* extensions), *Gtk-Perl* (*Perl* with *Gtk* extensions), or *PyQt* (*Python* with *Qt* extensions).

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36.8. Security Issues

36.8.1. Infected Shell Scripts

A brief warning about script security is indicated. A shell script may contain a *worm*, *trojan*, or even a *virus*. For that reason, never run as *root* a script (or permit it to be inserted into the system startup scripts in `/etc/rc.d`) unless you have obtained said script from a trusted source or you have carefully analyzed it to make certain it does nothing harmful.

Various researchers at Bell Labs and other sites, including M. Douglas McIlroy, Tom Duff, and Fred Cohen have investigated the implications of shell script viruses. They conclude that it is all too easy for even a novice, a "script kiddie," to write one. [\[1\]](#)

Here is yet another reason to learn scripting. Being able to look at and understand scripts may protect your system from being compromised by a rogue script.

36.8.2. Hiding Shell Script Source

For security purposes, it may be necessary to render a script unreadable. If only there were a utility to create a stripped binary executable from a script. Francisco Rosales' [shc -- generic shell script compiler](#) does exactly that.

Unfortunately, according to [an article](#) in the October, 2005 *Linux Journal*, the binary can, in at least some cases, be decrypted to recover the original script source. Still, this could be a useful method of keeping scripts secure from all but the most skilled hackers.

36.8.3. Writing Secure Shell Scripts

Dan Stromberg suggests the following guidelines for writing (relatively) secure shell scripts.

- Don't put secret data in [environment variables](#).
- Don't pass secret data in an external command's arguments (pass them in via a [pipe](#) or [redirection](#) instead).
- Set your `$PATH` carefully. Don't just trust whatever path you inherit from the caller if your script is running as *root*. In fact, whenever you use an environment variable inherited from the caller, think about what could happen if the caller put something misleading in the variable, e.g., if the caller set `$HOME` to `/etc`.

Notes

[\[1\]](#) See Marius van Oers' article, [Unix Shell Scripting Malware](#), and also the [Denning reference](#) in the *bibliography*.

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Portability Issues

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36.9. Portability Issues

It is easier to port a shell than a shell script.

--Larry Wall

This book deals specifically with Bash scripting on a GNU/Linux system. All the same, users of **sh** and **ksh** will find much of value here.

As it happens, many of the various shells and scripting languages seem to be converging toward the [POSIX 1003.2](#) standard. Invoking Bash with the `--posix` option or inserting a `set -o posix` at the head of a script causes Bash to conform very closely to this standard. Another alternative is to use a `#!/bin/sh` [sha-bang header](#) in the script, rather than `#!/bin/bash`. [1] Note that `/bin/sh` is a [link](#) to `/bin/bash` in Linux and certain other flavors of UNIX, and a script invoked this way disables extended Bash functionality.

Most Bash scripts will run as-is under **ksh**, and vice-versa, since Chet Ramey has been busily porting **ksh** features to the latest versions of Bash.

On a commercial UNIX machine, scripts using GNU-specific features of standard commands may not work. This has become less of a problem in the last few years, as the GNU utilities have pretty much displaced their proprietary counterparts even on "big-iron" UNIX. [Caldera's release of the source](#) to many of the original UNIX utilities has accelerated the trend.

Bash has certain features that the traditional [Bourne shell](#) lacks. Among these are:

- Certain extended [invocation options](#)
- [Command substitution](#) using `$()` notation
- [Brace expansion](#)
- Certain [array](#) operations, and [associative arrays](#)
- The [double brackets](#) extended test construct
- The [double-parentheses](#) arithmetic-evaluation construct
- Certain [string manipulation](#) operations
- [Process substitution](#)
- A Regular Expression [matching operator](#)
- Bash-specific [builtins](#)
- [Coproceses](#)

See the [Bash F.A.Q.](#) for a complete listing.

36.9.1. A Test Suite

Let us illustrate some of the incompatibilities between Bash and the classic Bourne shell. Download and install the ["Heirloom Bourne Shell"](#) and run the following script, first using Bash, then the classic `sh`.

Example 36-23. Test Suite

```
1 #!/bin/bash
2 # test-suite.sh
3 # A partial Bash compatibility test suite.
4 # Run this on your version of Bash, or some other shell.
5
6 default_option=FAIL          # Tests below will fail unless . . .
7
```

```
8 echo
9 echo -n "Testing "
10 sleep 1; echo -n ". "
11 sleep 1; echo -n ". "
12 sleep 1; echo ". "
13 echo
14
15 # Double brackets
16 String="Double brackets supported?"
17 echo -n "Double brackets test: "
18 if [[ "$String" = "Double brackets supported?" ]]
19 then
20     echo "PASS"
21 else
22     echo "FAIL"
23 fi
24
25
26 # Double brackets and regex matching
27 String="Regex matching supported?"
28 echo -n "Regex matching: "
29 if [[ "$String" =~ R.....matching* ]]
30 then
31     echo "PASS"
32 else
33     echo "FAIL"
34 fi
35
36
37 # Arrays
38 test_arr=$default_option      # FAIL
39 Array=( If supports arrays will print PASS )
40 test_arr=${Array[5]}
41 echo "Array test: $test_arr"
42
43
44 # Command Substitution
45 csub_test ()
46 {
47     echo "PASS"
48 }
49
50 test_csub=$default_option     # FAIL
51 test_csub=$(csub_test)
52 echo "Command substitution test: $test_csub"
53
54 echo
55
56 # Completing this script is an exercise for the reader.
57 # Add to the above similar tests for double parentheses,
58 #+ brace expansion, process substitution, etc.
59
60 exit $?
```

Notes

[1] Or, better yet, [#!/bin/env sh](#).

36.10. Shell Scripting Under Windows

Even users running *that other* OS can run UNIX-like shell scripts, and therefore benefit from many of the lessons of this book. The [Cygwin](#) package from Cygnus and the [MKS utilities](#) from Mortice Kern Associates add shell scripting capabilities to Windows.

Another alternative is [UWIN](#), written by David Korn of AT&T, of [Korn Shell](#) fame.

In 2006, Microsoft released the Windows Powershell®, which contains limited Bash-like command-line scripting capabilities.

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Chapter 37. Bash, versions 2, 3, and 4

37.1. Bash, version 2

The current version of *Bash*, the one you have running on your machine, is most likely version 2.xx.yy, 3.xx.yy, or 4.xx.yy.

```
bash$ echo $BASH_VERSION
3.2.25(1)-release
```

The version 2 update of the classic Bash scripting language added array variables, string and parameter expansion, and a better method of indirect variable references, among other features.

Example 37-1. String expansion

```
1 #!/bin/bash
2
3 # String expansion.
4 # Introduced with version 2 of Bash.
5
6 # Strings of the form '$xxx'
7 #+ have the standard escaped characters interpreted.
8
9 echo $'Ringing bell 3 times \a \a \a'
10 # May only ring once with certain terminals.
11 # Or ...
12 # May not ring at all, depending on terminal settings.
13 echo $'Three form feeds \f \f \f'
14 echo $'10 newlines \n\n\n\n\n\n\n\n\n\n'
15 echo $'\102\141\163\150'
16 # B a s h
17 # Octal equivalent of characters.
18
19 exit
```

Example 37-2. Indirect variable references - the new way

```
1 #!/bin/bash
2
3 # Indirect variable referencing.
4 # This has a few of the attributes of references in C++.
5
6
7 a=letter_of_alphabet
8 letter_of_alphabet=z
9
10 echo "a = $a" # Direct reference.
11
12 echo "Now a = ${!a}" # Indirect reference.
13 # The ${!variable} notation is more intuitive than the old
14 #+ eval var1=${$var2}
15
16 echo
17
18 t=table_cell_3
19 table_cell_3=24
20 echo "t = ${!t}" # t = 24
21 table_cell_3=387
```

```

22 echo "Value of t changed to ${!t}"      # 387
23 # No 'eval' necessary.
24
25 # This is useful for referencing members of an array or table,
26 #+ or for simulating a multi-dimensional array.
27 # An indexing option (analogous to pointer arithmetic)
28 #+ would have been nice. Sigh.
29
30 exit 0
31
32 # See also, ind-ref.sh example.

```

Example 37-3. Simple database application, using indirect variable referencing

```

1 #!/bin/bash
2 # resistor-inventory.sh
3 # Simple database / table-lookup application.
4
5 # ===== #
6 # Data
7
8 B1723_value=470                # Ohms
9 B1723_powerdissip=.25         # Watts
10 B1723_colorcode="yellow-violet-brown" # Color bands
11 B1723_loc=173                # Where they are
12 B1723_inventory=78           # How many
13
14 B1724_value=1000
15 B1724_powerdissip=.25
16 B1724_colorcode="brown-black-red"
17 B1724_loc=24N
18 B1724_inventory=243
19
20 B1725_value=10000
21 B1725_powerdissip=.125
22 B1725_colorcode="brown-black-orange"
23 B1725_loc=24N
24 B1725_inventory=89
25
26 # ===== #
27
28
29 echo
30
31 PS3='Enter catalog number: '
32
33 echo
34
35 select catalog_number in "B1723" "B1724" "B1725"
36 do
37     Inv=${catalog_number}_inventory
38     Val=${catalog_number}_value
39     Pdissip=${catalog_number}_powerdissip
40     Loc=${catalog_number}_loc
41     Ccode=${catalog_number}_colorcode
42
43     echo
44     echo "Catalog number $catalog_number:"
45     # Now, retrieve value, using indirect referencing.
46     echo "There are ${!Inv} of  [${!Val} ohm / ${!Pdissip} watt]\
47     resistors in stock." #      ^      ^
48     # As of Bash 4.2, you can replace "ohm" with \u2126 (using echo -e).

```

```

49  echo "These are located in bin # ${!Loc}."
50  echo "Their color code is \"${!Ccode}\"."
51
52  break
53 done
54
55 echo; echo
56
57 # Exercises:
58 # -----
59 # 1) Rewrite this script to read its data from an external file.
60 # 2) Rewrite this script to use arrays,
61 #+   rather than indirect variable referencing.
62 #   Which method is more straightforward and intuitive?
63 #   Which method is easier to code?
64
65
66 # Notes:
67 # -----
68 # Shell scripts are inappropriate for anything except the most simple
69 #+ database applications, and even then it involves workarounds and kludges.
70 # Much better is to use a language with native support for data structures,
71 #+ such as C++ or Java (or even Perl).
72
73 exit 0

```

Example 37-4. Using arrays and other miscellaneous trickery to deal four random hands from a deck of cards

```

1  #!/bin/bash
2  # cards.sh
3
4  # Deals four random hands from a deck of cards.
5
6  UNPICKED=0
7  PICKED=1
8
9  DUPE_CARD=99
10
11 LOWER_LIMIT=0
12 UPPER_LIMIT=51
13 CARDS_IN_SUIT=13
14 CARDS=52
15
16 declare -a Deck
17 declare -a Suits
18 declare -a Cards
19 # It would have been easier to implement and more intuitive
20 #+ with a single, 3-dimensional array.
21 # Perhaps a future version of Bash will support multidimensional arrays.
22
23
24 initialize_Deck ()
25 {
26  i=$LOWER_LIMIT
27  until [ "$i" -gt $UPPER_LIMIT ]
28  do
29    Deck[i]=$UNPICKED # Set each card of "Deck" as unpicked.
30    let "i += 1"
31  done
32  echo
33 }

```

```

34
35 initialize_Suits ()
36 {
37 Suits[0]=C #Clubs
38 Suits[1]=D #Diamonds
39 Suits[2]=H #Hearts
40 Suits[3]=S #Spades
41 }
42
43 initialize_Cards ()
44 {
45 Cards=(2 3 4 5 6 7 8 9 10 J Q K A)
46 # Alternate method of initializing an array.
47 }
48
49 pick_a_card ()
50 {
51 card_number=$RANDOM
52 let "card_number %= $CARDS" # Restrict range to 0 - 51, i.e., 52 cards.
53 if [ "${Deck[card_number]}" -eq $UNPICKED ]
54 then
55     Deck[card_number]=$PICKED
56     return $card_number
57 else
58     return $DUPE_CARD
59 fi
60 }
61
62 parse_card ()
63 {
64 number=$1
65 let "suit_number = number / CARDS_IN_SUIT"
66 suit=${Suits[suit_number]}
67 echo -n "$suit-"
68 let "card_no = number % CARDS_IN_SUIT"
69 Card=${Cards[card_no]}
70 printf %-4s $Card
71 # Print cards in neat columns.
72 }
73
74 seed_random () # Seed random number generator.
75 { # What happens if you don't do this?
76 seed=`eval date +%s`
77 let "seed %= 32766"
78 RANDOM=$seed
79 } # Consider other methods of seeding the random number generator.
80
81 deal_cards ()
82 {
83 echo
84
85 cards_picked=0
86 while [ "$cards_picked" -le $UPPER_LIMIT ]
87 do
88     pick_a_card
89     t=$?
90
91     if [ "$t" -ne $DUPE_CARD ]
92     then
93         parse_card $t
94
95         u=$cards_picked+1
96         # Change back to 1-based indexing, temporarily. Why?
97         let "u %= $CARDS_IN_SUIT"
98         if [ "$u" -eq 0 ] # Nested if/then condition test.
99         then

```

```
100     echo
101     echo
102     fi          # Each hand set apart with a blank line.
103
104     let "cards_picked += 1"
105     fi
106 done
107
108 echo
109
110 return 0
111 }
112
113
114 # Structured programming:
115 # Entire program logic modularized in functions.
116
117 #=====
118 seed_random
119 initialize_Deck
120 initialize_Suits
121 initialize_Cards
122 deal_cards
123 #=====
124
125 exit
126
127
128
129 # Exercise 1:
130 # Add comments to thoroughly document this script.
131
132 # Exercise 2:
133 # Add a routine (function) to print out each hand sorted in suits.
134 # You may add other bells and whistles if you like.
135
136 # Exercise 3:
137 # Simplify and streamline the logic of the script.
```

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37.2. Bash, version 3

On July 27, 2004, Chet Ramey released version 3 of Bash. This update fixed quite a number of bugs and added new features.

Some of the more important added features:

- A new, more generalized `{a..z}` [brace expansion](#) operator.

```
1 #!/bin/bash
2
3 for i in {1..10}
4 #   Simpler and more straightforward than
5 #+ for i in $(seq 10)
6 do
7   echo -n "$i "
8 done
9
10 echo
11
12 # 1 2 3 4 5 6 7 8 9 10
13
14
15
16 # Or just . . .
17
18 echo {a..z}      # a b c d e f g h i j k l m n o p q r s t u v w x y z
19 echo {e..m}     # e f g h i j k l m
20 echo {z..a}     # z y x w v u t s r q p o n m l k j i h g f e d c b a
21                # Works backwards, too.
22 echo {25..30}   # 25 26 27 28 29 30
23 echo {3..-2}    # 3 2 1 0 -1 -2
24 echo {X..d}     # X Y Z [ ] ^ _ ` a b c d
25                # Shows (some of) the ASCII characters between Z and a,
26                #+ but don't rely on this type of behavior because . . .
27 echo {]}..a}   # {]}..a}
28                # Why?
29
30
31 # You can tack on prefixes and suffixes.
32 echo "Number #{1..4}, ..."
33     # Number #1, Number #2, Number #3, Number #4, ...
34
35
36 # You can concatenate brace-expansion sets.
37 echo {1..3}{x..z}" +" ..."
38     # 1x + 1y + 1z + 2x + 2y + 2z + 3x + 3y + 3z + ...
39     # Generates an algebraic expression.
40     # This could be used to find permutations.
41
42 # You can nest brace-expansion sets.
43 echo {{a..c},{1..3}}
44     # a b c 1 2 3
45     # The "comma operator" splices together strings.
46
47 # #####
48 # Unfortunately, brace expansion does not lend itself to parameterization.
49 var1=1
50 var2=5
51 echo {$var1..$var2} # {1..5}
52
```

```

53
54 # Yet, as Emiliano G. points out, using "eval" overcomes this limitation.
55
56 start=0
57 end=10
58 for index in $(eval echo {$start..$end})
59 do
60     echo -n "$index "    # 0 1 2 3 4 5 6 7 8 9 10
61 done
62
63 echo

```

- The `${!array[@]}` operator, which expands to all the indices of a given [array](#).

```

1 #!/bin/bash
2
3 Array=(element-zero element-one element-two element-three)
4
5 echo ${Array[0]}    # element-zero
6                    # First element of array.
7
8 echo ${!Array[@]}  # 0 1 2 3
9                    # All the indices of Array.
10
11 for i in ${!Array[@]}
12 do
13     echo ${Array[i]} # element-zero
14                    # element-one
15                    # element-two
16                    # element-three
17                    #
18                    # All the elements in Array.
19 done

```

- The `=~` [Regular Expression](#) matching operator within a [double brackets](#) test expression. (Perl has a similar operator.)

```

1 #!/bin/bash
2
3 variable="This is a fine mess."
4
5 echo "$variable"
6
7 # Regex matching with =~ operator within [[ double brackets ]].
8 if [[ "$variable" =~ T.....fin*es* ]]
9 # NOTE: As of version 3.2 of Bash, expression to match no longer quoted.
10 then
11     echo "match found"
12     # match found
13 fi

```

Or, more usefully:

```

1 #!/bin/bash
2
3 input=$1
4
5
6 if [[ "$input" =~ "[0-9][0-9][0-9]-[0-9][0-9]-[0-9][0-9][0-9]" ]]
7 #
8 # NNN-NN-NNNN (where each N is a digit).
9 then
10     echo "Social Security number."
11     # Process SSN.
12 else

```




```
13 echo "Not a Social Security number!"
14 # Or, ask for corrected input.
15 fi
```

For additional examples of using the `=~` operator, see [Example A-29](#), [Example 19-14](#), [Example A-35](#), and [Example A-24](#).

-

The new set `-o pipefail` option is useful for debugging [pipes](#). If this option is set, then the [exit status](#) of a pipe is the exit status of the last command in the pipe to *fail* (return a non-zero value), rather than the actual final command in the pipe.

See [Example 16-43](#).

 The update to version 3 of Bash breaks a few scripts that worked under earlier versions. *Test critical legacy scripts to make sure they still work!*

As it happens, a couple of the scripts in the *Advanced Bash Scripting Guide* had to be fixed up (see [Example 9-4](#), for instance).

37.2.1. Bash, version 3.1

The version 3.1 update of Bash introduces a number of bugfixes and a few minor changes.

- The `+=` operator is now permitted in places where previously only the `=` assignment operator was recognized.

```
1 a=1
2 echo $a          # 1
3
4 a+=5             # Won't work under versions of Bash earlier than 3.1.
5 echo $a          # 15
6
7 a+=Hello
8 echo $a          # 15Hello
```

Here, `+=` functions as a *string concatenation* operator. Note that its behavior in this particular context is different than within a [let](#) construct.

```
1 a=1
2 echo $a          # 1
3
4 let a+=5         # Integer arithmetic, rather than string concatenation.
5 echo $a          # 6
6
7 let a+=Hello    # Doesn't "add" anything to a.
8 echo $a          # 6
```

Jeffrey Haemer points out that this concatenation operator can be quite useful. In this instance, we append a directory to the `$PATH`.

```
bash$ echo $PATH
/usr/bin:/bin:/usr/local/bin:/usr/X11R6/bin:/usr/games

bash$ PATH+=:/opt/bin

bash$ echo $PATH
/usr/bin:/bin:/usr/local/bin:/usr/X11R6/bin:/usr/games:/opt/bin
```

37.2.2. Bash, version 3.2

This is pretty much a bugfix update.

- In [global parameter substitutions](#), the pattern no longer anchors at the start of the string.
- The `--wordexp` option disables [process substitution](#).
- The `=~` [Regular Expression match operator](#) no longer requires [quoting](#) of the *pattern* within `[[...]]`.



In fact, quoting in this context is *not* advisable as it may cause *regex* evaluation to fail. Chet Ramey states in the [Bash FAQ](#) that quoting explicitly disables regex evaluation. See also the [Ubuntu Bug List](#) and [Wikinerds on Bash syntax](#).

Setting `shopt -s compat31` in a script causes reversion to the original behavior.

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37.3. Bash, version 4

Chet Ramey announced Version 4 of Bash on the 20th of February, 2009. This release has a number of significant new features, as well as some important bugfixes.

Among the new goodies:

- Associative arrays. [\[1\]](#)

An *associative* array can be thought of as a set of two linked arrays -- one holding the *data*, and the other the *keys* that index the individual elements of the *data* array.

Example 37-5. A simple address database

```
1 #!/bin/bash4
2 # fetch_address.sh
3
4 declare -A address
5 #      -A option declares associative array.
6
7 address[Charles]="414 W. 10th Ave., Baltimore, MD 21236"
8 address[John]="202 E. 3rd St., New York, NY 10009"
9 address[Wilma]="1854 Vermont Ave, Los Angeles, CA 90023"
10
11
12 echo "Charles's address is ${address[Charles]}."
13 # Charles's address is 414 W. 10th Ave., Baltimore, MD 21236.
14 echo "Wilma's address is ${address[Wilma]}."
15 # Wilma's address is 1854 Vermont Ave, Los Angeles, CA 90023.
16 echo "John's address is ${address[John]}."
17 # John's address is 202 E. 3rd St., New York, NY 10009.
18
19 echo
20
21 echo "${!address[*]}" # The array indices ...
22 # Charles John Wilma
```

Example 37-6. A somewhat more elaborate address database


```
1 #!/bin/bash4
2 # fetch_address-2.sh
3 # A more elaborate version of fetch_address.sh.
4
5 SUCCESS=0
6 E_DB=99 # Error code for missing entry.
7
8 declare -A address
9 #      -A option declares associative array.
10
11
12 store_address ()
13 {
14     address[$1]="$2"
15     return $?
16 }
```

```

16 }
17
18
19 fetch_address ()
20 {
21     if [[ -z "${address[$1]}" ]]
22     then
23         echo "$1's address is not in database."
24         return $E_DB
25     fi
26
27     echo "$1's address is ${address[$1]}."
28     return $?
29 }
30
31
32 store_address "Lucas Fayne" "414 W. 13th Ave., Baltimore, MD 21236"
33 store_address "Arvid Boyce" "202 E. 3rd St., New York, NY 10009"
34 store_address "Velma Winston" "1854 Vermont Ave, Los Angeles, CA 90023"
35 # Exercise:
36 # Rewrite the above store_address calls to read data from a file,
37 #+ then assign field 1 to name, field 2 to address in the array.
38 # Each line in the file would have a format corresponding to the above.
39 # Use a while-read loop to read from file, sed or awk to parse the fields.
40
41 fetch_address "Lucas Fayne"
42 # Lucas Fayne's address is 414 W. 13th Ave., Baltimore, MD 21236.
43 fetch_address "Velma Winston"
44 # Velma Winston's address is 1854 Vermont Ave, Los Angeles, CA 90023.
45 fetch_address "Arvid Boyce"
46 # Arvid Boyce's address is 202 E. 3rd St., New York, NY 10009.
47 fetch_address "Bozo Bozeman"
48 # Bozo Bozeman's address is not in database.
49
50 exit $? # In this case, exit code = 99, since that is function return.

```

See [Example A-53](#) for an interesting usage of an *associative array*.

 Elements of the *index* array may include embedded [space characters](#), or even leading and/or trailing space characters. However, index array elements containing *only whitespace* are *not* permitted.

```
1 address[ ]="Blank" # Error!
```

- Enhancements to the [case](#) construct: the `;;&` and `;&` terminators.

Example 37-7. Testing characters

```

1 #!/bin/bash4
2
3 test_char ()
4 {
5     case "$1" in
6         [[:print:]] ) echo "$1 is a printable character.";;& # |
7         # The ;;& terminator continues to the next pattern test. |
8         [[:alnum:]] ) echo "$1 is an alpha/numeric character.";;& # v
9         [[:alpha:]] ) echo "$1 is an alphabetic character.";;& # v
10        [[:lower:]] ) echo "$1 is a lowercase alphabetic character.";;&
11        [[:digit:]] ) echo "$1 is an numeric character.";& # |
12        # The ;& terminator executes the next statement ... # |
13        %%%@ @@@@ ) echo "*****";; # v
14 # ^^^^^^^ ... even with a dummy pattern.

```


But, be careful!

```
1 #!/bin/bash4
2
3 echo; echo
4 a=aaa
5 b=bbb
6 c=ccc
7
8 coproc echo "one two three"
9 while read -u ${COPROC[0]} a b c; # Note that this loop
10 do                               #+ runs in a subshell.
11   echo "Inside while-read loop: ";
12   echo "a = $a"; echo "b = $b"; echo "c = $c"
13   echo "coproc file descriptor: ${COPROC[0]}"
14 done
15
16 # a = one
17 # b = two
18 # c = three
19 # So far, so good, but ...
20
21 echo "-----"
22 echo "Outside while-read loop: "
23 echo "a = $a" # a =
24 echo "b = $b" # b =
25 echo "c = $c" # c =
26 echo "coproc file descriptor: ${COPROC[0]}"
27 echo
28 # The coproc is still running, but ...
29 #+ it still doesn't enable the parent process
30 #+ to "inherit" variables from the child process, the while-read loop.
31
32 # Compare this to the "badread.sh" script.
```



The coprocess is *asynchronous*, and this might cause a problem. It may terminate before another process has finished communicating with it.

```
1 #!/bin/bash4
2
3 coproc cpname { for i in {0..10}; do echo "index = $i"; done; }
4 #      ^^^^^ This is a *named* coprocess.
5 read -u ${cpname[0]}
6 echo $REPLY           # index = 0
7 echo ${COPROC[0]}    #+ No output ... the coprocess timed out
8 # after the first loop iteration.
9
10
11
12 # However, George Dimitriu has a partial fix.
13
14 coproc cpname { for i in {0..10}; do echo "index = $i"; done; sleep 1;
15 echo hi > myo; cat - >> myo; }
16 #      ^^^^^ This is a *named* coprocess.
17
18 echo "I am main"'\04' >&${cpname[1]}
19 myfd=${cpname[0]}
20 echo myfd=$myfd
21
22 ### while read -u $myfd
23 ### do
24 ###   echo $REPLY;
25 ### done
26
27 echo $cpname_PID
```

```

28
29 # Run this with and without the commented-out while-loop, and it is
30 #+ apparent that each process, the executing shell and the coprocess,
31 #+ waits for the other to finish writing in its own write-enabled pipe.

```

- The new **mapfile** builtin makes it possible to load an array with the contents of a text file without using a loop or [command substitution](#).

```

1 #!/bin/bash4
2
3 mapfile Arr1 < $0
4 # Same result as      Arr1=( $(cat $0) )
5 echo "${Arr1[@]}" # Copies this entire script out to stdout.
6
7 echo "--"; echo
8
9 # But, not the same as  read -a  !!!
10 read -a Arr2 < $0
11 echo "${Arr2[@]}" # Reads only first line of script into the array.
12
13 exit

```

- The [read](#) builtin got a minor facelift. The `-t` [timeout](#) option now accepts (decimal) fractional values [\[3\]](#) and the `-i` option permits preloading the edit buffer. [\[4\]](#) Unfortunately, these enhancements are still a work in progress and not (yet) usable in scripts.
- [Parameter substitution](#) gets *case-modification* operators.

```

1 #!/bin/bash4
2
3 var=veryMixedUpVariable
4 echo ${var}           # veryMixedUpVariable
5 echo ${var^}         # VeryMixedUpVariable
6 #                    *           First char --> uppercase.
7 echo ${var^^}       # VERYMIXEDUPVARIABLE
8 #                    **          All chars --> uppercase.
9 echo ${var,}        # veryMixedUpVariable
10 #                   *           First char --> lowercase.
11 echo ${var,,}       # verymixedupvariable
12 #                   **          All chars --> lowercase.

```

- The [declare](#) builtin now accepts the `-l` *lowercase* and `-c` *capitalize* options.

```

1 #!/bin/bash4
2
3 declare -l var1           # Will change to lowercase
4 var1=MixedCaseVARIABLE
5 echo "$var1"            # mixedcasevariable
6 # Same effect as      echo $var1 | tr A-Z a-z
7
8 declare -c var2         # Changes only initial char to uppercase.
9 var2=originally_lowercase
10 echo "$var2"          # Originally_lowercase
11 # NOT the same effect as  echo $var2 | tr a-z A-Z

```

- [Brace expansion](#) has more options.

Increment/decrement, specified in the final term within braces.

```

1 #!/bin/bash4
2
3 echo {40..60..2}
4 # 40 42 44 46 48 50 52 54 56 58 60
5 # All the even numbers, between 40 and 60.
6

```

```

7 echo {60..40..2}
8 # 60 58 56 54 52 50 48 46 44 42 40
9 # All the even numbers, between 40 and 60, counting backwards.
10 # In effect, a decrement.
11 echo {60..40..-2}
12 # The same output. The minus sign is not necessary.
13
14 # But, what about letters and symbols?
15 echo {X..d}
16 # X Y Z [ ] ^ _ ` a b c d
17 # Does not echo the \ which escapes a space.

```

Zero-padding, specified in the first term within braces, prefixes each term in the output with the *same number* of zeroes.

```

bash4$ echo {010..15}
010 011 012 013 014 015

bash4$ echo {000..10}
000 001 002 003 004 005 006 007 008 009 010

```

- [Substring extraction on positional parameters](#) now starts with `$0` as the *zero-index*. (This corrects an inconsistency in the treatment of positional parameters.)

```

1 #!/bin/bash
2 # show-params.bash
3 # Requires version 4+ of Bash.
4
5 # Invoke this scripts with at least one positional parameter.
6
7 E_BADPARAMS=99
8
9 if [ -z "$1" ]
10 then
11     echo "Usage $0 param1 ..."
12     exit $E_BADPARAMS
13 fi
14
15 echo ${@:0}
16
17 # bash3 show-params.bash4 one two three
18 # one two three
19
20 # bash4 show-params.bash4 one two three
21 # show-params.bash4 one two three
22
23 # $0          $1 $2 $3

```

- The new `**` [globbing](#) operator matches filenames and directories [recursively](#).

```

1 #!/bin/bash4
2 # filelist.bash4
3
4 shopt -s globstar # Must enable globstar, otherwise ** doesn't work.
5                 # The globstar shell option is new to version 4 of Bash.
6
7 echo "Using *"; echo
8 for filename in *
9 do
10     echo "$filename"
11 done # Lists only files in current directory ($PWD).
12
13 echo; echo "-----"; echo

```



```

14
15 echo "Using **"
16 for filename in **
17 do
18     echo "$filename"
19 done # Lists complete file tree, recursively.
20
21 exit
22
23 Using *
24
25 allmyfiles
26 filelist.bash4
27
28 -----
29
30 Using **
31
32 allmyfiles
33 allmyfiles/file.index.txt
34 allmyfiles/my_music
35 allmyfiles/my_music/me-singing-60s-folksongs.ogg
36 allmyfiles/my_music/me-singing-opera.ogg
37 allmyfiles/my_music/piano-lesson.1.ogg
38 allmyfiles/my_pictures
39 allmyfiles/my_pictures/at-beach-with-Jade.png
40 allmyfiles/my_pictures/picnic-with-Melissa.png
41 filelist.bash4

```

- The new [\\$BASHPID](#) internal variable.

-

There is a new [builtin](#) error-handling function named **command_not_found_handle**.

```

1 #!/bin/bash4
2
3 command_not_found_handle ()
4 { # Accepts implicit parameters.
5     echo "The following command is not valid: \"$1\""
6     echo "With the following argument(s): \"$2\" \"$3\" # $4, $5 ..."
7 } # $1, $2, etc. are not explicitly passed to the function.
8
9 bad_command arg1 arg2
10
11 # The following command is not valid: "bad_command"
12 # With the following argument(s): "arg1" "arg2"

```

Editorial comment

Associative arrays? Coprocesses? Whatever happened to the lean and mean Bash we have come to know and love? Could it be suffering from (horrors!) "feature creep"? Or perhaps even Korn shell envy?

Note to Chet Ramey: Please add only *essential* features in future Bash releases -- perhaps *for-each* loops and support for multi-dimensional arrays. [5] Most Bash users won't need, won't use, and likely won't greatly appreciate complex "features" like built-in debuggers, Perl interfaces, and bolt-on rocket boosters.

37.3.1. Bash, version 4.1

Version 4.1 of Bash, released in May, 2010, was primarily a bugfix update.

- The [printf](#) command now accepts a `-v` option for setting [array](#) indices.

- Within [double brackets](#), the > and < string comparison operators now conform to the [locale](#). Since the locale setting may affect the sorting order of string expressions, this has side-effects on comparison tests within `[[...]]` expressions.
 - The [read](#) builtin now takes a `-N` option (`read -N chars`), which causes the `read` to terminate after `chars` characters.
-

Example 37-8. Reading N characters

```
1 #!/bin/bash
2 # Requires Bash version -ge 4.1 ...
3
4 num_chars=61
5
6 read -N $num_chars var < $0 # Read first 61 characters of script!
7 echo "$var"
8 exit
9
10 ##### Output of Script #####
11
12 #!/bin/bash
13 # Requires Bash version -ge 4.1 ...
14
15 num_chars=61
```

- [Here documents](#) embedded in [\\$\(... \) command substitution](#) constructs may terminate with a simple `)`.
-

Example 37-9. Using a *here document* to set a variable

```
1 #!/bin/bash
2 # here-commsub.sh
3 # Requires Bash version -ge 4.1 ...
4
5 multi_line_var=$( cat <<ENDxxx
6 -----
7 This is line 1 of the variable
8 This is line 2 of the variable
9 This is line 3 of the variable
10 -----
11 ENDxxx)
12
13 # Rather than what Bash 4.0 requires:
14 #+ that the terminating limit string and
15 #+ the terminating close-parenthesis be on separate lines.
16
17 # ENDxxx
18 # )
19
20
21 echo "$multi_line_var"
22
23 # Bash still emits a warning, though.
24 # warning: here-document at line 10 delimited
25 #+ by end-of-file (wanted `ENDxxx')
```

37.3.2. Bash, version 4.2

Version 4.2 of Bash, released in February, 2011, contains a number of new features and enhancements, in addition to bugfixes.

- Bash now supports the the `\u` and `\U` *Unicode* escape.

Unicode is a cross-platform standard for encoding into numerical values letters and graphic symbols. This permits representing and displaying characters in foreign alphabets and unusual fonts.

```
1 echo -e '\u2630'    # Horizontal triple bar character.
2 # Equivalent to the more roundabout:
3 echo -e "\xE2\x98\xB0"
4                               # Recognized by earlier Bash versions.
5
6 echo -e '\u220F'    # PI (Greek letter and mathematical symbol)
7 echo -e '\u0416'    # Capital "ZHE" (Cyrillic letter)
8 echo -e '\u2708'    # Airplane (Dingbat font) symbol
9 echo -e '\u2622'    # Radioactivity trefoil
10
11 echo -e "The amplifier circuit requires a 100 \u2126 pull-up resistor."
12
13
14 unicode_var='\u2640'
15 echo -e $unicode_var      # Female symbol
16 printf "$unicode_var \n" # Female symbol, with newline
17
18
19 # And for something a bit more elaborate . . .
20
21 # We can store Unicode symbols in an associative array,
22 #+ then retrieve them by name.
23 # Run this in a gnome-terminal or a terminal with a large, bold font
24 #+ for better legibility.
25
26 declare -A symbol # Associative array.
27
28 symbol[script_E]='\u2130'
29 symbol[script_F]='\u2131'
30 symbol[script_J]='\u2110'
31 symbol[script_M]='\u2133'
32 symbol[Rx]='\u211E'
33 symbol[TEL]='\u2121'
34 symbol[FAX]='\u213B'
35 symbol[care_of]='\u2105'
36 symbol[account]='\u2100'
37 symbol[trademark]='\u2122'
38
39
40 echo -ne "${symbol[script_E]}    "
41 echo -ne "${symbol[script_F]}    "
42 echo -ne "${symbol[script_J]}    "
43 echo -ne "${symbol[script_M]}    "
44 echo -ne "${symbol[Rx]}          "
45 echo -ne "${symbol[TEL]}         "
46 echo -ne "${symbol[FAX]}         "
47 echo -ne "${symbol[care_of]}     "
48 echo -ne "${symbol[account]}     "
49 echo -ne "${symbol[trademark]}   "
50 echo
```



The above example uses the `$'...'` *string-expansion* construct.

When the `lastpipe` shell option is set, the last command in a [pipe](#) *doesn't run in a subshell*.

Example 37-10. Piping input to a [read](#)

```

1 #!/bin/bash
2 # lastpipe-option.sh
3
4 line='' # Null value.
5 echo "\$line = \"$line\" # $line =
6
7 echo
8
9 shopt -s lastpipe # Error on Bash version -lt 4.2.
10 echo "Exit status of attempting to set \"lastpipe\" option is $?"
11 # 1 if Bash version -lt 4.2, 0 otherwise.
12
13 echo
14
15 head -1 $0 | read line # Pipe the first line of the script to read.
16 # ^^^^^^^^^ Not in a subshell!!!
17
18 echo "\$line = \"$line\"
19 # Older Bash releases $line =
20 # Bash version 4.2 $line = #!/bin/bash

```

This option offers possible "fixups" for these example scripts: [Example 34-3](#) and [Example 15-8](#).

- Negative [array](#) indices permit counting backwards from the end of an array.
-

Example 37-11. Negative array indices

```

1 #!/bin/bash
2 # neg-array.sh
3 # Requires Bash, version -ge 4.2.
4
5 array=( zero one two three four five ) # Six-element array.
6 # 0 1 2 3 4 5
7 # -6 -5 -4 -3 -2 -1
8
9 # Negative array indices now permitted.
10 echo ${array[-1]} # five
11 echo ${array[-2]} # four
12 # ...
13 echo ${array[-6]} # zero
14 # Negative array indices count backward from the last element+1.
15
16 # But, you cannot index past the beginning of the array.
17 echo ${array[-7]} # array: bad array subscript
18
19
20 # So, what is this new feature good for?
21
22 echo "The last element in the array is "${array[-1]}"
23 # Which is quite a bit more straightforward than:
24 echo "The last element in the array is "${array[${#array[*]}-1]}"
25 echo
26
27 # And ...
28

```

```

29 index=0
30 let "neg_element_count = 0 - ${#array[*]}"
31 # Number of elements, converted to a negative number.
32
33 while [ $index -gt $neg_element_count ]; do
34     ((index--)); echo -n "${array[index]} "
35 done # Lists the elements in the array, backwards.
36     # We have just simulated the "tac" command on this array.
37
38 echo
39
40 # See also neg-offset.sh.

```

- [Substring extraction](#) uses a negative *length* parameter to specify an offset from the *end* of the target string.

Example 37-12. Negative parameter in string-extraction construct

```

1 #!/bin/bash
2 # Bash, version -ge 4.2
3 # Negative length-index in substring extraction.
4 # Important: It changes the interpretation of this construct!
5
6 stringZ=abcABC123ABCabc
7
8 echo ${stringZ} # abcABC123ABCabc
9 # Position within string: 0123456789.....
10 echo ${stringZ:2:3} # cAB
11 # Count 2 chars forward from string beginning, and extract 3 chars.
12 # ${string:position:length}
13
14 # So far, nothing new, but now ...
15
16 # abcABC123ABCabc
17 # Position within string: 0123....6543210
18 echo ${stringZ:3:-6} # ABC123
19 # ^
20 # Index 3 chars forward from beginning and 6 chars backward from end,
21 #+ and extract everything in between.
22 # ${string:offset-from-front:offset-from-end}
23 # When the "length" parameter is negative,
24 #+ it serves as an offset-from-end parameter.
25
26 # See also neg-array.sh.

```

Notes

- [1] To be more specific, Bash 4+ has *limited* support for associative arrays. It's a bare-bones implementation, and it lacks the much of the functionality of such arrays in other programming languages. Note, however, that [associative arrays in Bash seem to execute faster and more efficiently than numerically-indexed arrays](#).
- [2] Copyright 1995-2009 by Chester Ramey.
- [3] This only works with [pipes](#) and certain other *special* files.
- [4] But only in conjunction with [readline](#), i.e., from the command-line.
- [5] And while you're at it, consider fixing the notorious [piped read](#) problem.

Chapter 38. Endnotes

38.1. Author's Note

doce ut discas

(Teach, that you yourself may learn.)

How did I come to write a scripting book? It's a strange tale. It seems that a few years back I needed to learn shell scripting -- and what better way to do that than to read a good book on the subject? I was looking to buy a tutorial and reference covering all aspects of the subject. I was looking for a book that would take difficult concepts, turn them inside out, and explain them in excruciating detail, with well-commented examples. [1] In fact, I was looking for *this very book*, or something very much like it. Unfortunately, it didn't exist, and if I wanted it, I'd have to write it. And so, here we are, folks.

That reminds me of the apocryphal story about a mad professor. Crazy as a loon, the fellow was. At the sight of a book, any book -- at the library, at a bookstore, anywhere -- he would become totally obsessed with the idea that he could have written it, should have written it -- and done a better job of it to boot. He would thereupon rush home and proceed to do just that, write a book with the very same title. When he died some years later, he allegedly had several thousand books to his credit, probably putting even Asimov to shame. The books might not have been any good, who knows, but does that really matter? Here's a fellow who lived his dream, even if he was obsessed by it, driven by it . . . and somehow I can't help admiring the old coot.

Notes

- [1] This is the notorious *flog it to death* technique that works so well with slow learners, eccentrics, odd ducks, fools and geniuses.

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38.2. About the Author

Who is this guy anyhow?

The author claims no credentials or special qualifications, [1] other than a compulsion to write. [2]

This book is somewhat of a departure from his other major work, [HOW-2 Meet Women: The Shy Man's Guide to Relationships](#). He has also written the [Software-Building HOWTO](#). Of late, he has been trying his (heavy) hand at fiction: [Dave Dawson Over Berlin \(First Installment\)](#) [Dave Dawson Over Berlin \(Second Installment\)](#) and [Dave Dawson Over Berlin \(Third Installment\)](#) . He also has a few *Instructables* ([here](#), [here](#), [here](#), [here](#), and [here](#)) to his (dis)credit.

A Linux user since 1995 (Slackware 2.2, kernel 1.2.1), the author has emitted a few software truffles, including the [cruft](#) one-time pad encryption utility, the [mcalc](#) mortgage calculator, the [judge](#) Scrabble® adjudicator, the [yawl](#) word gaming list package, and the [Quacky](#) anagramming gaming package. He got off to a rather shaky start in the computer game -- programming FORTRAN IV on a CDC 3800 (on paper coding pads, with occasional forays on a keypunch machine and a Friden Flexowriter) -- and is not the least bit nostalgic for those days.

Living in an out-of-the-way community with wife and orange tabby, he cherishes human frailty, especially his own. [3]

Notes

- [1] In fact, he has no credentials or special qualifications. He's a school dropout with no formal credentials or professional experience whatsoever. None. Zero. Nada. Aside from the *ABS Guide*, his major claim to fame is a First Place in the sack race at the Colfax Elementary School Field Day in June, 1958.
- [2] Those who can, do. Those who can't . . . get an MCSE.
- [3] Sometimes it seems as if he has spent his entire life flouting conventional wisdom and defying the sonorous Voice of Authority: "*Hey, you can't do that!*"

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38.3. Where to Go For Help

[The author](#) is no longer supporting or updating this document. He will not answer questions about this book or about general scripting topics.

If you need assistance with a schoolwork assignment, read the pertinent sections of this and other reference works. Do your best to solve the problem using your own wits and resources. *Please do not waste the author's time.* You will get neither help nor sympathy. [\[1\]](#)

Likewise, kindly refrain from annoying the author with solicitations, offers of employment, or "business opportunities." He is doing just fine, and requires neither help nor sympathy, thank you.

Please note that the author will *not* answer scripting questions for Sun/Solaris/Oracle or Apple systems. The endarkened execs and the arachnoid corporate attorneys of those particular outfits have been using litigation in a predatory manner and/or as a weapon against the Open Source Community. Any Solaris or Apple users needing scripting help will therefore kindly direct their concerns to corporate customer service.

*... sophisticated in mechanism but possibly agile
operating under noises being extremely
suppressed ...*

--CI-300 printer manual

Notes

[\[1\]](#) Well, if you *absolutely* insist, you can try modifying [Example A-44](#) to suit your purposes.

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38.4. Tools Used to Produce This Book

38.4.1. Hardware

A used IBM Thinkpad, model 760XL laptop (P166, 104 meg RAM) running Red Hat 7.1/7.3. Sure, it's slow and has a funky keyboard, but it beats the heck out of a No. 2 pencil and a Big Chief tablet.

Update: upgraded to a 770Z Thinkpad (P2-366, 192 meg RAM) running FC3. Anyone feel like donating a later-model laptop to a starving writer <g>?

Update: upgraded to a T61 Thinkpad running Mandriva 2011. No longer starving <g>, but not too proud to accept donations.

38.4.2. Software and Printware

- i. Bram Moolenaar's powerful SGML-aware [vim](#) text editor.
- ii. [OpenJade](#), a DSSSL rendering engine for converting SGML documents into other formats.
- iii. [Norman Walsh's DSSSL stylesheets](#).
- iv. *DocBook, The Definitive Guide*, by Norman Walsh and Leonard Mueller (O'Reilly, ISBN 1-56592-580-7). This is still the standard reference for anyone attempting to write a document in Docbook SGML format.

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38.5. Credits

Community participation made this project possible. The author gratefully acknowledges that writing this book would have been unthinkable without help and feedback from all you people out there.

[Philippe Martin](#) translated the first version (0.1) of this document into DocBook/SGML. While not on the job at a small French company as a software developer, he enjoys working on GNU/Linux documentation and software, reading literature, playing music, and, for his peace of mind, making merry with friends. You may run across him somewhere in France or in the Basque Country, or you can email him at feloy@free.fr.

Philippe Martin also pointed out that positional parameters past \$9 are possible using {bracket} notation. (See [Example 4-5](#)).

[Stéphane Chazelas](#) sent a long list of corrections, additions, and example scripts. More than a contributor, he had, in effect, for a while taken on the role of *co-editor* for this document. *Merci beaucoup!*

Paulo Marcel Coelho Aragao offered many corrections, both major and minor, and contributed quite a number of helpful suggestions.

I would like to especially thank *Patrick Callahan*, *Mike Novak*, and *Pal Domokos* for catching bugs, pointing out ambiguities, and for suggesting clarifications and changes in the preliminary version (0.1) of this document. Their lively discussion of shell scripting and general documentation issues inspired me to try to make this document more readable.

I'm grateful to Jim Van Zandt for pointing out errors and omissions in version 0.2 of this document. He also contributed an instructive [example script](#).

Many thanks to [Jordi Sanfeliu](#) for giving permission to use his fine tree script ([Example A-16](#)), and to Rick Boivie for revising it.

Likewise, thanks to [Michel Charpentier](#) for permission to use his `dc` factoring script ([Example 16-52](#)).

Kudos to [Noah Friedman](#) for permission to use his string function script ([Example A-18](#)).

[Emmanuel Rouat](#) suggested corrections and additions on [command substitution](#), [aliases](#), and [path management](#). He also contributed a very nice sample `.bashrc` file ([Appendix M](#)).

[Heiner Steven](#) kindly gave permission to use his base conversion script, [Example 16-48](#). He also made a number of corrections and many helpful suggestions. Special thanks.

Rick Boivie contributed the delightfully recursive `pb.sh` script ([Example 36-11](#)), revised the `tree.sh` script ([Example A-16](#)), and suggested performance improvements for the `monthlypmt.sh` script ([Example 16-47](#)).

Florian Wisser enlightened me on some of the fine points of testing strings (see [Example 7-6](#)), and on other matters.

Oleg Philon sent suggestions concerning [cut](#) and [pidof](#).

Michael Zick extended the [empty array](#) example to demonstrate some surprising array properties. He also contributed the `isspammer` scripts ([Example 16-41](#) and [Example A-28](#)).

Marc-Jano Knopp sent corrections and clarifications on DOS batch files.

Hyun Jin Cha found several typos in the document in the process of doing a Korean translation. Thanks for pointing these out.

Andreas Abraham sent in a long list of typographical errors and other corrections. Special thanks!

Others contributing scripts, making helpful suggestions, and pointing out errors were Gabor Kiss, Leopold Toetsch, Peter Tillier, Marcus Berglof, Tony Richardson, Nick Drage (script ideas!), Rich Bartell, Jess Thrysoee, Adam Lazur, Bram Moolenaar, Baris Cicek, Greg Keraunen, Keith Matthews, Sandro Magi, Albert Reiner, Dim Segebart, Rory Winston, Lee Bigelow, Wayne Pollock, "jipe," "bojster," "nyal," "Hobbit," "Ender," "Little Monster" (Alexis), "Mark," "Patsie," "vladz," Peggy Russell, Emilio Conti, Ian. D. Allen, Hans-Joerg Diers, Arun Giridhar, Dennis Leeuw, Dan Jacobson, Aurelio Marinho Jargas, Edward Scholtz, Jean Helou, Chris Martin, Lee Maschmeyer, Bruno Haible, Wilbert Berendsen, Sebastien Godard, Bjön Eriksson, John MacDonald, John Lange, Joshua Tschida, Troy Engel, Manfred Schwarb, Amit Singh, Bill Gradwohl, E. Choroba, David Lombard, Jason Parker, Steve Parker, Bruce W. Clare, William Park, Vernia Damiano, Mihai Maties, Mark Alexander, Jeremy Impson, Ken Fuchs, Jared Martin, Frank Wang, Sylvain Fourmanoit, Matthew Sage, Matthew Walker, Kenny Stauffer, Filip Moritz, Andrzej Stefanski, Daniel Albers, Jeffrey Haemer, Stefano Palmeri, Nils Radtke, Sigurd Solaas, Sergey Rodin, Jeroen Domburg, Alfredo Pironti, Phil Braham, Bruno de Oliveira Schneider, Stefano Falsetto, Chris Morgan, Walter Dnes, Linc Fessenden, Michael Iatrou, Pharis Monalo, Jesse Gough, Fabian Kreutz, Mark Norman, Harald Koenig, Dan Stromberg, Peter Knowles, Francisco Lobo, Mariusz Gniazdowski, Sebastian Arming, Chetankumar Phulpagare, Benno Schulenberg, Tedman Eng, Jochen DeSmet, Juan Nicolas Ruiz, Oliver Beckstein, Achmed Darwish, Dotan Barak, Richard Neill, Albert Siersema, Omair Eshkenazi, Geoff Lee, Graham Ewart, JuanJo Ciarlante, Cliff Bamford, Nathan Coulter, Ramses Rodriguez Martinez, Evgeniy Ivanov, Craig Barnes, George Dimitriu, Kevin LeBlanc, Antonio Macchi, Tomas Pospisek, David Wheeler, Erik Brandsberg, YongYe, Andreas Kühne, Pádraig Brady, Joseph Steinhauser, and David Lawyer (himself an author of four HOWTOs).

My gratitude to [Chet Ramey](#) and Brian Fox for writing *Bash*, and building into it elegant and powerful scripting capabilities rivaling those of *ksh*.

Very special thanks to the hard-working volunteers at the [Linux Documentation Project](#). The LDP hosts a repository of Linux knowledge and lore, and has, to a great extent, enabled the publication of this book.

Thanks and appreciation to IBM, Red Hat, Google, the [Free Software Foundation](#), and all the good people fighting the good fight to keep Open Source software free and open.

Belated thanks to my fourth grade teacher, Miss Spencer, for emotional support and for convincing me that maybe, just maybe I wasn't a total loss.

Thanks most of all to my wife, Anita, for her encouragement, inspiration, and emotional support.

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38.6. Disclaimer

(This is a variant of the standard [LDP](#) disclaimer.)

No liability for the contents of this document can be accepted. Use the concepts, examples and information at your own risk. There may be errors, omissions, and inaccuracies that could cause you to lose data, harm your system, or induce involuntary electrocution, so *proceed with appropriate caution*. The author takes no responsibility for any damages, incidental or otherwise.

As it happens, it is highly unlikely that either you or your system will suffer ill effects, aside from uncontrollable hiccups. In fact, the *raison d'etre* of this book is to enable its readers to analyze shell scripts and determine whether they have [unanticipated consequences](#).

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Bibliography

*Those who do not understand UNIX are
condemned to reinvent it, poorly.*

--Henry Spencer

Edited by Peter Denning, *Computers Under Attack: Intruders, Worms, and Viruses*, ACM Press, 1990, 0-201-53067-8.

This compendium contains a couple of articles on shell script viruses.

*

Ken Burtch, [*Linux Shell Scripting with Bash*](#), 1st edition, Sams Publishing (Pearson), 2004, 0672326426.

Covers much of the same material as the *ABS Guide*, though in a different style.

*

Daniel Goldman, [*Definitive Guide to Sed*](#), 1st edition, 2013.

This ebook is an excellent introduction to *sed*. Rather than being a conversion from a printed volume, it was specifically designed and formatted for viewing on an ebook reader. Well-written, informative, and useful as a reference as well as a tutorial. Highly recommended.

*

Dale Dougherty and Arnold Robbins, *Sed and Awk*, 2nd edition, O'Reilly and Associates, 1997, 1-156592-225-5.

Unfolding the full power of shell scripting requires at least a passing familiarity with [*sed and awk*](#). This is the classic tutorial. It includes an excellent introduction to *Regular Expressions*. Recommended.

*

Jeffrey Friedl, *Mastering Regular Expressions*, O'Reilly and Associates, 2002, 0-596-00289-0.

Still the best all-around reference on [*Regular Expressions*](#).

*

Aleen Frisch, *Essential System Administration*, 3rd edition, O'Reilly and Associates, 2002, 0-596-00343-9.

This excellent manual provides a decent introduction to shell scripting from a sys admin point of view. It includes comprehensive explanations of the startup and initialization scripts in a UNIX system.

*

Stephen Kochan and Patrick Wood, *Unix Shell Programming*, Hayden, 1990, 067248448X.

Still considered a standard reference, though somewhat dated, and a bit "wooden" stylistically speaking. [\[1\]](#) In fact, this book was the *ABS Guide* author's first exposure to UNIX shell scripting, lo these many years ago.

*

Neil Matthew and Richard Stones, *Beginning Linux Programming*, Wrox Press, 1996, 1874416680.

Surprisingly good in-depth coverage of various programming languages available for Linux, including a fairly strong chapter on shell scripting.

*

Herbert Mayer, *Advanced C Programming on the IBM PC*, Windcrest Books, 1989, 0830693637.

Excellent coverage of algorithms and general programming practices. Highly recommended, but unfortunately out of print.

*

David Medinets, *Unix Shell Programming Tools*, McGraw-Hill, 1999, 0070397333.

Pretty good treatment of shell scripting, with examples, and a short intro to Tcl and Perl.

*

Cameron Newham and Bill Rosenblatt, *Learning the Bash Shell*, 2nd edition, O'Reilly and Associates, 1998, 1-56592-347-2.

This is a valiant effort at a decent shell primer, but sadly deficient in its coverage of writing scripts and lacking sufficient examples.

*

Anatole Olczak, *Bourne Shell Quick Reference Guide*, ASP, Inc., 1991, 093573922X.

A very handy pocket reference, despite lacking coverage of Bash-specific features.

*

Jerry Peek, Tim O'Reilly, and Mike Loukides, *Unix Power Tools*, 3rd edition, O'Reilly and Associates, Random House, 2002, 0-596-00330-7.

Contains a couple of sections of very informative in-depth articles on shell programming, but falls short of being a self-teaching manual. It reproduces much of the [Regular Expressions](#) tutorial from the Dougherty and Robbins book, above. The comprehensive coverage of UNIX commands makes this book worthy of a place on your bookshelf.

*

Clifford Pickover, *Computers, Pattern, Chaos, and Beauty*, St. Martin's Press, 1990, 0-312-04123-3.

A treasure trove of ideas and recipes for computer-based exploration of mathematical oddities.

*

George Polya, *How To Solve It*, Princeton University Press, 1973, 0-691-02356-5.

The classic tutorial on problem-solving methods (algorithms), with special emphasis on how to teach them.

*

Chet Ramey and Brian Fox, [The GNU Bash Reference Manual](#), Network Theory Ltd, 2003, 0-9541617-7-7.

This manual is the definitive reference for GNU Bash. The authors of this manual, Chet Ramey and Brian Fox, are the original developers of GNU Bash. For each copy sold, the publisher donates \$1 to the Free Software Foundation.

*

Arnold Robbins, *Bash Reference Card*, SSC, 1998, 1-58731-010-5.

Excellent Bash pocket reference (don't leave home without it, especially if you're a sysadmin). A bargain at \$4.95, but unfortunately no longer available for free download.

*

Arnold Robbins, *Effective Awk Programming*, Free Software Foundation / O'Reilly and Associates, 2000, 1-882114-26-4.

The absolute best [awk](#) tutorial and reference. The free electronic version of this book is part of the *awk* documentation, and printed copies of the latest version are available from O'Reilly and Associates.

This book served as an inspiration for the author of the *ABS Guide*.

*

Bill Rosenblatt, *Learning the Korn Shell*, O'Reilly and Associates, 1993, 1-56592-054-6.

This well-written book contains some excellent pointers on shell scripting in general.

*

Paul Sheer, *LINUX: Rute User's Tutorial and Exposition*, 1st edition, , 2002, 0-13-033351-4.

Very detailed and readable introduction to Linux system administration.

The book is available in print, or [on-line](#).

*

Ellen Siever and the staff of O'Reilly and Associates, *Linux in a Nutshell*, 2nd edition, O'Reilly and Associates, 1999, 1-56592-585-8.

The all-around best Linux command reference. It even has a Bash section.

*

Dave Taylor, *Wicked Cool Shell Scripts: 101 Scripts for Linux, Mac OS X, and Unix Systems*, 1st edition, No Starch Press, 2004, 1-59327-012-7.

Pretty much what the title promises . . .

*

The UNIX CD Bookshelf, 3rd edition, O'Reilly and Associates, 2003, 0-596-00392-7.

An array of seven UNIX books on CD ROM, including *UNIX Power Tools*, *Sed and Awk*, and *Learning the Korn Shell*. A complete set of all the UNIX references and tutorials you would ever need at about \$130. Buy this one, even if it means going into debt and not paying the rent.

Update: Seems to have somehow fallen out of print. Ah, well. You can still buy the dead-tree editions of these books.

*

The O'Reilly books on Perl. (Actually, *any* O'Reilly books.)

* * *

Other Resources

Fioretti, Marco, "Scripting for X Productivity," [Linux Journal](#), Issue 113, September, 2003, pp. 86-9.

Ben Okopnik's well-written *introductory Bash scripting* articles in issues 53, 54, 55, 57, and 59 of the [Linux Gazette](#), and his explanation of "The Deep, Dark Secrets of Bash" in issue 56.

Chet Ramey's *Bash - The GNU Shell*, a two-part series published in issues 3 and 4 of the [Linux Journal](#), July-August 1994.

Mike G's [Bash-Programming-Intro HOWTO](#).

Richard's [Unix Scripting Universe](#).

Chet Ramey's [Bash FAQ](#).

[Greg's WIKI: Bash FAQ](#).

Example shell scripts at [Lucc's Shell Scripts](#) .

Example shell scripts at [SHELLdorado](#) .

Example shell scripts at [Noah Friedman's script site](#).

[Examples](#) from the *The Bash Scripting Cookbook*, by Albing, Vossen, and Newham.

Example shell scripts at [zazzybob](#).

Steve Parker's [Shell Programming Stuff](#). In fact, all of his shell scripting books are highly recommended. See also Steve's [Arcade Games written in a shell script](#).

An excellent collection of Bash scripting tips, tricks, and resources at the [Bash Hackers Wiki](#).

Giles Orr's [Bash-Prompt HOWTO](#).

The [Pixelbeat command-line reference](#).

Very nice **sed**, **awk**, and regular expression tutorials at [The UNIX Grymoire](#).

The GNU [sed](#) and [gawk](#) manuals. As you recall, [gawk](#) is the enhanced GNU version of **awk**.

Many interesting sed scripts at the [seder's grab bag](#).

Tips and tricks at [Linux Reviews](#).

Trent Fisher's [groff tutorial](#).

David Wheeler's [Filenames in Shell](#) essay.

"Shelltris" and "shellitaire" at [Shell Script Games](#).

YongYe's wonderfully complex [Tetris game script](#).

Mark Komarinski's [Printing-Usage HOWTO](#).

[The Linux USB subsystem](#) (helpful in writing scripts affecting USB peripherals).

There is some nice material on [I/O redirection](#) in [chapter 10 of the textutils documentation](#) at the [University of Alberta site](#).

[Rick Hohensee](#) has written the *osimpa* i386 assembler entirely as Bash scripts.

dgatwood has a very nice [shell script games](#) site, featuring a Tetris® clone and solitaire.

Aurelio Marinho Jargas has written a [Regular expression wizard](#). He has also written an informative [book](#) on Regular Expressions, in Portuguese.

[Ben Tomkins](#) has created the [Bash Navigator](#) directory management tool.

[William Park](#) has been working on a project to incorporate certain *Awk* and *Python* features into Bash. Among these is a *gdbm* interface. He has released *bashdiff* on [Freshmeat.net](#). He has an [article](#) in the November, 2004 issue of the [Linux Gazette](#) on adding string functions to Bash, with a [followup article](#) in the December issue, and [yet another](#) in the January, 2005 issue.

Peter Knowles has written an [elaborate Bash script](#) that generates a book list on the [Sony Librie](#) e-book reader. This useful tool facilitates loading non-DRM user content on the *Librie* (and the newer *PRS-xxx-series* devices).

Tim Waugh's [xmlto](#) is an elaborate Bash script for converting Docbook XML documents to other formats.

Philip Patterson's [logforbash](#) logging/debugging script.

[AuctionGallery](#), an application for eBay "power sellers" coded in Bash.

Of historical interest are Colin Needham's *original International Movie Database (IMDB) reader polling scripts*, which nicely illustrate the use of [awk](#) for string parsing. Unfortunately, the URL link is broken.

Fritz Mehner has written a [bash-support plugin](#) for the *vim* text editor. He has also come up with his own [stylesheet for Bash](#). Compare it with the [ABS Guide Unofficial Stylesheet](#).

Penguin Pete has quite a number of shell scripting tips and hints on [his superb site](#). Highly recommended.

The excellent *Bash Reference Manual*, by Chet Ramey and Brian Fox, distributed as part of the *bash-2-doc* package (available as an [rpm](#)). See especially the instructive example scripts in this package.

John Lion's classic, [A Commentary on the Sixth Edition UNIX Operating System](#).

The [comp.os.unix.shell](#) newsgroup.

The [dd thread](#) on [Linux Questions](#).

The [comp.os.unix.shell FAQ](#).

Assorted comp.os.unix [FAQs](#).

The [Wikipedia article](#) covering [dc](#).

The [manpages](#) for **bash** and **bash2**, **date**, **expect**, **expr**, **find**, **grep**, **gzip**, **ln**, **patch**, **tar**, **tr**, **bc**, **xargs**. The *texinfo* documentation on **bash**, **dd**, **m4**, **gawk**, and **sed**.

Notes

- [1] It was hard to resist the obvious pun. No slight intended, since the book is a pretty decent introduction to the basic concepts of shell scripting.

Appendix A. Contributed Scripts

These scripts, while not fitting into the text of this document, do illustrate some interesting shell programming techniques. Some are useful, too. Have fun analyzing and running them.

Example A-1. *mailformat*: Formatting an e-mail message

```
1 #!/bin/bash
2 # mail-format.sh (ver. 1.1): Format e-mail messages.
3
4 # Gets rid of carets, tabs, and also folds excessively long lines.
5
6 # =====
7 #                               Standard Check for Script Argument(s)
8 ARGV=1
9 E_BADARGS=85
10 E_NOFILE=86
11
12 if [ $# -ne $ARGV ] # Correct number of arguments passed to script?
13 then
14     echo "Usage: `basename $0` filename"
15     exit $E_BADARGS
16 fi
17
18 if [ -f "$1" ] # Check if file exists.
19 then
20     file_name=$1
21 else
22     echo "File \"$1\" does not exist."
23     exit $E_NOFILE
24 fi
25 # -----
26
27 MAXWIDTH=70 # Width to fold excessively long lines to.
28
29 # =====
30 # A variable can hold a sed script.
31 # It's a useful technique.
32 sedscript='s/^>//
33 s/^ *>//
34 s/^ *//
35 s/ *//
36 # =====
37
38 # Delete carets and tabs at beginning of lines,
39 #+ then fold lines to $MAXWIDTH characters.
40 sed "$sedscript" $1 | fold -s --width=$MAXWIDTH
41 # -s option to "fold"
42 #+ breaks lines at whitespace, if possible.
43
44
45 # This script was inspired by an article in a well-known trade journal
46 #+ extolling a 164K MS Windows utility with similar functionality.
47 #
48 # An nice set of text processing utilities and an efficient
49 #+ scripting language provide an alternative to the bloated executables
50 #+ of a clunky operating system.
51
52 exit $?
```

Example A-2. *rn*: A simple-minded file renaming utility

This script is a modification of [Example 16-22](#).

```
1 #! /bin/bash
2 # rn.sh
3
4 # Very simple-minded filename "rename" utility (based on "lowercase.sh").
5 #
6 # The "ren" utility, by Vladimir Lanin (lanin@csd2.nyu.edu),
7 #+ does a much better job of this.
8
9
10 ARGS=2
11 E_BADARGS=85
12 ONE=1 # For getting singular/plural right (see below).
13
14 if [ $# -ne "$ARGS" ]
15 then
16     echo "Usage: `basename $0` old-pattern new-pattern"
17     # As in "rn gif jpg", which renames all gif files in working directory to jpg.
18     exit $E_BADARGS
19 fi
20
21 number=0 # Keeps track of how many files actually renamed.
22
23
24 for filename in *$1* # Traverse all matching files in directory.
25 do
26     if [ -f "$filename" ] # If finds match...
27     then
28         fname=`basename $filename` # Strip off path.
29         n=`echo $fname | sed -e "s/$1/$2/"` # Substitute new for old in filename.
30         mv $fname $n # Rename.
31         let "number += 1"
32     fi
33 done
34
35 if [ "$number" -eq "$ONE" ] # For correct grammar.
36 then
37     echo "$number file renamed."
38 else
39     echo "$number files renamed."
40 fi
41
42 exit $?
43
44
45 # Exercises:
46 # -----
47 # What types of files will this not work on?
48 # How can this be fixed?
```

Example A-3. *blank-rename*: Renames filenames containing blanks

This is an even simpler-minded version of previous script.

```
1 #! /bin/bash
2 # blank-rename.sh
3 #
4 # Substitutes underscores for blanks in all the filenames in a directory.
```

```

5
6 ONE=1                # For getting singular/plural right (see below).
7 number=0             # Keeps track of how many files actually renamed.
8 FOUND=0              # Successful return value.
9
10 for filename in *    #Traverse all files in directory.
11 do
12     echo "$filename" | grep -q " "      # Check whether filename
13     if [ $? -eq $FOUND ]                #+ contains space(s).
14     then
15         fname=$filename                  # Yes, this filename needs work.
16         n=`echo $fname | sed -e "s/ /_/g"` # Substitute underscore for blank.
17         mv "$fname" "$n"                 # Do the actual renaming.
18         let "number += 1"
19     fi
20 done
21
22 if [ "$number" -eq "$ONE" ]              # For correct grammar.
23 then
24     echo "$number file renamed."
25 else
26     echo "$number files renamed."
27 fi
28
29 exit 0

```

Example A-4. *encryptedpw*: Uploading to an ftp site, using a locally encrypted password

```

1 #!/bin/bash
2
3 # Example "ex72.sh" modified to use encrypted password.
4
5 # Note that this is still rather insecure,
6 #+ since the decrypted password is sent in the clear.
7 # Use something like "ssh" if this is a concern.
8
9 E_BADARGS=85
10
11 if [ -z "$1" ]
12 then
13     echo "Usage: `basename $0` filename"
14     exit $E_BADARGS
15 fi
16
17 Username=bozo          # Change to suit.
18 pword=/home/bozo/secret/password_encrypted.file
19 # File containing encrypted password.
20
21 Filename=`basename $1` # Strips pathname out of file name.
22
23 Server="XXX"
24 Directory="YYY"        # Change above to actual server name & directory.
25
26
27 Password=`cruft <$pword` # Decrypt password.
28 # Uses the author's own "cruft" file encryption package,
29 #+ based on the classic "onetime pad" algorithm,
30 #+ and obtainable from:
31 #+ Primary-site: ftp://ibiblio.org/pub/Linux/utils/file
32 #+ cruft-0.2.tar.gz [16k]
33
34

```

```
35 ftp -n $Server <<End-Of-Session
36 user $Username $Password
37 binary
38 bell
39 cd $Directory
40 put $Filename
41 bye
42 End-Of-Session
43 # -n option to "ftp" disables auto-logon.
44 # Note that "bell" rings 'bell' after each file transfer.
45
46 exit 0
```

Example A-5. *copy-cd*: Copying a data CD

```
1 #!/bin/bash
2 # copy-cd.sh: copying a data CD
3
4 CDROM=/dev/cdrom # CD ROM device
5 OF=/home/bozo/projects/cdimage.iso # output file
6 # /xxxx/xxxxxxxxx/ Change to suit your system.
7 BLOCKSIZE=2048
8 # SPEED=10 # If unspecified, uses max spd.
9 # DEVICE=/dev/cdrom older version.
10 DEVICE="1,0,0"
11
12 echo; echo "Insert source CD, but do *not* mount it."
13 echo "Press ENTER when ready. "
14 read ready # Wait for input, $ready not used.
15
16 echo; echo "Copying the source CD to $OF."
17 echo "This may take a while. Please be patient."
18
19 dd if=$CDROM of=$OF bs=$BLOCKSIZE # Raw device copy.
20
21
22 echo; echo "Remove data CD."
23 echo "Insert blank CDR."
24 echo "Press ENTER when ready. "
25 read ready # Wait for input, $ready not used.
26
27 echo "Copying $OF to CDR."
28
29 # cdrecord -v -isosize speed=$SPEED dev=$DEVICE $OF # Old version.
30 wodim -v -isosize dev=$DEVICE $OF
31 # Uses Joerg Schilling's "cdrecord" package (see its docs).
32 # http://www.fokus.gmd.de/nthp/employees/schilling/cdrecord.html
33 # Newer Linux distros may use "wodim" rather than "cdrecord" ...
34
35
36 echo; echo "Done copying $OF to CDR on device $CDROM."
37
38 echo "Do you want to erase the image file (y/n)? " # Probably a huge file.
39 read answer
40
41 case "$answer" in
42 [yY]) rm -f $OF
43 echo "$OF erased."
44 ;;
45 *) echo "$OF not erased.";;
46 esac
47
```



```

48 echo
49
50 # Exercise:
51 # Change the above "case" statement to also accept "yes" and "Yes" as input.
52
53 exit 0

```

Example A-6. Collatz series

```

1 #!/bin/bash
2 # collatz.sh
3
4 # The notorious "hailstone" or Collatz series.
5 # -----
6 # 1) Get the integer "seed" from the command-line.
7 # 2) NUMBER <-- seed
8 # 3) Print NUMBER.
9 # 4) If NUMBER is even, divide by 2, or
10 # 5) if odd, multiply by 3 and add 1.
11 # 6) NUMBER <-- result
12 # 7) Loop back to step 3 (for specified number of iterations).
13 #
14 # The theory is that every such sequence,
15 #+ no matter how large the initial value,
16 #+ eventually settles down to repeating "4,2,1..." cycles,
17 #+ even after fluctuating through a wide range of values.
18 #
19 # This is an instance of an "iterate,"
20 #+ an operation that feeds its output back into its input.
21 # Sometimes the result is a "chaotic" series.
22
23
24 MAX_ITERATIONS=200
25 # For large seed numbers (>32000), try increasing MAX_ITERATIONS.
26
27 h=${1:-$$} # Seed.
28 # Use $PID as seed,
29 #+ if not specified as command-line arg.
30
31 echo
32 echo "C($h) *- $MAX_ITERATIONS Iterations"
33 echo
34
35 for ((i=1; i<=MAX_ITERATIONS; i++))
36 do
37
38 # echo -n "$h      "
39 #      ^^^
40 #      tab
41 # printf does it better ...
42 COLWIDTH=%7d
43 printf $COLWIDTH $h
44
45 let "remainder = h % 2"
46 if [ "$remainder" -eq 0 ] # Even?
47 then
48 let "h /= 2" # Divide by 2.
49 else
50 let "h = h*3 + 1" # Multiply by 3 and add 1.
51 fi
52
53

```

```

54 COLUMNS=10                # Output 10 values per line.
55 let "line_break = i % $COLUMNS"
56 if [ "$line_break" -eq 0 ]
57 then
58     echo
59 fi
60
61 done
62
63 echo
64
65 # For more information on this strange mathematical function,
66 #+ see _Computers, Pattern, Chaos, and Beauty_, by Pickover, p. 185 ff.,
67 #+ as listed in the bibliography.
68
69 exit 0

```

Example A-7. *days-between*: Days between two dates

```

1 #!/bin/bash
2 # days-between.sh:      Number of days between two dates.
3 # Usage: ./days-between.sh [M]M/[D]D/YYYY [M]M/[D]D/YYYY
4 #
5 # Note: Script modified to account for changes in Bash, v. 2.05b +,
6 #+      that closed the loophole permitting large negative
7 #+      integer return values.
8
9 ARGS=2                # Two command-line parameters expected.
10 E_PARAM_ERR=85       # Param error.
11
12 REFYR=1600           # Reference year.
13 CENTURY=100
14 DIY=365
15 ADJ_DIY=367         # Adjusted for leap year + fraction.
16 MIY=12
17 DIM=31
18 LEAPCYCLE=4
19
20 MAXRETV=255         # Largest permissible
21                    #+ positive return value from a function.
22
23 diff=                # Declare global variable for date difference.
24 value=              # Declare global variable for absolute value.
25 day=                # Declare globals for day, month, year.
26 month=
27 year=
28
29
30 Param_Error ()      # Command-line parameters wrong.
31 {
32     echo "Usage: `basename $0` [M]M/[D]D/YYYY [M]M/[D]D/YYYY"
33     echo "      (date must be after 1/3/1600)"
34     exit $E_PARAM_ERR
35 }
36
37
38 Parse_Date ()       # Parse date from command-line params.
39 {
40     month=${1%/*}
41     dm=${1%/*}      # Day and month.
42     day=${dm#*/}
43     let "year = `basename $1`" # Not a filename, but works just the same.

```

```

44 }
45
46
47 check_date () # Checks for invalid date(s) passed.
48 {
49 [ "$day" -gt "$DIM" ] || [ "$month" -gt "$MIY" ] ||
50 [ "$year" -lt "$REFYR" ] && Param_Error
51 # Exit script on bad value(s).
52 # Uses or-list / and-list.
53 #
54 # Exercise: Implement more rigorous date checking.
55 }
56
57
58 strip_leading_zero () # Better to strip possible leading zero(s)
59 { #+ from day and/or month
60 return ${1#0} #+ since otherwise Bash will interpret them
61 } #+ as octal values (POSIX.2, sect 2.9.2.1).
62
63
64 day_index () # Gauss' Formula:
65 { # Days from March 1, 1600 to date passed as param.
66 # ^^^^^^^^^^^^^^^
67 day=$1
68 month=$2
69 year=$3
70
71 let "month = $month - 2"
72 if [ "$month" -le 0 ]
73 then
74 let "month += 12"
75 let "year -= 1"
76 fi
77
78 let "year -= $REFYR"
79 let "indexyr = $year / $CENTURY"
80
81
82 let "Days = $DIY*$year + $year/$LEAPCYCLE - $indexyr \
83 + $indexyr/$LEAPCYCLE + $ADJ_DIY*$month/$MIY + $day - $DIM"
84 # For an in-depth explanation of this algorithm, see
85 #+ http://weblogs.asp.net/pgreborio/archive/2005/01/06/347968.aspx
86
87
88 echo $Days
89
90 }
91
92
93 calculate_difference () # Difference between two day indices.
94 {
95 let "diff = $1 - $2" # Global variable.
96 }
97
98
99 abs () # Absolute value
100 { # Uses global "value" variable.
101 if [ "$1" -lt 0 ] # If negative
102 then #+ then
103 let "value = 0 - $1" #+ change sign,
104 else #+ else
105 let "value = $1" #+ leave it alone.
106 fi
107 }
108
109

```

```

110
111 if [ $# -ne "$ARGS" ]           # Require two command-line params.
112 then
113     Param_Error
114 fi
115
116 Parse_Date $1
117 check_date $day $month $year     # See if valid date.
118
119 strip_leading_zero $day          # Remove any leading zeroes
120 day=$?                           #+ on day and/or month.
121 strip_leading_zero $month
122 month=$?
123
124 let "date1 = `day_index $day $month $year`"
125
126
127 Parse_Date $2
128 check_date $day $month $year
129
130 strip_leading_zero $day
131 day=$?
132 strip_leading_zero $month
133 month=$?
134
135 date2=$(day_index $day $month $year) # Command substitution.
136
137
138 calculate_difference $date1 $date2
139
140 abs $diff                         # Make sure it's positive.
141 diff=$value
142
143 echo $diff
144
145 exit 0
146
147 # Exercise:
148 # -----
149 # If given only one command-line parameter, have the script
150 #+ use today's date as the second.
151
152
153 # Compare this script with
154 #+ the implementation of Gauss' Formula in a C program at
155 #+ http://buschencrew.hypermart.net/software/datedif

```

Example A-8. Making a *dictionary*

```

1 #!/bin/bash
2 # makedict.sh [make dictionary]
3
4 # Modification of /usr/sbin/mkdict (/usr/sbin/cracklib-forman) script.
5 # Original script copyright 1993, by Alec Muffett.
6 #
7 # This modified script included in this document in a manner
8 #+ consistent with the "LICENSE" document of the "Crack" package
9 #+ that the original script is a part of.
10
11 # This script processes text files to produce a sorted list
12 #+ of words found in the files.
13 # This may be useful for compiling dictionaries

```

```

14 #+ and for other lexicographic purposes.
15
16
17 E_BADARGS=85
18
19 if [ ! -r "$1" ]           # Need at least one
20 then                       #+ valid file argument.
21     echo "Usage: $0 files-to-process"
22     exit $E_BADARGS
23 fi
24
25
26 # SORT="sort"             # No longer necessary to define
27                           #+ options to sort. Changed from
28                           #+ original script.
29
30 cat $* |                  # Dump specified files to stdout.
31     tr A-Z a-z |          # Convert to lowercase.
32     tr ' ' '\012' |      # New: change spaces to newlines.
33 #     tr -cd '\012[a-z][0-9]' | # Get rid of everything
34                           #+ non-alphanumeric (in orig. script).
35     tr -c '\012a-z' '\012' | # Rather than deleting non-alpha
36                           #+ chars, change them to newlines.
37     sort |               # $SORT options unnecessary now.
38     uniq |               # Remove duplicates.
39     grep -v '^#' |      # Delete lines starting with #.
40     grep -v '^$'       # Delete blank lines.
41
42 exit $?

```

Example A-9. Soundex conversion

```

1 #!/bin/bash
2 # soundex.sh: Calculate "soundex" code for names
3
4 # =====
5 #         Soundex script
6 #         by
7 #         Mendel Cooper
8 #         thegrendel.abs@gmail.com
9 #         reldate: 23 January, 2002
10 #
11 #     Placed in the Public Domain.
12 #
13 # A slightly different version of this script appeared in
14 #+ Ed Schaefer's July, 2002 "Shell Corner" column
15 #+ in "Unix Review" on-line,
16 #+ http://www.unixreview.com/documents/uni1026336632258/
17 # =====
18
19
20 ARGCOUNT=1                # Need name as argument.
21 E_WRONGARGS=90
22
23 if [ $# -ne "$ARGCOUNT" ]
24 then
25     echo "Usage: `basename $0` name"
26     exit $E_WRONGARGS
27 fi
28
29
30 assign_value ()            # Assigns numerical value

```

```

31 {                                     #+ to letters of name.
32
33     val1=bfpv                          # 'b,f,p,v' = 1
34     val2=cgjksxz                      # 'c,g,j,k,q,s,x,z' = 2
35     val3=dt                            # etc.
36     val4=l
37     val5=mn
38     val6=r
39
40 # Exceptionally clever use of 'tr' follows.
41 # Try to figure out what is going on here.
42
43 value=$( echo "$1" \
44 | tr -d wh \
45 | tr $val1 1 | tr $val2 2 | tr $val3 3 \
46 | tr $val4 4 | tr $val5 5 | tr $val6 6 \
47 | tr -s 123456 \
48 | tr -d aeiouy )
49
50 # Assign letter values.
51 # Remove duplicate numbers, except when separated by vowels.
52 # Ignore vowels, except as separators, so delete them last.
53 # Ignore 'w' and 'h', even as separators, so delete them first.
54 #
55 # The above command substitution lays more pipe than a plumber <g>.
56
57 }
58
59
60 input_name="$1"
61 echo
62 echo "Name = $input_name"
63
64
65 # Change all characters of name input to lowercase.
66 # -----
67 name=$( echo $input_name | tr A-Z a-z )
68 # -----
69 # Just in case argument to script is mixed case.
70
71
72 # Prefix of soundex code: first letter of name.
73 # -----
74
75
76 char_pos=0                            # Initialize character position.
77 prefix0=${name:$char_pos:1}
78 prefix=`echo $prefix0 | tr a-z A-Z`
79                                           # Uppercase 1st letter of soundex.
80
81 let "char_pos += 1"                    # Bump character position to 2nd letter of name.
82 name1=${name:$char_pos}
83
84
85 # ++++++ Exception Patch ++++++
86 # Now, we run both the input name and the name shifted one char
87 #+ to the right through the value-assigning function.
88 # If we get the same value out, that means that the first two characters
89 #+ of the name have the same value assigned, and that one should cancel.
90 # However, we also need to test whether the first letter of the name
91 #+ is a vowel or 'w' or 'h', because otherwise this would bollix things up.
92
93 char1=`echo $prefix | tr A-Z a-z`      # First letter of name, lowercased.
94
95 assign_value $name
96 s1=$value

```

```

97 assign_value $name1
98 s2=$value
99 assign_value $char1
100 s3=$value
101 s3=9$s3                                # If first letter of name is a vowel
102                                         #+ or 'w' or 'h',
103                                         #+ then its "value" will be null (unset).
104                                         #+ Therefore, set it to 9, an otherwise
105                                         #+ unused value, which can be tested for.
106
107
108 if [[ "$s1" -ne "$s2" || "$s3" -eq 9 ]]
109 then
110     suffix=$s2
111 else
112     suffix=${s2:$char_pos}
113 fi
114 # ++++++ end Exception Patch ++++++
115
116
117 padding=000                            # Use at most 3 zeroes to pad.
118
119
120 soun=$prefix$suffix$padding            # Pad with zeroes.
121
122 MAXLEN=4                                # Truncate to maximum of 4 chars.
123 soundex=${soun:0:$MAXLEN}
124
125 echo "Soundex = $soundex"
126
127 echo
128
129 # The soundex code is a method of indexing and classifying names
130 #+ by grouping together the ones that sound alike.
131 # The soundex code for a given name is the first letter of the name,
132 #+ followed by a calculated three-number code.
133 # Similar sounding names should have almost the same soundex codes.
134
135 # Examples:
136 # Smith and Smythe both have a "S-530" soundex.
137 # Harrison = H-625
138 # Hargison = H-622
139 # Harriman = H-655
140
141 # This works out fairly well in practice, but there are numerous anomalies.
142 #
143 #
144 # The U.S. Census and certain other governmental agencies use soundex,
145 # as do genealogical researchers.
146 #
147 # For more information,
148 #+ see the "National Archives and Records Administration home page",
149 #+ http://www.nara.gov/genealogy/soundex/soundex.html
150
151
152
153 # Exercise:
154 # -----
155 # Simplify the "Exception Patch" section of this script.
156
157 exit 0

```

Example A-10. *Game of Life*

```

1 #!/bin/bash
2 # life.sh: "Life in the Slow Lane"
3 # Author: Mendel Cooper
4 # License: GPL3
5
6 # Version 0.2:   Patched by Daniel Albers
7 #+             to allow non-square grids as input.
8 # Version 0.2.1: Added 2-second delay between generations.
9
10 # ##### #
11 # This is the Bash script version of John Conway's "Game of Life". #
12 # "Life" is a simple implementation of cellular automata. #
13 # ----- #
14 # On a rectangular grid, let each "cell" be either "living" or "dead." #
15 # Designate a living cell with a dot, and a dead one with a blank space. #
16 #     Begin with an arbitrarily drawn dot-and-blank grid, #
17 #+     and let this be the starting generation: generation 0. #
18 # Determine each successive generation by the following rules: #
19 # 1) Each cell has 8 neighbors, the adjoining cells #
20 #+  left, right, top, bottom, and the 4 diagonals. #
21 # #
22 #             123 #
23 #             4*5   The * is the cell under consideration. #
24 #             678 #
25 # #
26 # 2) A living cell with either 2 or 3 living neighbors remains alive. #
27 SURVIVE=2 #
28 # 3) A dead cell with 3 living neighbors comes alive, a "birth." #
29 BIRTH=3 #
30 # 4) All other cases result in a dead cell for the next generation. #
31 # ##### #
32
33
34 startfile=gen0 # Read the starting generation from the file "gen0" ...
35 # Default, if no other file specified when invoking script.
36 #
37 if [ -n "$1" ] # Specify another "generation 0" file.
38 then
39     startfile="$1"
40 fi
41
42 #####
43 # Abort script if "startfile" not specified
44 #+ and
45 #+ default file "gen0" not present.
46
47 E_NOSTARTFILE=86
48
49 if [ ! -e "$startfile" ]
50 then
51     echo "Startfile \"$startfile\" missing!"
52     exit $E_NOSTARTFILE
53 fi
54 #####
55
56
57 ALIVE1=.
58 DEAD1=_
59 # Represent living and dead cells in the start-up file.
60
61 # -----#
62 # This script uses a 10 x 10 grid (may be increased,
63 #+ but a large grid will slow down execution).
64 ROWS=10
65 COLS=10
66 # Change above two variables to match desired grid size.

```



```

67 # -----#
68
69 GENERATIONS=10      # How many generations to cycle through.
70                    # Adjust this upwards
71                    #+ if you have time on your hands.
72
73 NONE_ALIVE=85       # Exit status on premature bailout,
74                    #+ if no cells left alive.
75 DELAY=2             # Pause between generations.
76 TRUE=0
77 FALSE=1
78 ALIVE=0
79 DEAD=1
80
81 avar=               # Global; holds current generation.
82 generation=0       # Initialize generation count.
83
84 # =====
85
86 let "cells = $ROWS * $COLS" # How many cells.
87
88 # Arrays containing "cells."
89 declare -a initial
90 declare -a current
91
92 display ()
93 {
94
95 alive=0             # How many cells alive at any given time.
96                    # Initially zero.
97
98 declare -a arr
99 arr=( `echo "$1"` ) # Convert passed arg to array.
100
101 element_count=${#arr[*]}
102
103 local i
104 local rowcheck
105
106 for ((i=0; i<$element_count; i++))
107 do
108
109 # Insert newline at end of each row.
110 let "rowcheck = $i % COLS"
111 if [ "$rowcheck" -eq 0 ]
112 then
113     echo # Newline.
114     echo -n " " # Indent.
115 fi
116
117 cell=${arr[i]}
118
119 if [ "$cell" = . ]
120 then
121     let "alive += 1"
122 fi
123
124 echo -n "$cell" | sed -e 's/_/ /g'
125 # Print out array, changing underscores to spaces.
126 done
127
128 return
129
130 }
131
132 IsValid () # Test if cell coordinate valid.

```

```

133 {
134
135     if [ -z "$1" -o -z "$2" ]           # Mandatory arguments missing?
136     then
137         return $FALSE
138     fi
139
140 local row
141 local lower_limit=0                   # Disallow negative coordinate.
142 local upper_limit
143 local left
144 local right
145
146 let "upper_limit = $ROWS * $COLS - 1" # Total number of cells.
147
148
149 if [ "$1" -lt "$lower_limit" -o "$1" -gt "$upper_limit" ]
150 then
151     return $FALSE                       # Out of array bounds.
152 fi
153
154 row=$2
155 let "left = $row * $COLS"              # Left limit.
156 let "right = $left + $COLS - 1"        # Right limit.
157
158 if [ "$1" -lt "$left" -o "$1" -gt "$right" ]
159 then
160     return $FALSE                       # Beyond row boundary.
161 fi
162
163 return $TRUE                           # Valid coordinate.
164
165 }
166
167
168 IsAlive ()                             # Test whether cell is alive.
169                                     # Takes array, cell number, and
170 {                                     #+ state of cell as arguments.
171     GetCount "$1" $2                  # Get alive cell count in neighborhood.
172     local nhbd=$?
173
174     if [ "$nhbd" -eq "$BIRTH" ]      # Alive in any case.
175     then
176         return $ALIVE
177     fi
178
179     if [ "$3" = "." -a "$nhbd" -eq "$SURVIVE" ]
180     then
181         return $ALIVE                 # Alive only if previously alive.
182     fi
183
184     return $DEAD                      # Defaults to dead.
185
186 }
187
188
189 GetCount ()                            # Count live cells in passed cell's neighborhood.
190                                     # Two arguments needed:
191                                     # $1) variable holding array
192                                     # $2) cell number
193 {
194     local cell_number=$2
195     local array
196     local top
197     local center
198     local bottom

```

```

199 local r
200 local row
201 local i
202 local t_top
203 local t_cen
204 local t_bot
205 local count=0
206 local ROW_NHBD=3
207
208 array=( `echo "$1"` )
209
210 let "top = $cell_number - $COLS - 1" # Set up cell neighborhood.
211 let "center = $cell_number - 1"
212 let "bottom = $cell_number + $COLS - 1"
213 let "r = $cell_number / $COLS"
214
215 for ((i=0; i<$ROW_NHBD; i++)) # Traverse from left to right.
216 do
217     let "t_top = $top + $i"
218     let "t_cen = $center + $i"
219     let "t_bot = $bottom + $i"
220
221
222     let "row = $r" # Count center row.
223     IsValid $t_cen $row # Valid cell position?
224     if [ $? -eq "$TRUE" ]
225     then
226         if [ ${array[$t_cen]} = "$ALIVE1" ] # Is it alive?
227         then # If yes, then ...
228             let "count += 1" # Increment count.
229         fi
230     fi
231
232     let "row = $r - 1" # Count top row.
233     IsValid $t_top $row
234     if [ $? -eq "$TRUE" ]
235     then
236         if [ ${array[$t_top]} = "$ALIVE1" ] # Redundancy here.
237         then # Can it be optimized?
238             let "count += 1"
239         fi
240     fi
241
242     let "row = $r + 1" # Count bottom row.
243     IsValid $t_bot $row
244     if [ $? -eq "$TRUE" ]
245     then
246         if [ ${array[$t_bot]} = "$ALIVE1" ]
247         then
248             let "count += 1"
249         fi
250     fi
251
252 done
253
254
255 if [ ${array[$cell_number]} = "$ALIVE1" ]
256 then
257     let "count -= 1" # Make sure value of tested cell itself
258     fi #+ is not counted.
259
260
261 return $count
262
263 }
264

```

```

265 next_gen ()                # Update generation array.
266 {
267
268 local array
269 local i=0
270
271 array=( `echo "$1"` )      # Convert passed arg to array.
272
273 while [ "$i" -lt "$cells" ]
274 do
275     IsAlive "$1" $i ${array[$i]} # Is the cell alive?
276     if [ $? -eq "$ALIVE" ]
277     then
278         array[$i]=.          # If alive, then
279         #+ represent the cell as a period.
280     else
281         array[$i]="_"        # Otherwise underscore
282         #+ (will later be converted to space).
283     fi
284     let "i += 1"
285 done
286
287 # let "generation += 1"      # Increment generation count.
288 ### Why was the above line commented out?
289
290 # Set variable to pass as parameter to "display" function.
291 avar=`echo ${array[@]}`     # Convert array back to string variable.
292 display "$avar"            # Display it.
293 echo; echo
294 echo "Generation $generation - $alive alive"
295
296 if [ "$alive" -eq 0 ]
297 then
298     echo
299     echo "Premature exit: no more cells alive!"
300     exit $NONE_ALIVE        # No point in continuing
301 fi
302 #+ if no live cells.
303 }
304
305
306 # =====
307
308 # main ()
309 # {
310
311 # Load initial array with contents of startup file.
312 initial=( `cat "$startupfile" | sed -e '/#/d' | tr -d '\n' | \
313 # Delete lines containing '#' comment character.
314     sed -e 's/\./\./g' -e 's/_/_/g` ` )
315 # Remove linefeeds and insert space between elements.
316
317 clear                # Clear screen.
318
319 echo #                Title
320 setterm -reverse on
321 echo "=====
322 setterm -reverse off
323 echo " $GENERATIONS generations"
324 echo "          of"
325 echo "\"Life in the Slow Lane\""
326 setterm -reverse on
327 echo "=====
328 setterm -reverse off
329
330 sleep $DELAY        # Display "splash screen" for 2 seconds.

```

```

331
332
333 # ----- Display first generation. -----
334 Gen0=`echo ${initial[@]}`
335 display "$Gen0"          # Display only.
336 echo; echo
337 echo "Generation $generation - $alive alive"
338 sleep $DELAY
339 # -----
340
341
342 let "generation += 1"    # Bump generation count.
343 echo
344
345 # ----- Display second generation. -----
346 Cur=`echo ${initial[@]}`
347 next_gen "$Cur"        # Update & display.
348 sleep $DELAY
349 # -----
350
351 let "generation += 1"    # Increment generation count.
352
353 # ----- Main loop for displaying subsequent generations -----
354 while [ "$generation" -le "$GENERATIONS" ]
355 do
356   Cur="$savar"
357   next_gen "$Cur"
358   let "generation += 1"
359   sleep $DELAY
360 done
361 # =====
362
363 echo
364 # }
365
366 exit 0    # EOF:EOF
367
368
369
370 # The grid in this script has a "boundary problem."
371 # The the top, bottom, and sides border on a void of dead cells.
372 # Exercise: Change the script to have the grid wrap around,
373 # +          so that the left and right sides will "touch,"
374 # +          as will the top and bottom.
375 #
376 # Exercise: Create a new "gen0" file to seed this script.
377 #           Use a 12 x 16 grid, instead of the original 10 x 10 one.
378 #           Make the necessary changes to the script,
379 #+         so it will run with the altered file.
380 #
381 # Exercise: Modify this script so that it can determine the grid size
382 #+         from the "gen0" file, and set any variables necessary
383 #+         for the script to run.
384 #           This would make unnecessary any changes to variables
385 #+         in the script for an altered grid size.
386 #
387 # Exercise: Optimize this script.
388 #           It has redundant code.

```

Example A-11. Data file for *Game of Life*

```
1 # gen0
```

```

2 #
3 # This is an example "generation 0" start-up file for "life.sh".
4 # -----
5 # The "gen0" file is a 10 x 10 grid using a period (.) for live cells,
6 #+ and an underscore (_) for dead ones. We cannot simply use spaces
7 #+ for dead cells in this file because of a peculiarity in Bash arrays.
8 # [Exercise for the reader: explain this.]
9 #
10 # Lines beginning with a '#' are comments, and the script ignores them.
11 __.__.____
12 __.__.____
13 _____.____.
14 __._____.
15 _____.____
16 .._.____.
17 _____.____
18 _____.____
19 __.__.____
20 .._.____.

```

+++

The following script is by Mark Moraes of the University of Toronto. See the file `Moraes-COPYRIGHT` for permissions and restrictions. This file is included in the combined [HTML/source tarball](#) of the *ABS Guide*.

Example A-12. *behead*: Removing mail and news message headers

```

1 #!/bin/sh
2 # Strips off the header from a mail/News message i.e. till the first
3 #+ empty line.
4 # Author: Mark Moraes, University of Toronto
5
6 # ==> These comments added by author of this document.
7
8 if [ $# -eq 0 ]; then
9 # ==> If no command-line args present, then works on file redirected to stdin.
10 sed -e '1,/^$/d' -e '/^[          ]*/d'
11 # --> Delete empty lines and all lines until
12 # --> first one beginning with white space.
13 else
14 # ==> If command-line args present, then work on files named.
15 for i do
16     sed -e '1,/^$/d' -e '/^[          ]*/d' $i
17     # --> Ditto, as above.
18 done
19 fi
20
21 exit
22
23 # ==> Exercise: Add error checking and other options.
24 # ==>
25 # ==> Note that the small sed script repeats, except for the arg passed.
26 # ==> Does it make sense to embed it in a function? Why or why not?
27
28
29 /*
30 * Copyright University of Toronto 1988, 1989.
31 * Written by Mark Moraes
32 *
33 * Permission is granted to anyone to use this software for any purpose on
34 * any computer system, and to alter it and redistribute it freely, subject
35 * to the following restrictions:

```

```

36 *
37 * 1. The author and the University of Toronto are not responsible
38 *   for the consequences of use of this software, no matter how awful,
39 *   even if they arise from flaws in it.
40 *
41 * 2. The origin of this software must not be misrepresented, either by
42 *   explicit claim or by omission. Since few users ever read sources,
43 *   credits must appear in the documentation.
44 *
45 * 3. Altered versions must be plainly marked as such, and must not be
46 *   misrepresented as being the original software. Since few users
47 *   ever read sources, credits must appear in the documentation.
48 *
49 * 4. This notice may not be removed or altered.
50 */

```

+

Antek Sawicki contributed the following script, which makes very clever use of the parameter substitution operators discussed in [Section 10.2](#).

Example A-13. *password*: Generating random 8-character passwords

```

1 #!/bin/bash
2 #
3 #
4 # Random password generator for Bash 2.x +
5 #+ by Antek Sawicki <tenox@tenox.tc>,
6 #+ who generously gave usage permission to the ABS Guide author.
7 #
8 # ==> Comments added by document author ==>
9
10
11 MATRIX="0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz"
12 # ==> Password will consist of alphanumeric characters.
13 LENGTH="8"
14 # ==> May change 'LENGTH' for longer password.
15
16
17 while [ "${n:=1}" -le "$LENGTH" ]
18 # ==> Recall that := is "default substitution" operator.
19 # ==> So, if 'n' has not been initialized, set it to 1.
20 do
21     PASS="$PASS${MATRIX:${RANDOM%${#MATRIX}}:1}"
22     # ==> Very clever, but tricky.
23
24     # ==> Starting from the innermost nesting...
25     # ==> ${#MATRIX} returns length of array MATRIX.
26
27     # ==> $RANDOM%${#MATRIX} returns random number between 1
28     # ==> and [length of MATRIX] - 1.
29
30     # ==> ${MATRIX:${RANDOM%${#MATRIX}}:1}
31     # ==> returns expansion of MATRIX at random position, by length 1.
32     # ==> See {var:pos:len} parameter substitution in Chapter 9.
33     # ==> and the associated examples.
34
35     # ==> PASS=... simply pastes this result onto previous PASS (concatenation).
36
37     # ==> To visualize this more clearly, uncomment the following line
38     #
39     echo "$PASS"

```

```

39 # ==> to see PASS being built up,
40 # ==> one character at a time, each iteration of the loop.
41
42 let n+=1
43 # ==> Increment 'n' for next pass.
44 done
45
46 echo "$PASS"      # ==> Or, redirect to a file, as desired.
47
48 exit 0

```

+

James R. Van Zandt contributed this script which uses named pipes and, in his words, "really exercises quoting and escaping."

Example A-14. *fifo*: Making daily backups, using named pipes

```

1 #!/bin/bash
2 # ==> Script by James R. Van Zandt, and used here with his permission.
3
4 # ==> Comments added by author of this document.
5
6
7 HERE=`uname -n`      # ==> hostname
8 THERE=bilbo
9 echo "starting remote backup to $THERE at `date +%r`"
10 # ==> `date +%r` returns time in 12-hour format, i.e. "08:08:34 PM".
11
12 # make sure /pipe really is a pipe and not a plain file
13 rm -rf /pipe
14 mkfifo /pipe        # ==> Create a "named pipe", named "/pipe" ...
15
16 # ==> 'su xyz' runs commands as user "xyz".
17 # ==> 'ssh' invokes secure shell (remote login client).
18 su xyz -c "ssh $THERE \"cat > /home/xyz/backup/${HERE}-daily.tar.gz\" < /pipe"&
19 cd /
20 tar -czf - bin boot dev etc home info lib man root sbin share usr var > /pipe
21 # ==> Uses named pipe, /pipe, to communicate between processes:
22 # ==> 'tar/gzip' writes to /pipe and 'ssh' reads from /pipe.
23
24 # ==> The end result is this backs up the main directories, from / on down.
25
26 # ==> What are the advantages of a "named pipe" in this situation,
27 # ==>+ as opposed to an "anonymous pipe", with |?
28 # ==> Will an anonymous pipe even work here?
29
30 # ==> Is it necessary to delete the pipe before exiting the script?
31 # ==> How could that be done?
32
33
34 exit 0

```

+

Stéphane Chazelas used the following script to demonstrate generating prime numbers without arrays.

Example A-15. Generating prime numbers using the modulo operator

```
1 #!/bin/bash
2 # primes.sh: Generate prime numbers, without using arrays.
3 # Script contributed by Stephane Chazelas.
4
5 # This does *not* use the classic "Sieve of Eratosthenes" algorithm,
6 #+ but instead the more intuitive method of testing each candidate number
7 #+ for factors (divisors), using the "%" modulo operator.
8
9
10 LIMIT=1000                # Primes, 2 ... 1000.
11
12 Primes()
13 {
14     (( n = $1 + 1 ))      # Bump to next integer.
15     shift                # Next parameter in list.
16     # echo "_n=$n i=$i_"
17
18     if (( n == LIMIT ))
19     then echo $*
20     return
21     fi
22
23     for i; do
24         # echo "-n=$n i=$i-"
25         (( i * i > n )) && break # Optimization.
26         (( n % i )) && continue # Sift out non-primes using modulo operator.
27         Primes $n $@      # Recursion inside loop.
28     return
29     done
30
31     Primes $n $@ $n      # Recursion outside loop.
32                         # Successively accumulate
33                         #+ positional parameters.
34                         # "$@" is the accumulating list of primes.
35 }
36
37 Primes 1
38
39 exit $?
40
41 # Pipe output of the script to 'fmt' for prettier printing.
42
43 # Uncomment lines 16 and 24 to help figure out what is going on.
44
45 # Compare the speed of this algorithm for generating primes
46 #+ with the Sieve of Eratosthenes (ex68.sh).
47
48
49 # Exercise: Rewrite this script without recursion.
```

+

Rick Boivie's revision of Jordi Sanfeliu's *tree* script.

Example A-16. *tree*: Displaying a directory tree

```
1 #!/bin/bash
2 # tree.sh
3
4 # Written by Rick Boivie.
```

```

5 # Used with permission.
6 # This is a revised and simplified version of a script
7 #+ by Jordi Sanfeliu (the original author), and patched by Ian Kjos.
8 # This script replaces the earlier version used in
9 #+ previous releases of the Advanced Bash Scripting Guide.
10 # Copyright (c) 2002, by Jordi Sanfeliu, Rick Boivie, and Ian Kjos.
11
12 # ==> Comments added by the author of this document.
13
14
15 search () {
16 for dir in `echo *`
17 # ==> `echo *` lists all the files in current working directory,
18 #+ ==> without line breaks.
19 # ==> Similar effect to for dir in *
20 # ==> but "dir in `echo *`" will not handle filenames with blanks.
21 do
22   if [ -d "$dir" ] ; then # ==> If it is a directory (-d)...
23     zz=0                 # ==> Temp variable, keeping track of
24                         #     directory level.
25     while [ $zz != $1 ] # Keep track of inner nested loop.
26       do
27         echo -n "| "      # ==> Display vertical connector symbol,
28                         # ==> with 2 spaces & no line feed
29                         #     in order to indent.
30         zz=`expr $zz + 1` # ==> Increment zz.
31       done
32
33     if [ -L "$dir" ] ; then # ==> If directory is a symbolic link...
34       echo "+---$dir" `ls -l $dir | sed 's/^.*'$dir' //'`
35       # ==> Display horiz. connector and list directory name, but...
36       # ==> delete date/time part of long listing.
37     else
38       echo "+---$dir"      # ==> Display horizontal connector symbol...
39       # ==> and print directory name.
40       numdirs=`expr $numdirs + 1` # ==> Increment directory count.
41       if cd "$dir" ; then        # ==> If can move to subdirectory...
42         search `expr $1 + 1`    # with recursion ;- )
43         # ==> Function calls itself.
44         cd ..
45       fi
46     fi
47   fi
48 done
49 }
50
51 if [ $# != 0 ] ; then
52   cd $1 # Move to indicated directory.
53 #else # stay in current directory
54 fi
55
56 echo "Initial directory = `pwd`"
57 numdirs=0
58
59 search 0
60 echo "Total directories = $numdirs"
61
62 exit 0

```

Patsie's version of a directory *tree* script.

Example A-17. *tree2*: Alternate directory tree script

```

1 #!/bin/bash
2 # tree2.sh
3
4 # Lightly modified/reformatted by ABS Guide author.
5 # Included in ABS Guide with permission of script author (thanks!).
6
7 ## Recursive file/dirsizes checking script, by Patsie
8 ##
9 ## This script builds a list of files/directories and their size (du -akx)
10 ## and processes this list to a human readable tree shape
11 ## The 'du -akx' is only as good as the permissions the owner has.
12 ## So preferably run as root* to get the best results, or use only on
13 ## directories for which you have read permissions. Anything you can't
14 ## read is not in the list.
15
16 #* ABS Guide author advises caution when running scripts as root!
17
18
19 ##### THIS IS CONFIGURABLE #####
20
21 TOP=5 # Top 5 biggest (sub)directories.
22 MAXRECURS=5 # Max 5 subdirectories/recursions deep.
23 E_BL=80 # Blank line already returned.
24 E_DIR=81 # Directory not specified.
25
26
27 ##### DON'T CHANGE ANYTHING BELOW THIS LINE #####
28
29 PID=$$ # Our own process ID.
30 SELF=`basename $0` # Our own program name.
31 TMP="/tmp/${SELF}.${PID}.tmp" # Temporary 'du' result.
32
33 # Convert number to dotted thousand.
34 function dot { echo " $*" |
35 sed -e :a -e 's/\([0-9]\)\{3\}/\1,\2/;ta' |
36 tail -c 12; }
37
38 # Usage: tree <recursion> <indent prefix> <min size> <directory>
39 function tree {
40 recurs="$1" # How deep nested are we?
41 prefix="$2" # What do we display before file/dirname?
42 minsize="$3" # What is the minimum file/dirsizes?
43 dirname="$4" # Which directory are we checking?
44
45 # Get ($TOP) biggest subdirs/subfiles from TMP file.
46 LIST=`egrep "[[:space:]]${dirname}/[^/]*$" "$TMP" |
47 awk '{if($1>"$minsize") print;}' | sort -nr | head -$TOP`
48 [ -z "$LIST" ] && return # Empty list, then go back.
49
50 cnt=0
51 num=`echo "$LIST" | wc -l` # How many entries in the list.
52
53 ## Main loop
54 echo "$LIST" | while read size name; do
55 ((cnt+=1)) # Count entry number.
56 bname=`basename "$name"` # We only need a basename of the entry.
57 [ -d "$name" ] && bname="$bname/" # If it's a directory, append a slash.
58 echo "`dot $size`$prefix +-$bname"
59 # Display the result.
60 # Call ourself recursively if it's a directory
61 #+ and we're not nested too deep ($MAXRECURS).
62 # The recursion goes up: $((recurs+1))
63 # The prefix gets a space if it's the last entry,
64 #+ or a pipe if there are more entries.
65 # The minimum file/dirsizes becomes

```

```

67     #+ a tenth of his parent: $((size/10)).
68     # Last argument is the full directory name to check.
69     if [ -d "$name" -a $recurs -lt $MAXRECURS ]; then
70         [ $cnt -lt $num ] \
71         || (tree $((recurs+1)) "$prefix " $((size/10)) "$name") \
72         && (tree $((recurs+1)) "$prefix |" $((size/10)) "$name")
73     fi
74 done
75
76 [ $? -eq 0 ] && echo "          $prefix"
77 # Every time we jump back add a 'blank' line.
78 return $_E_BL
79 # We return 80 to tell we added a blank line already.
80 }
81
82 ###          ###
83 ### main program ###
84 ###          ###
85
86 rootdir="$@"
87 [ -d "$rootdir" ] ||
88 { echo "$SELF: Usage: $SELF <directory>" >&2; exit $_E_DIR; }
89 # We should be called with a directory name.
90
91 echo "Building inventory list, please wait ..."
92     # Show "please wait" message.
93 du -akx "$rootdir" 1>"$TMP" 2>/dev/null
94     # Build a temporary list of all files/dirs and their size.
95 size=`tail -1 "$TMP" | awk '{print $1}'`
96     # What is our rootdirectory's size?
97 echo "`dot $size` $rootdir"
98     # Display rootdirectory's entry.
99 tree 0 "" 0 "$rootdir"
100     # Display the tree below our rootdirectory.
101
102 rm "$TMP" 2>/dev/null
103     # Clean up TMP file.
104
105 exit $?

```

Noah Friedman permitted use of his *string function* script. It essentially reproduces some of the C-library string manipulation functions.

Example A-18. *string functions*: C-style string functions

```

1 #!/bin/bash
2
3 # string.bash --- bash emulation of string(3) library routines
4 # Author: Noah Friedman <friedman@prep.ai.mit.edu>
5 # ==>      Used with his kind permission in this document.
6 # Created: 1992-07-01
7 # Last modified: 1993-09-29
8 # Public domain
9
10 # Conversion to bash v2 syntax done by Chet Ramey
11
12 # Commentary:
13 # Code:
14
15 #:docstring strcat:
16 # Usage: strcat s1 s2
17 #
18 # Strcat appends the value of variable s2 to variable s1.

```

```

19 #
20 # Example:
21 #   a="foo"
22 #   b="bar"
23 #   strcat a b
24 #   echo $a
25 #   => foobar
26 #
27 #:end docstring:
28
29 ###;;;autoload   ==> Autoloading of function commented out.
30 function strcat ()
31 {
32     local s1_val s2_val
33
34     s1_val=${!1}           # indirect variable expansion
35     s2_val=${!2}
36     eval "$1"="\ "${s1_val}${s2_val}"\'
37     # ==> eval $1='${s1_val}${s2_val}' avoids problems,
38     # ==> if one of the variables contains a single quote.
39 }
40
41 #:docstring strncat:
42 # Usage: strncat s1 s2 $n
43 #
44 # Line strcat, but strncat appends a maximum of n characters from the value
45 # of variable s2. It copies fewer if the value of variable s2 is shorter
46 # than n characters. Echoes result on stdout.
47 #
48 # Example:
49 #   a=foo
50 #   b=barbaz
51 #   strncat a b 3
52 #   echo $a
53 #   => foobar
54 #
55 #:end docstring:
56
57 ###;;;autoload
58 function strncat ()
59 {
60     local s1="$1"
61     local s2="$2"
62     local -i n="$3"
63     local s1_val s2_val
64
65     s1_val=${!s1}         # ==> indirect variable expansion
66     s2_val=${!s2}
67
68     if [ ${#s2_val} -gt $n ]; then
69         s2_val=${s2_val:0:$n}   # ==> substring extraction
70     fi
71
72     eval "$s1"="\ "${s1_val}${s2_val}"\'
73     # ==> eval $1='${s1_val}${s2_val}' avoids problems,
74     # ==> if one of the variables contains a single quote.
75 }
76
77 #:docstring strcmp:
78 # Usage: strcmp $s1 $s2
79 #
80 # Strcmp compares its arguments and returns an integer less than, equal to,
81 # or greater than zero, depending on whether string s1 is lexicographically
82 # less than, equal to, or greater than string s2.
83 #:end docstring:
84

```

```

85 ###;;autoload
86 function strcmp ()
87 {
88     [ "$1" = "$2" ] && return 0
89
90     [ "${1}" '<' "${2}" ] > /dev/null && return -1
91
92     return 1
93 }
94
95 #:docstring strncmp:
96 # Usage: strncmp $s1 $s2 $n
97 #
98 # Like strcmp, but makes the comparison by examining a maximum of n
99 # characters (n less than or equal to zero yields equality).
100 #:end docstring:
101
102 ###;;autoload
103 function strncmp ()
104 {
105     if [ -z "${3}" -o "${3}" -le "0" ]; then
106         return 0
107     fi
108
109     if [ ${3} -ge ${#1} -a ${3} -ge ${#2} ]; then
110         strcmp "$1" "$2"
111         return $?
112     else
113         s1=${1:0:${3}}
114         s2=${2:0:${3}}
115         strcmp $s1 $s2
116         return $?
117     fi
118 }
119
120 #:docstring strlen:
121 # Usage: strlen s
122 #
123 # Strlen returns the number of characters in string literal s.
124 #:end docstring:
125
126 ###;;autoload
127 function strlen ()
128 {
129     eval echo "\${#${1}}"
130     # ==> Returns the length of the value of the variable
131     # ==> whose name is passed as an argument.
132 }
133
134 #:docstring strspn:
135 # Usage: strspn $s1 $s2
136 #
137 # Strspn returns the length of the maximum initial segment of string s1,
138 # which consists entirely of characters from string s2.
139 #:end docstring:
140
141 ###;;autoload
142 function strspn ()
143 {
144     # Unsetting IFS allows whitespace to be handled as normal chars.
145     local IFS=
146     local result="${1%[!${2}]*}"
147
148     echo ${#result}
149 }
150

```

```

151 #:docstring strcspn:
152 # Usage: strcspn $s1 $s2
153 #
154 # Strcspn returns the length of the maximum initial segment of string s1,
155 # which consists entirely of characters not from string s2.
156 #:end docstring:
157
158 ###;;;autoload
159 function strcspn ()
160 {
161     # Unsetting IFS allows whitespace to be handled as normal chars.
162     local IFS=
163     local result="${1%%[${2}]}"
164
165     echo ${#result}
166 }
167
168 #:docstring strstr:
169 # Usage: strstr s1 s2
170 #
171 # Strstr echoes a substring starting at the first occurrence of string s2 in
172 # string s1, or nothing if s2 does not occur in the string. If s2 points to
173 # a string of zero length, strstr echoes s1.
174 #:end docstring:
175
176 ###;;;autoload
177 function strstr ()
178 {
179     # if s2 points to a string of zero length, strstr echoes s1
180     [ ${#2} -eq 0 ] && { echo "$1" ; return 0; }
181
182     # strstr echoes nothing if s2 does not occur in s1
183     case "$1" in
184     *$2*) ;;
185     *) return 1;;
186     esac
187
188     # use the pattern matching code to strip off the match and everything
189     # following it
190     first=${1/$2*/}
191
192     # then strip off the first unmatched portion of the string
193     echo "${1##$first}"
194 }
195
196 #:docstring strtok:
197 # Usage: strtok s1 s2
198 #
199 # Strtok considers the string s1 to consist of a sequence of zero or more
200 # text tokens separated by spans of one or more characters from the
201 # separator string s2. The first call (with a non-empty string s1
202 # specified) echoes a string consisting of the first token on stdout. The
203 # function keeps track of its position in the string s1 between separate
204 # calls, so that subsequent calls made with the first argument an empty
205 # string will work through the string immediately following that token. In
206 # this way subsequent calls will work through the string s1 until no tokens
207 # remain. The separator string s2 may be different from call to call.
208 # When no token remains in s1, an empty value is echoed on stdout.
209 #:end docstring:
210
211 ###;;;autoload
212 function strtok ()
213 {
214 :
215 }
216

```

```

217 #:docstring strtrunc:
218 # Usage: strtrunc $n $s1 {$s2} {$...}
219 #
220 # Used by many functions like strncmp to truncate arguments for comparison.
221 # Echoes the first n characters of each string s1 s2 ... on stdout.
222 #:end docstring:
223
224 ###;;;autoload
225 function strtrunc ()
226 {
227     n=$1 ; shift
228     for z; do
229         echo "${z:0:$n}"
230     done
231 }
232
233 # provide string
234
235 # string.bash ends here
236
237
238 # ===== #
239 # ==> Everything below here added by the document author.
240
241 # ==> Suggested use of this script is to delete everything below here,
242 # ==> and "source" this file into your own scripts.
243
244 # strcat
245 string0=one
246 string1=two
247 echo
248 echo "Testing \"strcat\" function:"
249 echo "Original \"string0\" = $string0"
250 echo "\"string1\" = $string1"
251 strcat string0 string1
252 echo "New \"string0\" = $string0"
253 echo
254
255 # strlen
256 echo
257 echo "Testing \"strlen\" function:"
258 str=123456789
259 echo "\"str\" = $str"
260 echo -n "Length of \"str\" = "
261 strlen str
262 echo
263
264
265
266 # Exercise:
267 # -----
268 # Add code to test all the other string functions above.
269
270
271 exit 0

```

Michael Zick's complex array example uses the [md5sum](#) check sum command to encode directory information.

Example A-19. Directory information

```

1 #! /bin/bash
2 # directory-info.sh

```



```

3 # Parses and lists directory information.
4
5 # NOTE: Change lines 273 and 353 per "README" file.
6
7 # Michael Zick is the author of this script.
8 # Used here with his permission.
9
10 # Controls
11 # If overridden by command arguments, they must be in the order:
12 #   Arg1: "Descriptor Directory"
13 #   Arg2: "Exclude Paths"
14 #   Arg3: "Exclude Directories"
15 #
16 # Environment Settings override Defaults.
17 # Command arguments override Environment Settings.
18
19 # Default location for content addressed file descriptors.
20 MD5UCFS=${1:-${MD5UCFS:-'/tmpfs/ucfs'}}
21
22 # Directory paths never to list or enter
23 declare -a \
24   EXCLUDE_PATHS=${2:-${EXCLUDE_PATHS:-'(/proc /dev /devfs /tmpfs)'}}
25
26 # Directories never to list or enter
27 declare -a \
28   EXCLUDE_DIRS=${3:-${EXCLUDE_DIRS:-'(ucfs lost+found tmp wtmp)'}}
29
30 # Files never to list or enter
31 declare -a \
32   EXCLUDE_FILES=${3:-${EXCLUDE_FILES:-'(core "Name with Spaces")'}}
33
34
35 # Here document used as a comment block.
36 : <<LSfieldsDoc
37 # # # # # List Filesystem Directory Information # # # # #
38 #
39 # ListDirectory "FileGlob" "Field-Array-Name"
40 # or
41 # ListDirectory -of "FileGlob" "Field-Array-Filename"
42 # '-of' meaning 'output to filename'
43 # # # # #
44
45 String format description based on: ls (GNU fileutils) version 4.0.36
46
47 Produces a line (or more) formatted:
48 inode permissions hard-links owner group ...
49 32736 -rw-----      1 mszick  mszick
50
51 size      day month date hh:mm:ss year path
52 2756608 Sun Apr 20 08:53:06 2003 /home/mszick/core
53
54 Unless it is formatted:
55 inode permissions hard-links owner group ...
56 266705 crw-rw----      1    root  uucp
57
58 major minor day month date hh:mm:ss year path
59 4,  68 Sun Apr 20 09:27:33 2003 /dev/ttyS4
60 NOTE: that pesky comma after the major number
61
62 NOTE: the 'path' may be multiple fields:
63 /home/mszick/core
64 /proc/982/fd/0 -> /dev/null
65 /proc/982/fd/1 -> /home/mszick/.xsession-errors
66 /proc/982/fd/13 -> /tmp/tmpfZVVOcs (deleted)
67 /proc/982/fd/7 -> /tmp/kde-mszick/ksycoca
68 /proc/982/fd/8 -> socket:[11586]

```

```

69 /proc/982/fd/9 -> pipe:[11588]
70
71 If that isn't enough to keep your parser guessing,
72 either or both of the path components may be relative:
73 ../Built-Shared -> Built-Static
74 ../linux-2.4.20.tar.bz2 -> ../../../../SRCS/linux-2.4.20.tar.bz2
75
76 The first character of the 11 (10?) character permissions field:
77 's' Socket
78 'd' Directory
79 'b' Block device
80 'c' Character device
81 'l' Symbolic link
82 NOTE: Hard links not marked - test for identical inode numbers
83 on identical filesystems.
84 All information about hard linked files are shared, except
85 for the names and the name's location in the directory system.
86 NOTE: A "Hard link" is known as a "File Alias" on some systems.
87 '-' An undistinguished file
88
89 Followed by three groups of letters for: User, Group, Others
90 Character 1: '-' Not readable; 'r' Readable
91 Character 2: '-' Not writable; 'w' Writable
92 Character 3, User and Group: Combined execute and special
93 '-' Not Executable, Not Special
94 'x' Executable, Not Special
95 's' Executable, Special
96 'S' Not Executable, Special
97 Character 3, Others: Combined execute and sticky (tacky?)
98 '-' Not Executable, Not Tacky
99 'x' Executable, Not Tacky
100 't' Executable, Tacky
101 'T' Not Executable, Tacky
102
103 Followed by an access indicator
104 Haven't tested this one, it may be the eleventh character
105 or it may generate another field
106 ' ' No alternate access
107 '+' Alternate access
108 LSfieldsDoc
109
110
111 ListDirectory()
112 {
113     local -a T
114     local -i of=0           # Default return in variable
115     # OLD_IFS=$IFS         # Using BASH default ' \t\n'
116
117     case "$#" in
118         3)     case "$1" in
119                 -of)   of=1 ; shift ;;
120                 * )   return 1 ;;
121             esac ;;
122         2)     : ;;          # Poor man's "continue"
123         *)     return 1 ;;
124     esac
125
126     # NOTE: the (ls) command is NOT quoted (")
127     T=( $(ls --inode --ignore-backups --almost-all --directory \
128         --full-time --color=none --time=status --sort=none \
129         --format=long $1) )
130
131     case $of in
132         # Assign T back to the array whose name was passed as $2
133         0) eval $2=\( \ "${T[@]}" \) ;;
134         # Write T into filename passed as $2

```

```

135         1) echo "${T[@]}" > "$2" ;;
136     esac
137     return 0
138 }
139
140 # # # # # Is that string a legal number? # # # # #
141 #
142 #   IsNumber "Var"
143 # # # # # There has to be a better way, sigh...
144
145 IsNumber()
146 {
147     local -i int
148     if [ $# -eq 0 ]
149     then
150         return 1
151     else
152         (let int=$1) 2>/dev/null
153         return $?      # Exit status of the let thread
154     fi
155 }
156
157 # # # # # Index Filesystem Directory Information # # # # #
158 #
159 #   IndexList "Field-Array-Name" "Index-Array-Name"
160 # or
161 #   IndexList -if Field-Array-Filename Index-Array-Name
162 #   IndexList -of Field-Array-Name Index-Array-Filename
163 #   IndexList -if -of Field-Array-Filename Index-Array-Filename
164 # # # # #
165
166 : <<IndexListDoc
167 Walk an array of directory fields produced by ListDirectory
168
169 Having suppressed the line breaks in an otherwise line oriented
170 report, build an index to the array element which starts each line.
171
172 Each line gets two index entries, the first element of each line
173 (inode) and the element that holds the pathname of the file.
174
175 The first index entry pair (Line-Number==0) are informational:
176 Index-Array-Name[0] : Number of "Lines" indexed
177 Index-Array-Name[1] : "Current Line" pointer into Index-Array-Name
178
179 The following index pairs (if any) hold element indexes into
180 the Field-Array-Name per:
181 Index-Array-Name[Line-Number * 2] : The "inode" field element.
182 NOTE: This distance may be either +11 or +12 elements.
183 Index-Array-Name[(Line-Number * 2) + 1] : The "pathname" element.
184 NOTE: This distance may be a variable number of elements.
185 Next line index pair for Line-Number+1.
186 IndexListDoc
187
188
189
190 IndexList()
191 {
192     local -a LIST          # Local of listname passed
193     local -a -i INDEX=( 0 0 ) # Local of index to return
194     local -i Lidx Lcnt
195     local -i if=0 of=0     # Default to variable names
196
197     case "$#" in
198         0) return 1 ;;
199         1) return 1 ;;
200         2) : ;;          # Poor man's continue

```

```

201         3) case "$1" in
202             -if) if=1 ;;
203             -of) of=1 ;;
204             * ) return 1 ;;
205         esac ; shift ;;
206         4) if=1 ; of=1 ; shift ; shift ;;
207         *) return 1
208     esac
209
210     # Make local copy of list
211     case "$if" in
212         0) eval LIST=( \ "\${$1[@]}\ " ) ;;
213         1) LIST=( $(cat $1) ) ;;
214     esac
215
216     # Grok (grope?) the array
217     Lcnt=${#LIST[@]}
218     Lidx=0
219     until (( Lidx >= Lcnt ))
220     do
221         if IsNumber ${LIST[$Lidx]}
222         then
223             local -i inode name
224             local ft
225             inode=Lidx
226             local m=${LIST[$Lidx+2]}           # Hard Links field
227             ft=${LIST[$Lidx+1]:0:1}           # Fast-Stat
228             case $ft in
229                 b)      ((Lidx+=12)) ;;           # Block device
230                 c)      ((Lidx+=12)) ;;           # Character device
231                 *)      ((Lidx+=11)) ;;           # Anything else
232             esac
233             name=Lidx
234             case $ft in
235                 -)      ((Lidx+=1)) ;;           # The easy one
236                 b)      ((Lidx+=1)) ;;           # Block device
237                 c)      ((Lidx+=1)) ;;           # Character device
238                 d)      ((Lidx+=1)) ;;           # The other easy one
239                 l)      ((Lidx+=3)) ;;           # At LEAST two more fields
240             # A little more elegance here would handle pipes,
241             #+ sockets, deleted files - later.
242             *)          until IsNumber ${LIST[$Lidx]} || ((Lidx >= Lcnt))
243             do
244                 ((Lidx+=1))
245             done
246             ;;
247             # Not required
248             esac
249             INDEX[${#INDEX[*]}]=$inode
250             INDEX[${#INDEX[*]}]=$name
251             INDEX[0]=${INDEX[0]}+1           # One more "line" found
252             # echo "Line: ${INDEX[0]} Type: $ft Links: $m Inode: \
253             # ${LIST[$inode]} Name: ${LIST[$name]}"
254         else
255             ((Lidx+=1))
256         fi
257     done
258     case "$of" in
259         0) eval $2=( \ "\${INDEX[@]}\ " ) ;;
260         1) echo "${INDEX[0]}" > "$2" ;;
261     esac
262     return 0           # What could go wrong?
263 }
264
265 # # # # # Content Identify File # # # # #
266 #

```

```

267 # DigestFile Input-Array-Name Digest-Array-Name
268 # or
269 # DigestFile -if Input-FileName Digest-Array-Name
270 # # # # #
271
272 # Here document used as a comment block.
273 : <<DigestFilesDoc
274
275 The key (no pun intended) to a Unified Content File System (UCFS)
276 is to distinguish the files in the system based on their content.
277 Distinguishing files by their name is just so 20th Century.
278
279 The content is distinguished by computing a checksum of that content.
280 This version uses the md5sum program to generate a 128 bit checksum
281 representative of the file's contents.
282 There is a chance that two files having different content might
283 generate the same checksum using md5sum (or any checksum). Should
284 that become a problem, then the use of md5sum can be replace by a
285 cryptographic signature. But until then...
286
287 The md5sum program is documented as outputting three fields (and it
288 does), but when read it appears as two fields (array elements). This
289 is caused by the lack of whitespace between the second and third field.
290 So this function gropes the md5sum output and returns:
291 [0] 32 character checksum in hexadecimal (UCFS filename)
292 [1] Single character: ' ' text file, '*' binary file
293 [2] Filesystem (20th Century Style) name
294 Note: That name may be the character '-' indicating STDIN read.
295
296 DigestFilesDoc
297
298
299
300 DigestFile()
301 {
302     local if=0 # Default, variable name
303     local -a T1 T2
304
305     case "$#" in
306     3) case "$1" in
307         -if) if=1 ; shift ;;
308         * ) return 1 ;;
309         esac ;;
310     2) : ;; # Poor man's "continue"
311     *) return 1 ;;
312     esac
313
314     case $if in
315     0) eval T1=\( \"\${$1\[@]\}\\" \)
316         T2=( $(echo ${T1[@]} | md5sum -) )
317         ;;
318     1) T2=( $(md5sum $1) )
319         ;;
320     esac
321
322     case ${#T2[@]} in
323     0) return 1 ;;
324     1) return 1 ;;
325     2) case ${T2[1]:0:1} in # SanScrit-2.0.5
326         \*) T2[${#T2[@]}]=${T2[1]:1}
327             T2[1]=\*
328             ;;
329         *) T2[${#T2[@]}]=${T2[1]}
330             T2[1]=" "
331             ;;
332     esac

```

```

333     ;;
334 3) : ;; # Assume it worked
335 *) return 1 ;;
336 esac
337
338 local -i len=${#T2[0]}
339 if [ $len -ne 32 ] ; then return 1 ; fi
340 eval $2=( \ "$\{T2[@]\}\ " \ )
341 }
342
343 # # # # # Locate File # # # # #
344 #
345 # LocateFile [-l] FileName Location-Array-Name
346 # or
347 # LocateFile [-l] -of FileName Location-Array-FileName
348 # # # # #
349
350 # A file location is Filesystem-id and inode-number
351
352 # Here document used as a comment block.
353 : <<StatFieldsDoc
354 Based on stat, version 2.2
355 stat -t and stat -lt fields
356 [0] name
357 [1] Total size
358 File - number of bytes
359 Symbolic link - string length of pathname
360 [2] Number of (512 byte) blocks allocated
361 [3] File type and Access rights (hex)
362 [4] User ID of owner
363 [5] Group ID of owner
364 [6] Device number
365 [7] Inode number
366 [8] Number of hard links
367 [9] Device type (if inode device) Major
368 [10] Device type (if inode device) Minor
369 [11] Time of last access
370 May be disabled in 'mount' with noatime
371 atime of files changed by exec, read, pipe, utime, mknod (mmap?)
372 atime of directories changed by addition/deletion of files
373 [12] Time of last modification
374 mtime of files changed by write, truncate, utime, mknod
375 mtime of directories changed by addtition/deletion of files
376 [13] Time of last change
377 ctime reflects time of changed inode information (owner, group
378 permissions, link count
379 -*-*- Per:
380 Return code: 0
381 Size of array: 14
382 Contents of array
383 Element 0: /home/mszick
384 Element 1: 4096
385 Element 2: 8
386 Element 3: 41e8
387 Element 4: 500
388 Element 5: 500
389 Element 6: 303
390 Element 7: 32385
391 Element 8: 22
392 Element 9: 0
393 Element 10: 0
394 Element 11: 1051221030
395 Element 12: 1051214068
396 Element 13: 1051214068
397
398 For a link in the form of linkname -> realname

```

```

399 stat -t linkname returns the linkname (link) information
400 stat -lt linkname returns the realname information
401
402 stat -tf and stat -ltf fields
403 [0] name
404 [1] ID-0? # Maybe someday, but Linux stat structure
405 [2] ID-0? # does not have either LABEL nor UUID
406 # fields, currently information must come
407 # from file-system specific utilities
408 These will be munged into:
409 [1] UUID if possible
410 [2] Volume Label if possible
411 Note: 'mount -l' does return the label and could return the UUID
412
413 [3] Maximum length of filenames
414 [4] Filesystem type
415 [5] Total blocks in the filesystem
416 [6] Free blocks
417 [7] Free blocks for non-root user(s)
418 [8] Block size of the filesystem
419 [9] Total inodes
420 [10] Free inodes
421
422 *-*- Per:
423 Return code: 0
424 Size of array: 11
425 Contents of array
426 Element 0: /home/mszick
427 Element 1: 0
428 Element 2: 0
429 Element 3: 255
430 Element 4: ef53
431 Element 5: 2581445
432 Element 6: 2277180
433 Element 7: 2146050
434 Element 8: 4096
435 Element 9: 1311552
436 Element 10: 1276425
437
438 StatFieldsDoc
439
440
441 # LocateFile [-l] FileName Location-Array-Name
442 # LocateFile [-l] -of FileName Location-Array-FileName
443
444 LocateFile()
445 {
446     local -a LOC LOC1 LOC2
447     local lk="" of=0
448
449     case "$#" in
450     0) return 1 ;;
451     1) return 1 ;;
452     2) : ;;
453     *) while (( "$#" > 2 ))
454         do
455             case "$1" in
456             -l) lk=-1 ;;
457             -of) of=1 ;;
458             *) return 1 ;;
459             esac
460             shift
461             done ;;
462     esac
463
464 # More Sanscrit-2.0.5

```

```

465     # LOC1=( $(stat -t $lk $1) )
466     # LOC2=( $(stat -tf $lk $1) )
467     # Uncomment above two lines if system has "stat" command installed.
468     LOC=( ${LOC1[@]:0:1} ${LOC1[@]:3:11}
469           ${LOC2[@]:1:2} ${LOC2[@]:4:1} )
470
471     case "$of" in
472         0) eval $2=\( \("${$LOC[@]}\)" \) ;;
473         1) echo "${LOC[@]}" > "$2" ;;
474     esac
475     return 0
476 # Which yields (if you are lucky, and have "stat" installed)
477 # -*- Location Discriptor -*-
478 # Return code: 0
479 # Size of array: 15
480 # Contents of array
481 # Element 0: /home/mszick           20th Century name
482 # Element 1: 41e8                 Type and Permissions
483 # Element 2: 500                   User
484 # Element 3: 500                   Group
485 # Element 4: 303                   Device
486 # Element 5: 32385                 inode
487 # Element 6: 22                    Link count
488 # Element 7: 0                     Device Major
489 # Element 8: 0                     Device Minor
490 # Element 9: 1051224608             Last Access
491 # Element 10: 1051214068            Last Modify
492 # Element 11: 1051214068            Last Status
493 # Element 12: 0                     UUID (to be)
494 # Element 13: 0                     Volume Label (to be)
495 # Element 14: ef53                  Filesystem type
496 }
497
498
499
500 # And then there was some test code
501
502 ListArray() # ListArray Name
503 {
504     local -a Ta
505
506     eval Ta=\( \("${$1[@]}\)" \)
507     echo
508     echo "-*- List of Array -*- "
509     echo "Size of array $1: ${#Ta[*]}"
510     echo "Contents of array $1:"
511     for (( i=0 ; i<${#Ta[*]} ; i++ ))
512     do
513         echo -e "\tElement $i: ${Ta[$i]}"
514     done
515     return 0
516 }
517
518 declare -a CUR_DIR
519 # For small arrays
520 ListDirectory "${PWD}" CUR_DIR
521 ListArray CUR_DIR
522
523 declare -a DIR_DIG
524 DigestFile CUR_DIR DIR_DIG
525 echo "The new \"name\" (checksum) for ${CUR_DIR[9]} is ${DIR_DIG[0]}"
526
527 declare -a DIR_ENT
528 # BIG_DIR # For really big arrays - use a temporary file in ramdisk
529 # BIG-DIR # ListDirectory -of "${CUR_DIR[11]}/*" "/tmpfs/junk2"
530 ListDirectory "${CUR_DIR[11]}/*" DIR_ENT

```



```

531
532 declare -a DIR_IDX
533 # BIG-DIR # IndexList -if "/tmpfs/junk2" DIR_IDX
534 IndexList DIR_ENT DIR_IDX
535
536 declare -a IDX_DIG
537 # BIG-DIR # DIR_ENT=( $(cat /tmpfs/junk2) )
538 # BIG-DIR # DigestFile -if /tmpfs/junk2 IDX_DIG
539 DigestFile DIR_ENT IDX_DIG
540 # Small (should) be able to parallize IndexList & DigestFile
541 # Large (should) be able to parallize IndexList & DigestFile & the assignment
542 echo "The \"name\" (checksum) for the contents of ${PWD} is ${IDX_DIG[0]}"
543
544 declare -a FILE_LOC
545 LocateFile ${PWD} FILE_LOC
546 ListArray FILE_LOC
547
548 exit 0

```

Stéphane Chazelas demonstrates object-oriented programming in a Bash script.

Mariusz Gniazdowski contributed a [hash](#) library for use in scripts.

Example A-20. Library of hash functions

```

1 # Hash:
2 # Hash function library
3 # Author: Mariusz Gniazdowski <mariusz.gn-at-gmail.com>
4 # Date: 2005-04-07
5
6 # Functions making emulating hashes in Bash a little less painful.
7
8
9 #   Limitations:
10 # * Only global variables are supported.
11 # * Each hash instance generates one global variable per value.
12 # * Variable names collisions are possible
13 #+ if you define variable like __hash__hashname_key
14 # * Keys must use chars that can be part of a Bash variable name
15 #+ (no dashes, periods, etc.).
16 # * The hash is created as a variable:
17 #   ... hashname_keyname
18 #   So if someone will create hashes like:
19 #     myhash_ + mykey = myhash__mykey
20 #     myhash + _mykey = myhash__mykey
21 #   Then there will be a collision.
22 #   (This should not pose a major problem.)
23
24
25 Hash_config_varname_prefix=__hash__
26
27
28 # Emulates: hash[key]=value
29 #
30 # Params:
31 # 1 - hash
32 # 2 - key
33 # 3 - value
34 function hash_set {
35     eval "${Hash_config_varname_prefix}${1}_${2}=\"${3}\""
36 }
37
38

```

```

39 # Emulates:  value=hash[key]
40 #
41 # Params:
42 # 1 - hash
43 # 2 - key
44 # 3 - value (name of global variable to set)
45 function hash_get_into {
46     eval "$3=\${Hash_config_varname_prefix}${1}_${2}\""
47 }
48
49
50 # Emulates:  echo hash[key]
51 #
52 # Params:
53 # 1 - hash
54 # 2 - key
55 # 3 - echo params (like -n, for example)
56 function hash_echo {
57     eval "echo $3 \${Hash_config_varname_prefix}${1}_${2}\""
58 }
59
60
61 # Emulates:  hash1[key1]=hash2[key2]
62 #
63 # Params:
64 # 1 - hash1
65 # 2 - key1
66 # 3 - hash2
67 # 4 - key2
68 function hash_copy {
69     eval "${Hash_config_varname_prefix}${1}_${2}\
70 =\${Hash_config_varname_prefix}${3}_${4}\""
71 }
72
73
74 # Emulates:  hash[keyN-1]=hash[key2]=...hash[key1]
75 #
76 # Copies first key to rest of keys.
77 #
78 # Params:
79 # 1 - hash1
80 # 2 - key1
81 # 3 - key2
82 # . . .
83 # N - keyN
84 function hash_dup {
85     local hashName="$1" keyName="$2"
86     shift 2
87     until [ $# -le 0 ]; do
88         eval "${Hash_config_varname_prefix}${hashName}_${1}\
89 =\${Hash_config_varname_prefix}${hashName}_${keyName}\""
90         shift;
91         done;
92 }
93
94
95 # Emulates:  unset hash[key]
96 #
97 # Params:
98 # 1 - hash
99 # 2 - key
100 function hash_unset {
101     eval "unset ${Hash_config_varname_prefix}${1}_${2}"
102 }
103
104

```

```

105 # Emulates something similar to:  ref=&hash[key]
106 #
107 # The reference is name of the variable in which value is held.
108 #
109 # Params:
110 # 1 - hash
111 # 2 - key
112 # 3 - ref - Name of global variable to set.
113 function hash_get_ref_into {
114     eval "$3=\"\${Hash_config_varname_prefix}${1}_${2}\""
115 }
116
117
118 # Emulates something similar to:  echo &hash[key]
119 #
120 # That reference is name of variable in which value is held.
121 #
122 # Params:
123 # 1 - hash
124 # 2 - key
125 # 3 - echo params (like -n for example)
126 function hash_echo_ref {
127     eval "echo $3 \"\${Hash_config_varname_prefix}${1}_${2}\""
128 }
129
130
131
132 # Emulates something similar to:  $$hash[key] (param1, param2, ...)
133 #
134 # Params:
135 # 1 - hash
136 # 2 - key
137 # 3,4, ... - Function parameters
138 function hash_call {
139     local hash key
140     hash=$1
141     key=$2
142     shift 2
143     eval "eval \"\${Hash_config_varname_prefix}${hash}_${key} \\\"\\\"\\$@\\\"\\\"\""
144 }
145
146
147 # Emulates something similar to:  isset(hash[key]) or hash[key]==NULL
148 #
149 # Params:
150 # 1 - hash
151 # 2 - key
152 # Returns:
153 # 0 - there is such key
154 # 1 - there is no such key
155 function hash_is_set {
156     eval "if [[ \"\${Hash_config_varname_prefix}${1}_${2}-a\" = \"a\" &&
157     \"\${Hash_config_varname_prefix}${1}_${2}-b\" = \"b\" ]]
158     then return 1; else return 0; fi"
159 }
160
161
162 # Emulates something similar to:
163 #   foreach($hash as $key => $value) { fun($key,$value); }
164 #
165 # It is possible to write different variations of this function.
166 # Here we use a function call to make it as "generic" as possible.
167 #
168 # Params:
169 # 1 - hash
170 # 2 - function name

```

```

171 function hash_foreach {
172     local keyname oldIFS="$IFS"
173     IFS=' '
174     for i in $(eval "echo \${!${Hash_config_varname_prefix}${1}_*}"); do
175         keyname=$(eval "echo \${i##${Hash_config_varname_prefix}${1}_}")
176         eval "$2 $keyname \\"$${i}\""
177     done
178     IFS="$oldIFS"
179 }
180
181 # NOTE: In lines 103 and 116, ampersand changed.
182 # But, it doesn't matter, because these are comment lines anyhow.

```

Here is an example script using the foregoing hash library.

Example A-21. Colorizing text using hash functions

```

1 #!/bin/bash
2 # hash-example.sh: Colorizing text.
3 # Author: Mariusz Gniazdowski <mariusz.gn-at-gmail.com>
4
5 . Hash.lib      # Load the library of functions.
6
7 hash_set colors red          "\033[0;31m"
8 hash_set colors blue        "\033[0;34m"
9 hash_set colors light_blue  "\033[1;34m"
10 hash_set colors light_red   "\033[1;31m"
11 hash_set colors cyan        "\033[0;36m"
12 hash_set colors light_green "\033[1;32m"
13 hash_set colors light_gray  "\033[0;37m"
14 hash_set colors green       "\033[0;32m"
15 hash_set colors yellow      "\033[1;33m"
16 hash_set colors light_purple "\033[1;35m"
17 hash_set colors purple      "\033[0;35m"
18 hash_set colors reset_color "\033[0;00m"
19
20
21 # $1 - keyname
22 # $2 - value
23 try_colors() {
24     echo -en "$2"
25     echo "This line is $1."
26 }
27 hash_foreach colors try_colors
28 hash_echo colors reset_color -en
29
30 echo -e '\nLet us overwrite some colors with yellow.\n'
31 # It's hard to read yellow text on some terminals.
32 hash_dup colors yellow red light_green blue green light_gray cyan
33 hash_foreach colors try_colors
34 hash_echo colors reset_color -en
35
36 echo -e '\nLet us delete them and try colors once more . . .\n'
37
38 for i in red light_green blue green light_gray cyan; do
39     hash_unset colors $i
40 done
41 hash_foreach colors try_colors
42 hash_echo colors reset_color -en
43
44 hash_set other txt "Other examples . . ."
45 hash_echo other txt
46 hash_get_into other txt text

```

```

47 echo $text
48
49 hash_set other my_fun try_colors
50 hash_call other my_fun purple "`hash_echo colors purple`"
51 hash_echo colors reset_color -en
52
53 echo; echo "Back to normal?"; echo
54
55 exit $?
56
57 # On some terminals, the "light" colors print in bold,
58 # and end up looking darker than the normal ones.
59 # Why is this?
60

```

An example illustrating the mechanics of hashing, but from a different point of view.

Example A-22. More on hash functions

```

1 #!/bin/bash
2 # $Id: ha.sh,v 1.2 2005/04/21 23:24:26 oliver Exp $
3 # Copyright 2005 Oliver Beckstein
4 # Released under the GNU Public License
5 # Author of script granted permission for inclusion in ABS Guide.
6 # (Thank you!)
7
8 #-----
9 # pseudo hash based on indirect parameter expansion
10 # API: access through functions:
11 #
12 # create the hash:
13 #
14 #     newhash Lovers
15 #
16 # add entries (note single quotes for spaces)
17 #
18 #     addhash Lovers Tristan Isolde
19 #     addhash Lovers 'Romeo Montague' 'Juliet Capulet'
20 #
21 # access value by key
22 #
23 #     gethash Lovers Tristan ----> Isolde
24 #
25 # show all keys
26 #
27 #     keyshash Lovers ----> 'Tristan' 'Romeo Montague'
28 #
29 #
30 # Convention: instead of perls' foo{bar} = boing' syntax,
31 # use
32 #     '_foo_bar=boing' (two underscores, no spaces)
33 #
34 # 1) store key   in _NAME_keys[]
35 # 2) store value in _NAME_values[] using the same integer index
36 # The integer index for the last entry is _NAME_ptr
37 #
38 # NOTE: No error or sanity checks, just bare bones.
39
40
41 function _inihash () {
42     # private function
43     # call at the beginning of each procedure
44     # defines: _keys _values _ptr

```

```

45 #
46 # Usage: _inhash NAME
47 local name=$1
48 _keys=_${name}_keys
49 _values=_${name}_values
50 _ptr=_${name}_ptr
51 }
52
53 function newhash () {
54 # Usage: newhash NAME
55 #     NAME should not contain spaces or dots.
56 #     Actually: it must be a legal name for a Bash variable.
57 # We rely on Bash automatically recognising arrays.
58 local name=$1
59 local _keys _values _ptr
60 _inhash ${name}
61 eval ${_ptr}=0
62 }
63
64
65 function addhash () {
66 # Usage: addhash NAME KEY 'VALUE with spaces'
67 #     arguments with spaces need to be quoted with single quotes ''
68 local name=$1 k="$2" v="$3"
69 local _keys _values _ptr
70 _inhash ${name}
71
72 #echo "DEBUG(addhash): ${_ptr}=${!_ptr}"
73
74 eval let ${_ptr}=${_ptr}+1
75 eval "${_keys}[${!_ptr}]=\"${k}\""
76 eval "${_values}[${!_ptr}]=\"${v}\""
77 }
78
79 function gethash () {
80 # Usage: gethash NAME KEY
81 #     Returns boing
82 #     ERR=0 if entry found, 1 otherwise
83 # That's not a proper hash --
84 #+ we simply linearly search through the keys.
85 local name=$1 key="$2"
86 local _keys _values _ptr
87 local k v i found h
88 _inhash ${name}
89
90 # _ptr holds the highest index in the hash
91 found=0
92
93 for i in $(seq 1 ${!_ptr}); do
94 h="\${_${_keys}[${i}]}" # Safer to do it in two steps,
95 eval k=${h}           #+ especially when quoting for spaces.
96 if [ "${k}" = "${key}" ]; then found=1; break; fi
97 done;
98
99 [ ${found} = 0 ] && return 1;
100 # else: i is the index that matches the key
101 h="\${_${_values}[${i}]}"
102 eval echo "${h}"
103 return 0;
104 }
105
106 function keyshash () {
107 # Usage: keyshash NAME
108 # Returns list of all keys defined for hash name.
109 local name=$1 key="$2"
110 local _keys _values _ptr

```

```

111     local k i h
112     _inihash ${name}
113
114     # _ptr holds the highest index in the hash
115     for i in $(seq 1 ${!_ptr}); do
116     h="\${${_keys}[$i]}" # Safer to do it in two steps,
117     eval k=${h}          #+ especially when quoting for spaces.
118     echo -n "'${k}' "
119     done;
120 }
121
122
123 # -----
124
125 # Now, let's test it.
126 # (Per comments at the beginning of the script.)
127 newhash Lovers
128 addhash Lovers Tristan Isolde
129 addhash Lovers 'Romeo Montague' 'Juliet Capulet'
130
131 # Output results.
132 echo
133 gethash Lovers Tristan      # Isolde
134 echo
135 keyshash Lovers             # 'Tristan' 'Romeo Montague'
136 echo; echo
137
138
139 exit 0
140
141 # Exercise:
142 # -----
143
144 # Add error checks to the functions.

```

Now for a script that installs and mounts those cute USB keychain solid-state "hard drives."

Example A-23. Mounting USB keychain storage devices

```

1 #!/bin/bash
2 # ==> usb.sh
3 # ==> Script for mounting and installing pen/keychain USB storage devices.
4 # ==> Runs as root at system startup (see below).
5 # ==>
6 # ==> Newer Linux distros (2004 or later) autodetect
7 # ==> and install USB pen drives, and therefore don't need this script.
8 # ==> But, it's still instructive.
9
10 # This code is free software covered by GNU GPL license version 2 or above.
11 # Please refer to http://www.gnu.org/ for the full license text.
12 #
13 # Some code lifted from usb-mount by Michael Hamilton's usb-mount (LGPL)
14 #+ see http://users.acrix.co.nz/michael/usbmount.html
15 #
16 # INSTALL
17 # -----
18 # Put this in /etc/hotplug/usb/diskonkey.
19 # Then look in /etc/hotplug/usb.distmap, and copy all usb-storage entries
20 #+ into /etc/hotplug/usb.usermap, substituting "usb-storage" for "diskonkey".
21 # Otherwise this code is only run during the kernel module invocation/removal
22 #+ (at least in my tests), which defeats the purpose.
23 #
24 # TODO

```

```

25 # ----
26 # Handle more than one diskonkey device at one time (e.g. /dev/diskonkey1
27 #+ and /mnt/diskonkey1), etc. The biggest problem here is the handling in
28 #+ devlabel, which I haven't yet tried.
29 #
30 # AUTHOR and SUPPORT
31 # -----
32 # Konstantin Riabitsev, <icon linux duke edu>.
33 # Send any problem reports to my email address at the moment.
34 #
35 # ==> Comments added by ABS Guide author.
36
37
38
39 SYMLINKDEV=/dev/diskonkey
40 MOUNTPOINT=/mnt/diskonkey
41 DEVLABEL=/sbin/devlabel
42 DEVLABELCONFIG=/etc/sysconfig/devlabel
43 IAM=$0
44
45 ##
46 # Functions lifted near-verbatim from usb-mount code.
47 #
48 function allAttachedScsiUsb {
49     find /proc/scsi/ -path '/proc/scsi/usb-storage*' -type f |
50     xargs grep -l 'Attached: Yes'
51 }
52 function scsiDevFromScsiUsb {
53     echo $1 | awk -F"[-/]" '{ n=$(NF-1);
54     print "/dev/sd" substr("abcdefghijklmnopqrstuvwxy", n+1, 1) }'
55 }
56
57 if [ "${ACTION}" = "add" ] && [ -f "${DEVICE}" ]; then
58     ##
59     # lifted from usbcam code.
60     #
61     if [ -f /var/run/console.lock ]; then
62         CONSOLEOWNER=`cat /var/run/console.lock`
63     elif [ -f /var/lock/console.lock ]; then
64         CONSOLEOWNER=`cat /var/lock/console.lock`
65     else
66         CONSOLEOWNER=
67     fi
68     for procEntry in $(allAttachedScsiUsb); do
69         scsiDev=$(scsiDevFromScsiUsb $procEntry)
70         # Some bug with usb-storage?
71         # Partitions are not in /proc/partitions until they are accessed
72         #+ somehow.
73         /sbin/fdisk -l $scsiDev >/dev/null
74         ##
75         # Most devices have partitioning info, so the data would be on
76         #+ /dev/sd?1. However, some stupider ones don't have any partitioning
77         #+ and use the entire device for data storage. This tries to
78         #+ guess semi-intelligently if we have a /dev/sd?1 and if not, then
79         #+ it uses the entire device and hopes for the better.
80         #
81         if grep -q `basename $scsiDev`1 /proc/partitions; then
82             part="$scsiDev"1"
83         else
84             part=$scsiDev
85         fi
86         ##
87         # Change ownership of the partition to the console user so they can
88         #+ mount it.
89         #
90         if [ ! -z "$CONSOLEOWNER" ]; then

```



```

91         chown $CONSOLEOWNER:disk $part
92     fi
93     ##
94     # This checks if we already have this UUID defined with devlabel.
95     # If not, it then adds the device to the list.
96     #
97     prodid=`$DEVLABEL printid -d $part`
98     if ! grep -q $prodid $DEVLABELCONFIG; then
99         # cross our fingers and hope it works
100        $DEVLABEL add -d $part -s $SYMLINKDEV 2>/dev/null
101    fi
102    ##
103    # Check if the mount point exists and create if it doesn't.
104    #
105    if [ ! -e $MOUNTPOINT ]; then
106        mkdir -p $MOUNTPOINT
107    fi
108    ##
109    # Take care of /etc/fstab so mounting is easy.
110    #
111    if ! grep -q "^$SYMLINKDEV" /etc/fstab; then
112        # Add an fstab entry
113        echo -e \
114            "$SYMLINKDEV\t\t$MOUNTPOINT\t\tauto\tnoauto,owner,kudzu 0 0" \
115            >> /etc/fstab
116    fi
117    done
118    if [ ! -z "$REMOVER" ]; then
119        ##
120        # Make sure this script is triggered on device removal.
121        #
122        mkdir -p `dirname $REMOVER`
123        ln -s $IAM $REMOVER
124    fi
125    elif [ "${ACTION}" = "remove" ]; then
126        ##
127        # If the device is mounted, unmount it cleanly.
128        #
129        if grep -q "$MOUNTPOINT" /etc/mtab; then
130            # unmount cleanly
131            umount -l $MOUNTPOINT
132        fi
133        ##
134        # Remove it from /etc/fstab if it's there.
135        #
136        if grep -q "^$SYMLINKDEV" /etc/fstab; then
137            grep -v "^$SYMLINKDEV" /etc/fstab > /etc/.fstab.new
138            mv -f /etc/.fstab.new /etc/fstab
139        fi
140    fi
141
142    exit 0

```

Converting a text file to HTML format.

Example A-24. Converting to HTML

```

1 #!/bin/bash
2 # tohtml.sh [v. 0.2.01, reldate: 04/13/12, a teeny bit less buggy]
3
4 # Convert a text file to HTML format.
5 # Author: Mendel Cooper
6 # License: GPL3

```

```

7 # Usage: sh tohtml.sh < textfile > htmlfile
8 # Script can easily be modified to accept source and target filenames.
9
10 # Assumptions:
11 # 1) Paragraphs in (target) text file are separated by a blank line.
12 # 2) Jpeg images (*.jpg) are located in "images" subdirectory.
13 # In the target file, the image names are enclosed in square brackets,
14 # for example, [image01.jpg].
15 # 3) Emphasized (italic) phrases begin with a space+underscore
16 #+ or the first character on the line is an underscore,
17 #+ and end with an underscore+space or underscore+end-of-line.
18
19
20 # Settings
21 FNTSIZE=2 # Small-medium font size
22 IMGDIR="images" # Image directory
23 # Headers
24 HDR01='<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">'
25 HDR02='<!-- Converted to HTML by ***tohtml.sh*** script -->'
26 HDR03='<!-- script author: M. Leo Cooper <thegrendel.abs@gmail.com> -->'
27 HDR10='<html>'
28 HDR11='<head>'
29 HDR11a='</head>'
30 HDR12a='<title>'
31 HDR12b='</title>'
32 HDR121='<META NAME="GENERATOR" CONTENT="tohtml.sh script">'
33 HDR13='<body bgcolor="#dddddd">' # Change background color to suit.
34 HDR14a='<font size='
35 HDR14b='>'
36 # Footers
37 FTR10='</body>'
38 FTR11='</html>'
39 # Tags
40 BOLD="<b>"
41 CENTER="<center>"
42 END_CENTER="</center>"
43 LF="<br>"
44
45
46 write_headers ()
47 {
48 echo "$HDR01"
49 echo
50 echo "$HDR02"
51 echo "$HDR03"
52 echo
53 echo
54 echo "$HDR10"
55 echo "$HDR11"
56 echo "$HDR121"
57 echo "$HDR11a"
58 echo "$HDR13"
59 echo
60 echo -n "$HDR14a"
61 echo -n "$FNTSIZE"
62 echo "$HDR14b"
63 echo
64 echo "$BOLD" # Everything in bold (more easily readable).
65 }
66
67
68 process_text ()
69 {
70 while read line # Read one line at a time.
71 do
72 {

```

```

73     if [ ! "$line" ] # Blank line?
74     then             # Then new paragraph must follow.
75         echo
76         echo "$LF"   # Insert two <br> tags.
77         echo "$LF"
78         echo
79         continue    # Skip the underscore test.
80     else             # Otherwise . . .
81
82         if [[ "$line" =~ \[*jpg\] ]] # Is a graphic?
83         then             # Strip away brackets.
84             temp=$( echo "$line" | sed -e 's/\[\[\]' -e 's/\]\]' )
85             line="$SCENTER"  "$END_CENTER" "
86                                     # Add image tag.
87                                     # And, center it.
88         fi
89     fi
90 fi
91
92
93 echo "$line" | grep -q _
94 if [ "$?" -eq 0 ] # If line contains underscore ...
95 then
96     # =====
97     # Convert underscored phrase to italics.
98     temp=$( echo "$line" |
99             sed -e 's/ _/ <i>/' -e 's/_/<\i> /' |
100            sed -e 's/^_/<i>/' -e 's/_/<\i>/' )
101     # Process only underscores prefixed by space,
102     #+ or at beginning or end of line.
103     # Do not convert underscores embedded within a word!
104     line="$temp"
105     # Slows script execution. Can be optimized?
106     # =====
107 fi
108
109
110
111 # echo
112 echo "$line"
113 # echo
114 # Don't want extra blank lines in generated text!
115 } # End while
116 done
117 } # End process_text ()
118
119
120 write_footers () # Termination tags.
121 {
122     echo "$FTR10"
123     echo "$FTR11"
124 }
125
126
127 # main () {
128 # =====
129 write_headers
130 process_text
131 write_footers
132 # =====
133 # }
134
135 exit $?
136
137 # Exercises:
138 # -----

```

```
139 # 1) Fixup: Check for closing underscore before a comma or period.
140 # 2) Add a test for the presence of a closing underscore
141 #+ in phrases to be italicized.
```

Here is something to warm the hearts of webmasters and mistresses: a script that saves weblogs.

Example A-25. Preserving weblogs

```
1 #!/bin/bash
2 # archiveweblogs.sh v1.0
3
4 # Troy Engel <tengel@fluid.com>
5 # Slightly modified by document author.
6 # Used with permission.
7 #
8 # This script will preserve the normally rotated and
9 #+ thrown away weblogs from a default RedHat/Apache installation.
10 # It will save the files with a date/time stamp in the filename,
11 #+ bziped, to a given directory.
12 #
13 # Run this from crontab nightly at an off hour,
14 #+ as bzip2 can suck up some serious CPU on huge logs:
15 # 0 2 * * * /opt/sbin/archiveweblogs.sh
16
17
18 PROBLEM=66
19
20 # Set this to your backup dir.
21 BKP_DIR=/opt/backups/weblogs
22
23 # Default Apache/RedHat stuff
24 LOG_DAYS="4 3 2 1"
25 LOG_DIR=/var/log/httpd
26 LOG_FILES="access_log error_log"
27
28 # Default RedHat program locations
29 LS=/bin/ls
30 MV=/bin/mv
31 ID=/usr/bin/id
32 CUT=/bin/cut
33 COL=/usr/bin/column
34 BZ2=/usr/bin/bzip2
35
36 # Are we root?
37 USER=`$ID -u`
38 if [ "$USER" != "root" ]; then
39     echo "PANIC: Only root can run this script!"
40     exit $PROBLEM
41 fi
42
43 # Backup dir exists/writable?
44 if [ ! -x $BKP_DIR ]; then
45     echo "PANIC: $BKP_DIR doesn't exist or isn't writable!"
46     exit $PROBLEM
47 fi
48
49 # Move, rename and bzip2 the logs
50 for logday in $LOG_DAYS; do
51     for logfile in $LOG_FILES; do
52         MYFILE="$LOG_DIR/$logfile.$logday"
53         if [ -w $MYFILE ]; then
54             DTS=`$LS -lgo --time-style=+%Y%m%d $MYFILE | $COL -t | $CUT -d ' ' -f7`
55             $MV $MYFILE $BKP_DIR/$logfile.$DTS
```

```

56     $BZ2 $BKP_DIR/$logfile.$DTS
57     else
58     # Only spew an error if the file exists (ergo non-writable).
59     if [ -f $MYFILE ]; then
60     echo "ERROR: $MYFILE not writable. Skipping."
61     fi
62     fi
63 done
64 done
65
66 exit 0

```

How to keep the shell from expanding and reinterpreting text strings.

Example A-26. Protecting literal strings

```

1  #! /bin/bash
2  # protect_literal.sh
3
4  # set -vx
5
6  :<<-'_Protect_Literal_String_Doc'
7
8  Copyright (c) Michael S. Zick, 2003; All Rights Reserved
9  License: Unrestricted reuse in any form, for any purpose.
10 Warranty: None
11 Revision: $ID$
12
13 Documentation redirected to the Bash no-operation.
14 Bash will '/dev/null' this block when the script is first read.
15 (Uncomment the above set command to see this action.)
16
17 Remove the first (Sha-Bang) line when sourcing this as a library
18 procedure. Also comment out the example use code in the two
19 places where shown.
20
21
22 Usage:
23     _protect_literal_str 'Whatever string meets your ${fancy}'
24     Just echos the argument to standard out, hard quotes
25     restored.
26
27     $_protect_literal_str 'Whatever string meets your ${fancy}''
28     as the right-hand-side of an assignment statement.
29
30 Does:
31     As the right-hand-side of an assignment, preserves the
32     hard quotes protecting the contents of the literal during
33     assignment.
34
35 Notes:
36     The strange names (_*) are used to avoid trampling on
37     the user's chosen names when this is sourced as a
38     library.
39
40 _Protect_Literal_String_Doc
41
42 # The 'for illustration' function form
43
44 _protect_literal_str() {
45
46 # Pick an un-used, non-printing character as local IFS.
47 # Not required, but shows that we are ignoring it.

```

```

48     local IFS=$'\x1B'                # \ESC character
49
50 # Enclose the All-Elements-Of in hard quotes during assignment.
51     local tmp=$'\x27'$@$'\x27'
52 #     local tmp=$'\''$@$'\''        # Even uglier.
53
54     local len=${#tmp}                # Info only.
55     echo $tmp is $len long.          # Output AND information.
56 }
57
58 # This is the short-named version.
59 _pls() {
60     local IFS=$'\x1B'                # \ESC character (not required)
61     echo $'\x27'$@$'\x27'           # Hard quoted parameter glob
62 }
63
64 # :<<-'_Protect_Literal_String_Test'
65 # # # Remove the above "# " to disable this code. # # #
66
67 # See how that looks when printed.
68 echo
69 echo "-- Test One --"
70 _protect_literal_str 'Hello $user'
71 _protect_literal_str 'Hello "${username}"'
72 echo
73
74 # Which yields:
75 # -- Test One --
76 # 'Hello $user' is 13 long.
77 # 'Hello "${username}"' is 21 long.
78
79 # Looks as expected, but why all of the trouble?
80 # The difference is hidden inside the Bash internal order
81 #+ of operations.
82 # Which shows when you use it on the RHS of an assignment.
83
84 # Declare an array for test values.
85 declare -a arrayZ
86
87 # Assign elements with various types of quotes and escapes.
88 arrayZ=( zero "$(_pls 'Hello ${Me}')" 'Hello ${You}' "\'Pass: ${pw}\'" )
89
90 # Now list that array and see what is there.
91 echo "-- Test Two --"
92 for (( i=0 ; i<${#arrayZ[*]} ; i++ ))
93 do
94     echo Element $i: ${arrayZ[$i]} is: ${#arrayZ[$i]} long.
95 done
96 echo
97
98 # Which yields:
99 # -- Test Two --
100 # Element 0: zero is: 4 long.          # Our marker element
101 # Element 1: 'Hello ${Me}' is: 13 long. # Our "$(_pls '...') "
102 # Element 2: Hello ${You} is: 12 long. # Quotes are missing
103 # Element 3: \'Pass: \' is: 10 long.   # ${pw} expanded to nothing
104
105 # Now make an assignment with that result.
106 declare -a array2=( ${arrayZ[@]} )
107
108 # And print what happened.
109 echo "-- Test Three --"
110 for (( i=0 ; i<${#array2[*]} ; i++ ))
111 do
112     echo Element $i: ${array2[$i]} is: ${#array2[$i]} long.
113 done

```

```

114 echo
115
116 # Which yields:
117 # - - Test Three - -
118 # Element 0: zero is: 4 long.           # Our marker element.
119 # Element 1: Hello ${Me} is: 11 long.   # Intended result.
120 # Element 2: Hello is: 5 long.         # ${You} expanded to nothing.
121 # Element 3: 'Pass: is: 6 long.        # Split on the whitespace.
122 # Element 4: ' is: 1 long.             # The end quote is here now.
123
124 # Our Element 1 has had its leading and trailing hard quotes stripped.
125 # Although not shown, leading and trailing whitespace is also stripped.
126 # Now that the string contents are set, Bash will always, internally,
127 #+ hard quote the contents as required during its operations.
128
129 # Why?
130 # Considering our "$(_pls 'Hello ${Me}')" construction:
131 # " ... " -> Expansion required, strip the quotes.
132 # $( ... ) -> Replace with the result of..., strip this.
133 # _pls ' ... ' -> called with literal arguments, strip the quotes.
134 # The result returned includes hard quotes; BUT the above processing
135 #+ has already been done, so they become part of the value assigned.
136 #
137 # Similarly, during further usage of the string variable, the ${Me}
138 #+ is part of the contents (result) and survives any operations
139 # (Until explicitly told to evaluate the string).
140
141 # Hint: See what happens when the hard quotes ('$'\x27') are replaced
142 #+ with soft quotes ('$'\x22') in the above procedures.
143 # Interesting also is to remove the addition of any quoting.
144
145 # _Protect_Literal_String_Test
146 # # # Remove the above "# " to disable this code. # # #
147
148 exit 0

```

But, what if you *want* the shell to expand and reinterpret strings?

Example A-27. Unprotecting literal strings

```

1 #! /bin/bash
2 # unprotect_literal.sh
3
4 # set -vx
5
6 :<<-'_UnProtect_Literal_String_Doc'
7
8     Copyright (c) Michael S. Zick, 2003; All Rights Reserved
9     License: Unrestricted reuse in any form, for any purpose.
10    Warranty: None
11    Revision: $ID$
12
13    Documentation redirected to the Bash no-operation. Bash will
14    '/dev/null' this block when the script is first read.
15    (Uncomment the above set command to see this action.)
16
17    Remove the first (Sha-Bang) line when sourcing this as a library
18    procedure. Also comment out the example use code in the two
19    places where shown.
20
21
22    Usage:
23        Complement of the "$(_pls 'Literal String')" function.

```

```

24     (See the protect_literal.sh example.)
25
26     StringVar=$( _upls ProtectedStringVariable)
27
28     Does:
29         When used on the right-hand-side of an assignment statement;
30         makes the substitutions embedded in the protected string.
31
32     Notes:
33         The strange names (_*) are used to avoid trampling on
34         the user's chosen names when this is sourced as a
35         library.
36
37
38     _UnProtectLiteralStringDoc
39
40     _upls() {
41         local IFS=$'\x1B'           # \ESC character (not required)
42         eval echo $@               # Substitution on the glob.
43     }
44
45 # :<<-'_UnProtectLiteralStringTest'
46 # # # Remove the above "# " to disable this code. # # #
47
48
49     _pls() {
50         local IFS=$'\x1B'           # \ESC character (not required)
51         echo $'\x27'${@}$'\x27'    # Hard quoted parameter glob
52     }
53
54 # Declare an array for test values.
55 declare -a arrayZ
56
57 # Assign elements with various types of quotes and escapes.
58 arrayZ=( zero "$(_pls 'Hello ${Me}')" " 'Hello ${You}' "\'Pass: ${pw}\' " )
59
60 # Now make an assignment with that result.
61 declare -a array2=( ${arrayZ[@]} )
62
63 # Which yielded:
64 # - - Test Three - -
65 # Element 0: zero is: 4 long           # Our marker element.
66 # Element 1: Hello ${Me} is: 11 long  # Intended result.
67 # Element 2: Hello is: 5 long         # ${You} expanded to nothing.
68 # Element 3: 'Pass: is: 6 long        # Split on the whitespace.
69 # Element 4: ' is: 1 long             # The end quote is here now.
70
71 # set -vx
72
73 # Initialize 'Me' to something for the embedded ${Me} substitution.
74 # This needs to be done ONLY just prior to evaluating the
75 #+ protected string.
76 # (This is why it was protected to begin with.)
77
78 Me="to the array guy."
79
80 # Set a string variable destination to the result.
81 newVar=$( _upls ${array2[1]} )
82
83 # Show what the contents are.
84 echo $newVar
85
86 # Do we really need a function to do this?
87 newerVar=$(eval echo ${array2[1]})
88 echo $newerVar
89

```



```

90 # I guess not, but the _upls function gives us a place to hang
91 #+ the documentation on.
92 # This helps when we forget what a # construction like:
93 #+ $(eval echo ... ) means.
94
95 # What if Me isn't set when the protected string is evaluated?
96 unset Me
97 newestVar=${_upls ${array2[1]}}
98 echo $newestVar
99
100 # Just gone, no hints, no runs, no errors.
101
102 # Why in the world?
103 # Setting the contents of a string variable containing character
104 #+ sequences that have a meaning in Bash is a general problem in
105 #+ script programming.
106 #
107 # This problem is now solved in eight lines of code
108 #+ (and four pages of description).
109
110 # Where is all this going?
111 # Dynamic content Web pages as an array of Bash strings.
112 # Content set per request by a Bash 'eval' command
113 #+ on the stored page template.
114 # Not intended to replace PHP, just an interesting thing to do.
115 ###
116 # Don't have a webserver application?
117 # No problem, check the example directory of the Bash source;
118 #+ there is a Bash script for that also.
119
120 # _UnProtect_Literal_String_Test
121 # # # Remove the above "# " to disable this code. # # #
122
123 exit 0

```

This interesting script helps hunt down spammers.

Example A-28. Spammer Identification

```

1 #!/bin/bash
2
3 # $Id: is_spammer.bash,v 1.12.2.11 2004/10/01 21:42:33 mszick Exp $
4 # Above line is RCS info.
5
6 # The latest version of this script is available from http://www.morethan.org.
7 #
8 # Spammer-identification
9 # by Michael S. Zick
10 # Used in the ABS Guide with permission.
11
12
13
14 #####
15 # Documentation
16 # See also "Quickstart" at end of script.
17 #####
18
19 :<<- '__is_spammer_Doc_'
20
21     Copyright (c) Michael S. Zick, 2004
22     License: Unrestricted reuse in any form, for any purpose.
23     Warranty: None -{Its a script; the user is on their own.}-

```

```
24
25 Impatient?
26 Application code: goto "# # # Hunt the Spammer' program code # # #"
27 Example output: ";<<-'_is_spammer_outputs'"
28 How to use: Enter script name without arguments.
29 Or goto "Quickstart" at end of script.
30
31 Provides
32 Given a domain name or IP(v4) address as input:
33
34 Does an exhaustive set of queries to find the associated
35 network resources (short of recursing into TLDs).
36
37 Checks the IP(v4) addresses found against Blacklist
38 nameservers.
39
40 If found to be a blacklisted IP(v4) address,
41 reports the blacklist text records.
42 (Usually hyper-links to the specific report.)
43
44 Requires
45 A working Internet connection.
46 (Exercise: Add check and/or abort if not on-line when running script.)
47 Bash with arrays (2.05b+).
48
49 The external program 'dig' --
50 a utility program provided with the 'bind' set of programs.
51 Specifically, the version which is part of Bind series 9.x
52 See: http://www.isc.org
53
54 All usages of 'dig' are limited to wrapper functions,
55 which may be rewritten as required.
56 See: dig_wrappers.bash for details.
57 ("Additional documentation" -- below)
58
59 Usage
60 Script requires a single argument, which may be:
61 1) A domain name;
62 2) An IP(v4) address;
63 3) A filename, with one name or address per line.
64
65 Script accepts an optional second argument, which may be:
66 1) A Blacklist server name;
67 2) A filename, with one Blacklist server name per line.
68
69 If the second argument is not provided, the script uses
70 a built-in set of (free) Blacklist servers.
71
72 See also, the Quickstart at the end of this script (after 'exit').
73
74 Return Codes
75 0 - All OK
76 1 - Script failure
77 2 - Something is Blacklisted
78
79 Optional environment variables
80 SPAMMER_TRACE
81 If set to a writable file,
82 script will log an execution flow trace.
83
84 SPAMMER_DATA
85 If set to a writable file, script will dump its
86 discovered data in the form of GraphViz file.
87 See: http://www.research.att.com/sw/tools/graphviz
88
89 SPAMMER_LIMIT
```

```
90         Limits the depth of resource tracing.
91
92         Default is 2 levels.
93
94         A setting of 0 (zero) means 'unlimited' . . .
95         Caution: script might recurse the whole Internet!
96
97         A limit of 1 or 2 is most useful when processing
98         a file of domain names and addresses.
99         A higher limit can be useful when hunting spam gangs.
100
101
102 Additional documentation
103     Download the archived set of scripts
104     explaining and illustrating the function contained within this script.
105     http://bash.deta.in/mszick_clf.tar.bz2
106
107
108 Study notes
109     This script uses a large number of functions.
110     Nearly all general functions have their own example script.
111     Each of the example scripts have tutorial level comments.
112
113 Scripting project
114     Add support for IP(v6) addresses.
115     IP(v6) addresses are recognized but not processed.
116
117 Advanced project
118     Add the reverse lookup detail to the discovered information.
119
120     Report the delegation chain and abuse contacts.
121
122     Modify the GraphViz file output to include the
123     newly discovered information.
124
125 __is_spammer_Doc__
126
127 #####
128
129
130
131
132 #### Special IFS settings used for string parsing. ####
133
134 # Whitespace == :Space:Tab:Line Feed:Carriage Return:
135 WSP_IFS=$'\x20'$'\x09'$'\x0A'$'\x0D'
136
137 # No Whitespace == Line Feed:Carriage Return
138 NO_WSP=$'\x0A'$'\x0D'
139
140 # Field separator for dotted decimal IP addresses
141 ADR_IFS=${NO_WSP}'.'
142
143 # Array to dotted string conversions
144 DOT_IFS='.'${WSP_IFS}
145
146 # # # Pending operations stack machine # # #
147 # This set of functions described in func_stack.bash.
148 # (See "Additional documentation" above.)
149 # # #
150
151 # Global stack of pending operations.
152 declare -f -a _pending_
153 # Global sentinel for stack runners
154 declare -i _p_ctrl_
155 # Global holder for currently executing function
```

```

156 declare -f _pend_current_
157
158 # # # Debug version only - remove for regular use # # #
159 #
160 # The function stored in _pend_hook_ is called
161 # immediately before each pending function is
162 # evaluated. Stack clean, _pend_current_ set.
163 #
164 # This thingy demonstrated in pend_hook.bash.
165 declare -f _pend_hook_
166 # # #
167
168 # The do nothing function
169 pend_dummy() { : ; }
170
171 # Clear and initialize the function stack.
172 pend_init() {
173     unset _pending_[@]
174     pend_func pend_stop_mark
175     _pend_hook_='pend_dummy' # Debug only.
176 }
177
178 # Discard the top function on the stack.
179 pend_pop() {
180     if [ ${#_pending_[@]} -gt 0 ]
181     then
182         local -i _top_
183         _top_=${#_pending_[@]}-1
184         unset _pending_[$_top_]
185     fi
186 }
187
188 # pend_func function_name [$(printf '%q\n' arguments)]
189 pend_func() {
190     local IFS=${NO_WSP}
191     set -f
192     _pending_[${#_pending_[@]}]=${@}
193     set +f
194 }
195
196 # The function which stops the release:
197 pend_stop_mark() {
198     _p_ctrl_=0
199 }
200
201 pend_mark() {
202     pend_func pend_stop_mark
203 }
204
205 # Execute functions until 'pend_stop_mark' . . .
206 pend_release() {
207     local -i _top_ # Declare _top_ as integer.
208     _p_ctrl_=${#_pending_[@]}
209     while [ ${_p_ctrl_} -gt 0 ]
210     do
211         _top_=${#_pending_[@]}-1
212         _pend_current_=${_pending_[$_top_]}
213         unset _pending_[$_top_]
214         $_pend_hook_ # Debug only.
215         eval $_pend_current_
216     done
217 }
218
219 # Drop functions until 'pend_stop_mark' . . .
220 pend_drop() {
221     local -i _top_

```

```

222     local _pd_ctrl_=${#_pending_[@]}
223     while [ ${_pd_ctrl_} -gt 0 ]
224     do
225         _top_=$_pd_ctrl_-1
226         if [ "${_pending_[$_top]}" == 'pend_stop_mark' ]
227         then
228             unset _pending_[$_top_]
229             break
230         else
231             unset _pending_[$_top_]
232             _pd_ctrl=$_top_
233         fi
234     done
235     if [ ${#_pending_[@]} -eq 0 ]
236     then
237         pend_func pend_stop_mark
238     fi
239 }
240
241 ##### Array editors #####
242
243 # This function described in edit_exact.bash.
244 # (See "Additional documentation," above.)
245 # edit_exact <excludes_array_name> <target_array_name>
246 edit_exact() {
247     [ $# -eq 2 ] ||
248     [ $# -eq 3 ] || return 1
249     local -a _ee_Excludes
250     local -a _ee_Target
251     local _ee_x
252     local _ee_t
253     local IFS=${NO_WSP}
254     set -f
255     eval _ee_Excludes=\( \${1[@]} \)
256     eval _ee_Target=\( \${2[@]} \)
257     local _ee_len=${#_ee_Target[@]}      # Original length.
258     local _ee_cnt=${#_ee_Excludes[@]}   # Exclude list length.
259     [ ${_ee_len} -ne 0 ] || return 0    # Can't edit zero length.
260     [ ${_ee_cnt} -ne 0 ] || return 0    # Can't edit zero length.
261     for (( x = 0; x < ${_ee_cnt}; x++ ))
262     do
263         _ee_x=${_ee_Excludes[$x]}
264         for (( n = 0; n < ${_ee_len}; n++ ))
265         do
266             _ee_t=${_ee_Target[$n]}
267             if [ x"${_ee_t}" == x"${_ee_x}" ]
268             then
269                 unset _ee_Target[$n]    # Discard match.
270                 [ $# -eq 2 ] && break    # If 2 arguments, then done.
271             fi
272         done
273     done
274     eval $2=\( \${_ee_Target[@]} \)
275     set +f
276     return 0
277 }
278
279 # This function described in edit_by_glob.bash.
280 # edit_by_glob <excludes_array_name> <target_array_name>
281 edit_by_glob() {
282     [ $# -eq 2 ] ||
283     [ $# -eq 3 ] || return 1
284     local -a _ebg_Excludes
285     local -a _ebg_Target
286     local _ebg_x
287     local _ebg_t

```

```

288     local IFS=${NO_WSP}
289     set -f
290     eval _ebg_Excludes=\( \${1[@]} \)
291     eval _ebg_Target=\( \${2[@]} \)
292     local _ebg_len=${#_ebg_Target[@]}
293     local _ebg_cnt=${#_ebg_Excludes[@]}
294     [ ${_ebg_len} -ne 0 ] || return 0
295     [ ${_ebg_cnt} -ne 0 ] || return 0
296     for (( x = 0; x < ${_ebg_cnt} ; x++ ))
297     do
298         _ebg_x=${_ebg_Excludes[$x]}
299         for (( n = 0 ; n < ${_ebg_len} ; n++ ))
300         do
301             [ $# -eq 3 ] && _ebg_x=${_ebg_x}'*' # Do prefix edit
302             if [ ${_ebg_Target[$n]:=} ]      #+ if defined & set.
303             then
304                 _ebg_t=${_ebg_Target[$n]/#$_ebg_x/}
305                 [ ${#_ebg_t} -eq 0 ] && unset _ebg_Target[$n]
306             fi
307         done
308     done
309     eval $2=\( \${_ebg_Target[@]} \)
310     set +f
311     return 0
312 }
313
314 # This function described in unique_lines.bash.
315 # unique_lines <in_name> <out_name>
316 unique_lines() {
317     [ $# -eq 2 ] || return 1
318     local -a _ul_in
319     local -a _ul_out
320     local -i _ul_cnt
321     local -i _ul_pos
322     local _ul_tmp
323     local IFS=${NO_WSP}
324     set -f
325     eval _ul_in=\( \${1[@]} \)
326     _ul_cnt=${#_ul_in[@]}
327     for (( _ul_pos = 0 ; _ul_pos < ${_ul_cnt} ; _ul_pos++ ))
328     do
329         if [ ${_ul_in[$_ul_pos]:=} ]      # If defined & not empty
330         then
331             _ul_tmp=${_ul_in[$_ul_pos]}
332             _ul_out[${#_ul_out[@]}]=${_ul_tmp}
333             for (( zap = _ul_pos ; zap < ${_ul_cnt} ; zap++ ))
334             do
335                 [ ${_ul_in[$zap]:=} ] &&
336                 [ 'x'${_ul_in[$zap]} == 'x'${_ul_tmp} ] &&
337                 unset _ul_in[$zap]
338             done
339         fi
340     done
341     eval $2=\( \${_ul_out[@]} \)
342     set +f
343     return 0
344 }
345
346 # This function described in char_convert.bash.
347 # to_lower <string>
348 to_lower() {
349     [ $# -eq 1 ] || return 1
350     local _tl_out
351     _tl_out=${1//A/a}
352     _tl_out=${_tl_out//B/b}
353     _tl_out=${_tl_out//C/c}

```

```

354     _tl_out=${_tl_out//D/d}
355     _tl_out=${_tl_out//E/e}
356     _tl_out=${_tl_out//F/f}
357     _tl_out=${_tl_out//G/g}
358     _tl_out=${_tl_out//H/h}
359     _tl_out=${_tl_out//I/i}
360     _tl_out=${_tl_out//J/j}
361     _tl_out=${_tl_out//K/k}
362     _tl_out=${_tl_out//L/l}
363     _tl_out=${_tl_out//M/m}
364     _tl_out=${_tl_out//N/n}
365     _tl_out=${_tl_out//O/o}
366     _tl_out=${_tl_out//P/p}
367     _tl_out=${_tl_out//Q/q}
368     _tl_out=${_tl_out//R/r}
369     _tl_out=${_tl_out//S/s}
370     _tl_out=${_tl_out//T/t}
371     _tl_out=${_tl_out//U/u}
372     _tl_out=${_tl_out//V/v}
373     _tl_out=${_tl_out//W/w}
374     _tl_out=${_tl_out//X/x}
375     _tl_out=${_tl_out//Y/y}
376     _tl_out=${_tl_out//Z/z}
377     echo ${_tl_out}
378     return 0
379 }
380
381 ##### Application helper functions #####
382
383 # Not everybody uses dots as separators (APNIC, for example).
384 # This function described in to_dot.bash
385 # to_dot <string>
386 to_dot() {
387     [ $# -eq 1 ] || return 1
388     echo ${1//[#|@|%]/.}
389     return 0
390 }
391
392 # This function described in is_number.bash.
393 # is_number <input>
394 is_number() {
395     [ "$#" -eq 1 ] || return 1 # is blank?
396     [ x"$1" == 'x0' ] && return 0 # is zero?
397     local -i tst
398     let tst=$1 2>/dev/null # else is numeric!
399     return $?
400 }
401
402 # This function described in is_address.bash.
403 # is_address <input>
404 is_address() {
405     [ $# -eq 1 ] || return 1 # Blank ==> false
406     local -a _ia_input
407     local IFS=${ADR_IFS}
408     _ia_input=( $1 )
409     if [ ${#_ia_input[@]} -eq 4 ] &&
410         is_number ${_ia_input[0]} &&
411         is_number ${_ia_input[1]} &&
412         is_number ${_ia_input[2]} &&
413         is_number ${_ia_input[3]} &&
414         [ ${_ia_input[0]} -lt 256 ] &&
415         [ ${_ia_input[1]} -lt 256 ] &&
416         [ ${_ia_input[2]} -lt 256 ] &&
417         [ ${_ia_input[3]} -lt 256 ]
418     then
419         return 0

```

```

420     else
421         return 1
422     fi
423 }
424
425 # This function described in split_ip.bash.
426 # split_ip <IP_address>
427 #+ <array_name_norm> [<array_name_rev>]
428 split_ip() {
429     [ $# -eq 3 ] ||                # Either three
430     [ $# -eq 2 ] || return 1      #+ or two arguments
431     local -a _si_input
432     local IFS=${ADR_IFS}
433     _si_input=( $1 )
434     IFS=${WSP_IFS}
435     eval $2=\( \ \ ${_si_input[@]} \ \ )
436     if [ $# -eq 3 ]
437     then
438         # Build query order array.
439         local -a _dns_ip
440         _dns_ip[0]=${_si_input[3]}
441         _dns_ip[1]=${_si_input[2]}
442         _dns_ip[2]=${_si_input[1]}
443         _dns_ip[3]=${_si_input[0]}
444         eval $3=\( \ \ ${_dns_ip[@]} \ \ )
445     fi
446     return 0
447 }
448
449 # This function described in dot_array.bash.
450 # dot_array <array_name>
451 dot_array() {
452     [ $# -eq 1 ] || return 1      # Single argument required.
453     local -a _da_input
454     eval _da_input=\( \ \ ${1[@]} \ \ )
455     local IFS=${DOT_IFS}
456     local _da_output=${_da_input[@]}
457     IFS=${WSP_IFS}
458     echo ${_da_output}
459     return 0
460 }
461
462 # This function described in file_to_array.bash
463 # file_to_array <file_name> <line_array_name>
464 file_to_array() {
465     [ $# -eq 2 ] || return 1      # Two arguments required.
466     local IFS=${NO_WSP}
467     local -a _fta_tmp_
468     _fta_tmp_=( $(cat $1) )
469     eval $2=\( \ \ ${_fta_tmp_[@]} \ \ )
470     return 0
471 }
472
473 # Columnized print of an array of multi-field strings.
474 # col_print <array_name> <min_space> <
475 #+ tab_stop [tab_stops]>
476 col_print() {
477     [ $# -gt 2 ] || return 0
478     local -a _cp_inp
479     local -a _cp_spc
480     local -a _cp_line
481     local _cp_min
482     local _cp_mcnt
483     local _cp_pos
484     local _cp_cnt
485     local _cp_tab

```



```

486     local -i _cp
487     local -i _cpf
488     local _cp_fld
489     # WARNING: FOLLOWING LINE NOT BLANK -- IT IS QUOTED SPACES.
490     local _cp_max='
491     set -f
492     local IFS=${NO_WSP}
493     eval _cp_inp=\(\ \ \$\{$1\[@\]\)\ \ \)
494     [ ${#_cp_inp[@]} -gt 0 ] || return 0 # Empty is easy.
495     _cp_mcnt=$2
496     _cp_min=${_cp_max:1:${_cp_mcnt}}
497     shift
498     shift
499     _cp_cnt=$#
500     for (( _cp = 0 ; _cp < _cp_cnt ; _cp++ ))
501     do
502         _cp_spc[${#_cp_spc[@]}]="${_cp_max:2:$1}" #"
503         shift
504     done
505     _cp_cnt=${#_cp_inp[@]}
506     for (( _cp = 0 ; _cp < _cp_cnt ; _cp++ ))
507     do
508         _cp_pos=1
509         IFS=${NO_WSP}$'\x20'
510         _cp_line=( ${_cp_inp[${_cp}]} )
511         IFS=${NO_WSP}
512         for (( _cpf = 0 ; _cpf < ${#_cp_line[@]} ; _cpf++ ))
513         do
514             _cp_tab=${_cp_spc[${_cpf}]:${_cp_pos}}
515             if [ ${#_cp_tab} -lt ${_cp_mcnt} ]
516             then
517                 _cp_tab="${_cp_min}"
518             fi
519             echo -n "${_cp_tab}"
520             (( _cp_pos = ${_cp_pos} + ${#_cp_tab} ))
521             _cp_fld="${_cp_line[${_cpf}]}"
522             echo -n "${_cp_fld}"
523             (( _cp_pos = ${_cp_pos} + ${#_cp_fld} ))
524         done
525         echo
526     done
527     set +f
528     return 0
529 }
530
531 # # # # 'Hunt the Spammer' data flow # # # #
532
533 # Application return code
534 declare -i _hs_RC
535
536 # Original input, from which IP addresses are removed
537 # After which, domain names to check
538 declare -a uc_name
539
540 # Original input IP addresses are moved here
541 # After which, IP addresses to check
542 declare -a uc_address
543
544 # Names against which address expansion run
545 # Ready for name detail lookup
546 declare -a chk_name
547
548 # Addresses against which name expansion run
549 # Ready for address detail lookup
550 declare -a chk_address
551

```

```

552 # Recursion is depth-first-by-name.
553 # The expand_input_address maintains this list
554 #+ to prohibit looking up addresses twice during
555 #+ domain name recursion.
556 declare -a been_there_addr
557 been_there_addr=( '127.0.0.1' ) # Whitelist localhost
558
559 # Names which we have checked (or given up on)
560 declare -a known_name
561
562 # Addresses which we have checked (or given up on)
563 declare -a known_address
564
565 # List of zero or more Blacklist servers to check.
566 # Each 'known_address' will be checked against each server,
567 #+ with negative replies and failures suppressed.
568 declare -a list_server
569
570 # Indirection limit - set to zero == no limit
571 indirect=${SPAMMER_LIMIT:=2}
572
573 # # # # 'Hunt the Spammer' information output data # # # #
574
575 # Any domain name may have multiple IP addresses.
576 # Any IP address may have multiple domain names.
577 # Therefore, track unique address-name pairs.
578 declare -a known_pair
579 declare -a reverse_pair
580
581 # In addition to the data flow variables; known_address
582 #+ known_name and list_server, the following are output to the
583 #+ external graphics interface file.
584
585 # Authority chain, parent -> SOA fields.
586 declare -a auth_chain
587
588 # Reference chain, parent name -> child name
589 declare -a ref_chain
590
591 # DNS chain - domain name -> address
592 declare -a name_address
593
594 # Name and service pairs - domain name -> service
595 declare -a name_srvc
596
597 # Name and resource pairs - domain name -> Resource Record
598 declare -a name_resource
599
600 # Parent and Child pairs - parent name -> child name
601 # This MAY NOT be the same as the ref_chain followed!
602 declare -a parent_child
603
604 # Address and Blacklist hit pairs - address->server
605 declare -a address_hits
606
607 # Dump interface file data
608 declare -f _dot_dump
609 _dot_dump=pend_dummy # Initially a no-op
610
611 # Data dump is enabled by setting the environment variable SPAMMER_DATA
612 #+ to the name of a writable file.
613 declare _dot_file
614
615 # Helper function for the dump-to-dot-file function
616 # dump_to_dot <array_name> <prefix>
617 dump_to_dot() {

```

```

618     local -a _dda_tmp
619     local -i _dda_cnt
620     local _dda_form='      '${2}%'%04u %s\n'
621     local IFS=${NO_WSP}
622     eval _dda_tmp=\(\ \ \${1}\[@]\)\ \ \)
623     _dda_cnt=${#_dda_tmp[@]}
624     if [ ${_dda_cnt} -gt 0 ]
625     then
626         for (( _dda = 0 ; _dda < _dda_cnt ; _dda++ ))
627         do
628             printf "${_dda_form}" \
629                 "${_dda}" "${_dda_tmp[${_dda}]}" >>${_dot_file}
630         done
631     fi
632 }
633
634 # Which will also set _dot_dump to this function . . .
635 dump_dot() {
636     local -i _dd_cnt
637     echo '# Data vintage: $(date -R) >${_dot_file}'
638     echo '# ABS Guide: is_spammer.bash; v2, 2004-msz' >>${_dot_file}
639     echo >>${_dot_file}
640     echo 'digraph G {' >>${_dot_file}
641
642     if [ ${#known_name[@]} -gt 0 ]
643     then
644         echo >>${_dot_file}
645         echo '# Known domain name nodes' >>${_dot_file}
646         _dd_cnt=${#known_name[@]}
647         for (( _dd = 0 ; _dd < _dd_cnt ; _dd++ ))
648         do
649             printf '      N%04u [label="%s"] ;\n' \
650                 "${_dd}" "${known_name[${_dd}]}" >>${_dot_file}
651         done
652     fi
653
654     if [ ${#known_address[@]} -gt 0 ]
655     then
656         echo >>${_dot_file}
657         echo '# Known address nodes' >>${_dot_file}
658         _dd_cnt=${#known_address[@]}
659         for (( _dd = 0 ; _dd < _dd_cnt ; _dd++ ))
660         do
661             printf '      A%04u [label="%s"] ;\n' \
662                 "${_dd}" "${known_address[${_dd}]}" >>${_dot_file}
663         done
664     fi
665
666     echo >>${_dot_file}
667     echo '/*' >>${_dot_file}
668     echo ' * Known relationships :: User conversion to' >>${_dot_file}
669     echo ' * graphic form by hand or program required.' >>${_dot_file}
670     echo ' *' >>${_dot_file}
671
672     if [ ${#auth_chain[@]} -gt 0 ]
673     then
674         echo >>${_dot_file}
675         echo '# Authority ref. edges followed & field source.' >>${_dot_file}
676         dump_to_dot auth_chain AC
677     fi
678
679     if [ ${#ref_chain[@]} -gt 0 ]
680     then
681         echo >>${_dot_file}
682         echo '# Name ref. edges followed and field source.' >>${_dot_file}
683         dump_to_dot ref_chain RC

```

```

684     fi
685
686     if [ ${#name_address[@]} -gt 0 ]
687     then
688         echo >>${_dot_file}
689         echo '# Known name->address edges' >>${_dot_file}
690         dump_to_dot name_address NA
691     fi
692
693     if [ ${#name_srvc[@]} -gt 0 ]
694     then
695         echo >>${_dot_file}
696         echo '# Known name->service edges' >>${_dot_file}
697         dump_to_dot name_srvc NS
698     fi
699
700     if [ ${#name_resource[@]} -gt 0 ]
701     then
702         echo >>${_dot_file}
703         echo '# Known name->resource edges' >>${_dot_file}
704         dump_to_dot name_resource NR
705     fi
706
707     if [ ${#parent_child[@]} -gt 0 ]
708     then
709         echo >>${_dot_file}
710         echo '# Known parent->child edges' >>${_dot_file}
711         dump_to_dot parent_child PC
712     fi
713
714     if [ ${#list_server[@]} -gt 0 ]
715     then
716         echo >>${_dot_file}
717         echo '# Known Blacklist nodes' >>${_dot_file}
718         _dd_cnt=${#list_server[@]}
719         for ( ( _dd = 0 ; _dd < _dd_cnt ; _dd++ ) )
720         do
721             printf '    LS%04u [label="%s"] ;\n' \
722                 "${_dd}" "${list_server[${_dd}]}" >>${_dot_file}
723         done
724     fi
725
726     unique_lines address_hits address_hits
727     if [ ${#address_hits[@]} -gt 0 ]
728     then
729         echo >>${_dot_file}
730         echo '# Known address->Blacklist_hit edges' >>${_dot_file}
731         echo '# CAUTION: dig warnings can trigger false hits.' >>${_dot_file}
732         dump_to_dot address_hits AH
733     fi
734     echo >>${_dot_file}
735     echo ' * ' >>${_dot_file}
736     echo ' * That is a lot of relationships. Happy graphing.' >>${_dot_file}
737     echo ' */' >>${_dot_file}
738     echo '}' >>${_dot_file}
739     return 0
740 }
741
742 # # # # 'Hunt the Spammer' execution flow # # # #
743
744 # Execution trace is enabled by setting the
745 #+ environment variable SPAMMER_TRACE to the name of a writable file.
746 declare -a _trace_log
747 declare _log_file
748
749 # Function to fill the trace log

```

```

750 trace_logger() {
751     _trace_log[${#_trace_log[@]}]=${_pend_current_}
752 }
753
754 # Dump trace log to file function variable.
755 declare -f _log_dump
756 _log_dump=pend_dummy # Initially a no-op.
757
758 # Dump the trace log to a file.
759 dump_log() {
760     local -i _dl_cnt
761     _dl_cnt=${#_trace_log[@]}
762     for (( _dl = 0 ; _dl < _dl_cnt ; _dl++ ))
763     do
764         echo ${_trace_log[${_dl}]} >> ${_log_file}
765     done
766     _dl_cnt=${#_pending_[@]}
767     if [ ${_dl_cnt} -gt 0 ]
768     then
769         _dl_cnt=${_dl_cnt}-1
770         echo '# # # Operations stack not empty # # #' >> ${_log_file}
771         for (( _dl = ${_dl_cnt} ; _dl >= 0 ; _dl-- ))
772         do
773             echo ${_pending_[${_dl}]} >> ${_log_file}
774         done
775     fi
776 }
777
778 # # # Utility program 'dig' wrappers # # #
779 #
780 # These wrappers are derived from the
781 #+ examples shown in dig_wrappers.bash.
782 #
783 # The major difference is these return
784 #+ their results as a list in an array.
785 #
786 # See dig_wrappers.bash for details and
787 #+ use that script to develop any changes.
788 #
789 # # #
790
791 # Short form answer: 'dig' parses answer.
792
793 # Forward lookup :: Name -> Address
794 # short_fwd <domain_name> <array_name>
795 short_fwd() {
796     local -a _sf_reply
797     local -i _sf_rc
798     local -i _sf_cnt
799     IFS=${NO_WSP}
800     echo -n '.'
801     # echo 'sfwd: '${1}
802     _sf_reply=( $(dig +short ${1} -c in -t a 2>/dev/null) )
803     _sf_rc=$?
804     if [ ${_sf_rc} -ne 0 ]
805     then
806         _trace_log[${#_trace_log[@]}]='## Lookup error '${_sf_rc}' on '${1}' ##'
807     # [ ${_sf_rc} -ne 9 ] && pend_drop
808         return ${_sf_rc}
809     else
810         # Some versions of 'dig' return warnings on stdout.
811         _sf_cnt=${#_sf_reply[@]}
812         for (( _sf = 0 ; _sf < ${_sf_cnt} ; _sf++ ))
813         do
814             [ 'x'${_sf_reply[${_sf}]:0:2} == 'x;' ] &&
815                 unset _sf_reply[${_sf}]

```

```

816     done
817     eval $2=\( \${_sf_reply}\[@\]\ \)
818 fi
819 return 0
820 }
821
822 # Reverse lookup :: Address -> Name
823 # short_rev <ip_address> <array_name>
824 short_rev() {
825     local -a _sr_reply
826     local -i _sr_rc
827     local -i _sr_cnt
828     IFS=${NO_WSP}
829 echo -n '.'
830 # echo 'srev: '${1}
831 _sr_reply=( $(dig +short -x ${1} 2>/dev/null) )
832 _sr_rc=$?
833 if [ ${_sr_rc} -ne 0 ]
834 then
835     _trace_log[${#_trace_log[@]}]=### Lookup error '${_sr_rc}' on '${1}' ###
836 # [ ${_sr_rc} -ne 9 ] && pend_drop
837     return ${_sr_rc}
838 else
839     # Some versions of 'dig' return warnings on stdout.
840     _sr_cnt=${#_sr_reply[@]}
841     for (( _sr = 0 ; _sr < ${_sr_cnt} ; _sr++ ))
842     do
843         [ 'x'${_sr_reply[${_sr}]:0:2} == 'x;' ] &&
844             unset _sr_reply[${_sr}]
845     done
846     eval $2=\( \${_sr_reply}\[@\]\ \)
847 fi
848 return 0
849 }
850
851 # Special format lookup used to query blacklist servers.
852 # short_text <ip_address> <array_name>
853 short_text() {
854     local -a _st_reply
855     local -i _st_rc
856     local -i _st_cnt
857     IFS=${NO_WSP}
858 # echo 'stxt: '${1}
859 _st_reply=( $(dig +short ${1} -c in -t txt 2>/dev/null) )
860 _st_rc=$?
861 if [ ${_st_rc} -ne 0 ]
862 then
863     _trace_log[${#_trace_log[@]}]=###Text lookup error '${_st_rc}' on '${1}'###
864 # [ ${_st_rc} -ne 9 ] && pend_drop
865     return ${_st_rc}
866 else
867     # Some versions of 'dig' return warnings on stdout.
868     _st_cnt=${#_st_reply[@]}
869     for (( _st = 0 ; _st < ${_st_cnt} ; _st++ ))
870     do
871         [ 'x'${_st_reply[${_st}]:0:2} == 'x;' ] &&
872             unset _st_reply[${_st}]
873     done
874     eval $2=\( \${_st_reply}\[@\]\ \)
875 fi
876 return 0
877 }
878
879 # The long forms, a.k.a., the parse it yourself versions
880
881 # RFC 2782    Service lookups

```

```

882 # dig +noall +nofail +answer _ldap._tcp.openldap.org -t srv
883 # _<service>.<protocol>.<domain_name>
884 # _ldap._tcp.openldap.org. 3600 IN SRV 0 0 389 ldap.openldap.org.
885 # domain TTL Class SRV Priority Weight Port Target
886
887 # Forward lookup :: Name -> poor man's zone transfer
888 # long_fwd <domain_name> <array_name>
889 long_fwd() {
890     local -a _lf_reply
891     local -i _lf_rc
892     local -i _lf_cnt
893     IFS=${NO_WSP}
894     echo -n ':'
895     # echo 'lfwd: '${1}
896     _lf_reply=( $(
897         dig +noall +nofail +answer +authority +additional \
898             ${1} -t soa ${1} -t mx ${1} -t any 2>/dev/null) )
899     _lf_rc=$?
900     if [ ${_lf_rc} -ne 0 ]
901     then
902         _trace_log[${#_trace_log[@]}]='# Zone lookup err '${_lf_rc}' on '${1}' #'
903     # [ ${_lf_rc} -ne 9 ] && pend_drop
904         return ${_lf_rc}
905     else
906         # Some versions of 'dig' return warnings on stdout.
907         _lf_cnt=${#_lf_reply[@]}
908         for (( _lf = 0 ; _lf < ${_lf_cnt} ; _lf++ ))
909         do
910             [ 'x${_lf_reply[${_lf}]:0:2} == 'x;;' ] &&
911                 unset _lf_reply[${_lf}]
912         done
913         eval $2=\( \${_lf_reply[@]} \)
914     fi
915     return 0
916 }
917 # The reverse lookup domain name corresponding to the IPv6 address:
918 # 4321:0:1:2:3:4:567:89ab
919 # would be (nibble, I.E: Hexdigit) reversed:
920 # b.a.9.8.7.6.5.0.4.0.0.0.3.0.0.0.2.0.0.0.1.0.0.0.0.0.0.0.1.2.3.4.IP6.ARPA.
921
922 # Reverse lookup :: Address -> poor man's delegation chain
923 # long_rev <rev_ip_address> <array_name>
924 long_rev() {
925     local -a _lr_reply
926     local -i _lr_rc
927     local -i _lr_cnt
928     local _lr_dns
929     _lr_dns=${1}'.in-addr.arpa.'
930     IFS=${NO_WSP}
931     echo -n ':'
932     # echo 'lrev: '${1}
933     _lr_reply=( $(
934         dig +noall +nofail +answer +authority +additional \
935             ${_lr_dns} -t soa ${_lr_dns} -t any 2>/dev/null) )
936     _lr_rc=$?
937     if [ ${_lr_rc} -ne 0 ]
938     then
939         _trace_log[${#_trace_log[@]}]='# Deleg lkp error '${_lr_rc}' on '${1}' #'
940     # [ ${_lr_rc} -ne 9 ] && pend_drop
941         return ${_lr_rc}
942     else
943         # Some versions of 'dig' return warnings on stdout.
944         _lr_cnt=${#_lr_reply[@]}
945         for (( _lr = 0 ; _lr < ${_lr_cnt} ; _lr++ ))
946         do
947             [ 'x${_lr_reply[${_lr}]:0:2} == 'x;;' ] &&

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```

948         unset _lr_reply[${_lr}]
949     done
950     eval $2=( \${_lr_reply[@]\} \)
951 fi
952 return 0
953 }
954
955 # # # Application specific functions # # #
956
957 # Mung a possible name; suppresses root and TLDs.
958 # name_fixup <string>
959 name_fixup(){
960     local -a _nf_tmp
961     local -i _nf_end
962     local _nf_str
963     local IFS
964     _nf_str=$(to_lower ${1})
965     _nf_str=$(to_dot ${_nf_str})
966     _nf_end=${#_nf_str}-1
967     [ ${_nf_str:${_nf_end}} != '.' ] &&
968         _nf_str=${_nf_str}'.'
969     IFS=${ADR_IFS}
970     _nf_tmp=( ${_nf_str} )
971     IFS=${WSP_IFS}
972     _nf_end=${#_nf_tmp[@]}
973     case ${_nf_end} in
974     0) # No dots, only dots.
975         echo
976         return 1
977     ;;
978     1) # Only a TLD.
979         echo
980         return 1
981     ;;
982     2) # Maybe okay.
983         echo ${_nf_str}
984         return 0
985         # Needs a lookup table?
986         if [ ${#_nf_tmp[1]} -eq 2 ]
987         then # Country coded TLD.
988             echo
989             return 1
990         else
991             echo ${_nf_str}
992             return 0
993         fi
994     ;;
995     esac
996     echo ${_nf_str}
997     return 0
998 }
999
1000 # Grope and mung original input(s).
1001 split_input() {
1002     [ ${#uc_name[@]} -gt 0 ] || return 0
1003     local -i _si_cnt
1004     local -i _si_len
1005     local _si_str
1006     unique_lines uc_name uc_name
1007     _si_cnt=${#uc_name[@]}
1008     for (( _si = 0 ; _si < _si_cnt ; _si++ ))
1009     do
1010         _si_str=${uc_name[$_si]}
1011         if is_address ${_si_str}
1012         then
1013             uc_address[${#uc_address[@]}]=${_si_str}

```



```

1014         unset uc_name[$_si]
1015     else
1016         if ! uc_name[$_si]=$(name_fixup ${_si_str})
1017         then
1018             unset ucname[$_si]
1019         fi
1020     fi
1021 done
1022 uc_name=( ${uc_name[@]} )
1023 _si_cnt=${#uc_name[@]}
1024 _trace_log[${#_trace_log[@]}]='#Input '${_si_cnt}' unchkd name input(s).#'
1025 _si_cnt=${#uc_address[@]}
1026 _trace_log[${#_trace_log[@]}]='#Input '${_si_cnt}' unchkd addr input(s).#'
1027     return 0
1028 }
1029
1030 # # # Discovery functions -- recursively interlocked by external data # # #
1031 # # # The leading 'if list is empty; return 0' in each is required. # # #
1032
1033 # Recursion limiter
1034 # limit_chk() <next_level>
1035 limit_chk() {
1036     local -i _lc_lmt
1037     # Check indirection limit.
1038     if [ ${indirect} -eq 0 ] || [ $# -eq 0 ]
1039     then
1040         # The 'do-forever' choice
1041         echo 1 # Any value will do.
1042         return 0 # OK to continue.
1043     else
1044         # Limiting is in effect.
1045         if [ ${indirect} -lt ${1} ]
1046         then
1047             echo ${1} # Whatever.
1048             return 1 # Stop here.
1049         else
1050             _lc_lmt=${1}+1 # Bump the given limit.
1051             echo ${_lc_lmt} # Echo it.
1052             return 0 # OK to continue.
1053         fi
1054     fi
1055 }
1056
1057 # For each name in uc_name:
1058 #     Move name to chk_name.
1059 #     Add addresses to uc_address.
1060 #     Pend expand_input_address.
1061 #     Repeat until nothing new found.
1062 # expand_input_name <indirection_limit>
1063 expand_input_name() {
1064     [ ${#uc_name[@]} -gt 0 ] || return 0
1065     local -a _ein_addr
1066     local -a _ein_new
1067     local -i _ucn_cnt
1068     local -i _ein_cnt
1069     local _ein_tst
1070     _ucn_cnt=${#uc_name[@]}
1071
1072     if ! _ein_cnt=$(limit_chk ${1})
1073     then
1074         return 0
1075     fi
1076
1077     for (( _ein = 0 ; _ein < _ucn_cnt ; _ein++ ))
1078     do
1079         if short_fwd ${uc_name[$_ein]} _ein_new

```

```

1080     then
1081         for (( _ein_cnt = 0 ; _ein_cnt < ${#_ein_new[@]}; _ein_cnt++ ))
1082             do
1083                 _ein_tst=${_ein_new[${_ein_cnt}]}
1084                 if is_address ${_ein_tst}
1085                     then
1086                         _ein_addr[${#_ein_addr[@]}]=${_ein_tst}
1087                     fi
1088             done
1089         fi
1090     done
1091     unique_lines _ein_addr _ein_addr      # Scrub duplicates.
1092     edit_exact chk_address _ein_addr      # Scrub pending detail.
1093     edit_exact known_address _ein_addr    # Scrub already detailed.
1094 if [ ${#_ein_addr[@]} -gt 0 ]           # Anything new?
1095 then
1096     uc_address=( ${uc_address[@]} ${_ein_addr[@]} )
1097     pend_func expand_input_address ${1}
1098     _trace_log[${#_trace_log[@]}]='#Add '${_ein_addr[@]}' unchkd addr inp.#'
1099     fi
1100     edit_exact chk_name uc_name          # Scrub pending detail.
1101     edit_exact known_name uc_name        # Scrub already detailed.
1102     if [ ${#uc_name[@]} -gt 0 ]
1103         then
1104             chk_name=( ${chk_name[@]} ${uc_name[@]} )
1105             pend_func detail_each_name ${1}
1106         fi
1107     unset uc_name[@]
1108     return 0
1109 }
1110
1111 # For each address in uc_address:
1112 #     Move address to chk_address.
1113 #     Add names to uc_name.
1114 #     Pend expand_input_name.
1115 #     Repeat until nothing new found.
1116 # expand_input_address <indirection_limit>
1117 expand_input_address() {
1118     [ ${#uc_address[@]} -gt 0 ] || return 0
1119     local -a _eia_addr
1120     local -a _eia_name
1121     local -a _eia_new
1122     local -i _uca_cnt
1123     local -i _eia_cnt
1124     local _eia_tst
1125     unique_lines uc_address _eia_addr
1126     unset uc_address[@]
1127     edit_exact been_there_addr _eia_addr
1128     _uca_cnt=${#_eia_addr[@]}
1129     [ ${_uca_cnt} -gt 0 ] &&
1130         been_there_addr=( ${been_there_addr[@]} ${_eia_addr[@]} )
1131
1132     for (( _eia = 0 ; _eia < _uca_cnt ; _eia++ ))
1133         do
1134             if short_rev ${_eia_addr[${_eia}]} _eia_new
1135                 then
1136                 for (( _eia_cnt = 0 ; _eia_cnt < ${#_eia_new[@]} ; _eia_cnt++ ))
1137                     do
1138                         _eia_tst=${_eia_new[${_eia_cnt}]}
1139                         if _eia_tst=$(name_fixup ${_eia_tst})
1140                             then
1141                             _eia_name[${#_eia_name[@]}]=${_eia_tst}
1142                         fi
1143                     done
1144                 fi
1145             done

```

```

1146     unique_lines _eia_name _eia_name      # Scrub duplicates.
1147     edit_exact chk_name _eia_name        # Scrub pending detail.
1148     edit_exact known_name _eia_name      # Scrub already detailed.
1149     if [ ${#_eia_name[@]} -gt 0 ]        # Anything new?
1150     then
1151         uc_name=( ${uc_name[@]} ${_eia_name[@]} )
1152         pend_func expand_input_name ${1}
1153         _trace_log[${#_trace_log[@]}]='#Add '${_eia_name[@]}' unchkd name inp.#'
1154         fi
1155         edit_exact chk_address _eia_addr   # Scrub pending detail.
1156         edit_exact known_address _eia_addr # Scrub already detailed.
1157         if [ ${#_eia_addr[@]} -gt 0 ]     # Anything new?
1158         then
1159             chk_address=( ${chk_address[@]} ${_eia_addr[@]} )
1160             pend_func detail_each_address ${1}
1161         fi
1162         return 0
1163     }
1164
1165 # The parse-it-yourself zone reply.
1166 # The input is the chk_name list.
1167 # detail_each_name <indirection_limit>
1168 detail_each_name() {
1169     [ ${#chk_name[@]} -gt 0 ] || return 0
1170     local -a _den_chk      # Names to check
1171     local -a _den_name     # Names found here
1172     local -a _den_address  # Addresses found here
1173     local -a _den_pair    # Pairs found here
1174     local -a _den_rev      # Reverse pairs found here
1175     local -a _den_tmp     # Line being parsed
1176     local -a _den_auth    # SOA contact being parsed
1177     local -a _den_new     # The zone reply
1178     local -a _den_pc      # Parent-Child gets big fast
1179     local -a _den_ref     # So does reference chain
1180     local -a _den_nr      # Name-Resource can be big
1181     local -a _den_na      # Name-Address
1182     local -a _den_ns      # Name-Service
1183     local -a _den_achn    # Chain of Authority
1184     local -i _den_cnt     # Count of names to detail
1185     local -i _den_lmt     # Indirection limit
1186     local _den_who       # Named being processed
1187     local _den_rec       # Record type being processed
1188     local _den_cont      # Contact domain
1189     local _den_str       # Fixed up name string
1190     local _den_str2      # Fixed up reverse
1191     local IFS=${WSP_IFS}
1192
1193     # Local, unique copy of names to check
1194     unique_lines chk_name _den_chk
1195     unset chk_name[@]      # Done with globals.
1196
1197     # Less any names already known
1198     edit_exact known_name _den_chk
1199     _den_cnt=${#_den_chk[@]}
1200
1201     # If anything left, add to known_name.
1202     [ ${_den_cnt} -gt 0 ] &&
1203         known_name=( ${known_name[@]} ${_den_chk[@]} )
1204
1205     # for the list of (previously) unknown names . . .
1206     for (( _den = 0 ; _den < _den_cnt ; _den++ ))
1207     do
1208         _den_who=${_den_chk[${_den}]}
1209         if long_fwd ${_den_who} _den_new
1210         then
1211             unique_lines _den_new _den_new

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```

1212     if [ ${#_den_new[@]} -eq 0 ]
1213     then
1214         _den_pair[${#_den_pair[@]}]='0.0.0.0 '${_den_who}
1215     fi
1216
1217     # Parse each line in the reply.
1218     for (( _line = 0 ; _line < ${#_den_new[@]} ; _line++ ))
1219     do
1220         IFS=${NO_WSP}$'\x09'\x20'
1221         _den_tmp=( ${_den_new[${_line}]} )
1222         IFS=${WSP_IFS}
1223         # If usable record and not a warning message . . .
1224         if [ ${#_den_tmp[@]} -gt 4 ] && [ 'x'${_den_tmp[0]} != 'x;' ]
1225         then
1226             _den_rec=${_den_tmp[3]}
1227             _den_nr[${#_den_nr[@]}]=${_den_who}' '${_den_rec}
1228             # Begin at RFC1033 (+++)
1229             case ${_den_rec} in
1230
1231 #<name> [<t11>] [<class>] SOA <origin> <person>
1232             SOA) # Start Of Authority
1233             if _den_str=$(name_fixup ${_den_tmp[0]})
1234             then
1235                 _den_name[${#_den_name[@]}]=${_den_str}
1236                 _den_achn[${#_den_achn[@]}]=${_den_who}' '${_den_str}' SOA'
1237                 # SOA origin -- domain name of master zone record
1238                 if _den_str2=$(name_fixup ${_den_tmp[4]})
1239                 then
1240                     _den_name[${#_den_name[@]}]=${_den_str2}
1241                     _den_achn[${#_den_achn[@]}]=${_den_who}' '${_den_str2}' SOA.O'
1242                 fi
1243                 # Responsible party e-mail address (possibly bogus).
1244                 # Possibility of first.last@domain.name ignored.
1245                 set -f
1246                 if _den_str2=$(name_fixup ${_den_tmp[5]})
1247                 then
1248                     IFS=${ADR_IFS}
1249                     _den_auth=( ${_den_str2} )
1250                     IFS=${WSP_IFS}
1251                     if [ ${#_den_auth[@]} -gt 2 ]
1252                     then
1253                         _den_cont=${_den_auth[1]}
1254                         for (( _auth = 2 ; _auth < ${#_den_auth[@]} ; _auth++ ))
1255                         do
1256                             _den_cont=${_den_cont}'.'${_den_auth[${_auth}]}
1257                         done
1258                         _den_name[${#_den_name[@]}]=${_den_cont}'.'
1259                         _den_achn[${#_den_achn[@]}]=${_den_who}' '${_den_cont}'. SOA.C'
1260                     fi
1261                 fi
1262                 set +f
1263             fi
1264             ;;
1265
1266 A) # IP (v4) Address Record
1267             if _den_str=$(name_fixup ${_den_tmp[0]})
1268             then
1269                 _den_name[${#_den_name[@]}]=${_den_str}
1270                 _den_pair[${#_den_pair[@]}]=${_den_tmp[4]}' '${_den_str}
1271                 _den_na[${#_den_na[@]}]=${_den_str}' '${_den_tmp[4]}
1272                 _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' A'
1273             else
1274                 _den_pair[${#_den_pair[@]}]=${_den_tmp[4]}' unknown.domain'
1275                 _den_na[${#_den_na[@]}]='unknown.domain '${_den_tmp[4]}
1276                 _den_ref[${#_den_ref[@]}]=${_den_who}' unknown.domain A'
1277

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```

1278     fi
1279     _den_address[${#_den_address[@]}]=${_den_tmp[4]}
1280     _den_pc[${#_den_pc[@]}]=${_den_who}' '${_den_tmp[4]}
1281     ;;
1282
1283     NS) # Name Server Record
1284     # Domain name being serviced (may be other than current)
1285     if _den_str=$(name_fixup ${_den_tmp[0]})
1286     then
1287         _den_name[${#_den_name[@]}]=${_den_str}
1288         _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' NS'
1289
1290     # Domain name of service provider
1291     if _den_str2=$(name_fixup ${_den_tmp[4]})
1292     then
1293         _den_name[${#_den_name[@]}]=${_den_str2}
1294         _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str2}' NSH'
1295         _den_ns[${#_den_ns[@]}]=${_den_str2}' NS'
1296         _den_pc[${#_den_pc[@]}]=${_den_str}' '${_den_str2}
1297     fi
1298     fi
1299     ;;
1300
1301     MX) # Mail Server Record
1302     # Domain name being serviced (wildcards not handled here)
1303     if _den_str=$(name_fixup ${_den_tmp[0]})
1304     then
1305         _den_name[${#_den_name[@]}]=${_den_str}
1306         _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' MX'
1307     fi
1308     # Domain name of service provider
1309     if _den_str=$(name_fixup ${_den_tmp[5]})
1310     then
1311         _den_name[${#_den_name[@]}]=${_den_str}
1312         _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' MXH'
1313         _den_ns[${#_den_ns[@]}]=${_den_str}' MX'
1314         _den_pc[${#_den_pc[@]}]=${_den_who}' '${_den_str}
1315     fi
1316     ;;
1317
1318     PTR) # Reverse address record
1319     # Special name
1320     if _den_str=$(name_fixup ${_den_tmp[0]})
1321     then
1322         _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' PTR'
1323         # Host name (not a CNAME)
1324         if _den_str2=$(name_fixup ${_den_tmp[4]})
1325         then
1326             _den_rev[${#_den_rev[@]}]=${_den_str}' '${_den_str2}
1327             _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str2}' PTRH'
1328             _den_pc[${#_den_pc[@]}]=${_den_who}' '${_den_str}
1329         fi
1330     fi
1331     ;;
1332
1333     AAAA) # IP(v6) Address Record
1334     if _den_str=$(name_fixup ${_den_tmp[0]})
1335     then
1336         _den_name[${#_den_name[@]}]=${_den_str}
1337         _den_pair[${#_den_pair[@]}]=${_den_tmp[4]}' '${_den_str}
1338         _den_na[${#_den_na[@]}]=${_den_str}' '${_den_tmp[4]}
1339         _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' AAAA'
1340     else
1341         _den_pair[${#_den_pair[@]}]=${_den_tmp[4]}' unknown.domain'
1342         _den_na[${#_den_na[@]}]='unknown.domain' '${_den_tmp[4]}
1343         _den_ref[${#_den_ref[@]}]=${_den_who}' unknown.domain'

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```

1344         fi
1345         # No processing for IPv6 addresses
1346         _den_pc[${#_den_pc[@]}]=${_den_who}' '${_den_tmp[4]}
1347         ;;
1348
1349         CNAME) # Alias name record
1350             # Nickname
1351             if _den_str=$(name_fixup ${_den_tmp[0]})
1352             then
1353                 _den_name[${#_den_name[@]}]=${_den_str}
1354                 _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' CNAME'
1355                 _den_pc[${#_den_pc[@]}]=${_den_who}' '${_den_str}
1356             fi
1357             # Hostname
1358             if _den_str=$(name_fixup ${_den_tmp[4]})
1359             then
1360                 _den_name[${#_den_name[@]}]=${_den_str}
1361                 _den_ref[${#_den_ref[@]}]=${_den_who}' '${_den_str}' CHOST'
1362                 _den_pc[${#_den_pc[@]}]=${_den_who}' '${_den_str}
1363             fi
1364             ;;
1365 #       TXT)
1366 #       ;;
1367         esac
1368     fi
1369 done
1370 else # Lookup error == 'A' record 'unknown address'
1371     _den_pair[${#_den_pair[@]}]='0.0.0.0' '${_den_who}
1372 fi
1373 done
1374
1375 # Control dot array growth.
1376 unique_lines _den_achn _den_achn      # Works best, all the same.
1377 edit_exact auth_chain _den_achn      # Works best, unique items.
1378 if [ ${#_den_achn[@]} -gt 0 ]
1379 then
1380     IFS=${NO_WSP}
1381     auth_chain=( ${auth_chain[@]} ${_den_achn[@]} )
1382     IFS=${WSP_IFS}
1383 fi
1384
1385 unique_lines _den_ref _den_ref        # Works best, all the same.
1386 edit_exact ref_chain _den_ref        # Works best, unique items.
1387 if [ ${#_den_ref[@]} -gt 0 ]
1388 then
1389     IFS=${NO_WSP}
1390     ref_chain=( ${ref_chain[@]} ${_den_ref[@]} )
1391     IFS=${WSP_IFS}
1392 fi
1393
1394 unique_lines _den_na _den_na
1395 edit_exact name_address _den_na
1396 if [ ${#_den_na[@]} -gt 0 ]
1397 then
1398     IFS=${NO_WSP}
1399     name_address=( ${name_address[@]} ${_den_na[@]} )
1400     IFS=${WSP_IFS}
1401 fi
1402
1403 unique_lines _den_ns _den_ns
1404 edit_exact name_srvc _den_ns
1405 if [ ${#_den_ns[@]} -gt 0 ]
1406 then
1407     IFS=${NO_WSP}
1408     name_srvc=( ${name_srvc[@]} ${_den_ns[@]} )
1409     IFS=${WSP_IFS}

```

```

1410     fi
1411
1412     unique_lines _den_nr _den_nr
1413     edit_exact name_resource _den_nr
1414     if [ ${#_den_nr[@]} -gt 0 ]
1415     then
1416         IFS=${NO_WSP}
1417         name_resource=( ${name_resource[@]} ${_den_nr[@]} )
1418         IFS=${WSP_IFS}
1419     fi
1420
1421     unique_lines _den_pc _den_pc
1422     edit_exact parent_child _den_pc
1423     if [ ${#_den_pc[@]} -gt 0 ]
1424     then
1425         IFS=${NO_WSP}
1426         parent_child=( ${parent_child[@]} ${_den_pc[@]} )
1427         IFS=${WSP_IFS}
1428     fi
1429
1430     # Update list known_pair (Address and Name).
1431     unique_lines _den_pair _den_pair
1432     edit_exact known_pair _den_pair
1433     if [ ${#_den_pair[@]} -gt 0 ] # Anything new?
1434     then
1435         IFS=${NO_WSP}
1436         known_pair=( ${known_pair[@]} ${_den_pair[@]} )
1437         IFS=${WSP_IFS}
1438     fi
1439
1440     # Update list of reverse pairs.
1441     unique_lines _den_rev _den_rev
1442     edit_exact reverse_pair _den_rev
1443     if [ ${#_den_rev[@]} -gt 0 ] # Anything new?
1444     then
1445         IFS=${NO_WSP}
1446         reverse_pair=( ${reverse_pair[@]} ${_den_rev[@]} )
1447         IFS=${WSP_IFS}
1448     fi
1449
1450     # Check indirection limit -- give up if reached.
1451     if ! _den_lmt=$(limit_chk ${1})
1452     then
1453         return 0
1454     fi
1455
1456     # Execution engine is LIFO. Order of pend operations is important.
1457     # Did we define any new addresses?
1458     unique_lines _den_address _den_address # Scrub duplicates.
1459     edit_exact known_address _den_address # Scrub already processed.
1460     edit_exact un_address _den_address # Scrub already waiting.
1461     if [ ${#_den_address[@]} -gt 0 ] # Anything new?
1462     then
1463         uc_address=( ${uc_address[@]} ${_den_address[@]} )
1464         pend_func expand_input_address ${_den_lmt}
1465         _trace_log[${#_trace_log[@]}]='# Add '${_den_address[@]}' unchkd addr. #'
1466     fi
1467
1468     # Did we find any new names?
1469     unique_lines _den_name _den_name # Scrub duplicates.
1470     edit_exact known_name _den_name # Scrub already processed.
1471     edit_exact uc_name _den_name # Scrub already waiting.
1472     if [ ${#_den_name[@]} -gt 0 ] # Anything new?
1473     then
1474         uc_name=( ${uc_name[@]} ${_den_name[@]} )
1475         pend_func expand_input_name ${_den_lmt}

```

```

1476  _trace_log[${#_trace_log[@]}]='#Added '${#_den_name[@]} ' unchkd name#'
1477      fi
1478      return 0
1479  }
1480
1481  # The parse-it-yourself delegation reply
1482  # Input is the chk_address list.
1483  # detail_each_address <indirection_limit>
1484  detail_each_address() {
1485      [ ${#chk_address[@]} -gt 0 ] || return 0
1486      unique_lines chk_address chk_address
1487      edit_exact known_address chk_address
1488      if [ ${#chk_address[@]} -gt 0 ]
1489      then
1490          known_address=( ${known_address[@]} ${chk_address[@]} )
1491          unset chk_address[@]
1492      fi
1493      return 0
1494  }
1495
1496  # # # Application specific output functions # # #
1497
1498  # Pretty print the known pairs.
1499  report_pairs() {
1500      echo
1501      echo 'Known network pairs.'
1502      col_print known_pair 2 5 30
1503
1504      if [ ${#auth_chain[@]} -gt 0 ]
1505      then
1506          echo
1507          echo 'Known chain of authority.'
1508          col_print auth_chain 2 5 30 55
1509      fi
1510
1511      if [ ${#reverse_pair[@]} -gt 0 ]
1512      then
1513          echo
1514          echo 'Known reverse pairs.'
1515          col_print reverse_pair 2 5 55
1516      fi
1517      return 0
1518  }
1519
1520  # Check an address against the list of blacklist servers.
1521  # A good place to capture for GraphViz: address->status(server(reports))
1522  # check_lists <ip_address>
1523  check_lists() {
1524      [ $# -eq 1 ] || return 1
1525      local -a _cl_fwd_addr
1526      local -a _cl_rev_addr
1527      local -a _cl_reply
1528      local -i _cl_rc
1529      local -i _ls_cnt
1530      local _cl_dns_addr
1531      local _cl_lkup
1532
1533      split_ip ${1} _cl_fwd_addr _cl_rev_addr
1534      _cl_dns_addr=$(dot_array _cl_rev_addr)'. '
1535      _ls_cnt=${#list_server[@]}
1536      echo '    Checking address '${1}
1537      for (( _cl = 0 ; _cl < _ls_cnt ; _cl++ ))
1538      do
1539          _cl_lkup=${_cl_dns_addr}${list_server[${_cl}]}
1540          if short_text ${_cl_lkup} _cl_reply
1541          then

```



```

1542     if [ ${#_cl_reply[@]} -gt 0 ]
1543     then
1544         echo '           Records from '${list_server[${_cl}]}
1545         address_hits[${#address_hits[@]}]=${1}' '${list_server[${_cl}]}
1546         _hs_RC=2
1547         for (( _clr = 0 ; _clr < ${#_cl_reply[@]} ; _clr++ ))
1548         do
1549             echo '           '${_cl_reply[${_clr}]}
1550         done
1551     fi
1552 fi
1553 done
1554 return 0
1555 }
1556
1557 # # # The usual application glue # # #
1558
1559 # Who did it?
1560 credits() {
1561     echo
1562     echo 'Advanced Bash Scripting Guide: is_spammer.bash, v2, 2004-msz'
1563 }
1564
1565 # How to use it?
1566 # (See also, "Quickstart" at end of script.)
1567 usage() {
1568     cat <<-'_usage_statement_'
1569     The script is_spammer.bash requires either one or two arguments.
1570
1571     arg 1) May be one of:
1572     a) A domain name
1573     b) An IPv4 address
1574     c) The name of a file with any mix of names
1575         and addresses, one per line.
1576
1577     arg 2) May be one of:
1578     a) A Blacklist server domain name
1579     b) The name of a file with Blacklist server
1580         domain names, one per line.
1581     c) If not present, a default list of (free)
1582         Blacklist servers is used.
1583     d) If a filename of an empty, readable, file
1584         is given,
1585         Blacklist server lookup is disabled.
1586
1587     All script output is written to stdout.
1588
1589     Return codes: 0 -> All OK, 1 -> Script failure,
1590                 2 -> Something is Blacklisted.
1591
1592     Requires the external program 'dig' from the 'bind-9'
1593     set of DNS programs. See: http://www.isc.org
1594
1595     The domain name lookup depth limit defaults to 2 levels.
1596     Set the environment variable SPAMMER_LIMIT to change.
1597     SPAMMER_LIMIT=0 means 'unlimited'
1598
1599     Limit may also be set on the command-line.
1600     If arg#1 is an integer, the limit is set to that value
1601     and then the above argument rules are applied.
1602
1603     Setting the environment variable 'SPAMMER_DATA' to a filename
1604     will cause the script to write a GraphViz graphic file.
1605
1606     For the development version;
1607     Setting the environment variable 'SPAMMER_TRACE' to a filename

```

```

1608     will cause the execution engine to log a function call trace.
1609
1610 _usage_statement_
1611 }
1612
1613 # The default list of Blacklist servers:
1614 # Many choices, see: http://www.spews.org/lists.html
1615
1616 declare -a default_servers
1617 # See: http://www.spamhaus.org (Conservative, well maintained)
1618 default_servers[0]='sbl-xbl.spamhaus.org'
1619 # See: http://ordb.org (Open mail relays)
1620 default_servers[1]='relays.ordb.org'
1621 # See: http://www.spamcop.net/ (You can report spammers here)
1622 default_servers[2]='bl.spamcop.net'
1623 # See: http://www.spews.org (An 'early detect' system)
1624 default_servers[3]='l2.spews.dnsbl.sorbs.net'
1625 # See: http://www.dnsbl.us.sorbs.net/using.shtml
1626 default_servers[4]='dnsbl.sorbs.net'
1627 # See: http://dsbl.org/usage (Various mail relay lists)
1628 default_servers[5]='list.dsbl.org'
1629 default_servers[6]='multihop.dsbl.org'
1630 default_servers[7]='unconfirmed.dsbl.org'
1631
1632 # User input argument #1
1633 setup_input() {
1634     if [ -e ${1} ] && [ -r ${1} ] # Name of readable file
1635     then
1636         file_to_array ${1} uc_name
1637         echo 'Using filename >${1}< as input.'
1638     else
1639         if is_address ${1} # IP address?
1640         then
1641             uc_address=( ${1} )
1642             echo 'Starting with address >${1}<'
1643         else # Must be a name.
1644             uc_name=( ${1} )
1645             echo 'Starting with domain name >${1}<'
1646         fi
1647     fi
1648     return 0
1649 }
1650
1651 # User input argument #2
1652 setup_servers() {
1653     if [ -e ${1} ] && [ -r ${1} ] # Name of a readable file
1654     then
1655         file_to_array ${1} list_server
1656         echo 'Using filename >${1}< as blacklist server list.'
1657     else
1658         list_server=( ${1} )
1659         echo 'Using blacklist server >${1}<'
1660     fi
1661     return 0
1662 }
1663
1664 # User environment variable SPAMMER_TRACE
1665 live_log_die() {
1666     if [ ${SPAMMER_TRACE:=} ] # Wants trace log?
1667     then
1668         if [ ! -e ${SPAMMER_TRACE} ]
1669         then
1670             if ! touch ${SPAMMER_TRACE} 2>/dev/null
1671             then
1672                 pend_func echo $(printf '%q\n' \
1673                 'Unable to create log file >${SPAMMER_TRACE}<')

```

```

1674         pend_release
1675         exit 1
1676     fi
1677     _log_file=${SPAMMER_TRACE}
1678     _pend_hook_=trace_logger
1679     _log_dump=dump_log
1680 else
1681     if [ ! -w ${SPAMMER_TRACE} ]
1682     then
1683         pend_func echo $(printf '%q\n' \
1684             'Unable to write log file >'${SPAMMER_TRACE}'<')
1685         pend_release
1686         exit 1
1687     fi
1688     _log_file=${SPAMMER_TRACE}
1689     echo '' > ${_log_file}
1690     _pend_hook_=trace_logger
1691     _log_dump=dump_log
1692 fi
1693 fi
1694 return 0
1695 }
1696
1697 # User environment variable SPAMMER_DATA
1698 data_capture() {
1699     if [ ${SPAMMER_DATA:=} ]      # Wants a data dump?
1700     then
1701         if [ ! -e ${SPAMMER_DATA} ]
1702         then
1703             if ! touch ${SPAMMER_DATA} 2>/dev/null
1704             then
1705                 pend_func echo $(printf '%q\n' \
1706                     'Unable to create data output file >'${SPAMMER_DATA}'<')
1707                 pend_release
1708                 exit 1
1709             fi
1710             _dot_file=${SPAMMER_DATA}
1711             _dot_dump=dump_dot
1712         else
1713             if [ ! -w ${SPAMMER_DATA} ]
1714             then
1715                 pend_func echo $(printf '%q\n' \
1716                     'Unable to write data output file >'${SPAMMER_DATA}'<')
1717                 pend_release
1718                 exit 1
1719             fi
1720             _dot_file=${SPAMMER_DATA}
1721             _dot_dump=dump_dot
1722         fi
1723     fi
1724     return 0
1725 }
1726
1727 # Grope user specified arguments.
1728 do_user_args() {
1729     if [ $# -gt 0 ] && is_number $1
1730     then
1731         indirect=$1
1732         shift
1733     fi
1734
1735     case $# in
1736         1)
1737             if ! setup_input $1      # Needs error checking.
1738             then
1739                 pend_release

```

```

1740         $_log_dump
1741         exit 1
1742     fi
1743     list_server=( ${default_servers[@]} )
1744     _list_cnt=${#list_server[@]}
1745     echo 'Using default blacklist server list.'
1746     echo 'Search depth limit: '${indirect}
1747     ;;
1748 2)
1749     if ! setup_input $1    # Needs error checking.
1750     then
1751         pend_release
1752         $_log_dump
1753         exit 1
1754     fi
1755     if ! setup_servers $2 # Needs error checking.
1756     then
1757         pend_release
1758         $_log_dump
1759         exit 1
1760     fi
1761     echo 'Search depth limit: '${indirect}
1762     ;;
1763 *)
1764     pend_func usage
1765     pend_release
1766     $_log_dump
1767     exit 1
1768     ;;
1769 esac
1770 return 0
1771 }
1772
1773 # A general purpose debug tool.
1774 # list_array <array_name>
1775 list_array() {
1776     [ $# -eq 1 ] || return 1 # One argument required.
1777
1778     local -a _la_lines
1779     set -f
1780     local IFS=${NO_WSP}
1781     eval _la_lines=(\ \ ${1[@]}\ \ \ )
1782     echo
1783     echo "Element count "${#_la_lines[@]}" array "${1}
1784     local _ln_cnt=${#_la_lines[@]}
1785
1786     for (( _i = 0; _i < ${_ln_cnt}; _i++ ))
1787     do
1788         echo 'Element '${_i} > '${_la_lines[_i]}'<'
1789     done
1790     set +f
1791     return 0
1792 }
1793
1794 # # # 'Hunt the Spammer' program code # # #
1795 pend_init # Ready stack engine.
1796 pend_func credits # Last thing to print.
1797
1798 # # # Deal with user # # #
1799 live_log_die # Setup debug trace log.
1800 data_capture # Setup data capture file.
1801 echo
1802 do_user_args $@
1803
1804 # # # Haven't exited yet - There is some hope # # #
1805 # Discovery group - Execution engine is LIFO - pend

```



```
1872 69.56.202.146 ns1.alojamentos.ws.
1873 69.56.202.146 alojamentos.ws.
1874 66.235.180.113 ns1.alojamentos.org.
1875 66.235.181.192 ns2.alojamentos.org.
1876 66.235.180.113 alojamentos.org.
1877 66.235.180.113 web6.alojamentos.org.
1878 216.234.234.30 ns1.theplanet.com.
1879 12.96.160.115 ns2.theplanet.com.
1880 216.185.111.52 mail1.theplanet.com.
1881 69.56.141.4 spooling.theplanet.com.
1882 216.185.111.40 theplanet.com.
1883 216.185.111.40 www.theplanet.com.
1884 216.185.111.52 mail.theplanet.com.
1885
1886 Checking Blacklist servers.
1887 Checking address 66.98.208.97
1888 Records from dnsbl.sorbs.net
1889 "Spam Received See: http://www.dnsbl.sorbs.net/lookup.shtml?66.98.208.97"
1890 Checking address 69.56.202.147
1891 Checking address 69.56.202.146
1892 Checking address 66.235.180.113
1893 Checking address 66.235.181.192
1894 Checking address 216.185.111.40
1895 Checking address 216.234.234.30
1896 Checking address 12.96.160.115
1897 Checking address 216.185.111.52
1898 Checking address 69.56.141.4
1899
1900 Advanced Bash Scripting Guide: is_spammer.bash, v2, 2004-msz
1901
1902 _is_spammer_outputs_
1903
1904 exit ${_hs_RC}
1905
1906 #####
1907 # The script ignores everything from here on down #
1908 #+ because of the 'exit' command, just above. #
1909 #####
1910
1911
1912
1913 Quickstart
1914 =====
1915
1916 Prerequisites
1917
1918 Bash version 2.05b or 3.00 (bash --version)
1919 A version of Bash which supports arrays. Array
1920 support is included by default Bash configurations.
1921
1922 'dig,' version 9.x.x (dig $HOSTNAME, see first line of output)
1923 A version of dig which supports the +short options.
1924 See: dig_wrappers.bash for details.
1925
1926
1927 Optional Prerequisites
1928
1929 'named,' a local DNS caching program. Any flavor will do.
1930 Do twice: dig $HOSTNAME
1931 Check near bottom of output for: SERVER: 127.0.0.1#53
1932 That means you have one running.
1933
1934
1935 Optional Graphics Support
1936
1937 'date,' a standard *nix thing. (date -R)
```

1938
1939 dot Program to convert graphic description file to a
1940 diagram. (dot -V)
1941 A part of the Graph-Viz set of programs.
1942 See: [<http://www.research.att.com/sw/tools/graphviz/> | GraphViz]
1943
1944 'dotty,' a visual editor for graphic description files.
1945 Also a part of the Graph-Viz set of programs.
1946
1947
1948
1949
1950 Quick Start
1951
1952 In the same directory as the is_spammer.bash script;
1953 Do: ./is_spammer.bash
1954
1955 Usage Details
1956
1957 1. Blacklist server choices.
1958
1959 (a) To use default, built-in list: Do nothing.
1960
1961 (b) To use your own list:
1962
1963 i. Create a file with a single Blacklist server
1964 domain name per line.
1965
1966 ii. Provide that filename as the last argument to
1967 the script.
1968
1969 (c) To use a single Blacklist server: Last argument
1970 to the script.
1971
1972 (d) To disable Blacklist lookups:
1973
1974 i. Create an empty file (touch spammer.nul)
1975 Your choice of filename.
1976
1977 ii. Provide the filename of that empty file as the
1978 last argument to the script.
1979
1980 2. Search depth limit.
1981
1982 (a) To use the default value of 2: Do nothing.
1983
1984 (b) To set a different limit:
1985 A limit of 0 means: no limit.
1986
1987 i. export SPAMMER_LIMIT=1
1988 or whatever limit you want.
1989
1990 ii. OR provide the desired limit as the first
1991 argument to the script.
1992
1993 3. Optional execution trace log.
1994
1995 (a) To use the default setting of no log output: Do nothing.
1996
1997 (b) To write an execution trace log:
1998 export SPAMMER_TRACE=spammer.log
1999 or whatever filename you want.
2000
2001 4. Optional graphic description file.
2002
2003 (a) To use the default setting of no graphic file: Do nothing.

2004
2005 (b) To write a Graph-Viz graphic description file:
2006 export SPAMMER_DATA=spammer.dot
2007 or whatever filename you want.
2008
2009 5. Where to start the search.
2010
2011 (a) Starting with a single domain name:
2012
2013 i. Without a command-line search limit: First
2014 argument to script.
2015
2016 ii. With a command-line search limit: Second
2017 argument to script.
2018
2019 (b) Starting with a single IP address:
2020
2021 i. Without a command-line search limit: First
2022 argument to script.
2023
2024 ii. With a command-line search limit: Second
2025 argument to script.
2026
2027 (c) Starting with (mixed) multiple name(s) and/or address(es):
2028 Create a file with one name or address per line.
2029 Your choice of filename.
2030
2031 i. Without a command-line search limit: Filename as
2032 first argument to script.
2033
2034 ii. With a command-line search limit: Filename as
2035 second argument to script.
2036
2037 6. What to do with the display output.
2038
2039 (a) To view display output on screen: Do nothing.
2040
2041 (b) To save display output to a file: Redirect stdout to a filename.
2042
2043 (c) To discard display output: Redirect stdout to /dev/null.
2044
2045 7. Temporary end of decision making.
2046 press RETURN
2047 wait (optionally, watch the dots and colons).
2048
2049 8. Optionally check the return code.
2050
2051 (a) Return code 0: All OK
2052
2053 (b) Return code 1: Script setup failure
2054
2055 (c) Return code 2: Something was blacklisted.
2056
2057 9. Where is my graph (diagram)?
2058
2059 The script does not directly produce a graph (diagram).
2060 It only produces a graphic description file. You can
2061 process the graphic descriptor file that was output
2062 with the 'dot' program.
2063
2064 Until you edit that descriptor file, to describe the
2065 relationships you want shown, all that you will get is
2066 a bunch of labeled name and address nodes.
2067
2068 All of the script's discovered relationships are within
2069 a comment block in the graphic descriptor file, each


```
2070 with a descriptive heading.
2071
2072 The editing required to draw a line between a pair of
2073 nodes from the information in the descriptor file may
2074 be done with a text editor.
2075
2076 Given these lines somewhere in the descriptor file:
2077
2078 # Known domain name nodes
2079
2080 N0000 [label="guardproof.info." ] ;
2081
2082 N0002 [label="third.guardproof.info." ] ;
2083
2084
2085
2086 # Known address nodes
2087
2088 A0000 [label="61.141.32.197" ] ;
2089
2090
2091
2092 /*
2093
2094 # Known name->address edges
2095
2096 NA0000 third.guardproof.info. 61.141.32.197
2097
2098
2099
2100 # Known parent->child edges
2101
2102 PC0000 guardproof.info. third.guardproof.info.
2103
2104 */
2105
2106 Turn that into the following lines by substituting node
2107 identifiers into the relationships:
2108
2109 # Known domain name nodes
2110
2111 N0000 [label="guardproof.info." ] ;
2112
2113 N0002 [label="third.guardproof.info." ] ;
2114
2115
2116
2117 # Known address nodes
2118
2119 A0000 [label="61.141.32.197" ] ;
2120
2121
2122
2123 # PC0000 guardproof.info. third.guardproof.info.
2124
2125 N0000->N0002 ;
2126
2127
2128
2129 # NA0000 third.guardproof.info. 61.141.32.197
2130
2131 N0002->A0000 ;
2132
2133
2134
2135 /*
```



```

19 OUTFILE=whois.txt # Output file.
20 PORT=4321
21
22
23 if [ -z "$1" ] # Check for (required) command-line arg.
24 then
25     echo "Usage: $0 domain name or IP address"
26     exit $_BADARGS
27 fi
28
29
30 if [[ "$1" =~ [a-zA-Z][a-zA-Z]$ ]] # Ends in two alpha chars?
31 then # It's a domain name &&
32     #+ must do host lookup.
33     IPADDR=$(host -W $HOSTWAIT $1 | awk '{print $4}')
34     # Doing host lookup
35     #+ to get IP address.
36     # Extract final field.
37 else
38     IPADDR="$1" # Command-line arg was IP address.
39 fi
40
41 echo; echo "IP Address is: "$IPADDR"; echo
42
43 if [ -e "$OUTFILE" ]
44 then
45     rm -f "$OUTFILE"
46     echo "Stale output file \"$OUTFILE\" removed."; echo
47 fi
48
49
50 # Sanity checks.
51 # (This section needs more work.)
52 # =====
53 if [ -z "$IPADDR" ]
54 # No response.
55 then
56     echo "Host not found!"
57     exit $_NOHOST # Bail out.
58 fi
59
60 if [[ "$IPADDR" =~ ^[;] ]]
61 # ;; Connection timed out; no servers could be reached.
62 then
63     echo "Host lookup timed out!"
64     exit $_TIMEOUT # Bail out.
65 fi
66
67 if [[ "$IPADDR" =~ [(NXDOMAIN)]$ ]]
68 # Host xxxxxxxxxx.xxx not found: 3(NXDOMAIN)
69 then
70     echo "Host not found!"
71     exit $_NOHOST # Bail out.
72 fi
73
74 if [[ "$IPADDR" =~ [(SERVFAIL)]$ ]]
75 # Host xxxxxxxxxx.xxx not found: 2(SERVFAIL)
76 then
77     echo "Host not found!"
78     exit $_NOHOST # Bail out.
79 fi
80
81
82
83
84 # ===== Main body of script =====

```

```

85
86 AFRINICquery() {
87 # Define the function that queries AFRINIC. Echo a notification to the
88 #+ screen, and then run the actual query, redirecting output to $OUTFILE.
89
90 echo "Searching for $IPADDR in whois.afrinic.net"
91 whois -h whois.afrinic.net "$IPADDR" > $OUTFILE
92
93 # Check for presence of reference to an rwhois.
94 # Warn about non-functional rwhois.infosat.net server
95 #+ and attempt rwhois query.
96 if grep -e "^remarks: .*rwhois\[^\ ]\+" "$OUTFILE"
97 then
98 echo " " >> $OUTFILE
99 echo "****" >> $OUTFILE
100 echo "****" >> $OUTFILE
101 echo "Warning: rwhois.infosat.net was not working \
102 as of 2005/02/02" >> $OUTFILE
103 echo " when this script was written." >> $OUTFILE
104 echo "****" >> $OUTFILE
105 echo "****" >> $OUTFILE
106 echo " " >> $OUTFILE
107 RWHOIS=`grep "^remarks: .*rwhois\[^\ ]\+" "$OUTFILE" | tail -n 1 | \
108 sed "s/\(^.*\)\(rwhois\..*\)\(:4.*\)/\2/"`
109 whois -h ${RWHOIS}:${PORT} "$IPADDR" >> $OUTFILE
110 fi
111 }
112
113 APNICquery() {
114 echo "Searching for $IPADDR in whois.apnic.net"
115 whois -h whois.apnic.net "$IPADDR" > $OUTFILE
116
117 # Just about every country has its own internet registrar.
118 # I don't normally bother consulting them, because the regional registry
119 #+ usually supplies sufficient information.
120 # There are a few exceptions, where the regional registry simply
121 #+ refers to the national registry for direct data.
122 # These are Japan and South Korea in APNIC, and Brasil in LACNIC.
123 # The following if statement checks $OUTFILE (whois.txt) for the presence
124 #+ of "KR" (South Korea) or "JP" (Japan) in the country field.
125 # If either is found, the query is re-run against the appropriate
126 #+ national registry.
127
128 if grep -E "^country:[ ]+KR$" "$OUTFILE"
129 then
130 echo "Searching for $IPADDR in whois.krnic.net"
131 whois -h whois.krnic.net "$IPADDR" >> $OUTFILE
132 elif grep -E "^country:[ ]+JP$" "$OUTFILE"
133 then
134 echo "Searching for $IPADDR in whois.nic.ad.jp"
135 whois -h whois.nic.ad.jp "$IPADDR"/e >> $OUTFILE
136 fi
137 }
138
139 ARINquery() {
140 echo "Searching for $IPADDR in whois.arin.net"
141 whois -h whois.arin.net "$IPADDR" > $OUTFILE
142
143 # Several large internet providers listed by ARIN have their own
144 #+ internal whois service, referred to as "rwhois".
145 # A large block of IP addresses is listed with the provider
146 #+ under the ARIN registry.
147 # To get the IP addresses of 2nd-level ISPs or other large customers,
148 #+ one has to refer to the rwhois server on port 4321.
149 # I originally started with a bunch of "if" statements checking for
150 #+ the larger providers.

```

```

151 # This approach is unwieldy, and there's always another rwhois server
152 #+ that I didn't know about.
153 # A more elegant approach is to check $OUTFILE for a reference
154 #+ to a whois server, parse that server name out of the comment section,
155 #+ and re-run the query against the appropriate rwhois server.
156 # The parsing looks a bit ugly, with a long continued line inside
157 #+ backticks.
158 # But it only has to be done once, and will work as new servers are added.
159 #@ ABS Guide author comment: it isn't all that ugly, and is, in fact,
160 #@+ an instructive use of Regular Expressions.
161
162 if grep -E "^Comment: .*rwhois.[^ ]+" "$OUTFILE"
163 then
164     RWHOIS=`grep -e "^Comment:.*rwhois\[^\ ]\+" "$OUTFILE" | tail -n 1 |\
165     sed "s/^\(.*\) \(rwhois\[^\ ]\+\) \(.*\)/\2/"`
166     echo "Searching for $IPADDR in ${RWHOIS}"
167     whois -h ${RWHOIS}:${PORT} "$IPADDR" >> $OUTFILE
168 fi
169 }
170
171 LACNICquery() {
172     echo "Searching for $IPADDR in whois.lacnic.net"
173     whois -h whois.lacnic.net "$IPADDR" > $OUTFILE
174
175 # The following if statement checks $OUTFILE (whois.txt) for
176 #+ the presence of "BR" (Brasil) in the country field.
177 # If it is found, the query is re-run against whois.registro.br.
178
179 if grep -E "^country:[ ]+BR$" "$OUTFILE"
180 then
181     echo "Searching for $IPADDR in whois.registro.br"
182     whois -h whois.registro.br "$IPADDR" >> $OUTFILE
183 fi
184 }
185
186 RIPEquery() {
187     echo "Searching for $IPADDR in whois.ripe.net"
188     whois -h whois.ripe.net "$IPADDR" > $OUTFILE
189 }
190
191 # Initialize a few variables.
192 # * slash8 is the most significant octet
193 # * slash16 consists of the two most significant octets
194 # * octet2 is the second most significant octet
195
196
197
198
199 slash8=`echo $IPADDR | cut -d. -f 1`
200 if [ -z "$slash8" ] # Yet another sanity check.
201 then
202     echo "Undefined error!"
203     exit $_UNDEF
204 fi
205 slash16=`echo $IPADDR | cut -d. -f 1-2`
206 # ^ Period specified as 'cut' delimiter.
207 if [ -z "$slash16" ]
208 then
209     echo "Undefined error!"
210     exit $_UNDEF
211 fi
212 octet2=`echo $slash16 | cut -d. -f 2`
213 if [ -z "$octet2" ]
214 then
215     echo "Undefined error!"
216     exit $_UNDEF

```

```
217 fi
218
219
220 # Check for various odds and ends of reserved space.
221 # There is no point in querying for those addresses.
222
223 if [ $slash8 == 0 ]; then
224     echo $IPADDR is "This Network" space\; Not querying
225 elif [ $slash8 == 10 ]; then
226     echo $IPADDR is RFC1918 space\; Not querying
227 elif [ $slash8 == 14 ]; then
228     echo $IPADDR is "Public Data Network" space\; Not querying
229 elif [ $slash8 == 127 ]; then
230     echo $IPADDR is loopback space\; Not querying
231 elif [ $slash16 == 169.254 ]; then
232     echo $IPADDR is link-local space\; Not querying
233 elif [ $slash8 == 172 ] && [ $octet2 -ge 16 ] && [ $octet2 -le 31 ];then
234     echo $IPADDR is RFC1918 space\; Not querying
235 elif [ $slash16 == 192.168 ]; then
236     echo $IPADDR is RFC1918 space\; Not querying
237 elif [ $slash8 -ge 224 ]; then
238     echo $IPADDR is either Multicast or reserved space\; Not querying
239 elif [ $slash8 -ge 200 ] && [ $slash8 -le 201 ]; then LACNICquery "$IPADDR"
240 elif [ $slash8 -ge 202 ] && [ $slash8 -le 203 ]; then APNICquery "$IPADDR"
241 elif [ $slash8 -ge 210 ] && [ $slash8 -le 211 ]; then APNICquery "$IPADDR"
242 elif [ $slash8 -ge 218 ] && [ $slash8 -le 223 ]; then APNICquery "$IPADDR"
243
244 # If we got this far without making a decision, query ARIN.
245 # If a reference is found in $OUTFILE to APNIC, AFRINIC, LACNIC, or RIPE,
246 #+ query the appropriate whois server.
247
248 else
249     ARINquery "$IPADDR"
250     if grep "whois.afrinic.net" "$OUTFILE"; then
251         AFRINICquery "$IPADDR"
252     elif grep -E "^OrgID:[ ]+RIPE$" "$OUTFILE"; then
253         RIPEquery "$IPADDR"
254     elif grep -E "^OrgID:[ ]+APNIC$" "$OUTFILE"; then
255         APNICquery "$IPADDR"
256     elif grep -E "^OrgID:[ ]+LACNIC$" "$OUTFILE"; then
257         LACNICquery "$IPADDR"
258     fi
259 fi
260
261 #@ -----
262 # Try also:
263 # wget http://logi.cc/nw/whois.php3?ACTION=doQuery&DOMAIN=$IPADDR
264 #@ -----
265
266 # We've now finished the querying.
267 # Echo a copy of the final result to the screen.
268
269 cat $OUTFILE
270 # Or "less $OUTFILE" . . .
271
272
273 exit 0
274
275 #@ ABS Guide author comments:
276 #@ Nothing fancy here, but still a very useful tool for hunting spammers.
277 #@ Sure, the script can be cleaned up some, and it's still a bit buggy,
278 #@+ (exercise for reader), but all the same, it's a nice piece of coding
279 #@+ by Walter Dnes.
280 #@ Thank you!
```

Example A-30. Making *wget* easier to use

```
1 #!/bin/bash
2 # wgetter2.bash
3
4 # Author: Little Monster [monster@monstruum.co.uk]
5 # ==> Used in ABS Guide with permission of script author.
6 # ==> This script still needs debugging and fixups (exercise for reader).
7 # ==> It could also use some additional editing in the comments.
8
9
10 # This is wgetter2 --
11 #+ a Bash script to make wget a bit more friendly, and save typing.
12
13 # Carefully crafted by Little Monster.
14 # More or less complete on 02/02/2005.
15 # If you think this script can be improved,
16 #+ email me at: monster@monstruum.co.uk
17 # ==> and cc: to the author of the ABS Guide, please.
18 # This script is licenced under the GPL.
19 # You are free to copy, alter and re-use it,
20 #+ but please don't try to claim you wrote it.
21 # Log your changes here instead.
22
23 # =====
24 # changelog:
25
26 # 07/02/2005. Fixups by Little Monster.
27 # 02/02/2005. Minor additions by Little Monster.
28 # (See after # ++++++ )
29 # 29/01/2005. Minor stylistic edits and cleanups by author of ABS Guide.
30 # Added exit error codes.
31 # 22/11/2004. Finished initial version of second version of wgetter:
32 # wgetter2 is born.
33 # 01/12/2004. Changed 'runn' function so it can be run 2 ways --
34 # either ask for a file name or have one input on the CL.
35 # 01/12/2004. Made sensible handling of no URL's given.
36 # 01/12/2004. Made loop of main options, so you don't
37 # have to keep calling wgetter 2 all the time.
38 # Runs as a session instead.
39 # 01/12/2004. Added looping to 'runn' function.
40 # Simplified and improved.
41 # 01/12/2004. Added state to recursion setting.
42 # Enables re-use of previous value.
43 # 05/12/2004. Modified the file detection routine in the 'runn' function
44 # so it's not fooled by empty values, and is cleaner.
45 # 01/02/2004. Added cookie finding routine from later version (which
46 # isn't ready yet), so as not to have hard-coded paths.
47 # =====
48
49 # Error codes for abnormal exit.
50 E_USAGE=67 # Usage message, then quit.
51 E_NO_OPTS=68 # No command-line args entered.
52 E_NO_URLS=69 # No URLs passed to script.
53 E_NO_SAVEFILE=70 # No save filename passed to script.
54 E_USER_EXIT=71 # User decides to quit.
55
56
57 # Basic default wget command we want to use.
58 # This is the place to change it, if required.
59 # NB: if using a proxy, set http_proxy = yourproxy in .wgetrc.
60 # Otherwise delete --proxy=on, below.
```

```

61 # =====
62 CommandA="wget -nc -c -t 5 --progress=bar --random-wait --proxy=on -r"
63 # =====
64
65
66
67 # -----
68 # Set some other variables and explain them.
69
70 pattern=" -A .jpg,.JPG,.jpeg,.JPEG,.gif,.GIF,.htm,.html,.shtml,.php"
71             # wget's option to only get certain types of file.
72             # comment out if not using
73 today=`date +%F` # Used for a filename.
74 home=$HOME      # Set HOME to an internal variable.
75             # In case some other path is used, change it here.
76 depthDefault=3 # Set a sensible default recursion.
77 Depth=$depthDefault # Otherwise user feedback doesn't tie in properly.
78 RefA=""        # Set blank referring page.
79 Flag=""        # Default to not saving anything,
80             #+ or whatever else might be wanted in future.
81 lister=""      # Used for passing a list of urls directly to wget.
82 Woptions=""    # Used for passing wget some options for itself.
83 inFile=""     # Used for the run function.
84 newFile=""    # Used for the run function.
85 savePath="$home/w-save"
86 Config="$home/.wgetter2rc"
87             # This is where some variables can be stored,
88             #+ if permanently changed from within the script.
89 Cookie_List="$home/.cookielist"
90             # So we know where the cookies are kept . . .
91 cFlag=""      # Part of the cookie file selection routine.
92
93 # Define the options available. Easy to change letters here if needed.
94 # These are the optional options; you don't just wait to be asked.
95
96 save=s # Save command instead of executing it.
97 cook=c # Change cookie file for this session.
98 help=h # Usage guide.
99 list=l # Pass wget the -i option and URL list.
100 runn=r # Run saved commands as an argument to the option.
101 inpu=i # Run saved commands interactively.
102 wopt=w # Allow to enter options to pass directly to wget.
103 # -----
104
105
106 if [ -z "$1" ]; then # Make sure we get something for wget to eat.
107     echo "You must at least enter a URL or option!"
108     echo "-$help for usage."
109     exit $E_NO_OPTS
110 fi
111
112
113
114 # ++++++
115 # added added added added added added added added added added added
116
117 if [ ! -e "$Config" ]; then # See if configuration file exists.
118     echo "Creating configuration file, $Config"
119     echo "# This is the configuration file for wgetter2" > "$Config"
120     echo "# Your customised settings will be saved in this file" >> "$Config"
121 else
122     source $Config # Import variables we set outside the script.
123 fi
124
125 if [ ! -e "$Cookie_List" ]; then
126     # Set up a list of cookie files, if there isn't one.

```



```

127 echo "Hunting for cookies . . ."
128 find -name cookies.txt >> $Cookie_List # Create the list of cookie files.
129 fi # Isolate this in its own 'if' statement,
130     #+ in case we got interrupted while searching.
131
132 if [ -z "$cFlag" ]; then # If we haven't already done this . . .
133     echo                # Make a nice space after the command prompt.
134     echo "Looks like you haven't set up your source of cookies yet."
135     n=0                # Make sure the counter
136                       #+ doesn't contain random values.
137     while read; do
138         Cookies[$n]=$REPLY # Put the cookie files we found into an array.
139         echo "$n) ${Cookies[$n]}" # Create a menu.
140         n=$(( n + 1 )) # Increment the counter.
141     done < $Cookie_List # Feed the read statement.
142     echo "Enter the number of the cookie file you want to use."
143     echo "If you won't be using cookies, just press RETURN."
144     echo
145     echo "I won't be asking this again. Edit $Config"
146     echo "If you decide to change at a later date"
147     echo "or use the -${cook} option for per session changes."
148     read
149     if [ ! -z $REPLY ]; then # User didn't just press return.
150         Cookie="--load-cookies ${Cookies[$REPLY]}"
151         # Set the variable here as well as in the config file.
152
153         echo "Cookie=\" --load-cookies ${Cookies[$REPLY]}\" >> $Config
154     fi
155     echo "cFlag=1" >> $Config # So we know not to ask again.
156 fi
157
158 # end added section end added section end added section end added section
159 # ++++++
160
161
162
163 # Another variable.
164 # This one may or may not be subject to variation.
165 # A bit like the small print.
166 CookiesON=$Cookie
167 # echo "cookie file is $CookiesON" # For debugging.
168 # echo "home is ${home}" # For debugging.
169 # Got caught with this one!
170
171
172 wopts()
173 {
174     echo "Enter options to pass to wget."
175     echo "It is assumed you know what you're doing."
176     echo
177     echo "You can pass their arguments here too."
178     # That is to say, everything passed here is passed to wget.
179
180     read Wopts
181     # Read in the options to be passed to wget.
182
183     Woptions=" $Wopts"
184     # ^ Why the leading space?
185     # Assign to another variable.
186     # Just for fun, or something . . .
187
188     echo "passing options ${Wopts} to wget"
189     # Mainly for debugging.
190     # Is cute.
191
192     return

```

```

193 }
194
195
196 save_func()
197 {
198 echo "Settings will be saved."
199 if [ ! -d $savePath ]; then # See if directory exists.
200     mkdir $savePath # Create the directory to save things in
201                     #+ if it isn't already there.
202 fi
203
204 Flag=S
205 # Tell the final bit of code what to do.
206 # Set a flag since stuff is done in main.
207
208 return
209 }
210
211
212 usage() # Tell them how it works.
213 {
214     echo "Welcome to wgetter. This is a front end to wget."
215     echo "It will always run wget with these options:"
216     echo "$CommandA"
217     echo "and the pattern to match: $pattern \
218 (which you can change at the top of this script).\"
219     echo "It will also ask you for recursion depth, \
220 and if you want to use a referring page.\"
221     echo "Wgetter accepts the following options:"
222     echo ""
223     echo "-$help : Display this help."
224     echo "-$save : Save the command to a file $savePath/wget-($today) \
225 instead of running it.\"
226     echo "-$runn : Run saved wget commands instead of starting a new one -\"
227     echo "Enter filename as argument to this option.\"
228     echo "-$inpu : Run saved wget commands interactively --\"
229     echo "The script will ask you for the filename.\"
230     echo "-$cook : Change the cookies file for this session.\"
231     echo "-$list : Tell wget to use URL's from a list instead of \
232 from the command-line.\"
233     echo "-$wopt : Pass any other options direct to wget.\"
234     echo ""
235     echo "See the wget man page for additional options \
236 you can pass to wget.\"
237     echo ""
238
239     exit $E_USAGE # End here. Don't process anything else.
240 }
241
242
243
244 list_func() # Gives the user the option to use the -i option to wget,
245             #+ and a list of URLs.
246 {
247 while [ 1 ]; do
248     echo "Enter the name of the file containing URL's (press q to change
249 your mind).\"
250     read urlfile
251     if [ ! -e \"$urlfile\" ] && [ \"$urlfile\" != q ]; then
252         # Look for a file, or the quit option.
253         echo "That file does not exist!\"
254     elif [ \"$urlfile\" = q ]; then # Check quit option.
255         echo "Not using a url list.\"
256         return
257     else
258         echo "using $urlfile.\"

```

```

259     echo "If you gave url's on the command-line, I'll use those first."
260         # Report wget standard behaviour to the user.
261     lister="-i $urlfile" # This is what we want to pass to wget.
262     return
263 fi
264 done
265 }
266
267
268 cookie_func() # Give the user the option to use a different cookie file.
269 {
270 while [ 1 ]; do
271     echo "Change the cookies file. Press return if you don't want to change
272 it."
273     read Cookies
274     # NB: this is not the same as Cookie, earlier.
275     # There is an 's' on the end.
276     # Bit like chocolate chips.
277     if [ -z "$Cookies" ]; then          # Escape clause for wusses.
278         return
279     elif [ ! -e "$Cookies" ]; then
280         echo "File does not exist. Try again." # Keep em going . . .
281     else
282         CookiesON="--load-cookies $Cookies" # File is good -- use it!
283         return
284     fi
285 done
286 }
287
288
289
290 run_func()
291 {
292 if [ -z "$OPTARG" ]; then
293 # Test to see if we used the in-line option or the query one.
294     if [ ! -d "$savePath" ]; then      # If directory doesn't exist . . .
295         echo "$savePath does not appear to exist."
296         echo "Please supply path and filename of saved wget commands:"
297         read newFile
298         until [ -f "$newFile" ]; do # Keep going till we get something.
299             echo "Sorry, that file does not exist. Please try again."
300             # Try really hard to get something.
301             read newFile
302         done
303
304
305 # -----
306 #     if [ -z ( grep wget ${newfile} ) ]; then
307 #         # Assume they haven't got the right file and bail out.
308 #         echo "Sorry, that file does not contain wget commands. Aborting."
309 #         exit
310 #     fi
311 #
312 # This is bogus code.
313 # It doesn't actually work.
314 # If anyone wants to fix it, feel free!
315 # -----
316
317
318     filePath="$${newFile}"
319 else
320 echo "Save path is $savePath"
321     echo "Please enter name of the file which you want to use."
322     echo "You have a choice of:"
323     ls $savePath          # Give them a choice.
324     read inFile

```

```

325     until [ -f "$savePath/$inFile" ]; do           # Keep going till
326                                                     #+ we get something.
327         if [ ! -f "${savePath}/${inFile}" ]; then # If file doesn't exist.
328             echo "Sorry, that file does not exist. Please choose from:"
329             ls $savePath                            # If a mistake is made.
330             read inFile
331         fi
332     done
333     filePath="${savePath}/${inFile}" # Make one variable . . .
334 fi
335 else filePath="${savePath}/${OPTARG}" # Which can be many things . . .
336 fi
337
338 if [ ! -f "$filePath" ]; then                    # If a bogus file got through.
339     echo "You did not specify a suitable file."
340     echo "Run this script with the -${save} option first."
341     echo "Aborting."
342     exit $E_NO_SAVEFILE
343 fi
344 echo "Using: $filePath"
345 while read; do
346     eval $REPLY
347     echo "Completed: $REPLY"
348 done < $filePath # Feed the actual file we are using into a 'while' loop.
349
350 exit
351 }
352
353
354
355 # Fish out any options we are using for the script.
356 # This is based on the demo in "Learning The Bash Shell" (O'Reilly).
357 while getopts ":$save$cook$help$list$runn:$inpu$wopt" opt
358 do
359     case $opt in
360         $save) save_func;; # Save some wgetter sessions for later.
361         $cook) cookie_func;; # Change cookie file.
362         $help) usage;; # Get help.
363         $list) list_func;; # Allow wget to use a list of URLs.
364         $runn) run_func;; # Useful if you are calling wgetter from,
365                             #+ for example, a cron script.
366         $inpu) run_func;; # When you don't know what your files are named.
367         $wopt) wopts;; # Pass options directly to wget.
368         \?) echo "Not a valid option."
369             echo "Use -${wopt} to pass options directly to wget,"
370             echo "or -${help} for help";; # Catch anything else.
371     esac
372 done
373 shift $((OPTIND - 1)) # Do funky magic stuff with $#.
374
375
376 if [ -z "$1" ] && [ -z "$lister" ]; then
377     # We should be left with at least one URL
378     #+ on the command-line, unless a list is
379     #+ being used -- catch empty CL's.
380     echo "No URL's given! You must enter them on the same line as wgetter2."
381     echo "E.g., wgetter2 http://somesite http://anothersite."
382     echo "Use $help option for more information."
383     exit $E_NO_URLS # Bail out, with appropriate error code.
384 fi
385
386 URLs=" $@"
387 # Use this so that URL list can be changed if we stay in the option loop.
388
389 while [ 1 ]; do
390     # This is where we ask for the most used options.

```

```

391 # (Mostly unchanged from version 1 of wgetter)
392 if [ -z $curDepth ]; then
393     Current=""
394 else Current=" Current value is $curDepth"
395 fi
396     echo "How deep should I go? \
397 (integer: Default is $depthDefault.$Current)"
398     read Depth # Recursion -- how far should we go?
399     inputB="" # Reset this to blank on each pass of the loop.
400     echo "Enter the name of the referring page (default is none).\"
401     read inputB # Need this for some sites.
402
403     echo "Do you want to have the output logged to the terminal"
404     echo "(y/n, default is yes)?"
405     read noHide # Otherwise wget will just log it to a file.
406
407     case $noHide in # Now you see me, now you don't.
408         y|Y ) hide="";;
409         n|N ) hide=" -b";;
410         * ) hide="";;
411     esac
412
413     if [ -z ${Depth} ]; then
414         # User accepted either default or current depth,
415         #+ in which case Depth is now empty.
416         if [ -z ${curDepth} ]; then
417             # See if a depth was set on a previous iteration.
418             Depth="$depthDefault"
419             # Set the default recursion depth if nothing
420             #+ else to use.
421         else Depth="$curDepth" # Otherwise, set the one we used before.
422         fi
423     fi
424     Recurse=" -l $Depth" # Set how deep we want to go.
425     curDepth=$Depth # Remember setting for next time.
426
427     if [ ! -z $inputB ]; then
428         RefA=" --referer=$inputB" # Option to use referring page.
429     fi
430
431     WGETTER="${CommandA}${pattern}${hide}${RefA}${Recurse}\
432 ${CookiesON}${lister}${Woptions}${URLS}"
433     # Just string the whole lot together . . .
434     # NB: no embedded spaces.
435     # They are in the individual elements so that if any are empty,
436     #+ we don't get an extra space.
437
438     if [ -z "${CookiesON}" ] && [ "$cFlag" = "1" ]; then
439         echo "Warning -- can't find cookie file"
440         # This should be changed,
441         #+ in case the user has opted to not use cookies.
442     fi
443
444     if [ "$Flag" = "S" ]; then
445         echo "$WGETTER" >> $savePath/wget-$(today)
446         # Create a unique filename for today, or append to it if it exists.
447         echo "$inputB" >> $savePath/site-list-$(today)
448         # Make a list, so it's easy to refer back to,
449         #+ since the whole command is a bit confusing to look at.
450         echo "Command saved to the file $savePath/wget-$(today)"
451         # Tell the user.
452         echo "Referring page URL saved to the file$ \
453 savePath/site-list-$(today)"
454         # Tell the user.
455         Saver=" with save option"
456         # Stick this somewhere, so it appears in the loop if set.

```

```

457 else
458     echo "*****"
459     echo "*****Getting*****"
460     echo "*****"
461     echo ""
462     echo "$WGETTER"
463     echo ""
464     echo "*****"
465     eval "$WGETTER"
466 fi
467
468     echo ""
469     echo "Starting over$$Saver."
470     echo "If you want to stop, press q."
471     echo "Otherwise, enter some URL's:"
472     # Let them go again. Tell about save option being set.
473
474     read
475     case $REPLY in
476     # Need to change this to a 'trap' clause.
477     q|Q ) exit $_E_USER_EXIT;; # Exercise for the reader?
478     * ) URLs=" $REPLY";;
479     esac
480
481     echo ""
482 done
483
484
485 exit 0

```

Example A-31. A *podcasting* script

```

1 #!/bin/bash
2
3 # bashpodder.sh:
4 # By Linc 10/1/2004
5 # Find the latest script at
6 #+ http://linc.homeunix.org:8080/scripts/bashpodder
7 # Last revision 12/14/2004 - Many Contributors!
8 # If you use this and have made improvements or have comments
9 #+ drop me an email at linc dot fessenden at gmail dot com
10 # I'd appreciate it!
11
12 # ==> ABS Guide extra comments.
13
14 # ==> Author of this script has kindly granted permission
15 # ==>+ for inclusion in ABS Guide.
16
17
18 # ==> #####
19 #
20 # ==> What is "podcasting"?
21
22 # ==> It's broadcasting "radio shows" over the Internet.
23 # ==> These shows can be played on iPods and other music file players.
24
25 # ==> This script makes it possible.
26 # ==> See documentation at the script author's site, above.
27
28 # ==> #####
29
30

```

```

31 # Make script crontab friendly:
32 cd $(dirname $0)
33 # ==> Change to directory where this script lives.
34
35 # datadir is the directory you want podcasts saved to:
36 datadir=$(date +%Y-%m-%d)
37 # ==> Will create a date-labeled directory, named: YYYY-MM-DD
38
39 # Check for and create datadir if necessary:
40 if test ! -d $datadir
41     then
42         mkdir $datadir
43 fi
44
45 # Delete any temp file:
46 rm -f temp.log
47
48 # Read the bp.conf file and wget any url not already
49 #+ in the podcast.log file:
50 while read podcast
51 do # ==> Main action follows.
52     file=$(wget -q $podcast -O - | tr '\r' '\n' | tr '\ ' '\ ' | \
53 sed -n 's/.*url="\([^"]*\)".*/\1/p')
54     for url in $file
55     do
56         echo $url >> temp.log
57         if ! grep "$url" podcast.log > /dev/null
58             then
59                 wget -q -P $datadir "$url"
60             fi
61         done
62     done < bp.conf
63
64 # Move dynamically created log file to permanent log file:
65 cat podcast.log >> temp.log
66 sort temp.log | uniq > podcast.log
67 rm temp.log
68 # Create an m3u playlist:
69 ls $datadir | grep -v m3u > $datadir/podcast.m3u
70
71
72 exit 0
73
74 #####
75 For a different scripting approach to Podcasting,
76 see Phil Salkie's article,
77 "Internet Radio to Podcast with Shell Tools"
78 in the September, 2005 issue of LINUX JOURNAL,
79 http://www.linuxjournal.com/article/8171
80 #####

```

Example A-32. Nightly backup to a firewire HD

```

1 #!/bin/bash
2 # nightly-backup.sh
3 # http://www.richardneill.org/source.php#nightly-backup-rsync
4 # Copyright (c) 2005 Richard Neill <backup@richardneill.org>.
5 # This is Free Software licensed under the GNU GPL.
6 # ==> Included in ABS Guide with script author's kind permission.
7 # ==> (Thanks!)
8
9 # This does a backup from the host computer to a locally connected

```

```

10 #+ firewire HDD using rsync and ssh.
11 # (Script should work with USB-connected device (see lines 40-43).
12 # It then rotates the backups.
13 # Run it via cron every night at 5am.
14 # This only backs up the home directory.
15 # If ownerships (other than the user's) should be preserved,
16 #+ then run the rsync process as root (and re-instate the -o).
17 # We save every day for 7 days, then every week for 4 weeks,
18 #+ then every month for 3 months.
19
20 # See: http://www.mikerubel.org/computers/rsync\_snapshots/
21 #+ for more explanation of the theory.
22 # Save as: $HOME/bin/nightly-backup_firewire-hdd.sh
23
24 # Known bugs:
25 # -----
26 # i) Ideally, we want to exclude ~/.tmp and the browser caches.
27
28 # ii) If the user is sitting at the computer at 5am,
29 #+ and files are modified while the rsync is occurring,
30 #+ then the BACKUP_JUSTINCASE branch gets triggered.
31 # To some extent, this is a
32 #+ feature, but it also causes a "disk-space leak".
33
34
35
36
37
38 ##### BEGIN CONFIGURATION SECTION #####
39 LOCAL_USER=rjn # User whose home directory should be backed up.
40 MOUNT_POINT=/backup # Mountpoint of backup drive.
41 # NO trailing slash!
42 # This must be unique (eg using a udev symlink)
43 # MOUNT_POINT=/media/disk # For USB-connected device.
44 SOURCE_DIR=/home/${LOCAL_USER} # NO trailing slash - it DOES matter to rsync.
45 BACKUP_DEST_DIR=${MOUNT_POINT}/backup/`hostname -s`.${LOCAL_USER}.nightly_backup
46 DRY_RUN=false #If true, invoke rsync with -n, to do a dry run.
47 # Comment out or set to false for normal use.
48 VERBOSE=false # If true, make rsync verbose.
49 # Comment out or set to false otherwise.
50 COMPRESS=false # If true, compress.
51 # Good for internet, bad on LAN.
52 # Comment out or set to false otherwise.
53
54 ### Exit Codes ###
55 E_VARS_NOT_SET=64
56 E_COMMANDLINE=65
57 E_MOUNT_FAIL=70
58 E_NOSOURCEDIR=71
59 E_UNMOUNTED=72
60 E_BACKUP=73
61 ##### END CONFIGURATION SECTION #####
62
63
64 # Check that all the important variables have been set:
65 if [ -z "$LOCAL_USER" ] ||
66 [ -z "$SOURCE_DIR" ] ||
67 [ -z "$MOUNT_POINT" ] ||
68 [ -z "$BACKUP_DEST_DIR" ]
69 then
70 echo 'One of the variables is not set! Edit the file: $0. BACKUP FAILED.'
71 exit $E_VARS_NOT_SET
72 fi
73
74 if [ "$#" != 0 ] # If command-line param(s) . . .
75 then # Here document(ation).

```



```

76 cat <<-ENDOFTEXT
77     Automatic Nightly backup run from cron.
78     Read the source for more details: $0
79     The backup directory is $BACKUP_DEST_DIR .
80     It will be created if necessary; initialisation is no longer required.
81
82     WARNING: Contents of $BACKUP_DEST_DIR are rotated.
83     Directories named 'backup.\$i' will eventually be DELETED.
84     We keep backups from every day for 7 days (1-8),
85     then every week for 4 weeks (9-12),
86     then every month for 3 months (13-15).
87
88     You may wish to add this to your crontab using 'crontab -e'
89     # Back up files: $SOURCE_DIR to $BACKUP_DEST_DIR
90     #+ every night at 3:15 am
91         15 03 * * * /home/$LOCAL_USER/bin/nightly-backup_firewire-hdd.sh
92
93     Don't forget to verify the backups are working,
94     especially if you don't read cron's mail!"
95 ENDOFTEXT
96 exit $E_COMMANDLINE
97 fi
98
99
100 # Parse the options.
101 # =====
102
103 if [ "$DRY_RUN" == "true" ]; then
104     DRY_RUN="-n"
105     echo "WARNING:"
106     echo "THIS IS A 'DRY RUN!'"
107     echo "No data will actually be transferred!"
108 else
109     DRY_RUN=""
110 fi
111
112 if [ "$VERBOSE" == "true" ]; then
113     VERBOSE="-v"
114 else
115     VERBOSE=""
116 fi
117
118 if [ "$COMPRESS" == "true" ]; then
119     COMPRESS="-z"
120 else
121     COMPRESS=""
122 fi
123
124
125 # Every week (actually of 8 days) and every month,
126 #+ extra backups are preserved.
127 DAY_OF_MONTH=`date +%d`           # Day of month (01..31).
128 if [ $DAY_OF_MONTH = 01 ]; then   # First of month.
129     MONTHSTART=true
130 elif [ $DAY_OF_MONTH = 08 \
131     -o $DAY_OF_MONTH = 16 \
132     -o $DAY_OF_MONTH = 24 ]; then
133     # Day 8,16,24 (use 8, not 7 to better handle 31-day months)
134     WEEKSTART=true
135 fi
136
137
138
139 # Check that the HDD is mounted.
140 # At least, check that *something* is mounted here!
141 # We can use something unique to the device, rather than just guessing

```

```
142 #+ the scsi-id by having an appropriate udev rule in
143 #+ /etc/udev/rules.d/10-rules.local
144 #+ and by putting a relevant entry in /etc/fstab.
145 # Eg: this udev rule:
146 # BUS="scsi", KERNEL="sd*", SYSFS{vendor}="WDC WD16",
147 # SYSFS{model}="00JB-00GVA0", NAME="%k", SYMLINK="lacie_1394d%n"
148
149 if mount | grep $MOUNT_POINT >/dev/null; then
150     echo "Mount point $MOUNT_POINT is indeed mounted. OK"
151 else
152     echo -n "Attempting to mount $MOUNT_POINT..."
153     # If it isn't mounted, try to mount it.
154     sudo mount $MOUNT_POINT 2>/dev/null
155
156     if mount | grep $MOUNT_POINT >/dev/null; then
157         UNMOUNT_LATER=TRUE
158         echo "OK"
159         # Note: Ensure that this is also unmounted
160         #+ if we exit prematurely with failure.
161     else
162         echo "FAILED"
163         echo -e "Nothing is mounted at $MOUNT_POINT. BACKUP FAILED!"
164         exit $E_MOUNT_FAIL
165     fi
166 fi
167
168
169 # Check that source dir exists and is readable.
170 if [ ! -r $SOURCE_DIR ] ; then
171     echo "$SOURCE_DIR does not exist, or cannot be read. BACKUP FAILED."
172     exit $E_NOSOURCEDIR
173 fi
174
175
176 # Check that the backup directory structure is as it should be.
177 # If not, create it.
178 # Create the subdirectories.
179 # Note that backup.0 will be created as needed by rsync.
180
181 for ((i=1;i<=15;i++)); do
182     if [ ! -d $BACKUP_DEST_DIR/backup.$i ]; then
183         if /bin/mkdir -p $BACKUP_DEST_DIR/backup.$i ; then
184             # ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^ No [ ] test brackets. Why?
185             echo "Warning: directory $BACKUP_DEST_DIR/backup.$i is missing,"
186             echo "or was not initialised. (Re-)creating it."
187         else
188             echo "ERROR: directory $BACKUP_DEST_DIR/backup.$i"
189             echo "is missing and could not be created."
190         if [ "$UNMOUNT_LATER" == "TRUE" ]; then
191             # Before we exit, unmount the mount point if necessary.
192             cd
193             sudo umount $MOUNT_POINT &&
194             echo "Unmounted $MOUNT_POINT again. Giving up."
195         fi
196         exit $E_UNMOUNTED
197     fi
198 fi
199 done
200
201
202 # Set the permission to 700 for security
203 #+ on an otherwise permissive multi-user system.
204 if ! /bin/chmod 700 $BACKUP_DEST_DIR ; then
205     echo "ERROR: Could not set permissions on $BACKUP_DEST_DIR to 700."
206
207     if [ "$UNMOUNT_LATER" == "TRUE" ]; then
```

```

208 # Before we exit, unmount the mount point if necessary.
209     cd ; sudo umount $MOUNT_POINT \
210     && echo "Unmounted $MOUNT_POINT again. Giving up."
211 fi
212
213 exit $E_UNMOUNTED
214 fi
215
216 # Create the symlink: current -> backup.1 if required.
217 # A failure here is not critical.
218 cd $BACKUP_DEST_DIR
219 if [ ! -h current ] ; then
220     if ! /bin/ln -s backup.1 current ; then
221         echo "WARNING: could not create symlink current -> backup.1"
222     fi
223 fi
224
225
226 # Now, do the rsync.
227 echo "Now doing backup with rsync..."
228 echo "Source dir: $SOURCE_DIR"
229 echo -e "Backup destination dir: $BACKUP_DEST_DIR\n"
230
231
232 /usr/bin/rsync $DRY_RUN $VERBOSE -a -S --delete --modify-window=60 \
233 --link-dest=../backup.1 $SOURCE_DIR $BACKUP_DEST_DIR/backup.0/
234
235 # Only warn, rather than exit if the rsync failed,
236 #+ since it may only be a minor problem.
237 # E.g., if one file is not readable, rsync will fail.
238 # This shouldn't prevent the rotation.
239 # Not using, e.g., `date +%a` since these directories
240 #+ are just full of links and don't consume *that much* space.
241
242 if [ $? != 0 ]; then
243     BACKUP_JUSTINCASE=backup.`date +%F_%T`.justincase
244     echo "WARNING: the rsync process did not entirely succeed."
245     echo "Something might be wrong."
246     echo "Saving an extra copy at: $BACKUP_JUSTINCASE"
247     echo "WARNING: if this occurs regularly, a LOT of space will be consumed,"
248     echo "even though these are just hard-links!"
249 fi
250
251 # Save a readme in the backup parent directory.
252 # Save another one in the recent subdirectory.
253 echo "Backup of $SOURCE_DIR on `hostname` was last run on \
254 `date`" > $BACKUP_DEST_DIR/README.txt
255 echo "This backup of $SOURCE_DIR on `hostname` was created on \
256 `date`" > $BACKUP_DEST_DIR/backup.0/README.txt
257
258 # If we are not in a dry run, rotate the backups.
259 [ -z "$DRY_RUN" ] &&
260
261 # Check how full the backup disk is.
262 # Warn if 90%. if 98% or more, we'll probably fail, so give up.
263 # (Note: df can output to more than one line.)
264 # We test this here, rather than before
265 #+ so that rsync may possibly have a chance.
266 DISK_FULL_PERCENT=`/bin/df $BACKUP_DEST_DIR |
267 tr "\n" ' ' | awk '{print $12}' | grep -oE [0-9]+`
268 echo "Disk space check on backup partition \
269 $MOUNT_POINT $DISK_FULL_PERCENT% full."
270 if [ $DISK_FULL_PERCENT -gt 90 ]; then
271     echo "Warning: Disk is greater than 90% full."
272 fi
273 if [ $DISK_FULL_PERCENT -gt 98 ]; then

```

```

274     echo "Error: Disk is full! Giving up."
275     if [ "$UNMOUNT_LATER" == "TRUE" ]; then
276         # Before we exit, unmount the mount point if necessary.
277         cd; sudo umount $MOUNT_POINT &&
278         echo "Unmounted $MOUNT_POINT again. Giving up."
279     fi
280     exit $E_UNMOUNTED
281 fi
282
283
284 # Create an extra backup.
285 # If this copy fails, give up.
286 if [ -n "$BACKUP_JUSTINCASE" ]; then
287     if ! /bin/cp -al $BACKUP_DEST_DIR/backup.0 \
288         $BACKUP_DEST_DIR/$BACKUP_JUSTINCASE
289     then
290         echo "ERROR: Failed to create extra copy \
291             $BACKUP_DEST_DIR/$BACKUP_JUSTINCASE"
292         if [ "$UNMOUNT_LATER" == "TRUE" ]; then
293             # Before we exit, unmount the mount point if necessary.
294             cd ;sudo umount $MOUNT_POINT &&
295             echo "Unmounted $MOUNT_POINT again. Giving up."
296         fi
297         exit $E_UNMOUNTED
298     fi
299 fi
300
301
302 # At start of month, rotate the oldest 8.
303 if [ "$MONTHSTART" == "true" ]; then
304     echo -e "\nStart of month. \
305     Removing oldest backup: $BACKUP_DEST_DIR/backup.15" &&
306     /bin/rm -rf $BACKUP_DEST_DIR/backup.15 &&
307     echo "Rotating monthly,weekly backups: \
308     $BACKUP_DEST_DIR/backup.[8-14] -> $BACKUP_DEST_DIR/backup.[9-15]" &&
309     /bin/mv $BACKUP_DEST_DIR/backup.14 $BACKUP_DEST_DIR/backup.15 &&
310     /bin/mv $BACKUP_DEST_DIR/backup.13 $BACKUP_DEST_DIR/backup.14 &&
311     /bin/mv $BACKUP_DEST_DIR/backup.12 $BACKUP_DEST_DIR/backup.13 &&
312     /bin/mv $BACKUP_DEST_DIR/backup.11 $BACKUP_DEST_DIR/backup.12 &&
313     /bin/mv $BACKUP_DEST_DIR/backup.10 $BACKUP_DEST_DIR/backup.11 &&
314     /bin/mv $BACKUP_DEST_DIR/backup.9 $BACKUP_DEST_DIR/backup.10 &&
315     /bin/mv $BACKUP_DEST_DIR/backup.8 $BACKUP_DEST_DIR/backup.9
316
317 # At start of week, rotate the second-oldest 4.
318 elif [ "$WEEKSTART" == "true" ]; then
319     echo -e "\nStart of week. \
320     Removing oldest weekly backup: $BACKUP_DEST_DIR/backup.12" &&
321     /bin/rm -rf $BACKUP_DEST_DIR/backup.12 &&
322
323     echo "Rotating weekly backups: \
324     $BACKUP_DEST_DIR/backup.[8-11] -> $BACKUP_DEST_DIR/backup.[9-12]" &&
325     /bin/mv $BACKUP_DEST_DIR/backup.11 $BACKUP_DEST_DIR/backup.12 &&
326     /bin/mv $BACKUP_DEST_DIR/backup.10 $BACKUP_DEST_DIR/backup.11 &&
327     /bin/mv $BACKUP_DEST_DIR/backup.9 $BACKUP_DEST_DIR/backup.10 &&
328     /bin/mv $BACKUP_DEST_DIR/backup.8 $BACKUP_DEST_DIR/backup.9
329
330 else
331     echo -e "\nRemoving oldest daily backup: $BACKUP_DEST_DIR/backup.8" &&
332     /bin/rm -rf $BACKUP_DEST_DIR/backup.8
333
334 fi &&
335
336 # Every day, rotate the newest 8.
337 echo "Rotating daily backups: \
338 $BACKUP_DEST_DIR/backup.[1-7] -> $BACKUP_DEST_DIR/backup.[2-8]" &&
339     /bin/mv $BACKUP_DEST_DIR/backup.7 $BACKUP_DEST_DIR/backup.8 &&

```

```

340     /bin/mv $BACKUP_DEST_DIR/backup.6 $BACKUP_DEST_DIR/backup.7  &&
341     /bin/mv $BACKUP_DEST_DIR/backup.5 $BACKUP_DEST_DIR/backup.6  &&
342     /bin/mv $BACKUP_DEST_DIR/backup.4 $BACKUP_DEST_DIR/backup.5  &&
343     /bin/mv $BACKUP_DEST_DIR/backup.3 $BACKUP_DEST_DIR/backup.4  &&
344     /bin/mv $BACKUP_DEST_DIR/backup.2 $BACKUP_DEST_DIR/backup.3  &&
345     /bin/mv $BACKUP_DEST_DIR/backup.1 $BACKUP_DEST_DIR/backup.2  &&
346     /bin/mv $BACKUP_DEST_DIR/backup.0 $BACKUP_DEST_DIR/backup.1  &&
347
348     SUCCESS=true
349
350
351     if [ "$UNMOUNT_LATER" == "TRUE" ]; then
352         # Unmount the mount point if it wasn't mounted to begin with.
353         cd ; sudo umount $MOUNT_POINT && echo "Unmounted $MOUNT_POINT again."
354     fi
355
356
357     if [ "$SUCCESS" == "true" ]; then
358         echo 'SUCCESS!'
359         exit 0
360     fi
361
362     # Should have already exited if backup worked.
363     echo 'BACKUP FAILED! Is this just a dry run? Is the disk full?) '
364     exit $E_BACKUP

```

Example A-33. An expanded *cd* command

```

1 #####
2 #
3 #     cdll
4 #     by Phil Braham
5 #
6 #     #####
7 #     Latest version of this script available from
8 #     http://freshmeat.net/projects/cd/
9 #     #####
10 #
11 #     .cd_new
12 #
13 #     An enhancement of the Unix cd command
14 #
15 #     There are unlimited stack entries and special entries. The stack
16 #     entries keep the last cd_maxhistory
17 #     directories that have been used. The special entries can be
18 #     assigned to commonly used directories.
19 #
20 #     The special entries may be pre-assigned by setting the environment
21 #     variables CDSn or by using the -u or -U command.
22 #
23 #     The following is a suggestion for the .profile file:
24 #
25 #             . cdll                # Set up the cd command
26 #     alias cd='cd_new'            # Replace the cd command
27 #             cd -U                # Upload pre-assigned entries for
28 #                                 #+ the stack and special entries
29 #             cd -D                # Set non-default mode
30 #             alias @="cd_new @"    # Allow @ to be used to get history
31 #
32 #     For help type:
33 #
34 #             cd -h or

```

```

35 #           cd -H
36 #
37 #
38 #####
39 #
40 #           Version 1.2.1
41 #
42 #           Written by Phil Braham - Realtime Software Pty Ltd
43 #           (realtime@mpx.com.au)
44 #           Please send any suggestions or enhancements to the author (also at
45 #           phil@braham.net)
46 #
47 #####
48
49 cd_hm ()
50 {
51     ${PRINTF} "%s" "cd [dir] [0-9] [@[s|h] [-g [<dir>]] [-d] \
52 [-D] [-r<n>] [dir|0-9] [-R<n>] [<dir>|0-9]
53 [-s<n>] [-S<n>] [-u] [-U] [-f] [-F] [-h] [-H] [-v]
54 <dir> Go to directory
55 0-n           Go to previous directory (0 is previous, 1 is last but 1 etc)
56              n is up to max history (default is 50)
57 @            List history and special entries
58 @h           List history entries
59 @s           List special entries
60 -g [<dir>]   Go to literal name (bypass special names)
61              This is to allow access to dirs called '0','1','-h' etc
62 -d           Change default action - verbose. (See note)
63 -D           Change default action - silent. (See note)
64 -s<n>       Go to the special entry <n>*
65 -S<n>       Go to the special entry <n>
66              and replace it with the current dir*
67 -r<n> [<dir>] Go to directory <dir>
68              and then put it on special entry <n>*
69 -R<n> [<dir>] Go to directory <dir>
70              and put current dir on special entry <n>*
71 -a<n>       Alternative suggested directory. See note below.
72 -f [<file>] File entries to <file>.
73 -u [<file>] Update entries from <file>.
74              If no filename supplied then default file
75              (${CDPath}${2:-"$CDFile"}) is used
76              -F and -U are silent versions
77 -v          Print version number
78 -h          Help
79 -H          Detailed help
80
81 *The special entries (0 - 9) are held until log off, replaced by another
82 entry or updated with the -u command
83
84 Alternative suggested directories:
85 If a directory is not found then CD will suggest any
86 possibilities. These are directories starting with the same letters
87 and if any are found they are listed prefixed with -a<n>
88 where <n> is a number.
89 It's possible to go to the directory by entering cd -a<n>
90 on the command line.
91
92 The directory for -r<n> or -R<n> may be a number.
93 For example:
94 $ cd -r3 4   Go to history entry 4 and put it on special entry 3
95 $ cd -R3 4   Put current dir on the special entry 3
96              and go to history entry 4
97 $ cd -s3     Go to special entry 3
98
99 Note that commands R,r,S and s may be used without a number
100 and refer to 0:

```

```

101     $ cd -s      Go to special entry 0
102     $ cd -S      Go to special entry 0 and make special
103                      entry 0 current dir
104     $ cd -r 1    Go to history entry 1 and put it on special entry 0
105     $ cd -r      Go to history entry 0 and put it on special entry 0
106     "
107         if ${TEST} "$CD_MODE" = "PREV"
108         then
109             ${PRINTF} "$cd_mnset"
110         else
111             ${PRINTF} "$cd_mset"
112         fi
113     }
114
115 cd_Hm ()
116 {
117     cd_hm
118     ${PRINTF} "%s" "
119     The previous directories (0-$cd_maxhistory) are stored in the
120     environment variables CD[0] - CD[$cd_maxhistory]
121     Similarly the special directories S0 - $cd_maxspecial are in
122     the environment variable CDS[0] - CDS[$cd_maxspecial]
123     and may be accessed from the command line
124
125     The default pathname for the -f and -u commands is $CDPath
126     The default filename for the -f and -u commands is $CDFile
127
128     Set the following environment variables:
129     CDL_PROMPTLEN - Set to the length of prompt you require.
130     Prompt string is set to the right characters of the
131     current directory.
132     If not set then prompt is left unchanged
133     CDL_PROMPT_PRE - Set to the string to prefix the prompt.
134     Default is:
135         non-root:  "\\[\e[01;34m\\]\\" (sets colour to blue).
136         root:      "\\[\e[01;31m\\]\\" (sets colour to red).
137     CDL_PROMPT_POST - Set to the string to suffix the prompt.
138     Default is:
139         non-root:  "\\[\e[00m\\]$\"
140                 (resets colour and displays $).
141         root:      "\\[\e[00m\\]#\"
142                 (resets colour and displays #).
143     CDPath - Set the default path for the -f & -u options.
144             Default is home directory
145     CDFile - Set the default filename for the -f & -u options.
146             Default is cdfile
147
148     "
149     cd_version
150
151 }
152
153 cd_version ()
154 {
155     printf "Version: ${VERSION_MAJOR}.${VERSION_MINOR} Date: ${VERSION_DATE}\n"
156 }
157
158 #
159 # Truncate right.
160 #
161 # params:
162 #   p1 - string
163 #   p2 - length to truncate to
164 #
165 # returns string in tcd
166 #

```

```

167 cd_right_trunc ()
168 {
169     local tlen=${2}
170     local plen=${#1}
171     local str="${1}"
172     local diff
173     local filler="<--"
174     if ${TEST} ${plen} -le ${tlen}
175     then
176         tcd="${str}"
177     else
178         let diff=${plen}-${tlen}
179         elen=3
180         if ${TEST} ${diff} -le 2
181         then
182             let elen=${diff}
183         fi
184         tlen=-${tlen}
185         let tlen=${tlen}+${elen}
186         tcd=${filler:0:elen}${str:tlen}
187     fi
188 }
189
190 #
191 # Three versions of do history:
192 #   cd_dohistory - packs history and specials side by side
193 #   cd_dohistoryH - Shows only history
194 #   cd_dohistoryS - Shows only specials
195 #
196 cd_dohistory ()
197 {
198     cd_getrc
199     ${PRINTF} "History:\n"
200     local -i count=${cd_histcount}
201     while ${TEST} ${count} -ge 0
202     do
203         cd_right_trunc "${CD[count]}" ${cd_lchar}
204         ${PRINTF} "%2d %-${cd_lchar}.${cd_lchar}s " ${count} "${tcd}"
205
206         cd_right_trunc "${CDS[count]}" ${cd_rchar}
207         ${PRINTF} "S%d %-${cd_rchar}.${cd_rchar}s\n" ${count} "${tcd}"
208         count=${count}-1
209     done
210 }
211
212 cd_dohistoryH ()
213 {
214     cd_getrc
215     ${PRINTF} "History:\n"
216     local -i count=${cd_maxhistory}
217     while ${TEST} ${count} -ge 0
218     do
219         ${PRINTF} "%${count} %-${cd_flchar}.${cd_flchar}s\n" ${CD[$count]}
220         count=${count}-1
221     done
222 }
223
224 cd_dohistoryS ()
225 {
226     cd_getrc
227     ${PRINTF} "Specials:\n"
228     local -i count=${cd_maxspecial}
229     while ${TEST} ${count} -ge 0
230     do
231         ${PRINTF} "S${count} %-${cd_flchar}.${cd_flchar}s\n" ${CDS[$count]}
232         count=${count}-1

```



```

233     done
234 }
235
236 cd_getrc ()
237 {
238     cd_flchar=$(stty -a | awk -F \;
239     '/rows/ { print $2 $3 }' | awk -F \ '{ print $4 }')
240     if ${TEST} ${cd_flchar} -ne 0
241     then
242         cd_lchar=${cd_flchar}/2-5
243         cd_rchar=${cd_flchar}/2-5
244         cd_flchar=${cd_flchar}-5
245     else
246         cd_flchar=${FLCHAR:=75}
247         # cd_flchar is used for for the @s & @h history
248         cd_lchar=${LCHAR:=35}
249         cd_rchar=${RCHAR:=35}
250     fi
251 }
252
253 cd_doselection ()
254 {
255     local -i nm=0
256     cd_doflag="TRUE"
257     if ${TEST} "${CD_MODE}" = "PREV"
258     then
259         if ${TEST} -z "$cd_npwd"
260         then
261             cd_npwd=0
262         fi
263     fi
264     tm=$(echo "${cd_npwd}" | cut -b 1)
265     if ${TEST} "${tm}" = "-"
266     then
267         pm=$(echo "${cd_npwd}" | cut -b 2)
268         nm=$(echo "${cd_npwd}" | cut -d $pm -f2)
269         case "${pm}" in
270             a) cd_npwd=${cd_sugg[$nm]} ;;
271             s) cd_npwd="${CDS[$nm]}" ;;
272             S) cd_npwd="${CDS[$nm]}" ; CDS[$nm]=`pwd` ;;
273             r) cd_npwd="$2" ; cd_specDir=$nm ; cd_doselection "$1" "$2";;
274             R) cd_npwd="$2" ; CDS[$nm]=`pwd` ; cd_doselection "$1" "$2";;
275         esac
276     fi
277
278     if ${TEST} "${cd_npwd}" != "." -a "${cd_npwd}" \
279     != ".." -a "${cd_npwd}" -le ${cd_maxhistory} >>/dev/null 2>&1
280     then
281         cd_npwd=${CD[$cd_npwd]}
282     else
283         case "$cd_npwd" in
284             @) cd_dohistory ; cd_doflag="FALSE" ;;
285             @h) cd_dohistoryH ; cd_doflag="FALSE" ;;
286             @s) cd_dohistoryS ; cd_doflag="FALSE" ;;
287             -h) cd_hm ; cd_doflag="FALSE" ;;
288             -H) cd_Hm ; cd_doflag="FALSE" ;;
289             -f) cd_fsave "SHOW" $2 ; cd_doflag="FALSE" ;;
290             -u) cd_upload "SHOW" $2 ; cd_doflag="FALSE" ;;
291             -F) cd_fsave "NOSHOW" $2 ; cd_doflag="FALSE" ;;
292             -U) cd_upload "NOSHOW" $2 ; cd_doflag="FALSE" ;;
293             -g) cd_npwd="$2" ;;
294             -d) cd_chdefm 1; cd_doflag="FALSE" ;;
295             -D) cd_chdefm 0; cd_doflag="FALSE" ;;
296             -r) cd_npwd="$2" ; cd_specDir=0 ; cd_doselection "$1" "$2";;
297             -R) cd_npwd="$2" ; CDS[0]=`pwd` ; cd_doselection "$1" "$2";;
298             -s) cd_npwd="${CDS[0]}" ;;

```

```

299         -S) cd_npwd="${CDS[0]}" ; CDS[0]='`pwd`' ;;
300         -v) cd_version ; cd_doflag="FALSE";;
301     esac
302     fi
303 }
304
305 cd_chdefm ()
306 {
307     if ${TEST} "${CD_MODE}" = "PREV"
308     then
309         CD_MODE=""
310         if ${TEST} $1 -eq 1
311         then
312             ${PRINTF} "${cd_mset}"
313         fi
314     else
315         CD_MODE="PREV"
316         if ${TEST} $1 -eq 1
317         then
318             ${PRINTF} "${cd_mnset}"
319         fi
320     fi
321 }
322
323 cd_fsave ()
324 {
325     local sfile=${CDPath}${2:-"$CDFile"}
326     if ${TEST} "$1" = "SHOW"
327     then
328         ${PRINTF} "Saved to %s\n" $sfile
329     fi
330     ${RM} -f ${sfile}
331     local -i count=0
332     while ${TEST} ${count} -le ${cd_maxhistory}
333     do
334         echo "CD[$count]=\"${CD[$count]}\\"" >> ${sfile}
335         count=$((count+1))
336     done
337     count=0
338     while ${TEST} ${count} -le ${cd_maxspecial}
339     do
340         echo "CDS[$count]=\"${CDS[$count]}\\"" >> ${sfile}
341         count=$((count+1))
342     done
343 }
344
345 cd_upload ()
346 {
347     local sfile=${CDPath}${2:-"$CDFile"}
348     if ${TEST} "${1}" = "SHOW"
349     then
350         ${PRINTF} "Loading from %s\n" ${sfile}
351     fi
352     . ${sfile}
353 }
354
355 cd_new ()
356 {
357     local -i count
358     local -i choose=0
359
360     cd_npwd="${1}"
361     cd_specDir=-1
362     cd_doselection "${1}" "${2}"
363
364     if ${TEST} ${cd_doflag} = "TRUE"

```

```

365     then
366         if ${TEST} "${CD[0]}" != "`pwd`"
367         then
368             count=${cd_maxhistory}
369             while ${TEST} $count -gt 0
370             do
371                 CD[$count]=${CD[$count-1]}
372                 count=$((count)-1)
373             done
374             CD[0]=`pwd`
375         fi
376         command cd "${cd_npwd}" 2>/dev/null
377     if ${TEST} $? -eq 1
378     then
379         ${PRINTF} "Unknown dir: %s\n" "${cd_npwd}"
380         local -i ftflag=0
381         for i in "${cd_npwd}"*
382         do
383             if ${TEST} -d "$i"
384             then
385                 if ${TEST} ${ftflag} -eq 0
386                 then
387                     ${PRINTF} "Suggest:\n"
388                     ftflag=1
389                 fi
390                 ${PRINTF} "\t-a${choose} %s\n" "$i"
391                 cd_sugg[$choose]="$i"
392                 choose=$((choose)+1)
393             fi
394         done
395     fi
396 fi
397
398 if ${TEST} ${cd_specDir} -ne -1
399 then
400     CDS[${cd_specDir}]=`pwd`
401 fi
402
403 if ${TEST} ! -z "${CDL_PROMPTLEN}"
404 then
405     cd_right_trunc "${PWD}" ${CDL_PROMPTLEN}
406     cd_rp=${CDL_PROMPT_PRE}${tcd}${CDL_PROMPT_POST}
407     export PS1="${echo -ne ${cd_rp}}"
408 fi
409 }
410 #####
411 #                                                                 #
412 #             Initialisation here                                #
413 #                                                                 #
414 #####
415 #
416 VERSION_MAJOR="1"
417 VERSION_MINOR="2.1"
418 VERSION_DATE="24-MAY-2003"
419 #
420 alias cd=cd_new
421 #
422 # Set up commands
423 RM=/bin/rm
424 TEST=test
425 PRINTF=printf          # Use builtin printf
426
427 #####
428 #                                                                 #
429 # Change this to modify the default pre- and post prompt strings. #
430 # These only come into effect if CDL_PROMPTLEN is set.          #

```

```

431 # #
432 #####
433 if ${TEST} ${EUID} -eq 0
434 then
435 #   CDL_PROMPT_PRE=${CDL_PROMPT_PRE:="$HOSTNAME@"}
436     CDL_PROMPT_PRE=${CDL_PROMPT_PRE:="\[\[\e[01;31m\]} # Root is in red
437     CDL_PROMPT_POST=${CDL_PROMPT_POST:="\[\[\e[00m\]}#" }
438 else
439     CDL_PROMPT_PRE=${CDL_PROMPT_PRE:="\[\[\e[01;34m\]} # Users in blue
440     CDL_PROMPT_POST=${CDL_PROMPT_POST:="\[\[\e[00m\]}$" }
441 fi
442 #####
443 #
444 # cd_maxhistory defines the max number of history entries allowed.
445 typeset -i cd_maxhistory=50
446
447 #####
448 #
449 # cd_maxspecial defines the number of special entries.
450 typeset -i cd_maxspecial=9
451 #
452 #
453 #####
454 #
455 # cd_histcount defines the number of entries displayed in
456 #+ the history command.
457 typeset -i cd_histcount=9
458 #
459 #####
460 export CDPATH=${HOME}/
461 # Change these to use a different #
462 #+ default path and filename #
463 export CDFILE=${CDFILE:=cdfile} # for the -u and -f commands #
464 #
465 #####
466 #
467 typeset -i cd_lchar cd_rchar cd_flchar
468 # This is the number of chars to allow for the #
469 cd_flchar=${FLCHAR:=75} #+ cd_flchar is used for for the @s & @h history#
470
471 typeset -ax CD CDS
472 #
473 cd_mset="\n\tDefault mode is now set - entering cd with no parameters \
474 has the default action\n\tUse cd -d or -D for cd to go to \
475 previous directory with no parameters\n"
476 cd_mnset="\n\tNon-default mode is now set - entering cd with no \
477 parameters is the same as entering cd 0\n\tUse cd -d or \
478 -D to change default cd action\n"
479
480 # ===== #
481
482
483
484 : <<DOCUMENTATION
485
486 Written by Phil Braham. Realtime Software Pty Ltd.
487 Released under GNU license. Free to use. Please pass any modifications
488 or comments to the author Phil Braham:
489
490 realtime@mpx.com.au
491 =====
492
493 cdll is a replacement for cd and incorporates similar functionality to
494 the bash pushd and popd commands but is independent of them.
495
496 This version of cdll has been tested on Linux using Bash. It will work

```

```
497 on most Linux versions but will probably not work on other shells without
498 modification.
499
500 Introduction
501 =====
502
503 cdll allows easy moving about between directories. When changing to a new
504 directory the current one is automatically put onto a stack. By default
505 50 entries are kept, but this is configurable. Special directories can be
506 kept for easy access - by default up to 10, but this is configurable. The
507 most recent stack entries and the special entries can be easily viewed.
508
509 The directory stack and special entries can be saved to, and loaded from,
510 a file. This allows them to be set up on login, saved before logging out
511 or changed when moving project to project.
512
513 In addition, cdll provides a flexible command prompt facility that allows,
514 for example, a directory name in colour that is truncated from the left
515 if it gets too long.
516
517
518 Setting up cdll
519 =====
520
521 Copy cdll to either your local home directory or a central directory
522 such as /usr/bin (this will require root access).
523
524 Copy the file cdfile to your home directory. It will require read and
525 write access. This a default file that contains a directory stack and
526 special entries.
527
528 To replace the cd command you must add commands to your login script.
529 The login script is one or more of:
530
531     /etc/profile
532     ~/.bash_profile
533     ~/.bash_login
534     ~/.profile
535     ~/.bashrc
536     /etc/bash.bashrc.local
537
538 To setup your login, ~/.bashrc is recommended, for global (and root) setup
539 add the commands to /etc/bash.bashrc.local
540
541 To set up on login, add the command:
542     . <dir>/cdll
543 For example if cdll is in your local home directory:
544     . ~/cdll
545 If in /usr/bin then:
546     . /usr/bin/cdll
547
548 If you want to use this instead of the builtin cd command then add:
549     alias cd='cd_new'
550 We would also recommend the following commands:
551     alias @='cd_new @'
552     cd -U
553     cd -D
554
555 If you want to use cdll's prompt facility then add the following:
556     CDL_PROMPTLEN=nn
557 Where nn is a number described below. Initially 99 would be suitable
558 number.
559
560 Thus the script looks something like this:
561
562     #####
```

```

563 # CD Setup
564 #####
565 CDL_PROMPTLEN=21 # Allow a prompt length of up to 21 characters
566 . /usr/bin/cdll # Initialise cdll
567 alias cd='cd_new' # Replace the built in cd command
568 alias @='cd_new @' # Allow @ at the prompt to display history
569 cd -U # Upload directories
570 cd -D # Set default action to non-posix
571 #####
572
573 The full meaning of these commands will become clear later.
574
575 There are a couple of caveats. If another program changes the directory
576 without calling cdll, then the directory won't be put on the stack and
577 also if the prompt facility is used then this will not be updated. Two
578 programs that can do this are pushd and popd. To update the prompt and
579 stack simply enter:
580
581 cd .
582
583 Note that if the previous entry on the stack is the current directory
584 then the stack is not updated.
585
586 Usage
587 =====
588 cd [dir] [0-9] [@[s|h] [-g <dir>] [-d] [-D] [-r<n>]
589 [dir|0-9] [-R<n>] [<dir>|0-9] [-s<n>] [-S<n>]
590 [-u] [-U] [-f] [-F] [-h] [-H] [-v]
591
592 <dir> Go to directory
593 0-n Goto previous directory (0 is previous,
594 1 is last but 1, etc.)
595 n is up to max history (default is 50)
596 @ List history and special entries (Usually available as $ @)
597 @h List history entries
598 @s List special entries
599 -g [<dir>] Go to literal name (bypass special names)
600 This is to allow access to dirs called '0','1','-h' etc
601 -d Change default action - verbose. (See note)
602 -D Change default action - silent. (See note)
603 -s<n> Go to the special entry <n>
604 -S<n> Go to the special entry <n>
605 and replace it with the current dir
606 -r<n> [<dir>] Go to directory <dir>
607 and then put it on special entry <n>
608 -R<n> [<dir>] Go to directory <dir>
609 and put current dir on special entry <n>
610 -a<n> Alternative suggested directory. See note below.
611 -f [<file>] File entries to <file>.
612 -u [<file>] Update entries from <file>.
613 If no filename supplied then default file (~/cdfile) is used
614 -F and -U are silent versions
615 -v Print version number
616 -h Help
617 -H Detailed help
618
619
620
621 Examples
622 =====
623
624 These examples assume non-default mode is set (that is, cd with no
625 parameters will go to the most recent stack directory), that aliases
626 have been set up for cd and @ as described above and that cd's prompt
627 facility is active and the prompt length is 21 characters.
628

```

```

629 /home/phil$ @
630 # List the entries with the @
631 History:
632 # Output of the @ command
633 .....
634 # Skipped these entries for brevity
635 1 /home/phil/ummdev S1 /home/phil/perl
636 # Most recent two history entries
637 0 /home/phil/perl/eg S0 /home/phil/umm/ummdev
638 # and two special entries are shown
639
640 /home/phil$ cd /home/phil/utils/Cdll
641 # Now change directories
642 /home/phil/utils/Cdll$ @
643 # Prompt reflects the directory.
644 History:
645 # New history
646 .....
647 1 /home/phil/perl/eg S1 /home/phil/perl
648 # History entry 0 has moved to 1
649 0 /home/phil S0 /home/phil/umm/ummdev
650 # and the most recent has entered
651
652 To go to a history entry:
653
654 /home/phil/utils/Cdll$ cd 1
655 # Go to history entry 1.
656 /home/phil/perl/eg$
657 # Current directory is now what was 1
658
659 To go to a special entry:
660
661 /home/phil/perl/eg$ cd -s1
662 # Go to special entry 1
663 /home/phil/umm/ummdev$
664 # Current directory is S1
665
666 To go to a directory called, for example, 1:
667
668 /home/phil$ cd -g 1
669 # -g ignores the special meaning of 1
670 /home/phil/1$
671
672 To put current directory on the special list as S1:
673 cd -r1 . # OR
674 cd -R1 . # These have the same effect if the directory is
675 #+ . (the current directory)
676
677 To go to a directory and add it as a special
678 The directory for -r<n> or -R<n> may be a number.
679 For example:
680 $ cd -r3 4 Go to history entry 4 and put it on special entry 3
681 $ cd -R3 4 Put current dir on the special entry 3 and go to
682 history entry 4
683 $ cd -s3 Go to special entry 3
684
685 Note that commands R,r,S and s may be used without a number and
686 refer to 0:
687 $ cd -s Go to special entry 0
688 $ cd -S Go to special entry 0 and make special entry 0
689 current dir
690 $ cd -r 1 Go to history entry 1 and put it on special entry 0
691 $ cd -r Go to history entry 0 and put it on special entry 0
692
693
694 Alternative suggested directories:

```

```

695
696 If a directory is not found, then CD will suggest any
697 possibilities. These are directories starting with the same letters
698 and if any are found they are listed prefixed with -a<n>
699 where <n> is a number. It's possible to go to the directory
700 by entering cd -a<n> on the command line.
701
702 Use cd -d or -D to change default cd action. cd -H will show
703 current action.
704
705 The history entries (0-n) are stored in the environment variables
706 CD[0] - CD[n]
707 Similarly the special directories S0 - 9 are in the environment
708 variable CDS[0] - CDS[9]
709 and may be accessed from the command line, for example:
710
711     ls -l ${CDS[3]}
712     cat ${CD[8]}/file.txt
713
714 The default pathname for the -f and -u commands is ~
715 The default filename for the -f and -u commands is cdfile
716
717
718 Configuration
719 =====
720
721 The following environment variables can be set:
722
723 CDL_PROMPTLEN - Set to the length of prompt you require.
724 Prompt string is set to the right characters of the current
725 directory. If not set, then prompt is left unchanged. Note
726 that this is the number of characters that the directory is
727 shortened to, not the total characters in the prompt.
728
729 CDL_PROMPT_PRE - Set to the string to prefix the prompt.
730 Default is:
731     non-root: "\\[\e[01;34m\\]" (sets colour to blue).
732     root:    "\\[\e[01;31m\\]" (sets colour to red).
733
734 CDL_PROMPT_POST - Set to the string to suffix the prompt.
735 Default is:
736     non-root: "\\[\e[00m\\]"$"
737             (resets colour and displays $).
738     root:    "\\[\e[00m\\]"#"
739             (resets colour and displays #).
740
741 Note:
742     CDL_PROMPT_PRE & _POST only t
743
744 CDPATH - Set the default path for the -f & -u options.
745         Default is home directory
746 CDFile - Set the default filename for the -f & -u options.
747         Default is cdfile
748
749
750 There are three variables defined in the file cdll which control the
751 number of entries stored or displayed. They are in the section labeled
752 'Initialisation here' towards the end of the file.
753
754 cd_maxhistory - The number of history entries stored.
755                Default is 50.
756 cd_maxspecial - The number of special entries allowed.
757                Default is 9.
758 cd_histcount  - The number of history and special entries
759                displayed. Default is 9.
760

```



```
761     Note that cd_maxspecial should be >= cd_histcount to avoid displaying
762     special entries that can't be set.
763
764
765 Version: 1.2.1 Date: 24-MAY-2003
766
767 DOCUMENTATION
```

Example A-34. A soundcard setup script

```
1 #!/bin/bash
2 # soundcard-on.sh
3
4 #   Script author: Mkarcher
5 #   http://www.thinkwiki.org/wiki   ...
6 #   /Script_for_configuring_the_CS4239_sound_chip_in_PnP_mode
7 #   ABS Guide author made minor changes and added comments.
8 #   Couldn't contact script author to ask for permission to use, but ...
9 #+ the script was released under the FDL,
10 #+ so its use here should be both legal and ethical.
11
12 #   Sound-via-pnp-script for Thinkpad 600E
13 #+ and possibly other computers with onboard CS4239/CS4610
14 #+ that do not work with the PCI driver
15 #+ and are not recognized by the PnP code of snd-cs4236.
16 #   Also for some 770-series Thinkpads, such as the 770x.
17 #   Run as root user, of course.
18 #
19 #   These are old and very obsolete laptop computers,
20 #+ but this particular script is very instructive,
21 #+ as it shows how to set up and hack device files.
22
23
24
25 #   Search for sound card pnp device:
26
27 for dev in /sys/bus/pnp/devices/*
28 do
29     grep CSC0100 $dev/id > /dev/null && WSSDEV=$dev
30     grep CSC0110 $dev/id > /dev/null && CTLDEV=$dev
31 done
32 # On 770x:
33 # WSSDEV = /sys/bus/pnp/devices/00:07
34 # CTLDEV = /sys/bus/pnp/devices/00:06
35 # These are symbolic links to /sys/devices/pnp0/ ...
36
37
38 #   Activate devices:
39 #   Thinkpad boots with devices disabled unless "fast boot" is turned off
40 #+ (in BIOS).
41
42 echo activate > $WSSDEV/resources
43 echo activate > $CTLDEV/resources
44
45
46 # Parse resource settings.
47
48 { read # Discard "state = active" (see below).
49     read bla port1
50     read bla port2
51     read bla port3
52     read bla irq
```

```

53 read bla dma1
54 read bla dma2
55 # The "bla's" are labels in the first field: "io," "state," etc.
56 # These are discarded.
57
58 # Hack: with PnPBIOS: ports are: port1: WSS, port2:
59 #+ OPL, port3: sb (unneeded)
60 # with ACPI-PnP:ports are: port1: OPL, port2: sb, port3: WSS
61 # (ACPI bios seems to be wrong here, the PnP-card-code in snd-cs4236.c
62 #+ uses the PnPBIOS port order)
63 # Detect port order using the fixed OPL port as reference.
64 if [ ${port2%%-*} = 0x388 ]
65 # ^^^ Strip out everything following hyphen in port address.
66 # So, if port1 is 0x530-0x537
67 #+ we're left with 0x530 -- the start address of the port.
68 then
69 # PnPBIOS: usual order
70 port=${port1%%-*}
71 oplport=${port2%%-*}
72 else
73 # ACPI: mixed-up order
74 port=${port3%%-*}
75 oplport=${port1%%-*}
76 fi
77 } < $WSSDEV/resources
78 # To see what's going on here:
79 # -----
80 # cat /sys/devices/pnp0/00:07/resources
81 #
82 # state = active
83 # io 0x530-0x537
84 # io 0x388-0x38b
85 # io 0x220-0x233
86 # irq 5
87 # dma 1
88 # dma 0
89 # ^^^ "bla" labels in first field (discarded).
90
91
92 { read # Discard first line, as above.
93 read bla port1
94 cport=${port1%%-*}
95 # ^^^
96 # Just want _start_ address of port.
97 } < $CTLDEV/resources
98
99
100 # Load the module:
101
102 modprobe --ignore-install snd-cs4236 port=$port cport=$cport\
103 fm_port=$oplport irq=$irq dma1=$dma1 dma2=$dma2 isapnp=0 index=0
104 # See the modprobe manpage.
105
106 exit $?

```

Example A-35. Locating split paragraphs in a text file

```

1 #!/bin/bash
2 # find-splitpara.sh
3 # Finds split paragraphs in a text file,
4 #+ and tags the line numbers.
5

```

```

6
7 ARGCOUNT=1      # Expect one arg.
8 OFF=0            # Flag states.
9 ON=1
10 E_WRONGARGS=85
11
12 file="$1"        # Target filename.
13 lineno=1        # Line number. Start at 1.
14 Flag=$OFF       # Blank line flag.
15
16 if [ $# -ne "$ARGCOUNT" ]
17 then
18     echo "Usage: `basename $0` FILENAME"
19     exit $E_WRONGARGS
20 fi
21
22 file_read ()     # Scan file for pattern, then print line.
23 {
24 while read line
25 do
26
27     if [[ "$line" =~ ^[a-z] && $Flag -eq $ON ]]
28     then # Line begins with lowercase character, following blank line.
29         echo -n "$lineno::  "
30         echo "$line"
31     fi
32
33
34     if [[ "$line" =~ ^$ ]]
35     then # If blank line,
36         Flag=$ON #+ set flag.
37     else
38         Flag=$OFF
39     fi
40
41     ((lineno++))
42
43 done
44 } < $file # Redirect file into function's stdin.
45
46 file_read
47
48
49 exit $?
50
51
52 # -----
53 This is line one of an example paragraph, bla, bla, bla.
54 This is line two, and line three should follow on next line, but
55
56 there is a blank line separating the two parts of the paragraph.
57 # -----
58
59 Running this script on a file containing the above paragraph
60 yields:
61
62 4::  there is a blank line separating the two parts of the paragraph.
63
64
65 There will be additional output for all the other split paragraphs
66 in the target file.

```

Example A-36. Insertion sort

```

1 #!/bin/bash
2 # insertion-sort.bash: Insertion sort implementation in Bash
3 #
4 # Heavy use of Bash array features:
5 # (string) slicing, merging, etc
6 # URL: http://www.lugmen.org.ar/~jjo/jjotip/insertion-sort.bash.d
7 #
8 # Author: JuanJo Ciarlante <jjo@irrigacion.gov.ar>
9 # Lightly reformatted by ABS Guide author.
10 # License: GPLv2
11 # Used in ABS Guide with author's permission (thanks!).
12 #
13 # Test with: ./insertion-sort.bash -t
14 # Or: bash insertion-sort.bash -t
15 # The following *doesn't* work:
16 # sh insertion-sort.bash -t
17 # Why not? Hint: which Bash-specific features are disabled
18 #+ when running a script by 'sh script.sh'?
19 #
20 : ${DEBUG:=0} # Debug, override with: DEBUG=1 ./scriptname . . .
21 # Parameter substitution -- set DEBUG to 0 if not previously set.
22
23 # Global array: "list"
24 typeset -a list
25 # Load whitespace-separated numbers from stdin.
26 if [ "$1" = "-t" ]; then
27 DEBUG=1
28 read -a list <<( od -Ad -w24 -t u2 /dev/urandom ) # Random list.
29 # ^ ^ process substitution
30 else
31 read -a list
32 fi
33 numelem=${#list[*]}
34
35 # Shows the list, marking the element whose index is $1
36 #+ by surrounding it with the two chars passed as $2.
37 # Whole line prefixed with $3.
38 showlist()
39 {
40 echo "$3"${list[@]:0:$1} ${2:0:1}${list[$1]}${2:1:1} ${list[@]:$1+1};
41 }
42
43 # Loop _pivot_ -- from second element to end of list.
44 for(( i=1; i<numelem; i++ )) do
45 ((DEBUG))&&showlist i "[" " "
46 # From current _pivot_, back to first element.
47 for(( j=i; j; j-- )) do
48 # Search for the 1st elem. less than current "pivot" . . .
49 [[ "${list[j-1]}" -le "${list[i]}" ]] && break
50 done
51 (( i==j )) && continue ## No insertion was needed for this element.
52 # . . . Move list[i] (pivot) to the left of list[j]:
53 list=(${list[@]:0:j} ${list[i]} ${list[j]}\
54 # {0,j-1} {i} {j}
55 # ${list[@]:j+1:i-(j+1)} ${list[@]:i+1})
56 # {j+1,i-1} {i+1,last}
57 ((DEBUG))&&showlist j "<>" "*"
58 done
59
60
61 echo
62 echo "-----"
63 echo $'Result:\n'${list[@]}
64
65 exit $?

```

Example A-37. Standard Deviation

```
1 #!/bin/bash
2 # sd.sh: Standard Deviation
3
4 # The Standard Deviation indicates how consistent a set of data is.
5 # It shows to what extent the individual data points deviate from the
6 #+ arithmetic mean, i.e., how much they "bounce around" (or cluster).
7 # It is essentially the average deviation-distance of the
8 #+ data points from the mean.
9
10 # ===== #
11 # To calculate the Standard Deviation:
12 #
13 # 1 Find the arithmetic mean (average) of all the data points.
14 # 2 Subtract each data point from the arithmetic mean,
15 # and square that difference.
16 # 3 Add all of the individual difference-squares in # 2.
17 # 4 Divide the sum in # 3 by the number of data points.
18 # This is known as the "variance."
19 # 5 The square root of # 4 gives the Standard Deviation.
20 # ===== #
21
22 count=0 # Number of data points; global.
23 SC=9 # Scale to be used by bc. Nine decimal places.
24 E_DATAFILE=90 # Data file error.
25
26 # ----- Set data file -----
27 if [ ! -z "$1" ] # Specify filename as cmd-line arg?
28 then
29     datafile="$1" # ASCII text file,
30 else #+ one (numerical) data point per line!
31     datafile=sample.dat
32 fi # See example data file, below.
33
34 if [ ! -e "$datafile" ]
35 then
36     echo "\"$datafile\" does not exist!"
37     exit $E_DATAFILE
38 fi
39 # -----
40
41
42 arith_mean ()
43 {
44     local rt=0 # Running total.
45     local am=0 # Arithmetic mean.
46     local ct=0 # Number of data points.
47
48     while read value # Read one data point at a time.
49     do
50         rt=$(echo "scale=$SC; $rt + $value" | bc)
51         (( ct++ ))
52     done
53
54     am=$(echo "scale=$SC; $rt / $ct" | bc)
55
56     echo $am; return $ct # This function "returns" TWO values!
57 # Caution: This little trick will not work if $ct > 255!
58 # To handle a larger number of data points,
59 #+ simply comment out the "return $ct" above.
60 } <"$datafile" # Feed in data file.
```

```

61
62 sd ()
63 {
64     mean1=$1 # Arithmetic mean (passed to function).
65     n=$2     # How many data points.
66     sum2=0   # Sum of squared differences ("variance").
67     avg2=0   # Average of $sum2.
68     sdev=0   # Standard Deviation.
69
70     while read value # Read one line at a time.
71     do
72         diff=$(echo "scale=$SC; $mean1 - $value" | bc)
73         # Difference between arith. mean and data point.
74         dif2=$(echo "scale=$SC; $diff * $diff" | bc) # Squared.
75         sum2=$(echo "scale=$SC; $sum2 + $dif2" | bc) # Sum of squares.
76     done
77
78     avg2=$(echo "scale=$SC; $sum2 / $n" | bc) # Avg. of sum of squares.
79     sdev=$(echo "scale=$SC; sqrt($avg2)" | bc) # Square root =
80     echo $sdev # Standard Deviation.
81
82 } <"$datafile" # Rewinds data file.
83
84
85 # ===== #
86 mean=$(arith_mean); count=$? # Two returns from function!
87 std_dev=$(sd $mean $count)
88
89 echo
90 echo "Number of data points in \"$datafile\" = $count"
91 echo "Arithmetic mean (average) = $mean"
92 echo "Standard Deviation = $std_dev"
93 echo
94 # ===== #
95
96 exit
97
98 # This script could stand some drastic streamlining,
99 #+ but not at the cost of reduced legibility, please.
100
101
102 # ++++++ #
103 # A sample data file (sample1.dat):
104
105 # 18.35
106 # 19.0
107 # 18.88
108 # 18.91
109 # 18.64
110
111
112 # $ sh sd.sh sample1.dat
113
114 # Number of data points in "sample1.dat" = 5
115 # Arithmetic mean (average) = 18.756000000
116 # Standard Deviation = .235338054
117 # ++++++ #

```

Example A-38. A *pad* file generator for shareware authors

```

1 #!/bin/bash
2 # pad.sh

```

```

3
4 #####
5 #           PAD (xml) file creator
6 #+ Written by Mendel Cooper <thegrendel.abs@gmail.com>.
7 #+ Released to the Public Domain.
8 #
9 # Generates a "PAD" descriptor file for shareware
10 #+ packages, according to the specifications
11 #+ of the ASP.
12 # http://www.asp-shareware.org/pad
13 #####
14
15
16 # Accepts (optional) save filename as a command-line argument.
17 if [ -n "$1" ]
18 then
19     savefile=$1
20 else
21     savefile=save_file.xml           # Default save_file name.
22 fi
23
24
25 # ===== PAD file headers =====
26 HDR1="<?xml version=\"1.0\" encoding=\"Windows-1252\" ?>"
27 HDR2="<XML_DIZ_INFO>"
28 HDR3="<MASTER_PAD_VERSION_INFO>"
29 HDR4="\\t<MASTER_PAD_VERSION>1.15</MASTER_PAD_VERSION>"
30 HDR5="\\t<MASTER_PAD_INFO>Portable Application Description, or PAD
31 for short, is a data set that is used by shareware authors to
32 disseminate information to anyone interested in their software products.
33 To find out more go to http://www.asp-shareware.org/pad</MASTER_PAD_INFO>"
34 HDR6="</MASTER_PAD_VERSION_INFO>"
35 # =====
36
37
38 fill_in ()
39 {
40     if [ -z "$2" ]
41     then
42         echo -n "$1? "           # Get user input.
43     else
44         echo -n "$1 $2? "       # Additional query?
45     fi
46
47     read var                     # May paste to fill in field.
48                                 # This shows how flexible "read" can be.
49
50     if [ -z "$var" ]
51     then
52         echo -e "\\t\\t<$1 />" >>$savefile     # Indent with 2 tabs.
53         return
54     else
55         echo -e "\\t\\t<$1>$var</$1>" >>$savefile
56         return ${#var}           # Return length of input string.
57     fi
58 }
59
60 check_field_length () # Check length of program description fields.
61 {
62     # $1 = maximum field length
63     # $2 = actual field length
64     if [ "$2" -gt "$1" ]
65     then
66         echo "Warning: Maximum field length of $1 characters exceeded!"
67     fi
68 }

```

```
69
70 clear          # Clear screen.
71 echo "PAD File Creator"
72 echo "---- ---- ----"
73 echo
74
75 # Write File Headers to file.
76 echo $HDR1 >$savefile
77 echo $HDR2 >>$savefile
78 echo $HDR3 >>$savefile
79 echo -e $HDR4 >>$savefile
80 echo -e $HDR5 >>$savefile
81 echo $HDR6 >>$savefile
82
83
84 # Company_Info
85 echo "COMPANY INFO"
86 CO_HDR="Company_Info"
87 echo "<$CO_HDR>" >>$savefile
88
89 fill_in Company_Name
90 fill_in Address_1
91 fill_in Address_2
92 fill_in City_Town
93 fill_in State_Province
94 fill_in Zip_Postal_Code
95 fill_in Country
96
97 # If applicable:
98 # fill_in ASP_Member "[Y/N]"
99 # fill_in ASP_Member_Number
100 # fill_in ESC_Member "[Y/N]"
101
102 fill_in Company_WebSite_URL
103
104 clear          # Clear screen between sections.
105
106 # Contact_Info
107 echo "CONTACT INFO"
108 CONTACT_HDR="Contact_Info"
109 echo "<$CONTACT_HDR>" >>$savefile
110 fill_in Author_First_Name
111 fill_in Author_Last_Name
112 fill_in Author_Email
113 fill_in Contact_First_Name
114 fill_in Contact_Last_Name
115 fill_in Contact_Email
116 echo -e "\t</$CONTACT_HDR>" >>$savefile
117 # END Contact_Info
118
119 clear
120
121 # Support_Info
122 echo "SUPPORT INFO"
123 SUPPORT_HDR="Support_Info"
124 echo "<$SUPPORT_HDR>" >>$savefile
125 fill_in Sales_Email
126 fill_in Support_Email
127 fill_in General_Email
128 fill_in Sales_Phone
129 fill_in Support_Phone
130 fill_in General_Phone
131 fill_in Fax_Phone
132 echo -e "\t</$SUPPORT_HDR>" >>$savefile
133 # END Support_Info
134
```



```
135 echo "</\$CO_HDR>" >>$savefile
136 # END Company_Info
137
138 clear
139
140 # Program_Info
141 echo "PROGRAM INFO"
142 PROGRAM_HDR="Program_Info"
143 echo "<\$PROGRAM_HDR>" >>$savefile
144 fill_in Program_Name
145 fill_in Program_Version
146 fill_in Program_Release_Month
147 fill_in Program_Release_Day
148 fill_in Program_Release_Year
149 fill_in Program_Cost_Dollars
150 fill_in Program_Cost_Other
151 fill_in Program_Type "[Shareware/Freeware/GPL]"
152 fill_in Program_Release_Status "[Beta, Major Upgrade, etc.]"
153 fill_in Program_Install_Support
154 fill_in Program_OS_Support "[Win9x/Win2k/Linux/etc.]"
155 fill_in Program_Language "[English/Spanish/etc.]"
156
157 echo; echo
158
159 # File_Info
160 echo "FILE INFO"
161 FILEINFO_HDR="File_Info"
162 echo "<\$FILEINFO_HDR>" >>$savefile
163 fill_in Filename_Versioned
164 fill_in Filename_Previous
165 fill_in Filename_Generic
166 fill_in Filename_Long
167 fill_in File_Size_Bytes
168 fill_in File_Size_K
169 fill_in File_Size_MB
170 echo -e "\t</\$FILEINFO_HDR>" >>$savefile
171 # END File_Info
172
173 clear
174
175 # Expire_Info
176 echo "EXPIRE INFO"
177 EXPIRE_HDR="Expire_Info"
178 echo "<\$EXPIRE_HDR>" >>$savefile
179 fill_in Has_Expire_Info "Y/N"
180 fill_in Expire_Count
181 fill_in Expire_Based_On
182 fill_in Expire_Other_Info
183 fill_in Expire_Month
184 fill_in Expire_Day
185 fill_in Expire_Year
186 echo -e "\t</\$EXPIRE_HDR>" >>$savefile
187 # END Expire_Info
188
189 clear
190
191 # More Program_Info
192 echo "ADDITIONAL PROGRAM INFO"
193 fill_in Program_Change_Info
194 fill_in Program_Specific_Category
195 fill_in Program_Categories
196 fill_in Includes_JAVA_VM "[Y/N]"
197 fill_in Includes_VB_Runtime "[Y/N]"
198 fill_in Includes_DirectX "[Y/N]"
199 # END More Program_Info
200
```

```

201 echo "</$PROGRAM_HDR>" >>$savefile
202 # END Program_Info
203
204 clear
205
206 # Program Description
207 echo "PROGRAM DESCRIPTIONS"
208 PROGDESC_HDR="Program_Descriptions"
209 echo "<$PROGDESC_HDR>" >>$savefile
210
211 LANG="English"
212 echo "<$LANG>" >>$savefile
213
214 fill_in Keywords "[comma + space separated]"
215 echo
216 echo "45, 80, 250, 450, 2000 word program descriptions"
217 echo "(may cut and paste into field)"
218 # It would be highly appropriate to compose the following
219 #+ "Char_Desc" fields with a text editor,
220 #+ then cut-and-paste the text into the answer fields.
221 echo
222 echo "          |-----45 characters-----|"
223 fill_in Char_Desc_45
224 check_field_length 45 "$?"
225 echo
226 fill_in Char_Desc_80
227 check_field_length 80 "$?"
228
229 fill_in Char_Desc_250
230 check_field_length 250 "$?"
231
232 fill_in Char_Desc_450
233 fill_in Char_Desc_2000
234
235 echo "</$LANG>" >>$savefile
236 echo "</$PROGDESC_HDR>" >>$savefile
237 # END Program Description
238
239 clear
240 echo "Done."; echo; echo
241 echo "Save file is: \"'$savefile'\""
242
243 exit 0

```

Example A-39. A *man* page editor

```

1 #!/bin/bash
2 # maned.sh
3 # A rudimentary man page editor
4
5 # Version: 0.1 (Alpha, probably buggy)
6 # Author: Mendel Cooper <thegrendel.abs@gmail.com>
7 # Reldate: 16 June 2008
8 # License: GPL3
9
10
11 savefile=      # Global, used in multiple functions.
12 E_NOINPUT=90  # User input missing (error). May or may not be critical.
13
14 # ===== Markup Tags ===== #
15 TopHeader=".TH"
16 NameHeader=".SH NAME"

```

```

17 SyntaxHeader=".SH SYNTAX"
18 SynopsisHeader=".SH SYNOPSIS"
19 InstallationHeader=".SH INSTALLATION"
20 DescHeader=".SH DESCRIPTION"
21 OptHeader=".SH OPTIONS"
22 FilesHeader=".SH FILES"
23 EnvHeader=".SH ENVIRONMENT"
24 AuthHeader=".SH AUTHOR"
25 BugsHeader=".SH BUGS"
26 SeeAlsoHeader=".SH SEE ALSO"
27 BOLD=".B"
28 # Add more tags, as needed.
29 # See groff docs for markup meanings.
30 # ===== #
31
32 start ()
33 {
34 clear                # Clear screen.
35 echo "ManEd"
36 echo "-----"
37 echo
38 echo "Simple man page creator"
39 echo "Author: Mendel Cooper"
40 echo "License: GPL3"
41 echo; echo; echo
42 }
43
44 progname ()
45 {
46 echo -n "Program name? "
47 read name
48
49 echo -n "Manpage section? [Hit RETURN for default (\`1\`)] "
50 read section
51 if [ -z "$section" ]
52 then
53 section=1 # Most man pages are in section 1.
54 fi
55
56 if [ -n "$name" ]
57 then
58 savefile="$name"."$section" # Filename suffix = section.
59 echo -n "$1 " >>$savefile
60 name1=$(echo "$name" | tr a-z A-Z) # Change to uppercase,
61 #+ per man page convention.
62 echo -n "$name1" >>$savefile
63 else
64 echo "Error! No input." # Mandatory input.
65 exit $E_NOINPUT # Critical!
66 # Exercise: The script-abort if no filename input is a bit clumsy.
67 # Rewrite this section so a default filename is used
68 #+ if no input.
69 fi
70
71 echo -n " \`${section}\`" >>$savefile # Append, always append.
72
73 echo -n "Version? "
74 read ver
75 echo -n " \`${section} $ver \`" >>$savefile
76 echo >>$savefile
77
78 echo -n "Short description [0 - 5 words]? "
79 read sdesc
80 echo "$NameHeader" >>$savefile
81 echo "$BOLD" "$name" >>$savefile
82 echo "\- "$sdesc" >>$savefile

```

```

83
84 }
85
86 fill_in ()
87 { # This function more or less copied from "pad.sh" script.
88     echo -n "$2? "          # Get user input.
89     read var                # May paste (a single line only!) to fill in field.
90
91     if [ -n "$var" ]
92     then
93         echo "$1 " >>$savefile
94         echo -n "$var" >>$savefile
95     else                    # Don't append empty field to file.
96         return $E_NOINPUT  # Not critical here.
97     fi
98
99     echo >>$savefile
100
101 }
102
103
104 end ()
105 {
106 clear
107 echo -n "Would you like to view the saved man page (y/n)? "
108 read ans
109 if [ "$ans" = "n" -o "$ans" = "N" ]; then exit; fi
110 exec less "$savefile" # Exit script and hand off control to "less" ...
111                      #+ ... which formats for viewing man page source.
112 }
113
114
115 # ----- #
116 start
117 progname "$TopHeader"
118 fill_in "$SynopsisHeader" "Synopsis"
119 fill_in "$DescHeader" "Long description"
120 # May paste in *single line* of text.
121 fill_in "$OptHeader" "Options"
122 fill_in "$FilesHeader" "Files"
123 fill_in "$AuthHeader" "Author"
124 fill_in "$BugsHeader" "Bugs"
125 fill_in "$SeeAlsoHeader" "See also"
126 # fill_in "$OtherHeader" ... as necessary.
127 end # ... exit not needed.
128 # ----- #
129
130 # Note that the generated man page will usually
131 #+ require manual fine-tuning with a text editor.
132 # However, it's a distinct improvement upon
133 #+ writing man source from scratch
134 #+ or even editing a blank man page template.
135
136 # The main deficiency of the script is that it permits
137 #+ pasting only a single text line into the input fields.
138 # This may be a long, cobbled-together line, which groff
139 # will automatically wrap and hyphenate.
140 # However, if you want multiple (newline-separated) paragraphs,
141 #+ these must be inserted by manual text editing on the
142 #+ script-generated man page.
143 # Exercise (difficult): Fix this!
144
145 # This script is not nearly as elaborate as the
146 #+ full-featured "manedit" package
147 #+ http://freshmeat.net/projects/manedit/
148 #+ but it's much easier to use.

```

Example A-40. Petals Around the Rose

```
1 #!/bin/bash -i
2 # petals.sh
3
4 #####
5 # Petals Around the Rose                                     #
6 #                                                         #
7 # Version 0.1 Created by Sergey Rodin                       #
8 # Version 0.2 Modded by ABS Guide Author                   #
9 #                                                         #
10 # License: GPL3                                           #
11 # Used in ABS Guide with permission.                       #
12 # #####                                                  #
13
14 hits=0           # Correct guesses.
15 WIN=6           # Mastered the game.
16 ALMOST=5        # One short of mastery.
17 EXIT=exit       # Give up early?
18
19 RANDOM=$$       # Seeds the random number generator from PID of script.
20
21
22 # Bones (ASCII graphics for dice)
23 bone1[1]="|      |"
24 bone1[2]="|      o |"
25 bone1[3]="|      o |"
26 bone1[4]="| o    o |"
27 bone1[5]="| o    o |"
28 bone1[6]="| o    o |"
29 bone2[1]="|      o |"
30 bone2[2]="|      |"
31 bone2[3]="|      o |"
32 bone2[4]="|      |"
33 bone2[5]="|      o |"
34 bone2[6]="| o    o |"
35 bone3[1]="|      |"
36 bone3[2]="| o    |"
37 bone3[3]="| o    |"
38 bone3[4]="| o    o |"
39 bone3[5]="| o    o |"
40 bone3[6]="| o    o |"
41 bone="+-----+"
42
43
44
45 # Functions
46
47 instructions () {
48
49     clear
50     echo -n "Do you need instructions? (y/n) "; read ans
51     if [ "$ans" = "y" -o "$ans" = "Y" ]; then
52         clear
53         echo -e '\E[34;47m' # Blue type.
54
55     # "cat document"
56         cat <<INSTRUCTIONSZZZ
57 The name of the game is Petals Around the Rose,
58 and that name is significant.
59 Five dice will roll and you must guess the "answer" for each roll.
60 It will be zero or an even number.
```

```

61 After your guess, you will be told the answer for the roll, but . . .
62 that's ALL the information you will get.
63
64 Six consecutive correct guesses admits you to the
65 Fellowship of the Rose.
66 INSTRUCTIONSZZZ
67
68     echo -e "\033[0m"    # Turn off blue.
69     else clear
70 fi
71
72 }
73
74
75 fortune ()
76 {
77     RANGE=7
78     FLOOR=0
79     number=0
80     while [ "$number" -le $FLOOR ]
81     do
82         number=$RANDOM
83         let "number %= $RANGE"    # 1 - 6.
84     done
85
86     return $number
87 }
88
89
90
91 throw () { # Calculate each individual die.
92     fortune; B1=$?
93     fortune; B2=$?
94     fortune; B3=$?
95     fortune; B4=$?
96     fortune; B5=$?
97
98     calc () { # Function embedded within a function!
99         case "$1" in
100             3 ) rose=2;;
101             5 ) rose=4;;
102             * ) rose=0;;
103         esac    # Simplified algorithm.
104                 # Doesn't really get to the heart of the matter.
105         return $rose
106     }
107
108     answer=0
109     calc "$B1"; answer=$(expr $answer + $(echo $?))
110     calc "$B2"; answer=$(expr $answer + $(echo $?))
111     calc "$B3"; answer=$(expr $answer + $(echo $?))
112     calc "$B4"; answer=$(expr $answer + $(echo $?))
113     calc "$B5"; answer=$(expr $answer + $(echo $?))
114 }
115
116
117
118 game ()
119 { # Generate graphic display of dice throw.
120     throw
121     echo -e "\033[1m"    # Bold.
122     echo -e "\n"
123     echo -e "$bone\t$bone\t$bone\t$bone\t$bone"
124     echo -e \
125 "$ {bone1[$B1]}\t${bone1[$B2]}\t${bone1[$B3]}\t${bone1[$B4]}\t${bone1[$B5]}"
126     echo -e \

```

```

127 "${bone2[$B1]}\t${bone2[$B2]}\t${bone2[$B3]}\t${bone2[$B4]}\t${bone2[$B5]}"
128 echo -e \
129 "${bone3[$B1]}\t${bone3[$B2]}\t${bone3[$B3]}\t${bone3[$B4]}\t${bone3[$B5]}"
130 echo -e "$bone\t$bone\t$bone\t$bone\t$bone"
131 echo -e "\n\n\t\t"
132 echo -e "\033[0m" # Turn off bold.
133 echo -n "There are how many petals around the rose? "
134 }
135
136
137
138 # ===== #
139
140 instructions
141
142 while [ "$petal" != "$EXIT" ] # Main loop.
143 do
144     game
145     read petal
146     echo "$petal" | grep [0-9] >/dev/null # Filter response for digit.
147                                           # Otherwise just roll dice again.
148     if [ "$?" -eq 0 ] # If-loop #1.
149     then
150         if [ "$petal" == "$answer" ]; then # If-loop #2.
151             echo -e "\nCorrect. There are $petal petals around the rose.\n"
152             (( hits++ ))
153
154             if [ "$hits" -eq "$WIN" ]; then # If-loop #3.
155                 echo -e '\E[31;47m' # Red type.
156                 echo -e "\033[1m" # Bold.
157                 echo "You have unraveled the mystery of the Rose Petals!"
158                 echo "Welcome to the Fellowship of the Rose!!!"
159                 echo "(You are herewith sworn to secrecy.)"; echo
160                 echo -e "\033[0m" # Turn off red & bold.
161                 break # Exit!
162             else echo "You have $hits correct so far."; echo
163
164                 if [ "$hits" -eq "$ALMOST" ]; then
165                     echo "Just one more gets you to the heart of the mystery!"; echo
166                 fi
167
168                 fi # Close if-loop #3.
169
170             else
171                 echo -e "\nWrong. There are $answer petals around the rose.\n"
172                 hits=0 # Reset number of correct guesses.
173                 fi # Close if-loop #2.
174
175             echo -n "Hit ENTER for the next roll, or type \"exit\" to end. "
176             read
177             if [ "$REPLY" = "$EXIT" ]; then exit
178             fi
179
180             fi # Close if-loop #1.
181
182         clear
183     done # End of main (while) loop.
184
185 ###
186
187 exit $?
188
189 # Resources:
190 # -----
191 # 1) http://en.wikipedia.org/wiki/Petals\_Around\_the\_Rose
192 # (Wikipedia entry.)

```

```
193 # 2) http://www.borrett.id.au/computing/petals-bg.htm
194 #      (How Bill Gates coped with the Petals Around the Rose challenge.)
```

Example A-41. Quacky: a Perquackey-type word game

```
1 #!/bin/bash
2 # qky.sh
3
4 #####
5 # QUACKEY: a somewhat simplified version of Perquackey [TM]. #
6 # #
7 # Author: Mendel Cooper <thegrendel.abs@gmail.com> #
8 # version 0.1.02      03 May, 2008 #
9 # License: GPL3 #
10 #####
11
12 WLIST=/usr/share/dict/word.lst
13 #      ^^^^^^^^ Word list file found here.
14 # ASCII word list, one word per line, UNIX format.
15 # A suggested list is the script author's "yaw1" word list package.
16 # http://bash.deta.in/yaw1-0.3.2.tar.gz
17 # or
18 # http://ibiblio.org/pub/Linux/libs/yaw1-0.3.2.tar.gz
19
20 NONCONS=0      # Word not constructable from letter set.
21 CONS=1         # Constructable.
22 SUCCESS=0
23 NG=1
24 FAILURE=''
25 NULL=0         # Zero out value of letter (if found).
26 MINWLEN=3     # Minimum word length.
27 MAXCAT=5      # Maximum number of words in a given category.
28 PENALTY=200   # General-purpose penalty for unacceptable words.
29 total=
30 E_DUP=70      # Duplicate word error.
31
32 TIMEOUT=10    # Time for word input.
33
34 NVLET=10      # 10 letters for non-vulnerable.
35 VULET=13     # 13 letters for vulnerable (not yet implemented!).
36
37 declare -a Words
38 declare -a Status
39 declare -a Score=( 0 0 0 0 0 0 0 0 0 0 0 )
40
41
42 letters=( a n s r t m l k p r b c i d s i d z e w u e t f
43 e y e r e f e g t g h h i t r s c i t i d i j a t a o l a
44 m n a n o v n w o s e l n o s p a q e e r a b r s a o d s
45 t g t i t l u e u v n e o x y m r k )
46 # Letter distribution table shamelessly borrowed from "Wordy" game,
47 #+ ca. 1992, written by a certain fine fellow named Mendel Cooper.
48
49 declare -a LS
50
51 numelements=${#letters[@]}
52 randseed="$1"
53
54 instructions ()
55 {
56     clear
57     echo "Welcome to QUACKEY, the anagramming word construction game."; echo
```



```

58 echo -n "Do you need instructions? (y/n) "; read ans
59
60 if [ "$ans" = "y" -o "$ans" = "Y" ]; then
61     clear
62     echo -e '\E[31;47m' # Red foreground. '\E[34;47m' for blue.
63     cat <<INSTRUCTION1
64
65 QUACKEY is a variant of Perquackey [TM].
66 The rules are the same, but the scoring is simplified
67 and plurals of previously played words are allowed.
68 "Vulnerable" play is not yet implemented,
69 but it is otherwise feature-complete.
70
71 As the game begins, the player gets 10 letters.
72 The object is to construct valid dictionary words
73 of at least 3-letter length from the letterset.
74 Each word-length category
75 -- 3-letter, 4-letter, 5-letter, ... --
76 fills up with the fifth word entered,
77 and no further words in that category are accepted.
78
79 The penalty for too-short (two-letter), duplicate, unconstructable,
80 and invalid (not in dictionary) words is -200. The same penalty applies
81 to attempts to enter a word in a filled-up category.
82
83 INSTRUCTION1
84
85 echo -n "Hit ENTER for next page of instructions. "; read az1
86
87     cat <<INSTRUCTION2
88
89 The scoring mostly corresponds to classic Perquackey:
90 The first 3-letter word scores    60, plus 10 for each additional one.
91 The first 4-letter word scores   120, plus 20 for each additional one.
92 The first 5-letter word scores   200, plus 50 for each additional one.
93 The first 6-letter word scores   300, plus 100 for each additional one.
94 The first 7-letter word scores   500, plus 150 for each additional one.
95 The first 8-letter word scores   750, plus 250 for each additional one.
96 The first 9-letter word scores  1000, plus 500 for each additional one.
97 The first 10-letter word scores 2000, plus 2000 for each additional one.
98
99 Category completion bonuses are:
100 3-letter words    100
101 4-letter words    200
102 5-letter words    400
103 6-letter words    800
104 7-letter words   2000
105 8-letter words  10000
106 This is a simplification of the absurdly baroque Perquackey bonus
107 scoring system.
108
109 INSTRUCTION2
110
111 echo -n "Hit ENTER for final page of instructions. "; read az1
112
113     cat <<INSTRUCTION3
114
115
116 Hitting just ENTER for a word entry ends the game.
117
118 Individual word entry is timed to a maximum of 10 seconds.
119 *** Timing out on an entry ends the game. ***
120 Aside from that, the game is untimed.
121
122 -----
123 Game statistics are automatically saved to a file.

```

```

124 -----
125
126 For competitive ("duplicate") play, a previous letterset
127 may be duplicated by repeating the script's random seed,
128 command-line parameter \$.
129 For example, "qky 7633" specifies the letterset
130 c a d i f r h u s k ...
131 INSTRUCTION3
132
133     echo; echo -n "Hit ENTER to begin game. "; read az1
134
135         echo -e "\033[0m"      # Turn off red.
136     else clear
137     fi
138
139     clear
140
141 }
142
143
144
145 seed_random ()
146 {
147     if [ -n "$randseed" ]      # Seed random number generator.
148     then                        # Can specify random seed.
149     #   RANDOM="$randseed"     #+ for play in competitive mode.
150     echo "RANDOM seed set to "$randseed"
151     else
152     randseed="$$"              # Or get random seed from process ID.
153     echo "RANDOM seed not specified, set to Process ID of script ($$)."
154     fi
155
156     RANDOM="$randseed"
157
158     echo
159 }
160
161
162 get_letterset ()
163 {
164     element=0
165     echo -n "Letterset:"
166
167     for lset in $(seq $NVLET)
168     do # Pick random letters to fill out letterset.
169         LS[element]="${letters[${(RANDOM%numelements)}]}"
170         ((element++))
171     done
172
173     echo
174     echo "${LS[@]}"
175
176 }
177
178
179 add_word ()
180 {
181     wrd="\$1"
182     local idx=0
183
184     Status[0]=" "
185     Status[3]=" "
186     Status[4]=" "
187
188     while [ "${Words[idx]}" != ' ' ]
189     do

```

```

190     if [ "${Words[idx]}" = "$wrld" ]
191     then
192         Status[3]="Duplicate-word-PENALTY"
193         let "Score[0]= 0 - $PENALTY"
194         let "Score[1]-=$PENALTY"
195         return $E_DUP
196     fi
197
198     ((idx++))
199 done
200
201 Words[idx]="$wrld"
202 get_score
203
204 }
205
206 get_score()
207 {
208     local wlen=0
209     local score=0
210     local bonus=0
211     local first_word=0
212     local add_word=0
213     local numwords=0
214
215     wlen=${#wrld}
216     numwords=${Score[wlen]}
217     Score[2]=0
218     Status[4]="    # Initialize "bonus" to 0.
219
220     case "$wlen" in
221         3) first_word=60
222            add_word=10;;
223         4) first_word=120
224            add_word=20;;
225         5) first_word=200
226            add_word=50;;
227         6) first_word=300
228            add_word=100;;
229         7) first_word=500
230            add_word=150;;
231         8) first_word=750
232            add_word=250;;
233         9) first_word=1000
234            add_word=500;;
235         10) first_word=2000
236             add_word=2000;; # This category modified from original rules!
237     esac
238
239     ((Score[wlen]++))
240     if [ ${Score[wlen]} -eq $MAXCAT ]
241     then # Category completion bonus scoring simplified!
242         case $wlen in
243             3 ) bonus=100;;
244             4 ) bonus=200;;
245             5 ) bonus=400;;
246             6 ) bonus=800;;
247             7 ) bonus=2000;;
248             8 ) bonus=10000;;
249         esac # Needn't worry about 9's and 10's.
250         Status[4]="Category-$wlen-completion***BONUS***"
251         Score[2]=$bonus
252     else
253         Status[4]="    # Erase it.
254     fi
255

```

```

256
257     let "score = $first_word + $add_word * $numwords"
258     if [ "$numwords" -eq 0 ]
259     then
260         Score[0]=$score
261     else
262         Score[0]=$add_word
263     fi # All this to distinguish last-word score
264         #+ from total running score.
265     let "Score[1] += ${Score[0]}"
266     let "Score[1] += ${Score[2]}"
267
268 }
269
270
271
272 get_word ()
273 {
274     local wrd=''
275     read -t $TIMEOUT wrd # Timed read.
276     echo $wrdr
277 }
278
279 is_constructable ()
280 { # This is the most complex and difficult-to-write function.
281     local -a local_LS=( "${LS[@]}" ) # Local copy of letter set.
282     local is_found=0
283     local idx=0
284     local pos
285     local strlen
286     local local_word=( "$1" )
287     strlen=${#local_word}
288
289     while [ "$idx" -lt "$strlen" ]
290     do
291         is_found=$(expr index "${local_LS[*]}" "${local_word:idx:1}")
292         if [ "$is_found" -eq "$NONCONS" ] # Not constructable!
293         then
294             echo "$FAILURE"; return
295         else
296             ((pos = ($is_found - 1) / 2)) # Compensate for spaces betw. letters!
297             local_LS[pos]=$NULL # Zero out used letters.
298             ((idx++)) # Bump index.
299         fi
300     done
301
302     echo "$SUCCESS"
303     return
304 }
305
306 is_valid ()
307 { # Surprisingly easy to check if word in dictionary ...
308     fgrep -qw "$1" "$WLIST" # ... courtesy of 'grep' ...
309     echo $?
310 }
311
312 check_word ()
313 {
314     if [ -z "$1" ]
315     then
316         return
317     fi
318
319     Status[1]=""
320     Status[2]=""
321     Status[3]=""

```

```

322 Status[4]=" "
323
324 iscons=$(is_constructable "$1")
325 if [ "$iscons" ]
326 then
327     Status[1]="constructable"
328     v=$(is_valid "$1")
329     if [ "$v" -eq "$SUCCESS" ]
330     then
331         Status[2]="valid"
332         strlen=${#1}
333
334         if [ ${Score[strlen]} -eq "$MAXCAT" ] # Category full!
335         then
336             Status[3]="Category-$strlen-overflow-PENALTY"
337             return $NG
338         fi
339
340         case "$strlen" in
341             1 | 2 )
342                 Status[3]="Two-letter-word-PENALTY"
343                 return $NG;;
344             * )
345                 Status[3]=" "
346                 return $SUCCESS;;
347             esac
348         else
349             Status[3]="Not-valid-PENALTY"
350             return $NG
351         fi
352     else
353         Status[3]="Not-constructable-PENALTY"
354         return $NG
355     fi
356
357     ### FIXME: Streamline the above code block.
358
359 }
360
361
362 display_words ()
363 {
364     local idx=0
365     local wlen0
366
367     clear
368     echo "Letterset:  ${LS[@]}"
369     echo "Threes:     Fours:     Fives:     Sixes:     Sevens:     Eights:"
370     echo "-----"
371
372
373
374     while [ "${Words[idx]}" != '' ]
375     do
376         wlen0=${#Words[idx]}
377         case "$wlen0" in
378             3) ;;
379             4) echo -n "           " ;;
380             5) echo -n "         " ;;
381             6) echo -n "       " ;;
382             7) echo -n "     " ;;
383             8) echo -n "   " ;;
384         esac
385         echo "${Words[idx]}"
386         ((idx++))
387     done

```

```

388
389   ### FIXME: The word display is pretty crude.
390 }
391
392
393 play ()
394 {
395   word="Start game"   # Dummy word, to start ...
396
397   while [ "$word" ]   # If player just hits return (null word),
398   do                 #+ then game ends.
399     echo "$word: "${Status[@]}"
400     echo -n "Last score: [${Score[0]}]   TOTAL score: [${Score[1]}]:   Next word: "
401     total=${Score[1]}
402     word=$(get_word)
403     check_word "$word"
404
405     if [ "$?" -eq "$SUCCESS" ]
406     then
407       add_word "$word"
408     else
409       let "Score[0]= 0 - $PENALTY"
410       let "Score[1]-=$PENALTY"
411     fi
412
413     display_words
414   done   # Exit game.
415
416   ### FIXME: The play () function calls too many other functions.
417   ### This verges on "spaghetti code" !!!
418 }
419
420 end_of_game ()
421 { # Save and display stats.
422
423   #####Autosave#####
424   savefile=qky.save.$$
425   #           ^^ PID of script
426   echo `date` >> $savefile
427   echo "Letterset # $randseed (random seed) ">> $savefile
428   echo -n "Letterset: " >> $savefile
429   echo "${LS[@]}" >> $savefile
430   echo "-----" >> $savefile
431   echo "Words constructed:" >> $savefile
432   echo "${Words[@]}" >> $savefile
433   echo >> $savefile
434   echo "Score: $total" >> $savefile
435
436   echo "Statistics for this round saved in \"${savefile}\""
437   #####
438
439   echo "Score for this round: $total"
440   echo "Words:  ${Words[@]}"
441 }
442
443 # -----#
444 instructions
445 seed_random
446 get_letset
447 play
448 end_of_game
449 # -----#
450
451 exit $?
452
453 # TODO:

```

```

454 #
455 # 1) Clean up code!
456 # 2) Prettify the display_words () function (maybe with widgets?).
457 # 3) Improve the time-out ... maybe change to untimed entry,
458 #+ but with a time limit for the overall round.
459 # 4) An on-screen countdown timer would be nice.
460 # 5) Implement "vulnerable" mode of play for compatibility with classic
461 #+ version of the game.
462 # 6) Improve save-to-file capability (and maybe make it optional).
463 # 7) Fix bugs!!!
464
465 # For more info, reference:
466 # http://bash.deta.in/qky.README.html

```

Example A-42. Nim

```

1 #!/bin/bash
2 # nim.sh: Game of Nim
3
4 # Author: Mendel Cooper
5 # Reldate: 15 July 2008
6 # License: GPL3
7
8 ROWS=5      # Five rows of pegs (or matchsticks).
9 WON=91     # Exit codes to keep track of wins/losses.
10 LOST=92    # Possibly useful if running in batch mode.
11 QUIT=99
12 peg_msg=  # Peg/Pegs?
13 Rows=( 0 5 4 3 2 1 ) # Array holding play info.
14 # ${Rows[0]} holds total number of pegs, updated after each turn.
15 # Other array elements hold number of pegs in corresponding row.
16
17 instructions ()
18 {
19     clear
20     tput bold
21     echo "Welcome to the game of Nim."; echo
22     echo -n "Do you need instructions? (y/n) "; read ans
23
24     if [ "$ans" = "y" -o "$ans" = "Y" ]; then
25         clear
26         echo -e '\E[33;41m' # Yellow fg., over red bg.; bold.
27         cat <<INSTRUCTIONS
28
29 Nim is a game with roots in the distant past.
30 This particular variant starts with five rows of pegs.
31
32 1:  | | | | |
33 2:  | | | |
34 3:  | | |
35 4:  | |
36 5:  |
37
38 The number at the left identifies the row.
39
40 The human player moves first, and alternates turns with the bot.
41 A turn consists of removing at least one peg from a single row.
42 It is permissable to remove ALL the pegs from a row.
43 For example, in row 2, above, the player can remove 1, 2, 3, or 4 pegs.
44 The player who removes the last peg loses.
45
46 The strategy consists of trying to be the one who removes

```

```

47 the next-to-last peg(s), leaving the loser with the final peg.
48
49 To exit the game early, hit ENTER during your turn.
50 INSTRUCTIONS
51
52 echo; echo -n "Hit ENTER to begin game. "; read azx
53
54     echo -e "\033[0m"      # Restore display.
55     else tput sgr0; clear
56 fi
57
58 clear
59
60 }
61
62
63 tally_up ()
64 {
65     let "Rows[0] = ${Rows[1]} + ${Rows[2]} + ${Rows[3]} + ${Rows[4]} + \
66     ${Rows[5]}"      # Add up how many pegs remaining.
67 }
68
69
70 display ()
71 {
72     index=1  # Start with top row.
73     echo
74
75     while [ "$index" -le "$ROWS" ]
76     do
77         p=${Rows[index]}
78         echo -n "$index:  "      # Show row number.
79
80         # -----
81         # Two concurrent inner loops.
82
83         indent=$index
84         while [ "$indent" -gt 0 ]
85         do
86             echo -n " "          # Staggered rows.
87             ((indent--))        # Spacing between pegs.
88         done
89
90         while [ "$p" -gt 0 ]
91         do
92             echo -n "| "
93             ((p--))
94         done
95         # -----
96
97     echo
98     ((index++))
99     done
100
101     tally_up
102
103     rp=${Rows[0]}
104
105     if [ "$rp" -eq 1 ]
106     then
107         peg_msg=peg
108         final_msg="Game over."
109     else
110         # Game not yet over . . .
111         peg_msg=pegs
112         final_msg=""      # . . . So "final message" is blank.
113     fi

```



```

113
114 echo "      $rp $peg_msg remaining."
115 echo "      "$final_msg""
116
117
118 echo
119 }
120
121 player_move ()
122 {
123
124 echo "Your move:"
125
126 echo -n "Which row? "
127 while read idx
128 do
129     # Validity check, etc.
130
131     if [ -z "$idx" ] # Hitting return quits.
132     then
133         echo "Premature exit."; echo
134         tput sgr0 # Restore display.
135         exit $QUIT
136     fi
137
138     if [ "$idx" -gt "$ROWS" -o "$idx" -lt 1 ] # Bounds check.
139     then
140         echo "Invalid row number!"
141         echo -n "Which row? "
142     else
143         break
144     fi
145     # TODO:
146     # Add check for non-numeric input.
147     # Also, script crashes on input outside of range of long double.
148     # Fix this.
149 done
150
151 echo -n "Remove how many? "
152 while read num
153 do
154     # Validity check.
155
156     if [ -z "$num" ]
157     then
158         echo "Premature exit."; echo
159         tput sgr0 # Restore display.
160         exit $QUIT
161     fi
162
163     if [ "$num" -gt ${Rows[idx]} -o "$num" -lt 1 ]
164     then
165         echo "Cannot remove $num!"
166         echo -n "Remove how many? "
167     else
168         break
169     fi
170 done
171 # TODO:
172 # Add check for non-numeric input.
173 # Also, script crashes on input outside of range of long double.
174 # Fix this.
175 let "Rows[idx] -= $num"
176
177 display
178 tally_up

```

```

179
180 if [ ${Rows[0]} -eq 1 ]
181 then
182     echo "        Human wins!"
183     echo "        Congratulations!"
184     tput sgr0    # Restore display.
185     echo
186     exit $WON
187 fi
188
189 if [ ${Rows[0]} -eq 0 ]
190 then
191     # Snatching defeat from the jaws of victory . . .
192     echo "        Fool!"
193     echo "        You just removed the last peg!"
194     echo "        Bot wins!"
195     tput sgr0    # Restore display.
196     echo
197     exit $LOST
198 }
199
200
201 bot_move ()
202 {
203
204     row_b=0
205     while [[ $row_b -eq 0 || ${Rows[row_b]} -eq 0 ]]
206     do
207         row_b=$RANDOM          # Choose random row.
208         let "row_b %= $ROWS"
209     done
210
211
212     num_b=0
213     r0=${Rows[row_b]}
214
215     if [ "$r0" -eq 1 ]
216     then
217         num_b=1
218     else
219         let "num_b = $r0 - 1"
220         # Leave only a single peg in the row.
221     fi
222     # Not a very strong strategy,
223     #+ but probably a bit better than totally random.
224
225     let "Rows[row_b] -= $num_b"
226     echo -n "Bot: "
227     echo "Removing from row $row_b ... "
228
229     if [ "$num_b" -eq 1 ]
230     then
231         peg_msg=peg
232     else
233         peg_msg=pegs
234     fi
235
236     echo "        $num_b $peg_msg."
237
238     display
239     tally_up
240
241     if [ ${Rows[0]} -eq 1 ]
242     then
243         echo "        Bot wins!"
244         tput sgr0    # Restore display.
245         exit $WON

```

```

245 fi
246
247 }
248
249
250 # ===== #
251 instructions      # If human player needs them . . .
252 tput bold         # Bold characters for easier viewing.
253 display           # Show game board.
254
255 while [ true ]    # Main loop.
256 do                # Alternate human and bot turns.
257     player_move
258     bot_move
259 done
260 # ===== #
261
262 # Exercise:
263 # -----
264 # Improve the bot's strategy.
265 # There is, in fact, a Nim strategy that can force a win.
266 # See the Wikipedia article on Nim: http://en.wikipedia.org/wiki/Nim
267 # Recode the bot to use this strategy (rather difficult).
268
269 # Curiosities:
270 # -----
271 # Nim played a prominent role in Alain Resnais' 1961 New Wave film,
272 #+ Last Year at Marienbad.
273 #
274 # In 1978, Leo Christopherson wrote an animated version of Nim,
275 #+ Android Nim, for the TRS-80 Model I.

```

Example A-43. A command-line stopwatch

```

1 #!/bin/sh
2 # sw.sh
3 # A command-line Stopwatch
4
5 # Author: Pádraig Brady
6 # http://www.pixelbeat.org/scripts/sw
7 # (Minor reformatting by ABS Guide author.)
8 # Used in ABS Guide with script author's permission.
9 # Notes:
10 # This script starts a few processes per lap, in addition to
11 # the shell loop processing, so the assumption is made that
12 # this takes an insignificant amount of time compared to
13 # the response time of humans (~.1s) (or the keyboard
14 # interrupt rate (~.05s)).
15 # '?' for splits must be entered twice if characters
16 # (erroneously) entered before it (on the same line).
17 # '?' since not generating a signal may be slightly delayed
18 # on heavily loaded systems.
19 # Lap timings on ubuntu may be slightly delayed due to:
20 # https://bugs.launchpad.net/bugs/62511
21 # Changes:
22 # V1.0, 23 Aug 2005, Initial release
23 # V1.1, 26 Jul 2007, Allow both splits and laps from single invocation.
24 # Only start timer after a key is pressed.
25 # Indicate lap number
26 # Cache programs at startup so there is less error
27 # due to startup delays.
28 # V1.2, 01 Aug 2007, Work around `date` commands that don't have

```

```

29 #                 nanoseconds.
30 #                 Use stty to change interrupt keys to space for
31 #                 laps etc.
32 #                 Ignore other input as it causes problems.
33 #     V1.3, 01 Aug 2007, Testing release.
34 #     V1.4, 02 Aug 2007, Various tweaks to get working under ubuntu
35 #                 and Mac OS X.
36 #     V1.5, 27 Jun 2008, set LANG=C as got vague bug report about it.
37
38 export LANG=C
39
40 ulimit -c 0 # No coredumps from SIGQUIT.
41 trap '' TSTP # Ignore Ctrl-Z just in case.
42 save_tty=`stty -g` && trap "stty $save_tty" EXIT # Restore tty on exit.
43 stty quit ' ' # Space for laps rather than Ctrl-\.
44 stty eof '?' # ? for splits rather than Ctrl-D.
45 stty -echo # Don't echo input.
46
47 cache_progs() {
48     stty > /dev/null
49     date > /dev/null
50     grep . < /dev/null
51     (echo "import time" | python) 2> /dev/null
52     bc < /dev/null
53     sed '' < /dev/null
54     printf 'l' > /dev/null
55     /usr/bin/time false 2> /dev/null
56     cat < /dev/null
57 }
58 cache_progs # To minimise startup delay.
59
60 date +%s.%N | grep -qF 'N' && use_python=1 # If `date` lacks nanoseconds.
61 now() {
62     if [ "$use_python" ]; then
63         echo "import time; print time.time()" 2>/dev/null | python
64     else
65         printf "%.2f" `date +%s.%N`
66     fi
67 }
68
69 fmt_seconds() {
70     seconds=$1
71     mins=`echo $seconds/60 | bc`
72     if [ "$mins" != "0" ]; then
73         seconds=`echo "$seconds - ($mins*60)" | bc`
74         echo "$mins:$seconds"
75     else
76         echo "$seconds"
77     fi
78 }
79
80 total() {
81     end=`now`
82     total=`echo "$end - $start" | bc`
83     fmt_seconds $total
84 }
85
86 stop() {
87     [ "$lapped" ] && lap "$laptime" "display"
88     total
89     exit
90 }
91
92 lap() {
93     laptime=`echo "$l1" | sed -n 's/.*real[^\0-9.]*\(.*)/\1/p`
94     [ ! "$laptime" -o "$laptime" = "0.00" ] && return

```

```

95     # Signals too frequent.
96     laptotal=`echo $laptime+0$laptotal | bc`
97     if [ "$2" = "display" ]; then
98         lapcount=`echo 0$lapcount+1 | bc`
99         laptime=`fmt_seconds $laptotal`
100        echo $laptime "($lapcount)"
101        lapped="true"
102        laptotal="0"
103    fi
104 }
105
106 echo -n "Space for lap | ? for split | Ctrl-C to stop | Space to start...">&2
107
108 while true; do
109     trap true INT QUIT # Set signal handlers.
110     laptime=`/usr/bin/time -p 2>&1 cat >/dev/null`
111     ret=$?
112     trap '' INT QUIT # Ignore signals within this script.
113     if [ $ret -eq 1 -o $ret -eq 2 -o $ret -eq 130 ]; then # SIGINT = stop
114         [ ! "$start" ] && { echo >&2; exit; }
115         stop
116     elif [ $ret -eq 3 -o $ret -eq 131 ]; then # SIGQUIT = lap
117         if [ ! "$start" ]; then
118             start=`now` || exit 1
119             echo >&2
120             continue
121         fi
122         lap "$laptime" "display"
123     else # eof = split
124         [ ! "$start" ] && continue
125         total
126         lap "$laptime" # Update laptotal.
127     fi
128 done
129
130 exit $?

```

Example A-44. An all-purpose shell scripting homework assignment solution

```

1 #!/bin/bash
2 # homework.sh: All-purpose homework assignment solution.
3 # Author: M. Leo Cooper
4 # If you substitute your own name as author, then it is plagiarism,
5 #+ possibly a lesser sin than cheating on your homework!
6 # License: Public Domain
7
8 # This script may be turned in to your instructor
9 #+ in fulfillment of ALL shell scripting homework assignments.
10 # It's sparsely commented, but you, the student, can easily remedy that.
11 # The script author repudiates all responsibility!
12
13 DLA=1
14 P1=2
15 P2=4
16 P3=7
17 PP1=0
18 PP2=8
19 MAXL=9
20 E_LZY=99
21
22 declare -a L
23 L[0]="3 4 0 17 29 8 13 18 19 17 20 2 19 14 17 28"

```

```

24 L[1]="8 29 12 14 18 19 29 4 12 15 7 0 19 8 2 0 11 11 24 29 17 4 6 17 4 19"
25 L[2]="29 19 7 0 19 29 8 29 7 0 21 4 29 13 4 6 11 4 2 19 4 3"
26 L[3]="19 14 29 2 14 12 15 11 4 19 4 29 19 7 8 18 29"
27 L[4]="18 2 7 14 14 11 22 14 17 10 29 0 18 18 8 6 13 12 4 13 19 26"
28 L[5]="15 11 4 0 18 4 29 0 2 2 4 15 19 29 12 24 29 7 20 12 1 11 4 29"
29 L[6]="4 23 2 20 18 4 29 14 5 29 4 6 17 4 6 8 14 20 18 29"
30 L[7]="11 0 25 8 13 4 18 18 27"
31 L[8]="0 13 3 29 6 17 0 3 4 29 12 4 29 0 2 2 14 17 3 8 13 6 11 24 26"
32 L[9]="19 7 0 13 10 29 24 14 20 26"
33
34 declare -a \
35 alph=( A B C D E F G H I J K L M N O P Q R S T U V W X Y Z . , : ' ' )
36
37
38 pt_lt ()
39 {
40     echo -n "${alph[$1]}"
41     echo -n -e "\a"
42     sleep $DLA
43 }
44
45 b_r ()
46 {
47     echo -e '\E[31;48m\033[1m'
48 }
49
50 cr ()
51 {
52     echo -e "\a"
53     sleep $DLA
54 }
55
56 restore ()
57 {
58     echo -e '\033[0m'           # Bold off.
59     tput sgr0                 # Normal.
60 }
61
62
63 p_l ()
64 {
65     for ltr in $1
66     do
67         pt_lt "$ltr"
68     done
69 }
70
71 # -----
72 b_r
73
74 for i in $(seq 0 $MAXL)
75 do
76     p_l "${L[i]}"
77     if [[ "$i" -eq "$P1" || "$i" -eq "$P2" || "$i" -eq "$P3" ]]
78     then
79         cr
80     elif [[ "$i" -eq "$PP1" || "$i" -eq "$PP2" ]]
81     then
82         cr; cr
83     fi
84 done
85
86 restore
87 # -----
88
89 echo

```

```
90
91 exit $_LZY
92
93 # A typical example of an obfuscated script that is difficult
94 #+ to understand, and frustrating to maintain.
95 # In your career as a sysadmin, you'll run into these critters
96 #+ all too often.
```

Example A-45. The Knight's Tour

```
1 #!/bin/bash
2 # ktour.sh
3
4 # author: mendel cooper
5 # reldate: 12 Jan 2009
6 # license: public domain
7 # (Not much sense GPLing something that's pretty much in the common
8 #+ domain anyhow.)
9
10 #####
11 #           The Knight's Tour, a classic problem.           #
12 #           =====                                           #
13 # The knight must move onto every square of the chess board, #
14 # but cannot revisit any square he has already visited.     #
15 #                                                             #
16 # And just why is Sir Knight unwelcome for a return visit?  #
17 # Could it be that he has a habit of partying into the wee #
18 #+ hours of the morning?                                     #
19 # Possibly he leaves pizza crusts in the bed, empty beer #
20 #+ bottles all over the floor, and clogs the plumbing. . . . #
21 #                                                             #
22 # -----                                                    #
23 #                                                             #
24 # Usage: ktour.sh [start-square] [stupid]                    #
25 #                                                             #
26 # Note that start-square can be a square number              #
27 #+ in the range 0 - 63 ... or                               #
28 # a square designator in conventional chess notation,       #
29 # such as a1, f5, h3, etc.                                   #
30 #                                                             #
31 # If start-square-number not supplied,                       #
32 #+ then starts on a random square somewhere on the board.   #
33 #                                                             #
34 # "stupid" as second parameter sets the stupid strategy.    #
35 #                                                             #
36 # Examples:                                                  #
37 # ktour.sh 23           starts on square #23 (h3)           #
38 # ktour.sh g6 stupid   starts on square #46,                #
39 #                       using "stupid" (non-Warnsdorff) #
40 #                       strategy. #
41 #####
42 DEBUG=          # Set this to echo debugging info to stdout.
43 SUCCESS=0
44 FAIL=99
45 BADMOVE=-999
46 FAILURE=1
47 LINELEN=21 # How many moves to display per line.
48 # ----- #
49 # Board array params
50 ROWS=8 # 8 x 8 board.
51 COLS=8
52 let "SQUARES = $ROWS * $COLS"
```

```

53 let "MAX = $$SQUARES - 1"
54 MIN=0
55 # 64 squares on board, indexed from 0 to 63.
56
57 VISITED=1
58 UNVISITED=-1
59 UNVSYM="##"
60 # ----- #
61 # Global variables.
62 startpos=      # Starting position (square #, 0 - 63).
63 curpos=        # Current position.
64 movenum=       # Move number.
65 CRITPOS=37     # Have to patch for f5 starting position!
66
67 declare -i board
68 # Use a one-dimensional array to simulate a two-dimensional one.
69 # This can make life difficult and result in ugly kludges; see below.
70 declare -i moves # Offsets from current knight position.
71
72
73 initialize_board ()
74 {
75     local idx
76
77     for idx in {0..63}
78     do
79         board[$idx]=$UNVISITED
80     done
81 }
82
83
84
85 print_board ()
86 {
87     local idx
88
89     echo " _____"
90     for row in {7..0}          # Reverse order of rows ...
91     do                        #+ so it prints in chessboard order.
92         let "rownum = $row + 1" # Start numbering rows at 1.
93         echo -n "$rownum |"     # Mark board edge with border and
94         for column in {0..7}   #+ "algebraic notation."
95         do
96             let "idx = $ROWS*$row + $column"
97             if [ ${board[idx]} -eq $UNVISITED ]
98             then
99                 echo -n "$UNVSYM  " ##
100            else
101                # Mark square with move number.
102                printf "%02d " "${board[idx]}"; echo -n " "
103            fi
104        done
105        echo -e -n "\b\b\b\b|" # \b is a backspace.
106        echo # -e enables echoing escaped chars.
107    done
108    echo " -----"
109    echo "  a   b   c   d   e   f   g   h"
110 }
111
112
113
114 failure()
115 { # Whine, then bail out.
116     echo
117     print_board
118     echo

```



```

119 echo      "   Waah!!! Ran out of squares to move to!"
120 echo -n "   Knight's Tour attempt ended"
121 echo      " on $(to_algebraic $currpos) [square #${currpos}]"
122 echo      "   after just $movenum moves!"
123 echo
124 exit $FAIL
125 }
126
127
128
129 xlat_coords ()    # Translate x/y coordinates to board position
130 {                #+ (board-array element #).
131     # For user input of starting board position as x/y coords.
132     # This function not used in initial release of ktour.sh.
133     # May be used in an updated version, for compatibility with
134     #+ standard implementation of the Knight's Tour in C, Python, etc.
135     if [ -z "$1" -o -z "$2" ]
136     then
137         return $FAIL
138     fi
139
140     local xc=$1
141     local yc=$2
142
143     let "board_index = $xc * $ROWS + yc"
144
145     if [ $board_index -lt $MIN -o $board_index -gt $MAX ]
146     then
147         return $FAIL    # Strayed off the board!
148     else
149         return $board_index
150     fi
151 }
152
153
154
155 to_algebraic ()    # Translate board position (board-array element #)
156 {                #+ to standard algebraic notation used by chess players.
157     if [ -z "$1" ]
158     then
159         return $FAIL
160     fi
161
162     local element_no=$1    # Numerical board position.
163     local col_arr=( a b c d e f g h )
164     local row_arr=( 1 2 3 4 5 6 7 8 )
165
166     let "row_no = $element_no / $ROWS"
167     let "col_no = $element_no % $ROWS"
168     t1=${col_arr[col_no]}; t2=${row_arr[row_no]}
169     local apos=$t1$t2    # Concatenate.
170     echo $apos
171 }
172
173
174
175 from_algebraic ()    # Translate standard algebraic chess notation
176 {                #+ to numerical board position (board-array element #).
177     # Or recognize numerical input & return it unchanged.
178     if [ -z "$1" ]
179     then
180         return $FAIL
181     fi    # If no command-line arg, then will default to random start pos.
182
183     local ix
184     local ix_count=0

```

```

185 local b_index      # Board index [0-63]
186 local alpos="$1"
187
188 arow=${alpos:0:1} # position = 0, length = 1
189 acol=${alpos:1:1}
190
191 if [[ $arow =~ [[:digit:]] ]] # Numerical input?
192 then # POSIX char class
193     if [[ $acol =~ [[:alpha:]] ]] # Number followed by a letter? Illegal!
194     then return $FAIL
195     else if [ $alpos -gt $MAX ] # Off board?
196     then return $FAIL
197     else return $alpos # Return digit(s) unchanged . . .
198     fi #+ if within range.
199     fi
200 fi
201
202 if [[ $acol -eq $MIN || $acol -gt $ROWS ]]
203 then # Outside of range 1 - 8?
204     return $FAIL
205 fi
206
207 for ix in a b c d e f g h
208 do # Convert column letter to column number.
209     if [ "$arow" = "$ix" ]
210     then
211         break
212     fi
213     ((ix_count++)) # Find index count.
214 done
215
216 ((acol--)) # Decrementing converts to zero-based array.
217 let "b_index = $ix_count + $acol * $ROWS"
218
219 if [ $b_index -gt $MAX ] # Off board?
220 then
221     return $FAIL
222 fi
223
224 return $b_index
225
226 }
227
228
229 generate_moves () # Calculate all valid knight moves,
230 { #+ relative to current position ($1),
231     #+ and store in ${moves} array.
232     local kt_hop=1 # One square :: short leg of knight move.
233     local kt_skip=2 # Two squares :: long leg of knight move.
234     local valmov=0 # Valid moves.
235     local row_pos; let "row_pos = $1 % $COLS"
236
237
238     let "move1 = -$kt_skip + $ROWS" # 2 sideways to-the-left, 1 up
239     if [[ `expr $row_pos - $kt_skip` -lt $MIN ]] # An ugly, ugly kludge!
240     then # Can't move off board.
241         move1=$BADMOVE # Not even temporarily.
242     else
243         ((valmov++))
244     fi
245     let "move2 = -$kt_hop + $kt_skip * $ROWS" # 1 sideways to-the-left, 2 up
246     if [[ `expr $row_pos - $kt_hop` -lt $MIN ]] # Kludge continued ...
247     then
248         move2=$BADMOVE
249     else
250         ((valmov++))

```

```

251     fi
252     let "move3 = $kt_hop + $kt_skip * $ROWS" # 1 sideways to-the-right, 2 up
253     if [[ `expr $row_pos + $kt_hop` -ge $COLS ]]
254     then
255         move3=$BADMOVE
256     else
257         ((valmov++))
258     fi
259     let "move4 = $kt_skip + $ROWS" # 2 sideways to-the-right, 1 up
260     if [[ `expr $row_pos + $kt_skip` -ge $COLS ]]
261     then
262         move4=$BADMOVE
263     else
264         ((valmov++))
265     fi
266     let "move5 = $kt_skip - $ROWS" # 2 sideways to-the-right, 1 dn
267     if [[ `expr $row_pos + $kt_skip` -ge $COLS ]]
268     then
269         move5=$BADMOVE
270     else
271         ((valmov++))
272     fi
273     let "move6 = $kt_hop - $kt_skip * $ROWS" # 1 sideways to-the-right, 2 dn
274     if [[ `expr $row_pos + $kt_hop` -ge $COLS ]]
275     then
276         move6=$BADMOVE
277     else
278         ((valmov++))
279     fi
280     let "move7 = -$kt_hop - $kt_skip * $ROWS" # 1 sideways to-the-left, 2 dn
281     if [[ `expr $row_pos - $kt_hop` -lt $MIN ]]
282     then
283         move7=$BADMOVE
284     else
285         ((valmov++))
286     fi
287     let "move8 = -$kt_skip - $ROWS" # 2 sideways to-the-left, 1 dn
288     if [[ `expr $row_pos - $kt_skip` -lt $MIN ]]
289     then
290         move8=$BADMOVE
291     else
292         ((valmov++))
293     fi # There must be a better way to do this.
294
295     local m=( $valmov $move1 $move2 $move3 $move4 $move5 $move6 $move7 $move8 )
296     # ${moves[0]} = number of valid moves.
297     # ${moves[1]} ... ${moves[8]} = possible moves.
298     echo "${m[*]}" # Elements of array to stdout for capture in a var.
299
300 }
301
302
303
304 is_on_board () # Is position actually on the board?
305 {
306     if [[ "$1" -lt "$MIN" || "$1" -gt "$MAX" ]]
307     then
308         return $FAILURE
309     else
310         return $SUCCESS
311     fi
312 }
313
314
315
316 do_move () # Move the knight!

```

```

317 {
318     local valid_moves=0
319     local aapos
320     currposl="$1"
321     lmin=$ROWS
322     iex=0
323     squarel=
324     mpm=
325     mov=
326     declare -a p_moves
327
328     ##### DECIDE-MOVE #####
329     if [ $startpos -ne $CRITPOS ]
330     then # CRITPOS = square #37
331         decide_move
332     else # Needs a special patch for startpos=37 !!!
333         decide_move_patched # Why this particular move and no other ???
334     fi
335     #####
336
337     (( ++movenum )) # Increment move count.
338     let "square = $currposl + ${moves[iex]}"
339
340     ##### DEBUG #####
341     if [ "$DEBUG" ]
342     then debug # Echo debugging information.
343     fi
344     #####
345
346     if [[ "$square" -gt $MAX || "$square" -lt $MIN ||
347         ${board[square]} -ne $UNVISITED ]]
348     then
349         (( --movenum )) # Decrement move count,
350         echo "RAN OUT OF SQUARES!!!" #+ since previous one was invalid.
351         return $FAIL
352     fi
353
354     board[square]=$movenum
355     currpos=$square # Update current position.
356     ((valid_moves++)); # moves[0]=$valid_moves
357     aapos=$(to_algebraic $square)
358     echo -n "$aapos "
359     test $(( $Moves % $LINELEN )) -eq 0 && echo
360     # Print LINELEN=21 moves per line. A valid tour shows 3 complete lines.
361     return $valid_moves # Found a square to move to!
362 }
363
364
365
366 do_move_stupid() # Dingbat algorithm,
367 { #+ courtesy of script author, *not* Warnsdorff.
368     local valid_moves=0
369     local movloc
370     local squareloc
371     local aapos
372     local cposloc="$1"
373
374     for movloc in {1..8}
375     do # Move to first-found unvisited square.
376         let "squareloc = $cposloc + ${moves[movloc]}"
377         is_on_board $squareloc
378         if [ $? -eq $SUCCESS ] && [ ${board[squareloc]} -eq $UNVISITED ]
379         then # Add conditions to above if-test to improve algorithm.
380             (( ++movenum ))
381             board[squareloc]=$movenum
382             currpos=$squareloc # Update current position.

```

```

383     ((valid_moves++));      # moves[0]=$valid_moves
384     aapos=$(to_algebraic $squareloc)
385     echo -n "$aapos "
386     test $(( $Moves % $LINELEN )) -eq 0 && echo # Print 21 moves/line.
387     return $valid_moves    # Found a square to move to!
388 fi
389 done
390
391 return $FAIL
392 # If no square found in all 8 loop iterations,
393 #+ then Knight's Tour attempt ends in failure.
394
395 # Dingbat algorithm will typically fail after about 30 - 40 moves,
396 #+ but executes _much_ faster than Warnsdorff's in do_move() function.
397 }
398
399
400
401 decide_move ()             # Which move will we make?
402 {                         # But, fails on startpos=37 !!!
403     for mov in {1..8}
404     do
405         let "square1 = $currpos1 + ${moves[mov]}"
406         is_on_board $square1
407         if [[ $? -eq $SUCCESS && ${board[square1]} -eq $UNVISITED ]]
408         then # Find accessible square with least possible future moves.
409             # This is Warnsdorff's algorithm.
410             # What happens is that the knight wanders toward the outer edge
411             #+ of the board, then pretty much spirals inward.
412             # Given two or more possible moves with same value of
413             #+ least-possible-future-moves, this implementation chooses
414             #+ the _first_ of those moves.
415             # This means that there is not necessarily a unique solution
416             #+ for any given starting position.
417
418             possible_moves $square1
419             mpm=$?
420             p_moves[mov]=$mpm
421
422             if [ $mpm -lt $lmin ] # If less than previous minimum ...
423             then #      ^^
424                 lmin=$mpm      # Update minimum.
425                 iex=$mov        # Save index.
426             fi
427
428         fi
429     done
430 }
431
432
433
434 decide_move_patched ()    # Decide which move to make,
435 { #      ^^^^^^^         #+ but only if startpos=37 !!!
436     for mov in {1..8}
437     do
438         let "square1 = $currpos1 + ${moves[mov]}"
439         is_on_board $square1
440         if [[ $? -eq $SUCCESS && ${board[square1]} -eq $UNVISITED ]]
441         then
442             possible_moves $square1
443             mpm=$?
444             p_moves[mov]=$mpm
445
446             if [ $mpm -le $lmin ] # If less-than-or equal to prev. minimum!
447             then #      ^^
448                 lmin=$mpm

```

```

449     iex=$mov
450     fi
451
452     fi
453 done                                     # There has to be a better way to do this.
454 }
455
456
457
458 possible_moves ()                       # Calculate number of possible moves,
459 {                                       #+ given the current position.
460
461     if [ -z "$1" ]
462     then
463         return $FAIL
464     fi
465
466     local curr_pos=$1
467     local valid_movl=0
468     local icx=0
469     local movl
470     local sq
471     declare -a movesloc
472
473     movesloc=( $(generate_moves $curr_pos) )
474
475     for movl in {1..8}
476     do
477         let "sq = $curr_pos + ${movesloc[movl]}"
478         is_on_board $sq
479         if [ $? -eq $SUCCESS ] && [ ${board[sq]} -eq $UNVISITED ]
480         then
481             ((valid_movl++));
482         fi
483     done
484
485     return $valid_movl                   # Found a square to move to!
486 }
487
488
489 strategy ()
490 {
491     echo
492
493     if [ -n "$STUPID" ]
494     then
495         for Moves in {1..63}
496         do
497             cposl=$1
498             moves=( $(generate_moves $currpos) )
499             do_move_stupid "$currpos"
500             if [ $? -eq $FAIL ]
501             then
502                 failure
503             fi
504         done
505     fi
506
507     # Don't need an "else" clause here,
508     #+ because Stupid Strategy will always fail and exit!
509     for Moves in {1..63}
510     do
511         cposl=$1
512         moves=( $(generate_moves $currpos) )
513         do_move "$currpos"
514         if [ $? -eq $FAIL ]

```

```

515     then
516         failure
517     fi
518
519 done
520     # Could have condensed above two do-loops into a single one,
521     echo  +#+ but this would have slowed execution.
522
523 print_board
524     echo
525     echo "Knight's Tour ends on $(to_algebraic $currpos) [square #${currpos}]."
526     return $SUCCESS
527 }
528
529 debug ()
530 {     # Enable this by setting DEBUG=1 near beginning of script.
531     local n
532
533     echo "======"
534     echo "  At move number  $movenum:"
535     echo "  *** possible moves = $mpm ***"
536     # echo "### square = $square ###"
537     echo "lmin = $lmin"
538     echo "${moves[@]}"
539
540     for n in {1..8}
541     do
542         echo -n "($n):${p_moves[n]} "
543     done
544
545     echo
546     echo "iex = $iex :: moves[iex] = ${moves[iex]}"
547     echo "square = $square"
548     echo "======"
549     echo
550 } # Gives pretty complete status after ea. move.
551
552
553
554 # ===== #
555 # int main () {
556 from_algebraic "$1"
557 startpos=$?
558 if [ "$startpos" -eq "$FAIL" ]           # Okay even if no $1.
559 then #             ^^^^^^^^^^^^^             Okay even if input -lt 0.
560     echo "No starting square specified (or illegal input)."
```

```

581
582 echo; echo "Starting from $algpos [square #startpos] ..."; echo
583 echo -n "Moves:"
584
585 strategy "$currpos"
586
587 echo
588
589 exit 0 # return 0;
590
591 # } # End of main() pseudo-function.
592 # ===== #
593
594
595 # Exercises:
596 # -----
597 #
598 # 1) Extend this example to a 10 x 10 board or larger.
599 # 2) Improve the "stupid strategy" by modifying the
600 # do_move_stupid function.
601 # Hint: Prevent straying into corner squares in early moves
602 # (the exact opposite of Warnsdorff's algorithm!).
603 # 3) This script could stand considerable improvement and
604 # streamlining, especially in the poorly-written
605 # generate_moves() function
606 # and in the DECIDE-MOVE patch in the do_move() function.
607 # Must figure out why standard algorithm fails for startpos=37 ...
608 #+ but _not_ on any other, including symmetrical startpos=26.
609 # Possibly, when calculating possible moves, counts the move back
610 #+ to the originating square. If so, it might be a relatively easy fix.

```

Example A-46. Magic Squares

```

1 #!/bin/bash
2 # msquare.sh
3 # Magic Square generator (odd-order squares only!)
4
5 # Author: mendel cooper
6 # reldate: 19 Jan. 2009
7 # License: Public Domain
8 # A C-program by the very talented Kwon Young Shin inspired this script.
9 # http://user.chollian.net/~brainstm/MagicSquare.htm
10
11 # Definition: A "magic square" is a two-dimensional array
12 # of integers in which all the rows, columns,
13 # and *long* diagonals add up to the same number.
14 # Being "square," the array has the same number
15 # of rows and columns. That number is the "order."
16 # An example of a magic square of order 3 is:
17 # 8 1 6
18 # 3 5 7
19 # 4 9 2
20 # All the rows, columns, and the two long diagonals add up to 15.
21
22
23 # Globals
24 EVEN=2
25 MAXSIZE=31 # 31 rows x 31 cols.
26 E_usage=90 # Invocation error.
27 dimension=
28 declare -i square
29

```



```

30 usage_message ()
31 {
32     echo "Usage: $0 order"
33     echo "    ... where \"order\" (square size) is an ODD integer"
34     echo "        in the range 3 - 31."
35     # Actually works for squares up to order 159,
36     #+ but large squares will not display pretty-printed in a term window.
37     # Try increasing MAXSIZE, above.
38     exit $E_usage
39 }
40
41
42 calculate ()          # Here's where the actual work gets done.
43 {
44     local row col index dimadj j k cell_val=1
45     dimension=$1
46
47     let "dimadj = $dimension * 3"; let "dimadj /= 2"    # x 1.5, then truncate.
48
49     for ((j=0; j < dimension; j++))
50     do
51         for ((k=0; k < dimension; k++))
52         do # Calculate indices, then convert to 1-dim. array index.
53             # Bash doesn't support multidimensional arrays. Pity.
54             let "col = $k - $j + $dimadj"; let "col %= $dimension"
55             let "row = $j * 2 - $k + $dimension"; let "row %= $dimension"
56             let "index = $row*($dimension) + $col"
57             square[$index]=cell_val; ((cell_val++))
58         done
59     done
60 } # Plain math, visualization not required.
61
62
63 print_square ()      # Output square, one row at a time.
64 {
65     local row col idx d1
66     let "d1 = $dimension - 1"    # Adjust for zero-indexed array.
67
68     for row in $(seq 0 $d1)
69     do
70
71         for col in $(seq 0 $d1)
72         do
73             let "idx = $row * $dimension + $col"
74             printf "%3d " "${square[idx]}"; echo -n " "
75         done # Displays up to 13th order neatly in 80-column term window.
76
77         echo # Newline after each row.
78     done
79 }
80
81
82 #####
83 if [[ -z "$1" ]] || [[ "$1" -gt $MAXSIZE ]]
84 then
85     usage_message
86 fi
87
88 let "test_even = $1 % $EVEN"
89 if [ $test_even -eq 0 ]
90 then # Can't handle even-order squares.
91     usage_message
92 fi
93
94 calculate $1
95 print_square # echo "${square[@]}" # DEBUG

```

```

96
97 exit $?
98 #####
99
100
101 # Exercises:
102 # -----
103 # 1) Add a function to calculate the sum of each row, column,
104 #    and *long* diagonal. The sums must match.
105 #    This is the "magic constant" of that particular order square.
106 # 2) Have the print_square function auto-calculate how much space
107 #    to allot between square elements for optimized display.
108 #    This might require parameterizing the "printf" line.
109 # 3) Add appropriate functions for generating magic squares
110 #    with an *even* number of rows/columns.
111 #    This is non-trivial(!).
112 #    See the URL for Kwon Young Shin, above, for help.

```

Example A-47. Fifteen Puzzle

```

1 #!/bin/bash
2 # fifteen.sh
3
4 # Classic "Fifteen Puzzle"
5 # Author: Antonio Macchi
6 # Lightly edited and commented by ABS Guide author.
7 # Used in ABS Guide with permission. (Thanks!)
8
9 # The invention of the Fifteen Puzzle is attributed to either
10 #+ Sam Loyd or Noyes Palmer Chapman.
11 # The puzzle was wildly popular in the late 19th-century.
12
13 # Object: Rearrange the numbers so they read in order,
14 #+ from 1 - 15:
15 #      | 1  2  3  4 |
16 #      | 5  6  7  8 |
17 #      | 9 10 11 12 |
18 #      |13 14 15   |
19 #      -----
20
21
22 #####
23 # Constants #
24 SQUARES=16 #
25 FAIL=70 #
26 E_PREMATURE_EXIT=80 #
27 #####
28
29
30 #####
31 # Data #
32 #####
33
34 Puzzle=( 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 " " )
35
36
37 #####
38 # Functions #
39 #####
40
41 function swap
42 {

```

```

43  local tmp
44
45  tmp=${Puzzle[$1]}
46  Puzzle[$1]=${Puzzle[$2]}
47  Puzzle[$2]=$tmp
48 }
49
50
51 function Jumble
52 { # Scramble the pieces at beginning of round.
53  local i pos1 pos2
54
55  for i in {1..100}
56  do
57    pos1=$(( $RANDOM % $SQUARES))
58    pos2=$(( $RANDOM % $SQUARES ))
59    swap $pos1 $pos2
60  done
61 }
62
63
64 function PrintPuzzle
65 {
66  local i1 i2 puzpos
67  puzpos=0
68
69  clear
70  echo "Enter quit to exit."; echo # Better than Ctl-C.
71
72  echo ",----.----.----.----." # Top border.
73  for i1 in {1..4}
74  do
75    for i2 in {1..4}
76    do
77      printf "| %2s " "${Puzzle[$puzpos]}"
78      (( puzpos++ ))
79    done
80    echo "|" # Right-side border.
81    test $i1 = 4 || echo "+----+----+----+----+"
82  done
83  echo "'----'----'----'----'" # Bottom border.
84 }
85
86
87 function GetNum
88 { # Test for valid input.
89  local puznum garbage
90
91  while true
92  do
93    echo "Moves: $moves" # Also counts invalid moves.
94    read -p "Number to move: " puznum garbage
95    if [ "$puznum" = "quit" ]; then echo; exit $E_PREMATURE_EXIT; fi
96    test -z "$puznum" -o -n "${puznum//[0-9]/}" && continue
97    test $puznum -gt 0 -a $puznum -lt $SQUARES && break
98  done
99  return $puznum
100 }
101
102
103 function GetPosFromNum
104 { # $1 = puzzle-number
105  local puzpos
106
107  for puzpos in {0..15}
108  do

```

```

109     test "${Puzzle[$puzpos]}" = "$1" && break
110 done
111 return $puzpos
112 }
113
114
115 function Move
116 { # $1=Puzzle-pos
117     test $1 -gt 3 && test "${Puzzle[$(( $1 - 4 ))]}" = " "\
118         && swap $1 $(( $1 - 4 )) && return 0
119     test $(( $1%4 )) -ne 3 && test "${Puzzle[$(( $1 + 1 ))]}" = " "\
120         && swap $1 $(( $1 + 1 )) && return 0
121     test $1 -lt 12 && test "${Puzzle[$(( $1 + 4 ))]}" = " "\
122         && swap $1 $(( $1 + 4 )) && return 0
123     test $(( $1%4 )) -ne 0 && test "${Puzzle[$(( $1 - 1 ))]}" = " " &&\
124         swap $1 $(( $1 - 1 )) && return 0
125     return 1
126 }
127
128
129 function Solved
130 {
131     local pos
132
133     for pos in {0..14}
134     do
135         test "${Puzzle[$pos]}" = $(( $pos + 1 )) || return $FAIL
136         # Check whether number in each square = square number.
137     done
138     return 0    # Successful solution.
139 }
140
141
142 ##### MAIN () #####
143 moves=0
144 Jumble
145
146 while true    # Loop continuously until puzzle solved.
147 do
148     echo; echo
149     PrintPuzzle
150     echo
151     while true
152     do
153         GetNum
154         puznum=$?
155         GetPosFromNum $puznum
156         puzpos=$?
157         ((moves++))
158         Move $puzpos && break
159     done
160     Solved && break
161 done
162
163 echo;echo
164 PrintPuzzle
165 echo; echo "BRAVO!"; echo
166
167 exit 0
168 #####
169
170 # Exercise:
171 # -----
172 # Rewrite the script to display the letters A - O,
173 #+ rather than the numbers 1 - 15.

```

Example A-48. *The Towers of Hanoi, graphic version*

```
1 #! /bin/bash
2 # The Towers Of Hanoi
3 # Original script (hanoi.bash) copyright (C) 2000 Amit Singh.
4 # All Rights Reserved.
5 # http://hanoi.kernelthread.com
6
7 # hanoi2.bash
8 # Version 2.00: modded for ASCII-graphic display.
9 # Version 2.01: fixed no command-line param bug.
10 # Uses code contributed by Antonio Macchi,
11 #+ with heavy editing by ABS Guide author.
12 # This variant falls under the original copyright, see above.
13 # Used in ABS Guide with Amit Singh's permission (thanks!).
14
15
16 ### Variables && sanity check ###
17
18 E_NOPARAM=86
19 E_BADPARAM=87 # Illegal no. of disks passed to script.
20 E_NOEXIT=88
21
22 DISKS=${1:-$E_NOPARAM} # Must specify how many disks.
23 Moves=0
24
25 MWIDTH=7
26 MARGIN=2
27 # Arbitrary "magic" constants; work okay for relatively small # of disks.
28 # BASEWIDTH=51 # Original code.
29 let "basewidth = $MWIDTH * $DISKS + $MARGIN" # "Base" beneath rods.
30 # Above "algorithm" could likely stand improvement.
31
32 ### Display variables ###
33 let "disks1 = $DISKS - 1"
34 let "spaces1 = $DISKS"
35 let "spaces2 = 2 * $DISKS"
36
37 let "lastmove_t = $DISKS - 1" # Final move?
38
39
40 declare -a Rod1 Rod2 Rod3
41
42 ### #####
43
44
45 function repeat { # $1=char $2=number of repetitions
46     local n # Repeat-print a character.
47
48     for (( n=0; n<$2; n++ )); do
49         echo -n "$1"
50     done
51 }
52
53 function FromRod {
54     local rod summit weight sequence
55
56     while true; do
57         rod=$1
58         test ${rod/^[123]/} || continue
59
60         sequence=$(echo $(seq 0 $disks1 | tac))
```

```

61     for summit in $sequence; do
62         eval weight=\${Rod${rod}}[${summit}]
63         test $weight -ne 0 &&
64             { echo "$rod $summit $weight"; return; }
65     done
66 done
67 }
68
69
70 function ToRod { # $1=previous (FromRod) weight
71     local rod firstfree weight sequence
72
73     while true; do
74         rod=$2
75         test ${rod/[^123]} || continue
76
77         sequence=$(echo $(seq 0 $disks1 | tac))
78         for firstfree in $sequence; do
79             eval weight=\${Rod${rod}}[${firstfree}]
80             test $weight -gt 0 && { (( firstfree++ )); break; }
81         done
82         test $weight -gt $1 -o $firstfree = 0 &&
83             { echo "$rod $firstfree"; return; }
84     done
85 }
86
87
88 function PrintRods {
89     local disk rod empty fill sp sequence
90
91
92     repeat " " $spaces1
93     echo -n "|"
94     repeat " " $spaces2
95     echo -n "|"
96     repeat " " $spaces2
97     echo "|"
98
99     sequence=$(echo $(seq 0 $disks1 | tac))
100    for disk in $sequence; do
101        for rod in {1..3}; do
102            eval empty=$(( $DISKS - (Rod${rod}}[${disk}] / 2) ))
103            eval fill=\${Rod${rod}}[${disk}]
104            repeat " " $empty
105            test $fill -gt 0 && repeat "*" $fill || echo -n "|"
106            repeat " " $empty
107        done
108        echo
109    done
110    repeat "=" $basewidth    # Print "base" beneath rods.
111    echo
112 }
113
114
115 display ()
116 {
117     echo
118     PrintRods
119
120     # Get rod-number, summit and weight
121     first=( `FromRod $1` )
122     eval Rod${first[0]}[${first[1]}]=0
123
124     # Get rod-number and first-free position
125     second=( `ToRod ${first[2]} $2` )
126     eval Rod${second[0]}[${second[1]}]=${first[2]}

```

```

127
128
129 echo; echo; echo
130 if [ "${Rod3[lastmove_t]}" = 1 ]
131 then # Last move? If yes, then display final position.
132     echo "+ Final Position: $Moves moves"; echo
133     PrintRods
134 fi
135 }
136
137
138 # From here down, almost the same as original (hanoi.bash) script.
139
140 dohanoi() { # Recursive function.
141     case $1 in
142         0)
143             ;;
144         *)
145             dohanoi "$(($1-1))" $2 $4 $3
146             if [ "$Moves" -ne 0 ]
147             then
148                 echo "+ Position after move $Moves"
149                 fi
150                 ((Moves++))
151                 echo -n "    Next move will be: "
152                 echo $2 "-->" $3
153                 display $2 $3
154                 dohanoi "$(($1-1))" $4 $3 $2
155                 ;;
156         esac
157     }
158
159
160 setup_arrays ()
161 {
162     local dim n elem
163
164     let "dim1 = $1 - 1"
165     elem=$dim1
166
167     for n in $(seq 0 $dim1)
168     do
169         let "Rod1[$elem] = 2 * $n + 1"
170         Rod2[$n]=0
171         Rod3[$n]=0
172         ((elem--))
173     done
174 }
175
176
177 ### Main ###
178
179 setup_arrays $DISKS
180 echo; echo "+ Start Position"
181
182 case $# in
183     1) case $((($1>0)) in # Must have at least one disk.
184         1)
185             disks=$1
186             dohanoi $1 1 3 2
187 #             Total moves = 2^n - 1, where n = number of disks.
188             echo
189             exit 0;
190             ;;
191         *)
192             echo "$0: Illegal value for number of disks";

```

```

193         exit $E_BADPARAM;
194         ;;
195     esac
196     ;;
197 *)
198     clear
199     echo "usage: $0 N"
200     echo "      Where \"N\" is the number of disks."
201     exit $E_NOPARAM;
202     ;;
203 esac
204
205 exit $E_NOEXIT # Shouldn't exit here.
206
207 # Note:
208 # Redirect script output to a file, otherwise it scrolls off display.

```

Example A-49. *The Towers of Hanoi, alternate graphic version*

```

1 #! /bin/bash
2 # The Towers Of Hanoi
3 # Original script (hanoi.bash) copyright (C) 2000 Amit Singh.
4 # All Rights Reserved.
5 # http://hanoi.kernelthread.com
6
7 # hanoi2.bash
8 # Version 2: modded for ASCII-graphic display.
9 # Uses code contributed by Antonio Macchi,
10 #+ with heavy editing by ABS Guide author.
11 # This variant also falls under the original copyright, see above.
12 # Used in ABS Guide with Amit Singh's permission (thanks!).
13
14
15 # Variables #
16 E_NOPARAM=86
17 E_BADPARAM=87 # Illegal no. of disks passed to script.
18 E_NOEXIT=88
19 DELAY=2 # Interval, in seconds, between moves. Change, if desired.
20 DISKS=$1
21 Moves=0
22
23 MWIDTH=7
24 MARGIN=2
25 # Arbitrary "magic" constants, work okay for relatively small # of disks.
26 # BASEWIDTH=51 # Original code.
27 let "basewidth = $MWIDTH * $DISKS + $MARGIN" # "Base" beneath rods.
28 # Above "algorithm" could likely stand improvement.
29
30 # Display variables.
31 let "disks1 = $DISKS - 1"
32 let "spaces1 = $DISKS"
33 let "spaces2 = 2 * $DISKS"
34
35 let "lastmove_t = $DISKS - 1" # Final move?
36
37
38 declare -a Rod1 Rod2 Rod3
39
40 #####
41
42
43 function repeat { # $1=char $2=number of repetitions

```



```

44 local n          # Repeat-print a character.
45
46 for (( n=0; n<$2; n++ )); do
47     echo -n "$1"
48 done
49 }
50
51 function FromRod {
52     local rod summit weight sequence
53
54     while true; do
55         rod=$1
56         test ${rod/[^123]/} || continue
57
58         sequence=$(echo $(seq 0 $disks1 | tac))
59         for summit in $sequence; do
60             eval weight=\${Rod${rod}}[${summit}]
61             test $weight -ne 0 &&
62                 { echo "$rod $summit $weight"; return; }
63         done
64     done
65 }
66
67
68 function ToRod { # $1=previous (FromRod) weight
69     local rod firstfree weight sequence
70
71     while true; do
72         rod=$2
73         test ${rod/[^123]} || continue
74
75         sequence=$(echo $(seq 0 $disks1 | tac))
76         for firstfree in $sequence; do
77             eval weight=\${Rod${rod}}[${firstfree}]
78             test $weight -gt 0 && { (( firstfree++ )); break; }
79         done
80         test $weight -gt $1 -o $firstfree = 0 &&
81             { echo "$rod $firstfree"; return; }
82     done
83 }
84
85
86 function PrintRods {
87     local disk rod empty fill sp sequence
88
89     tput cup 5 0
90
91     repeat " " $spaces1
92     echo -n "|"
93     repeat " " $spaces2
94     echo -n "|"
95     repeat " " $spaces2
96     echo "|"
97
98     sequence=$(echo $(seq 0 $disks1 | tac))
99     for disk in $sequence; do
100         for rod in {1..3}; do
101             eval empty=$(( $DISKS - (Rod${rod}}[${disk}] / 2) )
102             eval fill=\${Rod${rod}}[${disk}]
103             repeat " " $empty
104             test $fill -gt 0 && repeat "*" $fill || echo -n "|"
105             repeat " " $empty
106         done
107     done
108 done
109 repeat "=" $basewidth # Print "base" beneath rods.

```

```

110 echo
111 }
112
113
114 display ()
115 {
116     echo
117     PrintRods
118
119     # Get rod-number, summit and weight
120     first=( `FromRod $1` )
121     eval Rod${first[0]}[${first[1]}]=0
122
123     # Get rod-number and first-free position
124     second=( `ToRod ${first[2]} $2` )
125     eval Rod${second[0]}[${second[1]}]=${first[2]}
126
127
128     if [ "${Rod3[lastmove_t]}" = 1 ]
129     then # Last move? If yes, then display final position.
130         tput cup 0 0
131         echo; echo "+ Final Position: $Moves moves"
132         PrintRods
133     fi
134
135     sleep $DELAY
136 }
137
138 # From here down, almost the same as original (hanoi.bash) script.
139
140 dohanoi() { # Recursive function.
141     case $1 in
142         0)
143             ;;
144         *)
145             dohanoi "$(($1-1))" $2 $4 $3
146             if [ "$Moves" -ne 0 ]
147             then
148                 tput cup 0 0
149                 echo; echo "+ Position after move $Moves"
150                 fi
151                 ((Moves++))
152                 echo -n " Next move will be: "
153                 echo $2 "-->" $3
154                 display $2 $3
155                 dohanoi "$(($1-1))" $4 $3 $2
156             ;;
157         esac
158 }
159
160 setup_arrays ()
161 {
162     local dim n elem
163
164     let "dim1 = $1 - 1"
165     elem=$dim1
166
167     for n in $(seq 0 $dim1)
168     do
169         let "Rod1[$elem] = 2 * $n + 1"
170         Rod2[$n]=0
171         Rod3[$n]=0
172         ((elem--))
173     done
174 }
175

```

```

176
177 ###   Main   ###
178
179 trap "tput cnorm" 0
180 tput civis
181 clear
182
183 setup_arrays $DISKS
184
185 tput cup 0 0
186 echo; echo "+ Start Position"
187
188 case $# in
189     1) case (($1>0)) in          # Must have at least one disk.
190         1)
191             disks=$1
192             dohanoi $1 1 3 2
193 #             Total moves = 2^n - 1, where n = # of disks.
194             echo
195             exit 0;
196             ;;
197         *)
198             echo "$0: Illegal value for number of disks";
199             exit $E_BADPARAM;
200             ;;
201     esac
202     ;;
203     *)
204         echo "usage: $0 N"
205         echo "           Where \"N\" is the number of disks."
206         exit $E_NOPARAM;
207     ;;
208 esac
209
210 exit $E_NOEXIT    # Shouldn't exit here.
211
212 # Exercise:
213 # -----
214 # There is a minor bug in the script that causes the display of
215 #+ the next-to-last move to be skipped.
216 #+ Fix this.

```

Example A-50. An alternate version of the [getopt-simple.sh](#) script

```

1 #!/bin/bash
2 # UseGetOpt.sh
3
4 # Author: Peggy Russell <prusselltechgroup@gmail.com>
5
6 UseGetOpt () {
7     declare inputOptions
8     declare -r E_OPTERR=85
9     declare -r ScriptName=${0##*/}
10    declare -r ShortOpts="adf:hlt"
11    declare -r LongOpts="aoption,debug,file:,,help,log,test"
12
13 DoSomething () {
14     echo "The function name is '${FUNCNAME}'"
15     # Recall that $FUNCNAME is an internal variable
16     #+ holding the name of the function it is in.
17 }
18

```

```

19 inputOptions=$(getopt -o "${ShortOpts}" --long \
20     "${LongOpts}" --name "${ScriptName}" -- "${@}")
21
22 if [[ ($? -ne 0) || ($# -eq 0) ]]; then
23     echo "Usage: ${ScriptName} [-dhlt] {OPTION...}"
24     exit $E_OPTERR
25 fi
26
27 eval set -- "${inputOptions}"
28
29 # Only for educational purposes. Can be removed.
30 #-----
31 echo "++ Test: Number of arguments: [$#]"
32 echo '++ Test: Looping through "$@"'
33 for a in "$@"; do
34     echo "  ++ [$a]"
35 done
36 #-----
37
38 while true; do
39     case "${1}" in
40         --aoption | -a) # Argument found.
41             echo "Option [$1]"
42             ;;
43
44         --debug | -d) # Enable informational messages.
45             echo "Option [$1] Debugging enabled"
46             ;;
47
48         --file | -f) # Check for optional argument.
49             case "$2" in
50                 #+ Double colon is optional argument.
51                 "") # Not there.
52                     echo "Option [$1] Use default"
53                     shift
54                     ;;
55                 *) # Got it
56                     echo "Option [$1] Using input [$2]"
57                     shift
58                     ;;
59             esac
60             DoSomething
61             ;;
62
63         --log | -l) # Enable Logging.
64             echo "Option [$1] Logging enabled"
65             ;;
66
67         --test | -t) # Enable testing.
68             echo "Option [$1] Testing enabled"
69             ;;
70
71         --help | -h)
72             echo "Option [$1] Display help"
73             break
74             ;;
75
76         --) # Done! $# is argument number for "--", $@ is "--"
77             echo "Option [$1] Dash Dash"
78             break
79             ;;
80
81         *)
82             echo "Major internal error!"
83             exit 8
84

```

```

85     ;;
86
87     esac
88     echo "Number of arguments: [$#]"
89     shift
90 done
91
92 shift
93 # Only for educational purposes. Can be removed.
94 #-----
95 echo "++ Test: Number of arguments after \"--\" is [$#] They are: [$@]"
96 echo '++ Test: Looping through "$@"'
97 for a in "$@"; do
98     echo "  ++ [$a]"
99 done
100 #-----
101
102 }
103
104 ##### M A I N #####
105 # If you remove "function UseGetOpt () {" and corresponding "}",
106 #+ you can uncomment the "exit 0" line below, and invoke this script
107 #+ with the various options from the command-line.
108 #-----
109 # exit 0
110
111 echo "Test 1"
112 UseGetOpt -f myfile one "two three" four
113
114 echo;echo "Test 2"
115 UseGetOpt -h
116
117 echo;echo "Test 3 - Short Options"
118 UseGetOpt -adltf myfile anotherfile
119
120 echo;echo "Test 4 - Long Options"
121 UseGetOpt --aoption --debug --log --test --file myfile anotherfile
122
123 exit

```

Example A-51. The version of the *UseGetOpt.sh* example used in the [Tab Expansion appendix](#)

```

1 #!/bin/bash
2
3 # UseGetOpt-2.sh
4 # Modified version of the script for illustrating tab-expansion
5 #+ of command-line options.
6 # See the "Introduction to Tab Expansion" appendix.
7
8 # Possible options: -a -d -f -l -t -h
9 #+ --aoption, --debug --file --log --test -- help --
10
11 # Author of original script: Peggy Russell <prusselltechgroup@gmail.com>
12
13
14 # UseGetOpt () {
15     declare inputOptions
16     declare -r E_OPTERR=85
17     declare -r ScriptName=${0##*/}
18     declare -r ShortOpts="adf:hlt"
19     declare -r LongOpts="aoption,debug,file:,help,log,test"
20

```

```

21 DoSomething () {
22     echo "The function name is '${FUNCNAME}'"
23 }
24
25 inputOptions=$(getopt -o "${ShortOpts}" --long \
26     "${LongOpts}" --name "${ScriptName}" -- "${@}")
27
28 if [[ ($? -ne 0) || ($# -eq 0) ]]; then
29     echo "Usage: ${ScriptName} [-dhlt] {OPTION...}"
30     exit $E_OPTERR
31 fi
32
33 eval set -- "${inputOptions}"
34
35
36 while true; do
37     case "${1}" in
38         --aoption | -a) # Argument found.
39             echo "Option [$1]"
40             ;;
41
42         --debug | -d) # Enable informational messages.
43             echo "Option [$1] Debugging enabled"
44             ;;
45
46         --file | -f) # Check for optional argument.
47             case "$2" in
48                 #+ Double colon is optional argument.
49                 "") # Not there.
50                     echo "Option [$1] Use default"
51                     shift
52                     ;;
53                 *) # Got it
54                     echo "Option [$1] Using input [$2]"
55                     shift
56                     ;;
57             esac
58             DoSomething
59             ;;
60
61         --log | -l) # Enable Logging.
62             echo "Option [$1] Logging enabled"
63             ;;
64
65         --test | -t) # Enable testing.
66             echo "Option [$1] Testing enabled"
67             ;;
68
69         --help | -h)
70             echo "Option [$1] Display help"
71             break
72             ;;
73
74         --) # Done! $# is argument number for "--", $@ is "--"
75             echo "Option [$1] Dash Dash"
76             break
77             ;;
78
79         *)
80             echo "Major internal error!"
81             exit 8
82             ;;
83     esac
84
85     echo "Number of arguments: [$#]"

```

```
87     shift
88     done
89
90     shift
91
92 #   }
93
94 exit
```

Example A-52. Cycling through all the possible color backgrounds

```
1 #!/bin/bash
2
3 # show-all-colors.sh
4 # Displays all 256 possible background colors, using ANSI escape sequences.
5 # Author: Chetankumar Phulpagare
6 # Used in ABS Guide with permission.
7
8 T1=8
9 T2=6
10 T3=36
11 offset=0
12
13 for num1 in {0..7}
14 do {
15     for num2 in {0,1}
16     do {
17         shownum=`echo "$offset + $T1 * ${num2} + $num1" | bc`
18         echo -en "\E[0;48;5;${shownum}m color ${shownum} \E[0m"
19     }
20     done
21     echo
22 }
23 done
24
25 offset=16
26 for num1 in {0..5}
27 do {
28     for num2 in {0..5}
29     do {
30         for num3 in {0..5}
31         do {
32             shownum=`echo "$offset + $T2 * ${num3} \
33             + $num2 + $T3 * ${num1}" | bc`
34             echo -en "\E[0;48;5;${shownum}m color ${shownum} \E[0m"
35         }
36         done
37         echo
38     }
39     done
40 }
41 done
42
43 offset=232
44 for num1 in {0..23}
45 do {
46     shownum=`expr $offset + $num1`
47     echo -en "\E[0;48;5;${shownum}m ${shownum}\E[0m"
48 }
49 done
50
51 echo
```

Example A-53. Morse Code Practice

```
1 #!/bin/bash
2 # sam.sh, v. .01a
3 # Still Another Morse (code training script)
4 # With profuse apologies to Sam (F.B.) Morse.
5 # Author: Mendel Cooper
6 # License: GPL3
7 # Reldate: 05/25/11
8
9 # Morse code training script.
10 # Converts arguments to audible dots and dashes.
11 # Note: lowercase input only at this time.
12
13
14
15 # Get the wav files from the source tarball:
16 # http://bash.deta.in/abs-guide-latest.tar.bz2
17 DOT='soundfiles/dot.wav'
18 DASH='soundfiles/dash.wav'
19 # Maybe move soundfiles to /usr/local/sounds?
20
21 LETTERSPACE=300000 # Microseconds.
22 WORDSPACE=980000
23 # Nice and slow, for beginners. Maybe 5 wpm?
24
25 EXIT_MSG="May the Morse be with you!"
26 E_NOARGS=75 # No command-line args?
27
28
29
30 declare -A morse # Associative array!
31 # ===== #
32 morse[a]="dot; dash"
33 morse[b]="dash; dot; dot; dot"
34 morse[c]="dash; dot; dash; dot"
35 morse[d]="dash; dot; dot"
36 morse[e]="dot"
37 morse[f]="dot; dot; dash; dot"
38 morse[g]="dash; dash; dot"
39 morse[h]="dot; dot; dot; dot"
40 morse[i]="dot; dot;"
41 morse[j]="dot; dash; dash; dash"
42 morse[k]="dash; dot; dash"
43 morse[l]="dot; dash; dot; dot"
44 morse[m]="dash; dash"
45 morse[n]="dash; dot"
46 morse[o]="dash; dash; dash"
47 morse[p]="dot; dash; dash; dot"
48 morse[q]="dash; dash; dot; dash"
49 morse[r]="dot; dash; dot"
50 morse[s]="dot; dot; dot"
51 morse[t]="dash"
52 morse[u]="dot; dot; dash"
53 morse[v]="dot; dot; dot; dash"
54 morse[w]="dot; dash; dash"
55 morse[x]="dash; dot; dot; dash"
56 morse[y]="dash; dot; dash; dash"
57 morse[z]="dash; dash; dot; dot"
58 morse[0]="dash; dash; dash; dash; dash"
59 morse[1]="dot; dash; dash; dash; dash"
60 morse[2]="dot; dot; dash; dash; dash"
```



```

61 morse[3]="dot; dot; dot; dash; dash"
62 morse[4]="dot; dot; dot; dot; dash"
63 morse[5]="dot; dot; dot; dot; dot"
64 morse[6]="dash; dot; dot; dot; dot"
65 morse[7]="dash; dash; dot; dot; dot"
66 morse[8]="dash; dash; dash; dot; dot"
67 morse[9]="dash; dash; dash; dash; dot"
68 # The following must be escaped or quoted.
69 morse[?]="dot; dot; dash; dash; dot; dot"
70 morse[.]="dot; dash; dot; dash; dot; dash"
71 morse[,]="dash; dash; dot; dot; dash; dash"
72 morse[/]="dash; dot; dot; dash; dot"
73 morse[\@]="dot; dash; dash; dot; dash; dot"
74 # ===== #
75
76 play_letter ()
77 {
78     eval ${morse[$1]} # Play dots, dashes from appropriate sound files.
79     # Why is 'eval' necessary here?
80     usleep $LETTERSPACE # Pause in between letters.
81 }
82
83 extract_letters ()
84 {
85     # Slice string apart, letter by letter.
86     local pos=0 # Starting at left end of string.
87     local len=1 # One letter at a time.
88     strlen=${#1}
89     while [ $pos -lt $strlen ]
90     do
91         letter=${1:pos:len}
92         # ^^^^^^^^^^^ See Chapter 10.1.
93         play_letter $letter
94         echo -n "*" # Mark letter just played.
95         ((pos++))
96     done
97 }
98
99 ##### Play the sounds #####
100 dot() { aplay "$DOT" 2>/dev/null; }
101 dash() { aplay "$DASH" 2>/dev/null; }
102 #####
103
104 no_args ()
105 {
106     declare -a usage
107     usage=( $0 word1 word2 ... )
108
109     echo "Usage:"; echo
110     echo ${usage[*]}
111     for index in 0 1 2 3
112     do
113         extract_letters ${usage[index]}
114         usleep $WORDSPACE
115         echo -n " " # Print space between words.
116     done
117     # echo "Usage: $0 word1 word2 ... "
118     echo; echo
119 }
120
121
122 # int main()
123 # {
124
125 clear # Clear the terminal screen.
126 echo " SAM"

```

```

127 echo "Still Another Morse code trainer"
128 echo "    Author: Mendel Cooper"
129 echo; echo;
130
131 if [ -z "$1" ]
132 then
133     no_args
134     echo; echo; echo "$EXIT_MSG"; echo
135     exit $E_NOARGS
136 fi
137
138 echo; echo "$*"          # Print text that will be played.
139
140 until [ -z "$1" ]
141 do
142     extract_letters $1
143     shift             # On to next word.
144     usleep $WORDSPACE
145     echo -n " "       # Print space between words.
146 done
147
148 echo; echo; echo "$EXIT_MSG"; echo
149
150 exit 0
151 # }
152
153 # Exercises:
154 # -----
155 # 1) Have the script accept either lowercase or uppercase words
156 #+   as arguments. Hint: Use 'tr' . . .
157 # 2) Have the script optionally accept input from a text file.

```

Example A-54. Base64 encoding/decoding

```

1 #!/bin/bash
2 # base64.sh: Bash implementation of Base64 encoding and decoding.
3 #
4 # Copyright (c) 2011 vladz <vladz@devzero.fr>
5 # Used in ABSG with permission (thanks!).
6 #
7 # Encode or decode original Base64 (and also Base64url)
8 #+ from STDIN to STDOUT.
9 #
10 # Usage:
11 #
12 # Encode
13 # $ ./base64.sh < binary-file > binary-file.base64
14 # Decode
15 # $ ./base64.sh -d < binary-file.base64 > binary-file
16 #
17 # Reference:
18 #
19 # [1] RFC4648 - "The Base16, Base32, and Base64 Data Encodings"
20 #     http://tools.ietf.org/html/rfc4648#section-5
21
22
23 # The base64_charset[] array contains entire base64 charset,
24 # and additionally the character "=" ...
25 base64_charset=( {A..Z} {a..z} {0..9} + / = )
26                 # Nice illustration of brace expansion.
27
28 # Uncomment the ### line below to use base64url encoding instead of

```

```

29 #+ original base64.
30 ### base64_charset=( {A..Z} {a..z} {0..9} - _ = )
31
32 # Output text width when encoding
33 #+ (64 characters, just like openssl output).
34 text_width=64
35
36 function display_base64_char {
37 # Convert a 6-bit number (between 0 and 63) into its corresponding values
38 #+ in Base64, then display the result with the specified text width.
39 printf "${base64_charset[$1]}"; (( width++ ))
40 (( width % text_width == 0 )) && printf "\n"
41 }
42
43 function encode_base64 {
44 # Encode three 8-bit hexadecimal codes into four 6-bit numbers.
45 # We need two local int array variables:
46 # c8[]: to store the codes of the 8-bit characters to encode
47 # c6[]: to store the corresponding encoded values on 6-bit
48 declare -a -i c8 c6
49
50 # Convert hexadecimal to decimal.
51 c8=( $(printf "ibase=16; ${1:0:2}\n${1:2:2}\n${1:4:2}\n" | bc) )
52
53 # Let's play with bitwise operators
54 #+ (3x8-bit into 4x6-bits conversion).
55 (( c6[0] = c8[0] >> 2 ))
56 (( c6[1] = ((c8[0] & 3) << 4) | (c8[1] >> 4) ))
57
58 # The following operations depend on the c8 element number.
59 case ${#c8[*]} in
60 3) (( c6[2] = ((c8[1] & 15) << 2) | (c8[2] >> 6) ))
61 (( c6[3] = c8[2] & 63 )) ;;
62 2) (( c6[2] = (c8[1] & 15) << 2 ))
63 (( c6[3] = 64 )) ;;
64 1) (( c6[2] = c6[3] = 64 )) ;;
65 esac
66
67 for char in ${c6[@]}; do
68 display_base64_char ${char}
69 done
70 }
71
72 function decode_base64 {
73 # Decode four base64 characters into three hexadecimal ASCII characters.
74 # c8[]: to store the codes of the 8-bit characters
75 # c6[]: to store the corresponding Base64 values on 6-bit
76 declare -a -i c8 c6
77
78 # Find decimal value corresponding to the current base64 character.
79 for current_char in ${1:0:1} ${1:1:1} ${1:2:1} ${1:3:1}; do
80 [ "${current_char}" = "=" ] && break
81
82 position=0
83 while [ "${current_char}" != "${base64_charset[${position}]}" ]; do
84 (( position++ ))
85 done
86
87 c6=( ${c6[*]} ${position} )
88 done
89
90 # Let's play with bitwise operators
91 #+ (4x8-bit into 3x6-bits conversion).
92 (( c8[0] = (c6[0] << 2) | (c6[1] >> 4) ))
93
94 # The next operations depends on the c6 elements number.

```

```

95 case ${#c6[*]} in
96   3) (( c8[1] = ( (c6[1] & 15) << 4) | (c6[2] >> 2) ))
97       (( c8[2] = (c6[2] & 3) << 6 )); unset c8[2] ;;
98   4) (( c8[1] = ( (c6[1] & 15) << 4) | (c6[2] >> 2) ))
99       (( c8[2] = ( (c6[2] & 3) << 6) | c6[3] )) ;;
100 esac
101
102 for char in ${c8[*]}; do
103   printf "\x$(printf "%x" ${char})"
104 done
105 }
106
107
108 # main ()
109
110 if [ "$1" = "-d" ]; then # decode
111
112   # Reformat STDIN in pseudo 4x6-bit groups.
113   content=$(cat - | tr -d "\n" | sed -r "s/(. {4})/\1 /g")
114
115   for chars in ${content}; do decode_base64 ${chars}; done
116
117 else
118   # Make a hexdump of stdin and reformat in 3-byte groups.
119   content=$(cat - | xxd -ps -u | sed -r "s/(\w{6})/\1 /g" |
120           tr -d "\n")
121
122   for chars in ${content}; do encode_base64 ${chars}; done
123
124   echo
125
126 fi

```

Example A-55. Inserting text in a file using *sed*

```

1 #!/bin/bash
2 # Prepends a string at a specified line
3 #+ in files with names ending in "sample"
4 #+ in the current working directory.
5 # 000000000000000000000000000000000000000000000000000
6 # This script overwrites files!
7 # Be careful running it in a directory
8 #+ where you have important files!!!
9 # 000000000000000000000000000000000000000000000000000
10
11 # Create a couple of files to operate on ...
12 # 01sample
13 # 02sample
14 # ... etc.
15 # These files must not be empty, else the prepend will not work.
16
17 lineno=1 # Append at line 1 (prepend).
18 filespec="*sample" # Filename pattern to operate on.
19
20 string=$(whoami) # Will set your username as string to insert.
21 # It could just as easily be any other string.
22
23 for file in $filespec # Specify which files to alter.
24 do # ^^^^^^^^
25   sed -i "$lineno"i "$string" $file
26 # ^^-i option edits files in-place.
27 # ^ Insert (i) command.

```

```

28 echo "$file" altered!"
29 done
30
31 echo "Warning: files possibly clobbered!"
32
33 exit 0
34
35 # Exercise:
36 # Add error checking to this script.
37 # It needs it badly.

```

Example A-56. The Gronsfeld Cipher

```

1 #!/bin/bash
2 # gronsfeld.bash
3
4 # License: GPL3
5 # Reldate 06/23/11
6
7 # This is an implementation of the Gronsfeld Cipher.
8 # It's essentially a stripped-down variant of the
9 #+ polyalphabetic Vigenère Tableau, but with only 10 alphabets.
10 # The classic Gronsfeld has a numeric sequence as the key word,
11 #+ but here we substitute a letter string, for ease of use.
12 # Allegedly, this cipher was invented by the eponymous Count Gronsfeld
13 #+ in the 17th Century. It was at one time considered to be unbreakable.
14 # Note that this is ###not### a secure cipher by modern standards.
15
16 # Global Variables #
17 Enc_suffix="29379" # Encrypted text output with this 5-digit suffix.
18 # This functions as a decryption flag,
19 #+ and when used to generate passwords adds security.
20 Default_key="gronsfeldk"
21 # The script uses this if key not entered below
22 # (at "Keychain").
23 # Change the above two values frequently
24 #+ for added security.
25
26 GROUPLLEN=5 # Output in groups of 5 letters, per tradition.
27 alpha1=( abcdefghijklmnopqrstuvwxyz )
28 alpha2=( {A..Z} ) # Output in all caps, per tradition.
29 # Use alpha2=( {a..z} ) for password generator.
30 wraplen=26 # Wrap around if past end of alphabet.
31 dflag= # Decrypt flag (set if $Enc_suffix present).
32 E_NOARGS=76 # Missing command-line args?
33 DEBUG=77 # Debugging flag.
34 declare -a offsets # This array holds the numeric shift values for
35 #+ encryption/decryption.
36
37 #####Keychain#####
38 key= ### Put key here!!!
39 # 10 characters!
40 #####
41
42
43
44 # Function
45 : ()
46 { # Encrypt or decrypt, depending on whether $dflag is set.
47 # Why ": ()" as a function name? Just to prove that it can be done.
48
49 local idx keydx mlen off1 shft

```

```

50 local plaintext="$1"
51 local mlen=${#plaintext}
52
53 for (( idx=0; idx<$mlen; idx++ ))
54 do
55     let "keydx = $idx % $keylen"
56     shft=${offsets[keydx]}
57
58     if [ -n "$dflag" ]
59     then
60         # Decrypt!
61         let "off1 = $(expr index "${alpha[*]}" ${plaintext:idx:1}) - $shft"
62         # Shift backward to decrypt.
63     else
64         # Encrypt!
65         let "off1 = $(expr index "${alpha[*]}" ${plaintext:idx:1}) + $shft"
66         # Shift forward to encrypt.
67         test $(( $idx % $GROUPLEN)) = 0 && echo -n " " # Groups of 5 letters.
68         # Comment out above line for output as a string without whitespace,
69         #+ for example, if using the script as a password generator.
70     fi
71
72     ((off1--)) # Normalize. Why is this necessary?
73
74     if [ $off1 -lt 0 ]
75     then
76         # Catch negative indices.
77         let "off1 += $wraplen"
78     fi
79
80     ((off1 %= $wraplen)) # Wrap around if past end of alphabet.
81
82     echo -n "${alpha2[off1]}"
83 done
84
85 if [ -z "$dflag" ]
86 then
87     echo " $Enc_suffix"
88 #     echo "$Enc_suffix" # For password generator.
89 else
90     echo
91 fi
92
93 } # End encrypt/decrypt function.
94
95 # int main () {
96 # Check for command-line args.
97 if [ -z "$1" ]
98 then
99     echo "Usage: $0 TEXT TO ENCODE/DECODE"
100    exit $E_NOARGS
101 fi
102
103 if [ ${!#} == "$Enc_suffix" ]
104 #     ^^^^ Final command-line arg.
105 then
106     dflag=ON
107     echo -n "+" # Flag decrypted text with a "+" for easy ID.
108 fi
109
110 if [ -z "$key" ]
111 then
112     key="$Default_key" # "gronsfeldk" per above.
113 fi
114
115 keylen=${#key}

```

```

116
117 for (( idx=0; idx<$keylen; idx++ ))
118 do # Calculate shift values for encryption/decryption.
119   offsets[idx]=${expr index "${alpha[*]}" ${key:idx:1}) # Normalize.
120   ((offsets[idx]--)) # Necessary because "expr index" starts at 1,
121                     #+ whereas array count starts at 0.
122   # Generate array of numerical offsets corresponding to the key.
123   # There are simpler ways to accomplish this.
124 done
125
126 args=$(echo "$*" | sed -e 's/ //g' | tr A-Z a-z | sed -e 's/[0-9]//g')
127 # Remove whitespace and digits from command-line args.
128 # Can modify to also remove punctuation characters, if desired.
129
130     # Debug:
131     # echo "$args"; exit $DEBUG
132
133 : "$args" # Call the function named ":".
134 # : is a null operator, except . . . when it's a function name!
135
136 exit $? # } End-of-script
137
138
139 # ***** #
140 # This script can function as a password generator,
141 #+ with several minor mods, see above.
142 # That would allow an easy-to-remember password, even the word
143 #+ "password" itself, which encrypts to vrgfotvo29379
144 #+ a fairly secure password not susceptible to a dictionary attack.
145 # Or, you could use your own name (surely that's easy to remember!).
146 # For example, Bozo Bozeman encrypts to hfnbttdppkt29379.
147 # ***** #

```

Example A-57. Bingo Number Generator

```

1 #!/bin/bash
2 # bingo.sh
3 # Bingo number generator
4 # ReIdate 20Aug12, License: Public Domain
5
6 #####
7 # This script generates bingo numbers.
8 # Hitting a key generates a new number.
9 # Hitting 'q' terminates the script.
10 # In a given run of the script, there will be no duplicate numbers.
11 # When the script terminates, it prints a log of the numbers generated.
12 #####
13
14 MIN=1 # Lowest allowable bingo number.
15 MAX=75 # Highest allowable bingo number.
16 COLS=15 # Numbers in each column (B I N G O).
17 SINGLE_DIGIT_MAX=9
18
19 declare -a Numbers
20 Prefix=(B I N G O)
21
22 initialize_Numbers ()
23 { # Zero them out to start.
24   # They'll be incremented if chosen.
25   local index=0
26   until [ "$index" -gt $MAX ]
27   do

```

```

28     Numbers[index]=0
29     ((index++))
30 done
31
32     Numbers[0]=1    # Flag zero, so it won't be selected.
33 }
34
35
36 generate_number ()
37 {
38     local number
39
40     while [ 1 ]
41     do
42         let "number = $(expr $RANDOM % $MAX)"
43         if [ ${Numbers[number]} -eq 0 ]    # Number not yet called.
44         then
45             let "Numbers[number]+=1"      # Flag it in the array.
46             break                        # And terminate loop.
47         fi    # Else if already called, loop and generate another number.
48     done
49     # Exercise: Rewrite this more elegantly as an until-loop.
50
51     return $number
52 }
53
54
55 print_numbers_called ()
56 {    # Print out the called number log in neat columns.
57     # echo ${Numbers[@]}
58
59     local pre2=0                # Prefix a zero, so columns will align
60                                 #+ on single-digit numbers.
61
62     echo "Number Stats"
63
64     for (( index=1; index<=MAX; index++))
65     do
66         count=${Numbers[index]}
67         let "t = $index - 1"    # Normalize, since array begins with index 0.
68         let "column = $(expr $t / $COLS)"
69         pre=${Prefix[column]}
70         # echo -n "${Prefix[column]} "
71
72         if [ $(expr $t % $COLS) -eq 0 ]
73         then
74             echo    # Newline at end of row.
75         fi
76
77         if [ "$index" -gt $SINGLE_DIGIT_MAX ] # Check for single-digit number.
78         then
79             echo -n "$pre$index#$count "
80         else    # Prefix a zero.
81             echo -n "$pre$pre2$index#$count "
82         fi
83     done
84 done
85 }
86
87
88
89 # main () {
90 RANDOM=$$    # Seed random number generator.
91
92 initialize_Numbers    # Zero out the number tracking array.
93

```



```

94 clear
95 echo "Bingo Number Caller"; echo
96
97 while [[ "$key" != "q" ]] # Main loop.
98 do
99     read -s -nl -p "Hit a key for the next number [q to exit] " key
100     # Usually 'q' exits, but not always.
101     # Can always hit Ctl-C if q fails.
102     echo
103
104     generate_number; new_number=$?
105
106     let "column = $(expr $new_number / $COLS)"
107     echo -n "${Prefix[column]} " # B-I-N-G-O
108
109     echo $new_number
110 done
111
112 echo; echo
113
114 # Game over ...
115 print_numbers_called
116 echo; echo "[#0 = not called . . . #1 = called]"
117
118 echo
119
120 exit 0
121 # }
122
123
124 # Certainly, this script could stand some improvement.
125 #See also the author's Instructable:
126 #www.instructables.com/id/Binguino-An-Arduino-based-Bingo-Number-Generato/

```

To end this section, a review of the basics . . . and more.

Example A-58. Basics Reviewed

```

1 #!/bin/bash
2 # basics-reviewed.bash
3
4 # File extension == *.bash == specific to Bash
5
6 # Copyright (c) Michael S. Zick, 2003; All rights reserved.
7 # License: Use in any form, for any purpose.
8 # Revision: $ID$
9 #
10 # Edited for layout by M.C.
11 # (author of the "Advanced Bash Scripting Guide")
12 # Fixes and updates (04/08) by Cliff Bamford.
13
14
15 # This script tested under Bash versions 2.04, 2.05a and 2.05b.
16 # It may not work with earlier versions.
17 # This demonstration script generates one --intentional--
18 #+ "command not found" error message. See line 436.
19
20 # The current Bash maintainer, Chet Ramey, has fixed the items noted
21 #+ for later versions of Bash.
22
23
24
25 #####-----###

```

```

26     ### Pipe the output of this script to 'more' ###
27     ###+ else it will scroll off the page.      ###
28     ###                                         ###
29     ### You may also redirect its output      ###
30     ###+ to a file for examination.          ###
31     ###-----###
32
33
34
35 # Most of the following points are described at length in
36 #+ the text of the foregoing "Advanced Bash Scripting Guide."
37 # This demonstration script is mostly just a reorganized presentation.
38 #     -- msz
39
40 # Variables are not typed unless otherwise specified.
41
42 # Variables are named. Names must contain a non-digit.
43 # File descriptor names (as in, for example: 2>&1)
44 #+ contain ONLY digits.
45
46 # Parameters and Bash array elements are numbered.
47 # (Parameters are very similar to Bash arrays.)
48
49 # A variable name may be undefined (null reference).
50 unset VarNull
51
52 # A variable name may be defined but empty (null contents).
53 VarEmpty='' # Two, adjacent, single quotes.
54
55 # A variable name may be defined and non-empty.
56 VarSomething='Literal'
57
58 # A variable may contain:
59 # * A whole number as a signed 32-bit (or larger) integer
60 # * A string
61 # A variable may also be an array.
62
63 # A string may contain embedded blanks and may be treated
64 #+ as if it were a function name with optional arguments.
65
66 # The names of variables and the names of functions
67 #+ are in different namespaces.
68
69
70 # A variable may be defined as a Bash array either explicitly or
71 #+ implicitly by the syntax of the assignment statement.
72 # Explicit:
73 declare -a ArrayVar
74
75
76
77 # The echo command is a builtin.
78 echo $VarSomething
79
80 # The printf command is a builtin.
81 # Translate %s as: String-Format
82 printf %s $VarSomething # No linebreak specified, none output.
83 echo # Default, only linebreak output.
84
85
86
87
88 # The Bash parser word breaks on whitespace.
89 # Whitespace, or the lack of it is significant.
90 # (This holds true in general; there are, of course, exceptions.)
91

```

```
92
93
94
95 # Translate the DOLLAR_SIGN character as: Content-Of.
96
97 # Extended-Syntax way of writing Content-Of:
98 echo ${VarSomething}
99
100 # The ${ ... } Extended-Syntax allows more than just the variable
101 #+ name to be specified.
102 # In general, $VarSomething can always be written as: ${VarSomething}.
103
104 # Call this script with arguments to see the following in action.
105
106
107
108 # Outside of double-quotes, the special characters @ and *
109 #+ specify identical behavior.
110 # May be pronounced as: All-Elements-Of.
111
112 # Without specification of a name, they refer to the
113 #+ pre-defined parameter Bash-Array.
114
115
116
117 # Glob-Pattern references
118 echo $* # All parameters to script or function
119 echo ${*} # Same
120
121 # Bash disables filename expansion for Glob-Patterns.
122 # Only character matching is active.
123
124
125 # All-Elements-Of references
126 echo $@ # Same as above
127 echo ${@} # Same as above
128
129
130
131
132 # Within double-quotes, the behavior of Glob-Pattern references
133 #+ depends on the setting of IFS (Input Field Separator).
134 # Within double-quotes, All-Elements-Of references behave the same.
135
136
137 # Specifying only the name of a variable holding a string refers
138 #+ to all elements (characters) of a string.
139
140
141 # To specify an element (character) of a string,
142 #+ the Extended-Syntax reference notation (see below) MAY be used.
143
144
145
146
147 # Specifying only the name of a Bash array references
148 #+ the subscript zero element,
149 #+ NOT the FIRST DEFINED nor the FIRST WITH CONTENTS element.
150
151 # Additional qualification is needed to reference other elements,
152 #+ which means that the reference MUST be written in Extended-Syntax.
153 # The general form is: ${name[subscript]}.
154
155 # The string forms may also be used: ${name:subscript}
156 #+ for Bash-Arrays when referencing the subscript zero element.
157
```

```

158
159 # Bash-Arrays are implemented internally as linked lists,
160 #+ not as a fixed area of storage as in some programming languages.
161
162
163 # Characteristics of Bash arrays (Bash-Arrays):
164 # -----
165
166 # If not otherwise specified, Bash-Array subscripts begin with
167 #+ subscript number zero. Literally: [0]
168 # This is called zero-based indexing.
169 ###
170 # If not otherwise specified, Bash-Arrays are subscript packed
171 #+ (sequential subscripts without subscript gaps).
172 ###
173 # Negative subscripts are not allowed.
174 ###
175 # Elements of a Bash-Array need not all be of the same type.
176 ###
177 # Elements of a Bash-Array may be undefined (null reference).
178 # That is, a Bash-Array may be "subscript sparse."
179 ###
180 # Elements of a Bash-Array may be defined and empty (null contents).
181 ###
182 # Elements of a Bash-Array may contain:
183 # * A whole number as a signed 32-bit (or larger) integer
184 # * A string
185 # * A string formatted so that it appears to be a function name
186 # + with optional arguments
187 ###
188 # Defined elements of a Bash-Array may be undefined (unset).
189 # That is, a subscript packed Bash-Array may be changed
190 # + into a subscript sparse Bash-Array.
191 ###
192 # Elements may be added to a Bash-Array by defining an element
193 #+ not previously defined.
194 ###
195 # For these reasons, I have been calling them "Bash-Arrays".
196 # I'll return to the generic term "array" from now on.
197 # -- msz
198
199
200 echo "=====
201
202 # Lines 202 - 334 supplied by Cliff Bamford. (Thanks!)
203 # Demo --- Interaction with Arrays, quoting, IFS, echo, * and @ ---
204 #+ all affect how things work
205
206 ArrayVar[0]='zero' # 0 normal
207 ArrayVar[1]=one # 1 unquoted literal
208 ArrayVar[2]='two' # 2 normal
209 ArrayVar[3]='three' # 3 normal
210 ArrayVar[4]='I am four' # 4 normal with spaces
211 ArrayVar[5]='five' # 5 normal
212 unset ArrayVar[6] # 6 undefined
213 ArrayValue[7]='seven' # 7 normal
214 ArrayValue[8]='' # 8 defined but empty
215 ArrayValue[9]='nine' # 9 normal
216
217
218 echo '--- Here is the array we are using for this test'
219 echo
220 echo "ArrayVar[0]='zero' # 0 normal"
221 echo "ArrayVar[1]=one # 1 unquoted literal"
222 echo "ArrayVar[2]='two' # 2 normal"
223 echo "ArrayVar[3]='three' # 3 normal"

```

```

224 echo "ArrayVar[4]='I am four'           # 4 normal with spaces"
225 echo "ArrayVar[5]='five'               # 5 normal"
226 echo "unset ArrayVar[6]               # 6 undefined"
227 echo "ArrayValue[7]='seven'           # 7 normal"
228 echo "ArrayValue[8]=''                 # 8 defined but empty"
229 echo "ArrayValue[9]='nine'           # 9 normal"
230 echo
231
232
233 echo
234 echo '---Case0: No double-quotes, Default IFS of space,tab,newline ---'
235 IFS=$'\x20'$'\x09'$'\x0A'           # In exactly this order.
236 echo 'Here is: printf %q "${ArrayVar[*]}"'
237 printf %q "${ArrayVar[*]}"
238 echo
239 echo 'Here is: printf %q "${ArrayVar[@]}"'
240 printf %q "${ArrayVar[@]}"
241 echo
242 echo 'Here is: echo "${ArrayVar[*]}"'
243 echo "${ArrayVar[@]}"
244 echo 'Here is: echo "${ArrayVar[@]}"'
245 echo "${ArrayVar[@]}"
246
247 echo
248 echo '---Case1: Within double-quotes - Default IFS of space-tab-
249 newline ---'
250 IFS=$'\x20'$'\x09'$'\x0A'           # These three bytes,
251 echo 'Here is: printf %q "${ArrayVar[*]}"'
252 printf %q "${ArrayVar[*]}"
253 echo
254 echo 'Here is: printf %q "${ArrayVar[@]}"'
255 printf %q "${ArrayVar[@]}"
256 echo
257 echo 'Here is: echo "${ArrayVar[*]}"'
258 echo "${ArrayVar[@]}"
259 echo 'Here is: echo "${ArrayVar[@]}"'
260 echo "${ArrayVar[@]}"
261
262 echo
263 echo '---Case2: Within double-quotes - IFS is q'
264 IFS='q'
265 echo 'Here is: printf %q "${ArrayVar[*]}"'
266 printf %q "${ArrayVar[*]}"
267 echo
268 echo 'Here is: printf %q "${ArrayVar[@]}"'
269 printf %q "${ArrayVar[@]}"
270 echo
271 echo 'Here is: echo "${ArrayVar[*]}"'
272 echo "${ArrayVar[@]}"
273 echo 'Here is: echo "${ArrayVar[@]}"'
274 echo "${ArrayVar[@]}"
275
276 echo
277 echo '---Case3: Within double-quotes - IFS is ^'
278 IFS='^'
279 echo 'Here is: printf %q "${ArrayVar[*]}"'
280 printf %q "${ArrayVar[*]}"
281 echo
282 echo 'Here is: printf %q "${ArrayVar[@]}"'
283 printf %q "${ArrayVar[@]}"
284 echo
285 echo 'Here is: echo "${ArrayVar[*]}"'
286 echo "${ArrayVar[@]}"
287 echo 'Here is: echo "${ArrayVar[@]}"'
288 echo "${ArrayVar[@]}"
289

```

```

290 echo
291 echo '---Case4: Within double-quotes - IFS is ^ followed by
292 space,tab,newline'
293 IFS=$'\x20'\x09'\x0A'          # ^ + space tab newline
294 echo 'Here is: printf %q "${ArrayVar[*]}"'
295 printf %q "${ArrayVar[*]}"
296 echo
297 echo 'Here is: printf %q "${ArrayVar[@]}"'
298 printf %q "${ArrayVar[@]}"
299 echo
300 echo 'Here is: echo "${ArrayVar[*]}"'
301 echo "${ArrayVar[@]}"
302 echo 'Here is: echo "${ArrayVar[@]}"'
303 echo "${ArrayVar[@]}"
304
305 echo
306 echo '---Case6: Within double-quotes - IFS set and empty '
307 IFS=' '
308 echo 'Here is: printf %q "${ArrayVar[*]}"'
309 printf %q "${ArrayVar[*]}"
310 echo
311 echo 'Here is: printf %q "${ArrayVar[@]}"'
312 printf %q "${ArrayVar[@]}"
313 echo
314 echo 'Here is: echo "${ArrayVar[*]}"'
315 echo "${ArrayVar[@]}"
316 echo 'Here is: echo "${ArrayVar[@]}"'
317 echo "${ArrayVar[@]}"
318
319 echo
320 echo '---Case7: Within double-quotes - IFS is unset'
321 unset IFS
322 echo 'Here is: printf %q "${ArrayVar[*]}"'
323 printf %q "${ArrayVar[*]}"
324 echo
325 echo 'Here is: printf %q "${ArrayVar[@]}"'
326 printf %q "${ArrayVar[@]}"
327 echo
328 echo 'Here is: echo "${ArrayVar[*]}"'
329 echo "${ArrayVar[@]}"
330 echo 'Here is: echo "${ArrayVar[@]}"'
331 echo "${ArrayVar[@]}"
332
333 echo
334 echo '---End of Cases---'
335 echo "====="; echo
336
337
338
339 # Put IFS back to the default.
340 # Default is exactly these three bytes.
341 IFS=$'\x20'\x09'\x0A'          # In exactly this order.
342
343 # Interpretation of the above outputs:
344 #   A Glob-Pattern is I/O; the setting of IFS matters.
345 ###
346 #   An All-Elements-Of does not consider IFS settings.
347 ###
348 #   Note the different output using the echo command and the
349 #+ quoted format operator of the printf command.
350
351
352 # Recall:
353 #   Parameters are similar to arrays and have the similar behaviors.
354 ###
355 #   The above examples demonstrate the possible variations.

```

```

356 # To retain the shape of a sparse array, additional script
357 #+ programming is required.
358 ###
359 # The source code of Bash has a routine to output the
360 #+ [subscript]=value array assignment format.
361 # As of version 2.05b, that routine is not used,
362 #+ but that might change in future releases.
363
364
365
366 # The length of a string, measured in non-null elements (characters):
367 echo
368 echo '- - Non-quoted references - -'
369 echo 'Non-Null character count: '${#VarSomething}' characters.'
370
371 # test='Lit'$'\x00'eral' # '$'\x00' is a null character.
372 # echo ${#test} # See that?
373
374
375
376 # The length of an array, measured in defined elements,
377 #+ including null content elements.
378 echo
379 echo 'Defined content count: '${#ArrayVar[@]}' elements.'
380 # That is NOT the maximum subscript (4).
381 # That is NOT the range of the subscripts (1 . . 4 inclusive).
382 # It IS the length of the linked list.
383 ###
384 # Both the maximum subscript and the range of the subscripts may
385 #+ be found with additional script programming.
386
387 # The length of a string, measured in non-null elements (characters):
388 echo
389 echo '- - Quoted, Glob-Pattern references - -'
390 echo 'Non-Null character count: '"${#VarSomething}"' characters.'
391
392 # The length of an array, measured in defined elements,
393 #+ including null-content elements.
394 echo
395 echo 'Defined element count: '"${#ArrayVar[*]}"' elements.'
396
397 # Interpretation: Substitution does not effect the ${# ... } operation.
398 # Suggestion:
399 # Always use the All-Elements-Of character
400 #+ if that is what is intended (independence from IFS).
401
402
403
404 # Define a simple function.
405 # I include an underscore in the name
406 #+ to make it distinctive in the examples below.
407 ###
408 # Bash separates variable names and function names
409 #+ in different namespaces.
410 # The Mark-One eyeball isn't that advanced.
411 ###
412 _simple() {
413     echo -n 'SimpleFunc'$@ # Newlines are swallowed in
414 } #+ result returned in any case.
415
416
417 # The ( ... ) notation invokes a command or function.
418 # The $( ... ) notation is pronounced: Result-Of.
419
420
421 # Invoke the function _simple

```

```

422 echo
423 echo '- - Output of function _simple - -'
424 _simple                # Try passing arguments.
425 echo
426 # or
427 (_simple)              # Try passing arguments.
428 echo
429
430 echo '- Is there a variable of that name? -'
431 echo $_simple not defined      # No variable by that name.
432
433 # Invoke the result of function _simple (Error msg intended)
434
435 ###
436 $_simple                # Gives an error message:
437 #                      line 436: SimpleFunc: command not found
438 #                      -----
439
440 echo
441 ###
442
443 # The first word of the result of function _simple
444 #+ is neither a valid Bash command nor the name of a defined function.
445 ###
446 # This demonstrates that the output of _simple is subject to evaluation.
447 ###
448 # Interpretation:
449 #   A function can be used to generate in-line Bash commands.
450
451
452 # A simple function where the first word of result IS a bash command:
453 ###
454 _print() {
455     echo -n 'printf %q '$@
456 }
457
458 echo '- - Outputs of function _print - -'
459 _print parm1 parm2          # An Output NOT A Command.
460 echo
461
462 $_print parm1 parm2        # Executes: printf %q parm1 parm2
463                            # See above IFS examples for the
464                            #+ various possibilities.
465 echo
466
467 $_print $VarSomething)    # The predictable result.
468 echo
469
470
471
472 # Function variables
473 # -----
474
475 echo
476 echo '- - Function variables - -'
477 # A variable may represent a signed integer, a string or an array.
478 # A string may be used like a function name with optional arguments.
479
480 # set -vx                # Enable if desired
481 declare -f funcVar      #+ in namespace of functions
482
483 funcVar=_print          # Contains name of function.
484 $funcVar parm1         # Same as _print at this point.
485 echo
486
487 funcVar=$( _print )    # Contains result of function.

```



```

488 $funcVar                # No input, No output.
489 $funcVar $VarSomething  # The predictable result.
490 echo
491
492 funcVar=$(_print $VarSomething)  # $VarSomething replaced HERE.
493 $funcVar                        # The expansion is part of the
494 echo                             #+ variable contents.
495
496 funcVar="$(_print $VarSomething)" # $VarSomething replaced HERE.
497 $funcVar                        # The expansion is part of the
498 echo                             #+ variable contents.
499
500 # The difference between the unquoted and the double-quoted versions
501 #+ above can be seen in the "protect_literal.sh" example.
502 # The first case above is processed as two, unquoted, Bash-Words.
503 # The second case above is processed as one, quoted, Bash-Word.
504
505
506
507
508 # Delayed replacement
509 # -----
510
511 echo
512 echo '- - Delayed replacement - -'
513 funcVar="$(_print '$VarSomething')" # No replacement, single Bash-Word.
514 eval $funcVar                       # $VarSomething replaced HERE.
515 echo
516
517 VarSomething='NewThing'
518 eval $funcVar                       # $VarSomething replaced HERE.
519 echo
520
521 # Restore the original setting trashed above.
522 VarSomething=Literal
523
524 # There are a pair of functions demonstrated in the
525 #+ "protect_literal.sh" and "unprotect_literal.sh" examples.
526 # These are general purpose functions for delayed replacement literals
527 #+ containing variables.
528
529
530
531
532
533 # REVIEW:
534 # -----
535
536 # A string can be considered a Classic-Array of elements (characters).
537 # A string operation applies to all elements (characters) of the string
538 #+ (in concept, anyway).
539 ###
540 # The notation: ${array_name[@]} represents all elements of the
541 #+ Bash-Array: array_name.
542 ###
543 # The Extended-Syntax string operations can be applied to all
544 #+ elements of an array.
545 ###
546 # This may be thought of as a For-Each operation on a vector of strings.
547 ###
548 # Parameters are similar to an array.
549 # The initialization of a parameter array for a script
550 #+ and a parameter array for a function only differ
551 #+ in the initialization of ${0}, which never changes its setting.
552 ###
553 # Subscript zero of the script's parameter array contains

```

```

554 #+ the name of the script.
555 ###
556 # Subscript zero of a function's parameter array DOES NOT contain
557 #+ the name of the function.
558 # The name of the current function is accessed by the $FUNCNAME variable.
559 ###
560 # A quick, review list follows (quick, not short).
561
562 echo
563 echo '- - Test (but not change) - -'
564 echo '- null reference -'
565 echo -n ${VarNull-'NotSet'}' ' ' # NotSet
566 echo ${VarNull} # NewLine only
567 echo -n ${VarNull:--'NotSet'}' ' ' # NotSet
568 echo ${VarNull} # Newline only
569
570 echo '- null contents -'
571 echo -n ${VarEmpty-'Empty'}' ' ' # Only the space
572 echo ${VarEmpty} # Newline only
573 echo -n ${VarEmpty:--'Empty'}' ' ' # Empty
574 echo ${VarEmpty} # Newline only
575
576 echo '- contents -'
577 echo ${VarSomething-'Content'} # Literal
578 echo ${VarSomething:--'Content'} # Literal
579
580 echo '- Sparse Array -'
581 echo ${ArrayVar[@]-'not set'}
582
583 # ASCII-Art time
584 # State Y==yes, N==no
585 # - :-
586 # Unset Y Y ${# ... } == 0
587 # Empty N Y ${# ... } == 0
588 # Contents N N ${# ... } > 0
589
590 # Either the first and/or the second part of the tests
591 #+ may be a command or a function invocation string.
592 echo
593 echo '- - Test 1 for undefined - -'
594 declare -i t
595 _decT() {
596     t=$((t-1))
597 }
598
599 # Null reference, set: t == -1
600 t=${#VarNull} # Results in zero.
601 ${VarNull-_decT} # Function executes, t now -1.
602 echo $t
603
604 # Null contents, set: t == 0
605 t=${#VarEmpty} # Results in zero.
606 ${VarEmpty-_decT} # _decT function NOT executed.
607 echo $t
608
609 # Contents, set: t == number of non-null characters
610 VarSomething='_simple' # Set to valid function name.
611 t=${#VarSomething} # non-zero length
612 ${VarSomething-_decT} # Function _simple executed.
613 echo $t # Note the Append-To action.
614
615 # Exercise: clean up that example.
616 unset t
617 unset _decT
618 VarSomething=Literal
619

```

```

620 echo
621 echo '- - Test and Change - -'
622 echo '- Assignment if null reference -'
623 echo -n ${VarNull='NotSet'}' ' ' # NotSet NotSet
624 echo ${VarNull}
625 unset VarNull
626
627 echo '- Assignment if null reference -'
628 echo -n ${VarNull:='NotSet'}' ' ' # NotSet NotSet
629 echo ${VarNull}
630 unset VarNull
631
632 echo '- No assignment if null contents -'
633 echo -n ${VarEmpty='Empty'}' ' ' # Space only
634 echo ${VarEmpty}
635 VarEmpty=''
636
637 echo '- Assignment if null contents -'
638 echo -n ${VarEmpty:='Empty'}' ' ' # Empty Empty
639 echo ${VarEmpty}
640 VarEmpty=''
641
642 echo '- No change if already has contents -'
643 echo ${VarSomething='Content'} # Literal
644 echo ${VarSomething:='Content'} # Literal
645
646
647 # "Subscript sparse" Bash-Arrays
648 ###
649 # Bash-Arrays are subscript packed, beginning with
650 #+ subscript zero unless otherwise specified.
651 ###
652 # The initialization of ArrayVar was one way
653 #+ to "otherwise specify". Here is the other way:
654 ###
655 echo
656 declare -a ArraySparse
657 ArraySparse=( [1]=one [2]='' [4]='four' )
658 # [0]=null reference, [2]=null content, [3]=null reference
659
660 echo '- - Array-Sparse List - -'
661 # Within double-quotes, default IFS, Glob-Pattern
662
663 IFS=${'\x20'\$\'\x09'\$\'\x0A'}
664 printf %q "${ArraySparse[*]}"
665 echo
666
667 # Note that the output does not distinguish between "null content"
668 #+ and "null reference".
669 # Both print as escaped whitespace.
670 ###
671 # Note also that the output does NOT contain escaped whitespace
672 #+ for the "null reference(s)" prior to the first defined element.
673 ###
674 # This behavior of 2.04, 2.05a and 2.05b has been reported
675 #+ and may change in a future version of Bash.
676
677 # To output a sparse array and maintain the [subscript]=value
678 #+ relationship without change requires a bit of programming.
679 # One possible code fragment:
680 ###
681 # local l=${#ArraySparse[@]} # Count of defined elements
682 # local f=0 # Count of found subscripts
683 # local i=0 # Subscript to test
684 ( # Anonymous in-line function
685     for (( l=${#ArraySparse[@]}, f = 0, i = 0 ; f < l ; i++ ))

```

```

686     do
687         # 'if defined then...'
688         ${ArraySparse[$i]+ eval echo '\ ['$i']='${ArraySparse[$i]} ; (( f++ )) }
689     done
690 )
691
692 # The reader coming upon the above code fragment could
693 #+ might want to review "command lists" and "multiple commands on a line"
694 #+ in the text of the foregoing "Advanced Bash Scripting Guide."
695 ###
696 # Note:
697 # The "read -a array_name" version of the "read" command
698 #+ begins filling array_name at subscript zero.
699 # ArraySparse does not define a value at subscript zero.
700 ###
701 # The user needing to read/write a sparse array to either
702 #+ external storage or a communications socket must invent
703 #+ a read/write code pair suitable for their purpose.
704 ###
705 # Exercise: clean it up.
706
707 unset ArraySparse
708
709 echo
710 echo '- - Conditional alternate (But not change)- -'
711 echo '- No alternate if null reference -'
712 echo -n ${VarNull+'NotSet'}' ' '
713 echo ${VarNull}
714 unset VarNull
715
716 echo '- No alternate if null reference -'
717 echo -n ${VarNull:+'NotSet'}' ' '
718 echo ${VarNull}
719 unset VarNull
720
721 echo '- Alternate if null contents -'
722 echo -n ${VarEmpty+'Empty'}' ' ' # Empty
723 echo ${VarEmpty}
724 VarEmpty=''
725
726 echo '- No alternate if null contents -'
727 echo -n ${VarEmpty:+'Empty'}' ' ' # Space only
728 echo ${VarEmpty}
729 VarEmpty=''
730
731 echo '- Alternate if already has contents -'
732
733 # Alternate literal
734 echo -n ${VarSomething+'Content'}' ' ' # Content Literal
735 echo ${VarSomething}
736
737 # Invoke function
738 echo -n ${VarSomething:+ $_simple) }' ' ' # SimpleFunc Literal
739 echo ${VarSomething}
740 echo
741
742 echo '- - Sparse Array - -'
743 echo ${ArrayVar[@]+'Empty'} # An array of 'Empty'(ies)
744 echo
745
746 echo '- - Test 2 for undefined - -'
747
748 declare -i t
749 _incT() {
750     t=$((t+1))
751 }

```

```

752
753 # Note:
754 # This is the same test used in the sparse array
755 #+ listing code fragment.
756
757 # Null reference, set: t == -1
758 t=${#VarNull}-1 # Results in minus-one.
759 ${VarNull+ _incT } # Does not execute.
760 echo $t' Null reference'
761
762 # Null contents, set: t == 0
763 t=${#VarEmpty}-1 # Results in minus-one.
764 ${VarEmpty+ _incT } # Executes.
765 echo $t' Null content'
766
767 # Contents, set: t == (number of non-null characters)
768 t=${#VarSomething}-1 # non-null length minus-one
769 ${VarSomething+ _incT } # Executes.
770 echo $t' Contents'
771
772 # Exercise: clean up that example.
773 unset t
774 unset _incT
775
776 # ${name?err_msg} ${name:?err_msg}
777 # These follow the same rules but always exit afterwards
778 #+ if an action is specified following the question mark.
779 # The action following the question mark may be a literal
780 #+ or a function result.
781 ###
782 # ${name?} ${name:?} are test-only, the return can be tested.
783
784
785
786
787 # Element operations
788 # -----
789
790 echo
791 echo '- - Trailing sub-element selection - -'
792
793 # Strings, Arrays and Positional parameters
794
795 # Call this script with multiple arguments
796 #+ to see the parameter selections.
797
798 echo '- All -'
799 echo ${VarSomething:0} # all non-null characters
800 echo ${ArrayVar[@]:0} # all elements with content
801 echo ${@:0} # all parameters with content;
802 # ignoring parameter[0]
803
804 echo
805 echo '- All after -'
806 echo ${VarSomething:1} # all non-null after character[0]
807 echo ${ArrayVar[@]:1} # all after element[0] with content
808 echo ${@:2} # all after param[1] with content
809
810 echo
811 echo '- Range after -'
812 echo ${VarSomething:4:3} # ral
813 # Three characters after
814 # character[3]
815
816 echo '- Sparse array gotch -'
817 echo ${ArrayVar[@]:1:2} # four - The only element with content.

```

```

818             # Two elements after (if that many exist).
819             # the FIRST WITH CONTENTS
820             #+ (the FIRST WITH CONTENTS is being
821             #+ considered as if it
822             #+ were subscript zero).
823 # Executed as if Bash considers ONLY array elements with CONTENT
824 # printf %q "${ArrayVar[@]:0:3}" # Try this one
825
826 # In versions 2.04, 2.05a and 2.05b,
827 #+ Bash does not handle sparse arrays as expected using this notation.
828 #
829 # The current Bash maintainer, Chet Ramey, has corrected this.
830
831
832 echo '- Non-sparse array -'
833 echo ${@:2:2} # Two parameters following parameter[1]
834
835 # New victims for string vector examples:
836 stringZ=abcABC123ABCabc
837 arrayZ=( abcabc ABCABC 123123 ABCABC abcabc )
838 sparseZ=( [1]='abcabc' [3]='ABCABC' [4]='' [5]='123123' )
839
840 echo
841 echo ' - - Victim string - -'$stringZ'- - '
842 echo ' - - Victim array - -'${arrayZ[@]}'- - '
843 echo ' - - Sparse array - -'${sparseZ[@]}'- - '
844 echo ' - [0]==null ref, [2]==null ref, [4]==null content - '
845 echo ' - [1]=abcabc [3]=ABCABC [5]=123123 - '
846 echo ' - non-null-reference count: '${#sparseZ[@]} elements'
847
848 echo
849 echo '- - Prefix sub-element removal - -'
850 echo '- - Glob-Pattern match must include the first character. - -'
851 echo '- - Glob-Pattern may be a literal or a function result. - -'
852 echo
853
854
855 # Function returning a simple, Literal, Glob-Pattern
856 _abc() {
857     echo -n 'abc'
858 }
859
860 echo '- Shortest prefix -'
861 echo ${stringZ#123} # Unchanged (not a prefix).
862 echo ${stringZ#$_abc} # ABC123ABCabc
863 echo ${arrayZ[@]#abc} # Applied to each element.
864
865 # echo ${sparseZ[@]#abc} # Version-2.05b core dumps.
866 # Has since been fixed by Chet Ramey.
867
868 # The -it would be nice- First-Subscript-Of
869 # echo ${#sparseZ[@]#*} # This is NOT valid Bash.
870
871 echo
872 echo '- Longest prefix -'
873 echo ${stringZ##1*3} # Unchanged (not a prefix)
874 echo ${stringZ##a*C} # abc
875 echo ${arrayZ[@]##a*c} # ABCABC 123123 ABCABC
876
877 # echo ${sparseZ[@]##a*c} # Version-2.05b core dumps.
878 # Has since been fixed by Chet Ramey.
879
880 echo
881 echo '- - Suffix sub-element removal - -'
882 echo '- - Glob-Pattern match must include the last character. - -'
883 echo '- - Glob-Pattern may be a literal or a function result. - -'

```

```

884 echo
885 echo '- Shortest suffix -'
886 echo ${stringZ%1*3}           # Unchanged (not a suffix).
887 echo ${stringZ%$_abc}        # abcABC123ABC
888 echo ${arrayZ[@]%abc}        # Applied to each element.
889
890 # echo ${sparseZ[@]%abc}      # Version-2.05b core dumps.
891 # Has since been fixed by Chet Ramey.
892
893 # The -it would be nice- Last-Subscript-Of
894 # echo ${#sparseZ[@]%*}       # This is NOT valid Bash.
895
896 echo
897 echo '- Longest suffix -'
898 echo ${stringZ%1*3}           # Unchanged (not a suffix)
899 echo ${stringZ%%b*c}          # a
900 echo ${arrayZ[@]%b*c}        # a ABCABC 123123 ABCABC a
901
902 # echo ${sparseZ[@]%b*c}      # Version-2.05b core dumps.
903 # Has since been fixed by Chet Ramey.
904
905 echo
906 echo '- - Sub-element replacement - -'
907 echo '- - Sub-element at any location in string. - -'
908 echo '- - First specification is a Glob-Pattern - -'
909 echo '- - Glob-Pattern may be a literal or Glob-Pattern function result. - -'
910 echo '- - Second specification may be a literal or function result. - -'
911 echo '- - Second specification may be unspecified. Pronounce that'
912 echo '   as: Replace-With-Nothing (Delete) - -'
913 echo
914
915
916
917 # Function returning a simple, Literal, Glob-Pattern
918 _123() {
919     echo -n '123'
920 }
921
922 echo '- Replace first occurrence -'
923 echo ${stringZ/$_123/999}      # Changed (123 is a component).
924 echo ${stringZ/ABC/xyz}        # xyzABC123ABCabc
925 echo ${arrayZ[@]/ABC/xyz}      # Applied to each element.
926 echo ${sparseZ[@]/ABC/xyz}    # Works as expected.
927
928 echo
929 echo '- Delete first occurrence -'
930 echo ${stringZ/$_123/}
931 echo ${stringZ/ABC/}
932 echo ${arrayZ[@]/ABC/}
933 echo ${sparseZ[@]/ABC/}
934
935 # The replacement need not be a literal,
936 #+ since the result of a function invocation is allowed.
937 # This is general to all forms of replacement.
938 echo
939 echo '- Replace first occurrence with Result-Of -'
940 echo ${stringZ/$_123/$_simple}  # Works as expected.
941 echo ${arrayZ[@]/ca/$_simple}   # Applied to each element.
942 echo ${sparseZ[@]/ca/$_simple}  # Works as expected.
943
944 echo
945 echo '- Replace all occurrences -'
946 echo ${stringZ//[b2]/X}        # X-out b's and 2's
947 echo ${stringZ//abc/xyz}       # xyzABC123ABCxyz
948 echo ${arrayZ[@]//abc/xyz}     # Applied to each element.
949 echo ${sparseZ[@]//abc/xyz}    # Works as expected.

```

```

950
951 echo
952 echo '- Delete all occurrences -'
953 echo ${stringZ//[b2]/}
954 echo ${stringZ//abc/}
955 echo ${arrayZ[@]//abc/}
956 echo ${sparseZ[@]//abc/}
957
958 echo
959 echo '- - Prefix sub-element replacement - -'
960 echo '- - Match must include the first character. - -'
961 echo
962
963 echo '- Replace prefix occurrences -'
964 echo ${stringZ/#[b2]/X}           # Unchanged (neither is a prefix).
965 echo ${stringZ/#$_abc/XYZ}       # XYZABC123ABCabc
966 echo ${arrayZ[@]/#abc/XYZ}       # Applied to each element.
967 echo ${sparseZ[@]/#abc/XYZ}      # Works as expected.
968
969 echo
970 echo '- Delete prefix occurrences -'
971 echo ${stringZ/#[b2]/}
972 echo ${stringZ/#$_abc/}
973 echo ${arrayZ[@]/#abc/}
974 echo ${sparseZ[@]/#abc/}
975
976 echo
977 echo '- - Suffix sub-element replacement - -'
978 echo '- - Match must include the last character. - -'
979 echo
980
981 echo '- Replace suffix occurrences -'
982 echo ${stringZ/%[b2]/X}         # Unchanged (neither is a suffix).
983 echo ${stringZ/%$_abc/XYZ}      # abcABC123ABCXYZ
984 echo ${arrayZ[@]/%abc/XYZ}      # Applied to each element.
985 echo ${sparseZ[@]/%abc/XYZ}     # Works as expected.
986
987 echo
988 echo '- Delete suffix occurrences -'
989 echo ${stringZ/%[b2]/}
990 echo ${stringZ/%$_abc/}
991 echo ${arrayZ[@]/%abc/}
992 echo ${sparseZ[@]/%abc/}
993
994 echo
995 echo '- - Special cases of null Glob-Pattern - -'
996 echo
997
998 echo '- Prefix all -'
999 # null substring pattern means 'prefix'
1000 echo ${stringZ/#/NEW}           # NEWabcABC123ABCabc
1001 echo ${arrayZ[@]/#/NEW}          # Applied to each element.
1002 echo ${sparseZ[@]/#/NEW}        # Applied to null-content also.
1003                                 # That seems reasonable.
1004
1005 echo
1006 echo '- Suffix all -'
1007 # null substring pattern means 'suffix'
1008 echo ${stringZ/%/NEW}            # abcABC123ABCabcNEW
1009 echo ${arrayZ[@]/%/NEW}          # Applied to each element.
1010 echo ${sparseZ[@]/%/NEW}        # Applied to null-content also.
1011                                 # That seems reasonable.
1012
1013 echo
1014 echo '- - Special case For-Each Glob-Pattern - -'
1015 echo '- - - - This is a nice-to-have dream - - - -'

```



```

1016 echo
1017
1018 _GenFunc() {
1019     echo -n ${0}                # Illustration only.
1020     # Actually, that would be an arbitrary computation.
1021 }
1022
1023 # All occurrences, matching the Anything pattern.
1024 # Currently //*/ does not match null-content nor null-reference.
1025 # /#/ and /%/ does match null-content but not null-reference.
1026 echo ${sparseZ[@]//*/$_GenFunc}
1027
1028
1029 # A possible syntax would be to make
1030 #+ the parameter notation used within this construct mean:
1031 #   ${1} - The full element
1032 #   ${2} - The prefix, if any, to the matched sub-element
1033 #   ${3} - The matched sub-element
1034 #   ${4} - The suffix, if any, to the matched sub-element
1035 #
1036 # echo ${sparseZ[@]//*/$_GenFunc ${3}} # Same as ${1} here.
1037 # Perhaps it will be implemented in a future version of Bash.
1038
1039
1040 exit 0

```

Example A-59. Testing execution times of various commands

```

1 #!/bin/bash
2 # test-execution-time.sh
3 # Example by Erik Brandsberg, for testing execution time
4 #+ of certain operations.
5 # Referenced in the "Optimizations" section of "Miscellany" chapter.
6
7 count=50000
8 echo "Math tests"
9 echo "Math via \${( )}"
10 time for (( i=0; i< $count; i++))
11 do
12     result=${( $i%2 )}
13 done
14
15 echo "Math via *expr*:"
16 time for (( i=0; i< $count; i++))
17 do
18     result=`expr "$i%2"`
19 done
20
21 echo "Math via *let*:"
22 time for (( i=0; i< $count; i++))
23 do
24     let result=$i%2
25 done
26
27 echo
28 echo "Conditional testing tests"
29
30 echo "Test via case:"
31 time for (( i=0; i< $count; i++))
32 do
33     case ${i%2} in
34         0) : ;;

```

```

35     1) : ;;
36     esac
37 done
38
39 echo "Test with if [], no quotes:"
40 time for (( i=0; i< $count; i++))
41 do
42     if [ $(( $i%2 )) = 0 ]; then
43         :
44     else
45         :
46     fi
47 done
48
49 echo "Test with if [], quotes:"
50 time for (( i=0; i< $count; i++))
51 do
52     if [ "$(( $i%2 ))" = "0" ]; then
53         :
54     else
55         :
56     fi
57 done
58
59 echo "Test with if [], using -eq:"
60 time for (( i=0; i< $count; i++))
61 do
62     if [ $(( $i%2 )) -eq 0 ]; then
63         :
64     else
65         :
66     fi
67 done
68
69 exit $?

```

Example A-60. Associative arrays vs. conventional arrays (execution times)

```

1 #!/bin/bash
2 #  assoc-arr-test.sh
3 #  Benchmark test script to compare execution times of
4 #  numeric-indexed array vs. associative array.
5 #      Thank you, Erik Brandsberg.
6
7 count=100000      # May take a while for some of the tests below.
8 declare simple   # Can change to 20000, if desired.
9 declare -a array1
10 declare -A array2
11 declare -a array3
12 declare -A array4
13
14 echo "===Assignment tests==="
15 echo
16
17 echo "Assigning a simple variable:"
18 # References $i twice to equalize lookup times.
19 time for (( i=0; i< $count; i++)); do
20     simple=$i$i
21 done
22
23 echo "---"
24

```

```
25 echo "Assigning a numeric index array entry:"
26 time for (( i=0; i< $count; i++)); do
27     array1[$i]=$i
28 done
29
30 echo "---"
31
32 echo "Overwriting a numeric index array entry:"
33 time for (( i=0; i< $count; i++)); do
34     array1[$i]=$i
35 done
36
37 echo "---"
38
39 echo "Linear reading of numeric index array:"
40 time for (( i=0; i< $count; i++)); do
41     simple=array1[$i]
42 done
43
44 echo "---"
45
46 echo "Assigning an associative array entry:"
47 time for (( i=0; i< $count; i++)); do
48     array2[$i]=$i
49 done
50
51 echo "---"
52
53 echo "Overwriting an associative array entry:"
54 time for (( i=0; i< $count; i++)); do
55     array2[$i]=$i
56 done
57
58 echo "---"
59
60 echo "Linear reading an associative array entry:"
61 time for (( i=0; i< $count; i++)); do
62     simple=array2[$i]
63 done
64
65 echo "---"
66
67 echo "Assigning a random number to a simple variable:"
68 time for (( i=0; i< $count; i++)); do
69     simple=$RANDOM
70 done
71
72 echo "---"
73
74 echo "Assign a sparse numeric index array entry randomly into 64k cells:"
75 time for (( i=0; i< $count; i++)); do
76     array3[$RANDOM]=$i
77 done
78
79 echo "---"
80
81 echo "Reading sparse numeric index array entry:"
82 time for value in "${array3[@]}"; do
83     simple=$value
84 done
85
86 echo "---"
87
88 echo "Assigning a sparse associative array entry randomly into 64k cells:"
89 time for (( i=0; i< $count; i++)); do
90     array4[$RANDOM]=$i
```

```
91 done
92
93 echo "---"
94
95 echo "Reading sparse associative index array entry:"
96 time for value in "${array4[@]}; do
97     simple=$value
98 done
99
100 exit $?
```

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Bibliography

Reference Cards

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Appendix B. Reference Cards

The following reference cards provide a useful *summary* of certain scripting concepts. The foregoing text treats these matters in more depth, as well as giving usage examples.

Table B-1. Special Shell Variables

Variable	Meaning
\$0	Filename of script
\$1	Positional parameter #1
\$2 - \$9	Positional parameters #2 - #9
\${10}	Positional parameter #10
\$#	Number of positional parameters
"\$*"	All the positional parameters (as a single word) *
"\$@"	All the positional parameters (as separate strings)
\${#*}	Number of positional parameters
\${#@}	Number of positional parameters
\$?	Return value
\$\$	Process ID (PID) of script
\$-	Flags passed to script (using <i>set</i>)
\$_	Last argument of previous command
#!	Process ID (PID) of last job run in background

* *Must be quoted*, otherwise it defaults to \$@.

Table B-2. TEST Operators: Binary Comparison

Operator	Meaning	-----	Operator	Meaning
<u>Arithmetic Comparison</u>			<u>String Comparison</u>	
-eq	Equal to		=	Equal to
			==	Equal to
-ne	Not equal to		!=	Not equal to
-lt	Less than		\<	Less than (<u>ASCII</u>) *
-le	Less than or equal to			
-gt	Greater than		\>	Greater than (<u>ASCII</u>) *
-ge	Greater than or equal to			
			-z	String is empty
			-n	String is not empty
Arithmetic Comparison	<u>within double parentheses</u> ((...))			
>	Greater than			

>=	Greater than or equal to			
<	Less than			
<=	Less than or equal to			

* If within a double-bracket [[...]] test construct, then no escape \ is needed.

Table B-3. TEST Operators: Files

Operator	Tests Whether	-----	Operator	Tests Whether
-e	File exists		-s	File is not zero size
-f	File is a <i>regular</i> file			
-d	File is a <i>directory</i>		-r	File has <i>read</i> permission
-h	File is a symbolic link		-w	File has <i>write</i> permission
-L	File is a <i>symbolic link</i>		-x	File has <i>execute</i> permission
-b	File is a block device			
-c	File is a character device		-g	<i>sgid</i> flag set
-p	File is a pipe		-u	<i>suid</i> flag set
-S	File is a socket		-k	"sticky bit" set
-t	File is associated with a <i>terminal</i>			
-N	File modified since it was last read		F1 -nt F2	File F1 is <i>newer</i> than F2 *
-O	You own the file		F1 -ot F2	File F1 is <i>older</i> than F2 *
-G	<i>Group id</i> of file same as yours		F1 -ef F2	Files F1 and F2 are <i>hard links</i> to the same file *
!	NOT (inverts sense of above tests)			

* *Binary* operator (requires two operands).

Table B-4. Parameter Substitution and Expansion

Expression	Meaning
\${var}	Value of <i>var</i> (same as <i>\$var</i>)
\${var-\$DEFAULT}	If <i>var</i> not set, evaluate expression as <i>\$DEFAULT</i> *
\${var:-\$DEFAULT}	If <i>var</i> not set or is empty, evaluate expression as <i>\$DEFAULT</i> *
\${var=\$DEFAULT}	If <i>var</i> not set, evaluate expression as <i>\$DEFAULT</i> *
\${var:= \$DEFAULT}	If <i>var</i> not set or is empty, evaluate expression as <i>\$DEFAULT</i> *
\${var+\$OTHER}	If <i>var</i> set, evaluate expression as <i>\$OTHER</i> , otherwise as null string

<code>\${var:+\$OTHER}</code>	If <i>var</i> set, evaluate expression as <i>\$OTHER</i> , otherwise as null string
<code>\${var?\$ERR_MSG}</code>	If <i>var</i> not set, print <i>\$ERR_MSG</i> and abort script with an exit status of 1.*
<code>\${var:?\$ERR_MSG}</code>	If <i>var</i> not set, print <i>\$ERR_MSG</i> and abort script with an exit status of 1.*
<code>\${!varprefix*}</code>	Matches all previously declared variables beginning with <i>varprefix</i>
<code>\${!varprefix@}</code>	Matches all previously declared variables beginning with <i>varprefix</i>

* If *var* is set, evaluate the expression as *\$var* with no side-effects.

Note that some of the above behavior of operators has changed from earlier versions of Bash.

Table B-5. String Operations

Expression	Meaning
<code>\${#string}</code>	Length of <i>\$string</i>
<code>\${string:position}</code>	Extract substring from <i>\$string</i> at <i>\$position</i>
<code>\${string:position:length}</code>	Extract <i>\$length</i> characters substring from <i>\$string</i> at <i>\$position</i> [zero-indexed, first character is at position 0]
<code>\${string#substring}</code>	Strip shortest match of <i>\$substring</i> from front of <i>\$string</i>
<code>\${string##substring}</code>	Strip longest match of <i>\$substring</i> from front of <i>\$string</i>
<code>\${string%substring}</code>	Strip shortest match of <i>\$substring</i> from back of <i>\$string</i>
<code>\${string%%substring}</code>	Strip longest match of <i>\$substring</i> from back of <i>\$string</i>
<code>\${string/substring/replacement}</code>	Replace first match of <i>\$substring</i> with <i>\$replacement</i>
<code>\${string//substring/replacement}</code>	Replace <i>all</i> matches of <i>\$substring</i> with <i>\$replacement</i>
<code>\${string/#substring/replacement}</code>	If <i>\$substring</i> matches <i>front</i> end of <i>\$string</i> , substitute <i>\$replacement</i> for <i>\$substring</i>
<code>\${string/%substring/replacement}</code>	If <i>\$substring</i> matches <i>back</i> end of <i>\$string</i> , substitute <i>\$replacement</i> for <i>\$substring</i>
<code>expr match "\$string" '\$substring'</code>	Length of matching <i>\$substring*</i> at beginning of <i>\$string</i>
<code>expr "\$string" : '\$substring'</code>	Length of matching <i>\$substring*</i> at beginning of <i>\$string</i>
<code>expr index "\$string" \$substring</code>	

	Numerical position in <i>\$string</i> of first character in <i>\$substring*</i> that matches [0 if no match, first character counts as position 1]
expr substr <i>\$string</i> <i>\$position</i> <i>\$length</i>	Extract <i>\$length</i> characters from <i>\$string</i> starting at <i>\$position</i> [0 if no match, first character counts as position 1]
expr match " <i>\$string</i> " <i>'\(\$substring\)</i> '	Extract <i>\$substring*</i> , searching from beginning of <i>\$string</i>
expr " <i>\$string</i> " : <i>'\(\$substring\)</i> '	Extract <i>\$substring*</i> , searching from beginning of <i>\$string</i>
expr match " <i>\$string</i> " <i>'.*\(\$substring\)</i> '	Extract <i>\$substring*</i> , searching from end of <i>\$string</i>
expr " <i>\$string</i> " : <i>'.*\(\$substring\)</i> '	Extract <i>\$substring*</i> , searching from end of <i>\$string</i>

* Where *\$substring* is a [Regular Expression](#).

Table B-6. Miscellaneous Constructs

Expression	Interpretation
Brackets	
if [CONDITION]	Test construct
if [[CONDITION]]	Extended test construct
Array[1]=element1	Array initialization
[a-z]	Range of characters within a Regular Expression
Curly Brackets	
\${variable}	Parameter substitution
\${!variable}	Indirect variable reference
{ command1; command2; . . . commandN; }	Block of code
{string1,string2,string3,...}	Brace expansion
{a..z}	Extended brace expansion
{ }	Text replacement, after find and xargs
Parentheses	
(command1; command2)	Command group executed within a subshell
Array=(element1 element2 element3)	Array initialization
result=\$(COMMAND)	Command substitution , new style
>(COMMAND)	Process substitution
<(COMMAND)	Process substitution
Double Parentheses	
((var = 78))	Integer arithmetic

<code>var=\$((20 + 5))</code>	Integer arithmetic, with variable assignment
<code>((var++))</code>	<i>C-style</i> variable increment
<code>((var--))</code>	<i>C-style</i> variable decrement
<code>((var0 = var1<98?9:21))</code>	<i>C-style</i> ternary operation
Quoting	
<code>"\$variable"</code>	"Weak" quoting
<code>'string'</code>	'Strong' quoting
Back Quotes	
<code>result=`COMMAND`</code>	Command substitution , classic style

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Contributed Scripts

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Appendix C. A Sed and Awk Micro-Primer

This is a very brief introduction to the **sed** and **awk** text processing utilities. We will deal with only a few basic commands here, but that will suffice for understanding simple sed and awk constructs within shell scripts.

sed: a non-interactive text file editor

awk: a field-oriented pattern processing language with a C-style syntax

For all their differences, the two utilities share a similar invocation syntax, use [regular expressions](#), read input by default from `stdin`, and output to `stdout`. These are well-behaved UNIX tools, and they work together well. The output from one can be piped to the other, and their combined capabilities give shell scripts some of the power of [Perl](#).

 One important difference between the utilities is that while shell scripts can easily pass arguments to sed, it is more cumbersome for awk (see [Example 36-5](#) and [Example 28-2](#)).

C.1. Sed


Sed is a non-interactive [1] stream editor. It receives text input, whether from `stdin` or from a file, performs certain operations on specified lines of the input, one line at a time, then outputs the result to `stdout` or to a file. Within a shell script, *sed* is usually one of several tool components in a pipe.

Sed determines which lines of its input that it will operate on from the *address range* passed to it. [2] Specify this address range either by line number or by a pattern to match. For example, `3d` signals *sed* to delete line 3 of the input, and `/Windows/d` tells *sed* that you want every line of the input containing a match to "Windows" deleted.

Of all the operations in the *sed* toolkit, we will focus primarily on the three most commonly used ones. These are **printing** (to `stdout`), **deletion**, and **substitution**.

Table C-1. Basic sed operators

Operator	Name	Effect
<code>[address-range]/p</code>	print	Print [specified address range]
<code>[address-range]/d</code>	delete	Delete [specified address range]
<code>s/pattern1/pattern2/</code>	substitute	Substitute pattern2 for first instance of pattern1 in a line
<code>[address-range]/s/pattern1/pattern2/</code>	substitute	Substitute pattern2 for first instance of pattern1 in a line, over <i>address-range</i>
<code>[address-range]/y/pattern1/pattern2/</code>	transform	replace any character in pattern1 with the corresponding character in pattern2, over <i>address-range</i> (equivalent of tr)
<code>[address] i pattern Filename</code>	insert	Insert pattern at address indicated in file Filename. Usually used with <code>-i</code> <i>in-place</i> option.
<code>g</code>	global	Operate on <i>every</i> pattern match within each matched line of input

 Unless the `g` (*global*) operator is appended to a *substitute* command, the substitution operates only on the *first* instance of a pattern match within each line.


From the command-line and in a shell script, a *sed* operation may require quoting and certain options.

```
1 sed -e '/^$/d' $filename
2 # The -e option causes the next string to be interpreted as an editing instruction.
3 # (If passing only a single instruction to sed, the "-e" is optional.)
4 # The "strong" quotes (') protect the RE characters in the instruction
5 #+ from reinterpretation as special characters by the body of the script.
6 # (This reserves RE expansion of the instruction for sed.)
7 #
8 # Operates on the text contained in file $filename.
```

In certain cases, a *sed* editing command will not work with single quotes.

```
1 filename=file1.txt
2 pattern=BEGIN
3
4 sed "/^$pattern/d" "$filename" # Works as specified.
5 # sed '/^$pattern/d' "$filename" has unexpected results.
```

```
6 #      In this instance, with strong quoting (' ... '),
7 #+    "$pattern" will not expand to "BEGIN".
```

 *Sed* uses the `-e` option to specify that the following string is an instruction or set of instructions. If there is only a single instruction contained in the string, then this may be omitted.

```
1 sed -n '/xzy/p' $filename
2 # The -n option tells sed to print only those lines matching the pattern.
3 # Otherwise all input lines would print.
4 # The -e option not necessary here since there is only a single editing instruction.
```

Table C-2. Examples of sed operators

Notation	Effect
8d	Delete 8th line of input.
/^\$/d	Delete all blank lines.
1,/^\$/d	Delete from beginning of input up to, and including first blank line.
/Jones/p	Print only lines containing "Jones" (with <code>-n</code> option).
s/Windows/Linux/	Substitute "Linux" for first instance of "Windows" found in each input line.
s/BSOD/stability/g	Substitute "stability" for every instance of "BSOD" found in each input line.
s/ *\$//	Delete all spaces at the end of every line.
s/00*/0/g	Compress all consecutive sequences of zeroes into a single zero.
echo "Working on it." sed -e 'li How far are you along?'	Prints "How far are you along?" as first line, "Working on it" as second.
5i 'Linux is great.' file.txt	Inserts 'Linux is great.' at line 5 of the file file.txt.
/GUI/d	Delete all lines containing "GUI".
s/GUI//g	Delete all instances of "GUI", leaving the remainder of each line intact.

Substituting a zero-length string for another is equivalent to deleting that string within a line of input. This leaves the remainder of the line intact. Applying `s/GUI//` to the line

The most important parts of any application are its GUI and sound effects
results in

The most important parts of any application are its and sound effects

A backslash forces the **sed** replacement command to continue on to the next line. This has the effect of using the *newline* at the end of the first line as the *replacement string*.


```
1 s/^ */\
2 /g
```


This substitution replaces line-beginning spaces with a newline. The net result is to replace paragraph indents with a blank line between paragraphs.

An address range followed by one or more operations may require open and closed curly brackets, with appropriate newlines.

```
1 /[0-9A-Za-z] /,/^$/{
2 / ^$/d
3 }
```

This deletes only the first of each set of consecutive blank lines. That might be useful for single-spacing a text file, but retaining the blank line(s) between paragraphs.

 The usual delimiter that *sed* uses is /. However, *sed* allows other delimiters, such as %. This is useful when / is part of a replacement string, as in a file pathname. See [Example 11-10](#) and [Example 16-32](#).

 A quick way to double-space a text file is **sed G filename**.

For illustrative examples of *sed* within shell scripts, see:

1. [Example 36-1](#)
2. [Example 36-2](#)
3. [Example 16-3](#)
4. [Example A-2](#)
5. [Example 16-17](#)
6. [Example 16-27](#)
7. [Example A-12](#)
8. [Example A-16](#)
9. [Example A-17](#)
10. [Example 16-32](#)
11. [Example 11-10](#)
12. [Example 16-48](#)
13. [Example A-1](#)
14. [Example 16-14](#)
15. [Example 16-12](#)
16. [Example A-10](#)
17. [Example 19-12](#)
18. [Example 16-19](#)
19. [Example A-29](#)
20. [Example A-31](#)
21. [Example A-24](#)
22. [Example A-43](#)
23. [Example A-55](#)

For a more extensive treatment of *sed*, refer to the [pertinent references](#) in the [Bibliography](#).

Notes

- [1] *Sed* executes without user intervention.
- [2] If no address range is specified, the default is *all* lines.

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C.2. Awk

Awk [1] is a full-featured text processing language with a syntax reminiscent of C. While it possesses an extensive set of operators and capabilities, we will cover only a few of these here - the ones most useful in shell scripts.

Awk breaks each line of input passed to it into [fields](#). By default, a field is a string of consecutive characters delimited by [whitespace](#), though there are options for changing this. Awk parses and operates on each separate field. This makes it ideal for handling structured text files -- especially tables -- data organized into consistent chunks, such as rows and columns.

[Strong quoting](#) and [curly brackets](#) enclose blocks of awk code within a shell script.

```
1 # $1 is field #1, $2 is field #2, etc.
2
3 echo one two | awk '{print $1}'
4 # one
5
6 echo one two | awk '{print $2}'
7 # two
8
9 # But what is field #0 ($0)?
10 echo one two | awk '{print $0}'
11 # one two
12 # All the fields!
13
14
15 awk '{print $3}' $filename
16 # Prints field #3 of file $filename to stdout.
17
18 awk '{print $1 $5 $6}' $filename
19 # Prints fields #1, #5, and #6 of file $filename.
20
21 awk '{print $0}' $filename
22 # Prints the entire file!
23 # Same effect as:  cat $filename . . . or . . . sed ' ' $filename
```

We have just seen the awk *print* command in action. The only other feature of awk we need to deal with here is variables. Awk handles variables similarly to shell scripts, though a bit more flexibly.

```
1 { total += ${column_number} }
```

This adds the value of *column_number* to the running total of *total*>. Finally, to print "total", there is an **END** command block, executed after the script has processed all its input.

```
1 END { print total }
```

Corresponding to the **END**, there is a **BEGIN**, for a code block to be performed before awk starts processing its input.

The following example illustrates how **awk** can add text-parsing tools to a shell script.

Example C-1. Counting Letter Occurrences

```
1 #! /bin/sh
2 # letter-count2.sh: Counting letter occurrences in a text file.
3 #
4 # Script by nyal [nyal@voila.fr].
5 # Used in ABS Guide with permission.
6 # Recommended and reformatted by ABS Guide author.
```

```

7 # Version 1.1: Modified to work with gawk 3.1.3.
8 #           (Will still work with earlier versions.)
9
10
11 INIT_TAB_AWK=""
12 # Parameter to initialize awk script.
13 count_case=0
14 FILE_PARSE=$1
15
16 E_PARAMERR=85
17
18 usage()
19 {
20     echo "Usage: letter-count.sh file letters" 2>&1
21     # For example:  ./letter-count2.sh filename.txt a b c
22     exit $E_PARAMERR # Too few arguments passed to script.
23 }
24
25 if [ ! -f "$1" ] ; then
26     echo "$1: No such file." 2>&1
27     usage # Print usage message and exit.
28 fi
29
30 if [ -z "$2" ] ; then
31     echo "$2: No letters specified." 2>&1
32     usage
33 fi
34
35 shift # Letters specified.
36 for letter in `echo $@` # For each one . . .
37 do
38     INIT_TAB_AWK="$INIT_TAB_AWK tab_search[${count_case}] = \
39     \"${letter}\"; final_tab[${count_case}] = 0; "
40     # Pass as parameter to awk script below.
41     count_case=`expr $count_case + 1`
42 done
43
44 # DEBUG:
45 # echo $INIT_TAB_AWK;
46
47 cat $FILE_PARSE |
48 # Pipe the target file to the following awk script.
49
50 # -----
51 # Earlier version of script:
52 # awk -v tab_search=0 -v final_tab=0 -v tab=0 -v \
53 # nb_letter=0 -v chara=0 -v chara2=0 \
54
55 awk \
56 "BEGIN { $INIT_TAB_AWK } \
57 { split(\$0, tab, "\\"); \
58 for (chara in tab) \
59 { for (chara2 in tab_search) \
60 { if (tab_search[chara2] == tab[chara]) { final_tab[chara2]++ } } } } \
61 END { for (chara in final_tab) \
62 { print tab_search[chara] \" => \" final_tab[chara] } }"
63 # -----
64 # Nothing all that complicated, just . . .
65 #+ for-loops, if-tests, and a couple of specialized functions.
66
67 exit $?
68
69 # Compare this script to letter-count.sh.

```

For simpler examples of awk within shell scripts, see:

1. [Example 15-14](#)
2. [Example 20-8](#)
3. [Example 16-32](#)
4. [Example 36-5](#)
5. [Example 28-2](#)
6. [Example 15-20](#)
7. [Example 29-3](#)
8. [Example 29-4](#)
9. [Example 11-3](#)
10. [Example 16-61](#)
11. [Example 9-16](#)
12. [Example 16-4](#)
13. [Example 10-6](#)
14. [Example 36-19](#)
15. [Example 11-9](#)
16. [Example 36-4](#)
17. [Example 16-53](#)
18. [Example T-3](#)

That's all the awk we'll cover here, folks, but there's lots more to learn. See the appropriate references in the [Bibliography](#).

Notes

[1] Its name derives from the initials of its authors, Aho, Weinberg, and Kernighan.

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Appendix D. Parsing and Managing Pathnames

Emmanuel Rouat contributed the following example of parsing and transforming *filenames* and, in particular, [pathnames](#). It draws heavily on the functionality of *sed*.

```
1 #!/usr/bin/env bash
2 #-----
3 # Management of PATH, LD_LIBRARY_PATH, MANPATH variables...
4 # By Emmanuel Rouat <no-email>
5 # (Inspired by the bash documentation 'pathfuncs' and on
6 # discussions found on stackoverflow:
7 # http://stackoverflow.com/questions/370047/
8 # http://stackoverflow.com/questions/273909/#346860 )
9 # Last modified: Sat Sep 22 12:01:55 CEST 2012
10 #
11 # The following functions handle spaces correctly.
12 # These functions belong in .bash_profile rather than in
13 # .bashrc, I guess.
14 #
15 # The modular aspect of these functions should make it easy
16 # to expand them to handle path substitutions instead
17 # of path removal etc....
18 #
19 # See http://www.catonmat.net/blog/awk-one-liners-explained-part-two/
20 # (item 43) for an explanation of the 'duplicate-entries' removal
21 # (it's a nice trick!)
22 #-----
23
24 # Show $@ (usually PATH) as list.
25 function p_show() { local p="$@" && for p; do [[ ${!p} ]] &&
26 echo -e ${!p}://:\n; done }
27
28 # Filter out empty lines, multiple/trailing slashes, and duplicate entries.
29 function p_filter()
30 { awk '/^[ \t]*$/ {next} {sub(/\/+$/, "");gsub(/\/+/, "/")}!x[$0]++' ;}
31
32 # Rebuild list of items into ':' separated word (PATH-like).
33 function p_build() { paste -sd: ;}
34
35 # Clean $1 (typically PATH) and rebuild it
36 function p_clean()
37 { local p=${1} && eval ${p}='${p_show ${p} | p_filter | p_build}' ;}
38
39 # Remove $1 from $2 (found on stackoverflow, with modifications).
40 function p_rm()
41 { local d=$(echo $1 | p_filter) p=${2} &&
42 eval ${p}='${p_show ${p} | p_filter | grep -xv "${d}" | p_build}' ;}
43
44 # Same as previous, but filters on a pattern (dangerous...
45 #+ don't use 'bin' or '/' as pattern!).
46 function p_rmpat()
47 { local d=$(echo $1 | p_filter) p=${2} && eval ${p}='${p_show ${p} |
48 p_filter | grep -v "${d}" | p_build}' ;}
49
50 # Delete $1 from $2 and append it cleanly.
51 function p_append()
52 { local d=$(echo $1 | p_filter) p=${2} && p_rm "${d}" ${p} &&
53 eval ${p}='${p_show ${p} d | p_build}' ;}
54
55 # Delete $1 from $2 and prepend it cleanly.
56 function p_prepend()
57 { local d=$(echo $1 | p_filter) p=${2} && p_rm "${d}" ${p} &&
58 eval ${p}='${p_show d ${p} | p_build}' ;}
59
```

```

60 # Some tests:
61 echo
62 MYPATH="/bin:/usr/bin:/bin://bin/"
63 p_append "/project//my project/bin" MYPATH
64 echo "Append '/project//my project/bin' to '/bin:/usr/bin:/bin://bin/'"
65 echo "(result should be: /bin:/usr/bin:/project/my project/bin)"
66 echo $MYPATH
67
68 echo
69 MYOTHERPATH="/bin:/usr/bin:/bin:/project//my project/bin"
70 p_prepend "/project//my project/bin" MYOTHERPATH
71 echo "Prepend '/project//my project/bin' \
72 to '/bin:/usr/bin:/bin:/project//my project/bin/'"
73 echo "(result should be: /project/my project/bin:/bin:/usr/bin)"
74 echo $MYOTHERPATH
75
76 echo
77 p_prepend "/project//my project/bin" FOOPATH # FOOPATH doesn't exist.
78 echo "Prepend '/project//my project/bin' to an unset variable"
79 echo "(result should be: /project/my project/bin)"
80 echo $FOOPATH
81
82 echo
83 BARPATH="/a:/b://b c://a:/my local pub"
84 p_clean BARPATH
85 echo "Clean BARPATH='/a:/b://b c://a:/my local pub'"
86 echo "(result should be: /a:/b:/b c:/my local pub)"
87 echo $BARPATH

```

David Wheeler kindly permitted me to use his instructive examples.

```

1 Doing it correctly: A quick summary
2 by David Wheeler
3 http://www.dwheeler.com/essays/filenames-in-shell.html
4
5 So, how can you process filenames correctly in shell? Here's a quick
6 summary about how to do it correctly, for the impatient who "just want the
7 answer". In short: Double-quote to use "$variable" instead of $variable,
8 set IFS to just newline and tab, prefix all globs/filenames so they cannot
9 begin with "-" when expanded, and use one of a few templates that work
10 correctly. Here are some of those templates that work correctly:
11
12
13 IFS="$(printf '\n\t')"
14 # Remove SPACE, so filenames with spaces work well.
15
16 # Correct glob use:
17 #+ always use "for" loop, prefix glob, check for existence:
18 for file in /* ; do # Use "/*" ... NEVER bare "*" ...
19     if [ -e "$file" ] ; then # Make sure it isn't an empty match.
20         COMMAND ... "$file" ...
21     fi
22 done
23
24
25
26 # Correct glob use, but requires nonstandard bash extension.
27 shopt -s nullglob # Bash extension,
28 #+ so that empty glob matches will work.
29 for file in /* ; do # Use "/*", NEVER bare "*"
30     COMMAND ... "$file" ...
31 done
32
33

```

```

34
35 # These handle all filenames correctly;
36 #+ can be unwieldy if COMMAND is large:
37 find ... -exec COMMAND... {} \;
38 find ... -exec COMMAND... {} \+ # If multiple files are okay for COMMAND.
39
40
41
42 # This skips filenames with control characters
43 #+ (including tab and newline).
44 IFS="$(printf '\n\t')"
45 controlchars="$(printf '*[\001-\037\177]*')"
46 for file in $(find . ! -name "$controlchars") ; do
47     COMMAND "$file" ...
48 done
49
50
51
52 # Okay if filenames can't contain tabs or newlines --
53 #+ beware the assumption.
54 IFS="$(printf '\n\t')"
55 for file in $(find .) ; do
56     COMMAND "$file" ...
57 done
58
59
60
61 # Requires nonstandard but common extensions in find and xargs:
62 find . -print0 | xargs -0 COMMAND
63
64 # Requires nonstandard extensions to find and to shell (bash works).
65 # variables might not stay set once the loop ends:
66 find . -print0 | while IFS="" read -r -d "" file ; do ...
67     COMMAND "$file" # Use quoted "$file", not $file, everywhere.
68 done
69
70
71
72 # Requires nonstandard extensions to find and to shell (bash works).
73 # Underlying system must include named pipes (FIFOs)
74 #+ or the /dev/fd mechanism.
75 # In this version, variables *do* stay set after the loop ends,
76 # and you can read from stdin.
77 #+ (Change the 4 to another number if fd 4 is needed.)
78
79 while IFS="" read -r -d "" file <&4 ; do
80     COMMAND "$file" # Use quoted "$file" -- not $file, everywhere.
81 done 4< <(find . -print0)
82
83
84 # Named pipe version.
85 # Requires nonstandard extensions to find and to shell's read (bash ok).
86 # Underlying system must include named pipes (FIFOs).
87 # Again, in this version, variables *do* stay set after the loop ends,
88 # and you can read from stdin.
89 # (Change the 4 to something else if fd 4 needed).
90
91 mkfifo mypipe
92
93 find . -print0 > mypipe &
94 while IFS="" read -r -d "" file <&4 ; do
95     COMMAND "$file" # Use quoted "$file", not $file, everywhere.
96 done 4< mypipe

```



Appendix E. Exit Codes With Special Meanings

Table E-1. *Reserved Exit Codes*

Exit Code Number	Meaning	Example	Comments
1	Catchall for general errors	let "var1 = 1/0"	Miscellaneous errors, such as "divide by zero" and other impermissible operations
2	Misuse of shell builtins (according to Bash documentation)	empty_function() { }	Missing keyword or command, or permission problem (and diff return code on a failed binary file comparison).
126	Command invoked cannot execute	/dev/null	Permission problem or command is not an executable
127	"command not found"	illegal_command	Possible problem with \$PATH or a typo
128	Invalid argument to exit	exit 3.14159	exit takes only integer args in the range 0 - 255 (see first footnote)
128+n	Fatal error signal "n"	kill -9 \$PPID of script	\$? returns 137 (128 + 9)
130	Script terminated by Control-C	Ctrl-C	Control-C is fatal error signal 2, (130 = 128 + 2, see above)
255*	Exit status out of range	exit -1	exit takes only integer args in the range 0 - 255

According to the above table, exit codes 1 - 2, 126 - 165, and 255 [1] have special meanings, and should therefore be avoided for user-specified exit parameters. Ending a script with *exit 127* would certainly cause confusion when troubleshooting (is the error code a "command not found" or a user-defined one?). However, many scripts use an *exit 1* as a general bailout-upon-error. Since exit code 1 signifies so many possible errors, it is not particularly useful in debugging.

There has been an attempt to systematize exit status numbers (see `/usr/include/sysexit.h`), but this is intended for C and C++ programmers. A similar standard for scripting might be appropriate. The author of this document proposes restricting user-defined exit codes to the range 64 - 113 (in addition to 0, for success), to conform with the C/C++ standard. This would allot 50 valid codes, and make troubleshooting scripts more straightforward. [2] All user-defined exit codes in the accompanying examples to this document conform to this standard, except where overriding circumstances exist, as in [Example 9-2](#).

 Issuing a `$?` from the command-line after a shell script exits gives results consistent with the table above only from the Bash or *sh* prompt. Running the *C-shell* or *tcsh* may give different values in some cases.

Notes

- [1] Out of range exit values can result in unexpected exit codes. An exit value greater than 255 returns an exit code [modulo](#) 256. For example, *exit 3809* gives an exit code of 225 ($3809 \% 256 = 225$).
- [2] An update of `/usr/include/sysexit.h` allocates previously unused exit codes from 64 - 78. It may be anticipated that the range of unallotted exit codes will be further restricted in the future. The author of this document will *not* do fixups on the scripting examples to conform to the changing standard. This should not cause any problems, since there is no overlap or conflict in usage of exit codes between compiled C/C++ binaries and shell scripts.

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Appendix F. A Detailed Introduction to I/O and I/O Redirection

written by Stéphane Chazelas, and revised by the document author

A command expects the first three [file descriptors](#) to be available. The first, *fd 0* (standard input, `stdin`), is for reading. The other two (*fd 1*, `stdout` and *fd 2*, `stderr`) are for writing.

There is a `stdin`, `stdout`, and a `stderr` associated with each command. `ls 2>&1` means temporarily connecting the `stderr` of the `ls` command to the same "resource" as the shell's `stdout`.

By convention, a command reads its input from `fd 0` (`stdin`), prints normal output to `fd 1` (`stdout`), and error output to `fd 2` (`stderr`). If one of those three `fd`'s is not open, you may encounter problems:

```
bash$ cat /etc/passwd >&-
cat: standard output: Bad file descriptor
```

For example, when `xterm` runs, it first initializes itself. Before running the user's shell, `xterm` opens the terminal device (`/dev/pts/<n>` or something similar) three times.

At this point, Bash inherits these three file descriptors, and each command (child process) run by Bash inherits them in turn, except when you redirect the command. [Redirection](#) means reassigning one of the file descriptors to another file (or a pipe, or anything permissible). File descriptors may be reassigned locally (for a command, a command group, a [subshell](#), a [while or if or case or for loop](#)...), or globally, for the remainder of the shell (using [exec](#)).

`ls > /dev/null` means running `ls` with its `fd 1` connected to `/dev/null`.

```
bash$ lsof -a -p $$ -d0,1,2
COMMAND PID  USER  FD   TYPE DEVICE SIZE NODE NAME
bash    363 bozo   0u   CHR  136,1     3 /dev/pts/1
bash    363 bozo   1u   CHR  136,1     3 /dev/pts/1
bash    363 bozo   2u   CHR  136,1     3 /dev/pts/1

bash$ exec 2> /dev/null
bash$ lsof -a -p $$ -d0,1,2
COMMAND PID  USER  FD   TYPE DEVICE SIZE NODE NAME
bash    371 bozo   0u   CHR  136,1     3 /dev/pts/1
bash    371 bozo   1u   CHR  136,1     3 /dev/pts/1
bash    371 bozo   2w   CHR    1,3    120 /dev/null

bash$ bash -c 'lsof -a -p $$ -d0,1,2' | cat
COMMAND PID USER  FD   TYPE DEVICE SIZE NODE NAME
lsof    379 root   0u   CHR  136,1     3 /dev/pts/1
lsof    379 root   1w  FIFO    0,0    7118 pipe
lsof    379 root   2u   CHR  136,1     3 /dev/pts/1

bash$ echo "$(bash -c 'lsof -a -p $$ -d0,1,2' 2>&1)"
COMMAND PID USER  FD   TYPE DEVICE SIZE NODE NAME
lsof    426 root   0u   CHR  136,1     3 /dev/pts/1
lsof    426 root   1w  FIFO    0,0    7520 pipe
lsof    426 root   2w  FIFO    0,0    7520 pipe
```

This works for different types of redirection.

Exercise: Analyze the following script.

```
1 #! /usr/bin/env bash
2
3 mkfifo /tmp/fifo1 /tmp/fifo2
4 while read a; do echo "FIFO1: $a"; done < /tmp/fifo1 & exec 7> /tmp/fifo1
5 exec 8> >(while read a; do echo "FD8: $a, to fd7"; done >&7)
6
7 exec 3>&1
8 (
9 (
10 (
11   while read a; do echo "FIFO2: $a"; done < /tmp/fifo2 | tee /dev/stderr \
12     | tee /dev/fd/4 | tee /dev/fd/5 | tee /dev/fd/6 >&7 & exec 3> /tmp/fifo2
13
14   echo 1st, to stdout
15   sleep 1
16   echo 2nd, to stderr >&2
17   sleep 1
18   echo 3rd, to fd 3 >&3
19   sleep 1
20   echo 4th, to fd 4 >&4
21   sleep 1
22   echo 5th, to fd 5 >&5
23   sleep 1
24   echo 6th, through a pipe | sed 's/./PIPE: &, to fd 5/' >&5
25   sleep 1
26   echo 7th, to fd 6 >&6
27   sleep 1
28   echo 8th, to fd 7 >&7
29   sleep 1
30   echo 9th, to fd 8 >&8
31
32 ) 4>&1 >&3 3>&- | while read a; do echo "FD4: $a"; done 1>&3 5>&- 6>&-
33 ) 5>&1 >&3 | while read a; do echo "FD5: $a"; done 1>&3 6>&-
34 ) 6>&1 >&3 | while read a; do echo "FD6: $a"; done 3>&-
35
36 rm -f /tmp/fifo1 /tmp/fifo2
37
38
39 # For each command and subshell, figure out which fd points to what.
40 # Good luck!
41
42 exit 0
```

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Appendix G. Command-Line Options

Many executables, whether binaries or script files, accept options to modify their run-time behavior. For example: from the command-line, typing **command -o** would invoke *command*, with option `o`.

G.1. Standard Command-Line Options

Over time, there has evolved a loose standard for the meanings of command-line option flags. The GNU utilities conform more closely to this "standard" than older UNIX utilities.

Traditionally, UNIX command-line options consist of a dash, followed by one or more lowercase letters. The GNU utilities added a double-dash, followed by a complete word or compound word.

The two most widely-accepted options are:

- `-h`

`--help`

Help: Give usage message and exit.

- `-v`

`--version`

Version: Show program version and exit.

Other common options are:

- `-a`

`--all`

All: show *all* information or operate on *all* arguments.

- `-l`

`--list`

List: list files or arguments without taking other action.

- `-o`

Output filename

- `-q`

`--quiet`

Quiet: suppress `stdout`.

- `-r`

`-R`

`--recursive`

Recursive: Operate recursively (down directory tree).

- `-v`

`--verbose`

Verbose: output additional information to `stdout` or `stderr`.

- -z

--compress

Compress: apply compression (usually [gzip](#)).

However:

- In **tar** and **gawk**:

-f

--file


File: filename follows.

- In **cp**, **mv**, **rm**:

-f

--force

Force: force overwrite of target file(s).

 Many UNIX and Linux utilities deviate from this "standard," so it is dangerous to *assume* that a given option will behave in a standard way. Always check the man page for the command in question when in doubt.

A complete table of recommended options for the GNU utilities is available at [the GNU standards page](#).

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G.2. Bash Command-Line Options

Bash itself has a number of command-line options. Here are some of the more useful ones.

- `-c`

Read commands from the following string and assign any arguments to the [positional parameters](#).

```
bash$ bash -c 'set a b c d; IFS="+-;"; echo "$*"'  
a+b+c+d
```

- `-r`

`--restricted`

Runs the shell, or a script, in [restricted mode](#).

- `--posix`

Forces Bash to conform to [POSIX mode](#).

- `--version`

Display Bash version information and exit.

- `--`

End of options. Anything further on the command line is an argument, not an option.

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Appendix H. Important Files

startup files

These files contain the aliases and [environmental variables](#) made available to Bash running as a user shell and to all Bash scripts invoked after system initialization.

`/etc/profile`

Systemwide defaults, mostly setting the environment (all Bourne-type shells, not just Bash [\[1\]](#))

`/etc/bashrc`

systemwide functions and [aliases](#) for Bash

`$HOME/.bash_profile`

user-specific Bash environmental default settings, found in each user's home directory (the local counterpart to `/etc/profile`)

`$HOME/.bashrc`

user-specific Bash init file, found in each user's home directory (the local counterpart to `/etc/bashrc`). Only interactive shells and user scripts read this file. See [Appendix M](#) for a sample `.bashrc` file.

logout file

`$HOME/.bash_logout`

user-specific instruction file, found in each user's home directory. Upon exit from a login (Bash) shell, the commands in this file execute.

data files

`/etc/passwd`

A listing of all the user accounts on the system, their identities, their home directories, the groups they belong to, and their default shell. Note that the user passwords are *not* stored in this file, [\[2\]](#) but in `/etc/shadow` in encrypted form.

system configuration files

`/etc/sysconfig/hwconf`

Listing and description of attached hardware devices. This information is in text form and can be extracted and parsed.

```
bash$ grep -A 5 AUDIO /etc/sysconfig/hwconf
class: AUDIO
bus: PCI
detached: 0
driver: snd-intel8x0
desc: "Intel Corporation 82801CA/CAM AC'97 Audio Controller"
vendorId: 8086
```



This file is present on Red Hat and Fedora Core installations, but may be missing from other distros.

Notes

[\[1\]](#) This does not apply to **csh**, **tcsh**, and other shells not related to or descended from the classic Bourne shell (**sh**).

[\[2\]](#) In older versions of UNIX, passwords *were* stored in `/etc/passwd`, and that explains the name of the file.

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Appendix I. Important System Directories

Sysadmins and anyone else writing administrative scripts should be intimately familiar with the following system directories.

- `/bin`

Binaries (executables). Basic system programs and utilities (such as **bash**).

- `/usr/bin` [\[1\]](#)

More system binaries.

- `/usr/local/bin`

Miscellaneous binaries local to the particular machine.

- `/sbin`

System binaries. Basic system administrative programs and utilities (such as **fsck**).

- `/usr/sbin`

More system administrative programs and utilities.

- `/etc`

Et cetera. Systemwide configuration scripts.

Of particular interest are the [/etc/fstab](#) (filesystem table), [/etc/mtab](#) (mounted filesystem table), and the [/etc/inittab](#) files.

- `/etc/rc.d`

Boot scripts, on Red Hat and derivative distributions of Linux.

- `/usr/share/doc`

Documentation for installed packages.

- `/usr/man`

The systemwide [manpages](#).

- `/dev`

Device directory. Entries (but *not* mount points) for physical and virtual devices. See [Chapter 29](#).

- `/proc`

Process directory. Contains information and statistics about running processes and kernel parameters. See [Chapter 29](#).

- `/sys`

Systemwide device directory. Contains information and statistics about device and device names. This is newly added to Linux with the 2.6.X kernels.

- `/mnt`

Mount. Directory for mounting hard drive partitions, such as `/mnt/dos`, and physical devices. In newer Linux distros, the `/media` directory has taken over as the preferred mount point for I/O devices.

- `/media`

In newer Linux distros, the preferred mount point for I/O devices, such as CD/DVD drives or USB flash drives.

- `/var`

Variable (changeable) system files. This is a catchall "scratchpad" directory for data generated while a Linux/UNIX machine is running.

- `/var/log`

Systemwide log files.

- `/var/spool/mail`

User mail spool.

- `/lib`

Systemwide library files.

- `/usr/lib`


More systemwide library files.

- `/tmp`

System temporary files.

- `/boot`

System *boot* directory. The kernel, module links, system map, and boot manager reside here.

 Altering files in this directory may result in an unbootable system.

Notes

- [1] Some early UNIX systems had a fast, small-capacity fixed disk (containing `/`, the root partition), and a second drive which was larger, but slower (containing `/usr` and other partitions). The most frequently used programs and utilities therefore resided on the small-but-fast drive, in `/bin`, and the others on the slower drive, in `/usr/bin`.

This likewise accounts for the split between `/sbin` and `/usr/sbin`, `/lib` and `/usr/lib`, etc.

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Appendix J. An Introduction to Programmable Completion

The *programmable completion* feature in Bash permits typing a partial command, then pressing the [Tab] key to auto-complete the command sequence. [1] If multiple completions are possible, then [Tab] lists them all. Let's see how it works.

```
bash$ xtra[Tab]
xtraceroute      xtrapin          xtrapproto
xtraceroute.real xtrapinfo        xtrapreset
xtrapchar        xtrapout         xtrapstats

bash$ xtrac[Tab]
xtraceroute      xtraceroute.real

bash$ xtraceroute.r[Tab]
xtraceroute.real
```

Tab completion also works for variables and path names.

```
bash$ echo $BASH[Tab]
$BASH           $BASH_COMPLETION  $BASH_SUBSHELL
$BASH_ARGC      $BASH_COMPLETION_DIR $BASH_VERSINFO
$BASH_ARGV      $BASH_LINENO      $BASH_VERSION
$BASH_COMMAND   $BASH_SOURCE

bash$ echo /usr/local/[Tab]
bin/      etc/      include/ libexec/ sbin/      src/
doc/      games/    lib/      man/      share/
```

The Bash **complete** and **compgen** [builtins](#) make it possible for *tab completion* to recognize partial *parameters* and *options* to commands. In a very simple case, we can use **complete** from the command-line to specify a short list of acceptable parameters.

```
bash$ touch sample_command
bash$ touch file1.txt file2.txt file2.doc file30.txt file4.zzz
bash$ chmod +x sample_command
bash$ complete -f -X '!*.txt' sample_command

bash$ ./sample[Tab][Tab]
sample_command
file1.txt      file2.txt      file30.txt
```

The `-f` option to *complete* specifies filenames, and `-X` the filter pattern.

For anything more complex, we could write a script that specifies a list of acceptable command-line parameters. The **compgen** builtin expands a list of *arguments* to *generate* completion matches.

Let us take a [modified version](#) of the *UseGetOpt.sh* script as an example command. This script accepts a number of command-line parameters, preceded by either a single or double dash. And here is the corresponding *completion script*, by convention given a filename corresponding to its associated command.

Example J-1. Completion script for *UseGetOpt.sh*

```
1 # file: UseGetOpt-2
2 # UseGetOpt-2.sh parameter-completion
3
4 _UseGetOpt-2 () # By convention, the function name
5 {             #+ starts with an underscore.
6     local cur
7     # Pointer to current completion word.
8     # By convention, it's named "cur" but this isn't strictly necessary.
9
10    COMPREPLY=() # Array variable storing the possible completions.
11    cur=${COMP_WORDS[COMP_CWORD]}
12
13    case "$cur" in
14        -*)
15            COMPREPLY=( $( compgen -W '-a -d -f -l -t -h --option --debug \
16                            --file --log --test --help --' -- $cur ) );;
17    #   Generate the completion matches and load them into $COMPREPLY array.
18    #   xx) May add more cases here.
19    #   yy)
20    #   zz)
21    esac
22
23    return 0
24 }
25
26 complete -F _UseGetOpt-2 -o filenames ./UseGetOpt-2.sh
27 #     ^^ ^^^^^^^^^^^^^^^ Invokes the function _UseGetOpt-2.
```

Now, let's try it.

```
bash$ source UseGetOpt-2

bash$ ./UseGetOpt-2.sh -[Tab]
--          --option  --debug    --file     --help     --log      --test
-a         -d          -f         -h         -l         -t

bash$ ./UseGetOpt-2.sh --[Tab]
--          --option  --debug    --file     --help     --log      --test
```

We begin by [sourcing](#) the "completion script." This sets the command-line parameters. [\[2\]](#)

In the first instance, hitting **[Tab]** after a single dash, the output is all the possible parameters preceded by *one or more* dashes. Hitting **[Tab]** after *two* dashes gives the possible parameters preceded by *two or more* dashes.

Now, just what is the point of having to jump through flaming hoops to enable command-line tab completion? *It saves keystrokes.* [\[3\]](#)

--

Resources:

Bash [programmable completion](#) project

Mitch Frazier's [Linux Journal](#) article, [More on Using the Bash Complete Command](#)

Steve's excellent two-part article, "An Introduction to Bash Completion": [Part 1](#) and [Part 2](#)

Notes

- [1] This works only from the *command line*, of course, and not within a script.
- [2] Normally the default parameter completion files reside in either the `/etc/profile.d` directory or in `/etc/bash_completion`. These autoload on system startup. So, after writing a useful completion script, you might wish to move it (as *root*, of course) to one of these directories.
- [3] It has been extensively documented that programmers are willing to put in long hours of effort in order to save ten minutes of "unnecessary" labor. This is known as *optimization*.

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Appendix K. Localization

Localization is an undocumented Bash feature.

A localized shell script echoes its text output in the language defined as the system's locale. A Linux user in Berlin, Germany, would get script output in German, whereas his cousin in Berlin, Maryland, would get output from the same script in English.

To create a localized script, use the following template to write all messages to the user (error messages, prompts, etc.).

```
1 #!/bin/bash
2 # localized.sh
3 # Script by Stéphane Chazelas,
4 #+ modified by Bruno Haible, bugfixed by Alfredo Pironti.
5
6 . gettext.sh
7
8 E_CDERROR=65
9
10 error()
11 {
12     printf "$@" >&2
13     exit $E_CDERROR
14 }
15
16 cd $var || error "`eval_gettext \"Can't cd to \\$var.\"`"
17 # The triple backslashes (escapes) in front of $var needed
18 #+ "because eval_gettext expects a string
19 #+ where the variable values have not yet been substituted."
20 #     -- per Bruno Haible
21 read -p "`gettext \"Enter the value: \"" var
22 # ...
23
24
25 # -----
26 # Alfredo Pironti comments:
27
28 # This script has been modified to not use the "$"..." syntax in
29 #+ favor of the "`gettext \"...\"`" syntax.
30 # This is ok, but with the new localized.sh program, the commands
31 #+ "bash -D filename" and "bash --dump-po-string filename"
32 #+ will produce no output
33 #+ (because those command are only searching for the "$"..." strings)!
34 # The ONLY way to extract strings from the new file is to use the
35 # 'xgettext' program. However, the xgettext program is buggy.
36
37 # Note that 'xgettext' has another bug.
38 #
39 # The shell fragment:
40 #     gettext -s "I like Bash"
41 # will be correctly extracted, but . . .
42 #     xgettext -s "I like Bash"
43 # . . . fails!
44 # 'xgettext' will extract "-s" because
45 #+ the command only extracts the
46 #+ very first argument after the 'gettext' word.
47
48
49 # Escape characters:
50 #
51 # To localize a sentence like
52 #     echo -e "Hello\tworld!"
```

```

53 #+ you must use
54 #     echo -e "`gettext \"Hello\\tworld\""
55 # The "double escape character" before the `t' is needed because
56 #+ 'gettext' will search for a string like: 'Hello\tworld'
57 # This is because gettext will read one literal `\'
58 #+ and will output a string like "Bonjour\tmonde",
59 #+ so the 'echo' command will display the message correctly.
60 #
61 # You may not use
62 #     echo "`gettext -e \"Hello\tworld\""
63 #+ due to the xgettext bug explained above.
64 #
65 #
66 #
67 # Let's localize the following shell fragment:
68 #     echo "-h display help and exit"
69 #
70 # First, one could do this:
71 #     echo "`gettext \"-h display help and exit\""
72 # This way 'xgettext' will work ok,
73 #+ but the 'gettext' program will read "-h" as an option!
74 #
75 # One solution could be
76 #     echo "`gettext -- \"-h display help and exit\""
77 # This way 'gettext' will work,
78 #+ but 'xgettext' will extract "--", as referred to above.
79 #
80 # The workaround you may use to get this string localized is
81 #     echo -e "`gettext \"\\0-h display help and exit\""
82 # We have added a \0 (NULL) at the beginning of the sentence.
83 # This way 'gettext' works correctly, as does 'xgettext.'
84 # Moreover, the NULL character won't change the behavior
85 #+ of the 'echo' command.
86 # -----

```

```

bash$ bash -D localized.sh
"Can't cd to %s."
"Enter the value: "

```

This lists all the localized text. (The `-D` option lists double-quoted strings prefixed by a `$`, without executing the script.)

```

bash$ bash --dump-po-strings localized.sh
#: a:6
msgid "Can't cd to %s."
msgstr ""
#: a:7
msgid "Enter the value: "
msgstr ""

```

The `--dump-po-strings` option to Bash resembles the `-D` option, but uses [gettext](#) "po" format.



Bruno Haible points out:

Starting with `gettext-0.12.2`, `xgettext -o - localized.sh` is recommended instead of `bash --dump-po-strings localized.sh`, because `xgettext` . . .

1. understands the `gettext` and `eval_gettext` commands (whereas `bash --dump-po-strings` understands only its deprecated `$"..."` syntax)
2. can extract comments placed by the programmer, intended to be read by the translator.

This shell code is then not specific to Bash any more; it works the same way with Bash 1.x and other `/bin/sh` implementations.

Now, build a language .po file for each language that the script will be translated into, specifying the *msgstr*. Alfredo Pironti gives the following example:

fr.po:

```
1 #: a:6
2 msgid "Can't cd to $var."
3 msgstr "Impossible de se positionner dans le repertoire $var."
4 #: a:7
5 msgid "Enter the value: "
6 msgstr "Entrez la valeur : "
7
8 # The string are dumped with the variable names, not with the %s syntax,
9 #+ similar to C programs.
10 #+ This is a very cool feature if the programmer uses
11 #+ variable names that make sense!
```

Then, run [msgfmt](#).

msgfmt -o localized.sh.mo fr.po

Place the resulting `localized.sh.mo` file in the `/usr/local/share/locale/fr/LC_MESSAGES` directory, and at the beginning of the script, insert the lines:

```
1 TEXTDOMAINDIR=/usr/local/share/locale
2 TEXTDOMAIN=localized.sh
```

If a user on a French system runs the script, she will get French messages.



With older versions of Bash or other shells, localization requires [gettext](#), using the `-s` option. In this case, the script becomes:

```
1 #!/bin/bash
2 # localized.sh
3
4 E_CDERROR=65
5
6 error() {
7     local format=$1
8     shift
9     printf "$(gettext -s "$format")" "$@" >&2
10    exit $E_CDERROR
11 }
12 cd $var || error "Can't cd to %s." "$var"
13 read -p "$(gettext -s "Enter the value: ")" var
14 # ...
```

The `TEXTDOMAIN` and `TEXTDOMAINDIR` variables need to be set and exported to the environment. This should be done within the script itself.

This appendix written by Stéphane Chazelas, with modifications suggested by Alfredo Pironti, and by Bruno Haible, maintainer of GNU [gettext](#).

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Appendix L. History Commands

The Bash shell provides command-line tools for editing and manipulating a user's *command history*. This is primarily a convenience, a means of saving keystrokes.

Bash history commands:

1. **history**
2. **fc**

```
bash$ history
1  mount /mnt/cdrom
2  cd /mnt/cdrom
3  ls
...
```

Internal variables associated with Bash history commands:

1. \$HISTCMD
2. \$HISTCONTROL
3. \$HISTIGNORE
4. \$HISTFILE
5. \$HISTFILESIZE
6. \$HISTSIZ
7. \$HISTTIMEFORMAT (Bash, ver. 3.0 or later)
8. !!
9. !\$
10. !#
11. !N
12. !-N
13. !STRING
14. !?STRING?
15. ^STRING^string^

Unfortunately, the Bash history tools find no use in scripting.

```
1 #!/bin/bash
2 # history.sh
3 # A (vain) attempt to use the 'history' command in a script.
4
5 history                # No output.
6
7 var=$(history); echo "$var" # $var is empty.
8
9 # History commands are, by default, disabled within a script.
10 # However, as dhw points out,
11 #+ set -o history
12 #+ enables the history mechanism.
13
14 set -o history
15 var=$(history); echo "$var" # 1 var=$(history)
```

```
bash$ ./history.sh
(no output)
```

The [Advancing in the Bash Shell](#) site gives a good introduction to the use of history commands in Bash.

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Appendix M. Sample .bashrc and .bash_profile Files

The ~/ .bashrc file determines the behavior of interactive shells. A good look at this file can lead to a better understanding of Bash.

[Emmanuel Rouat](#) contributed the following very elaborate .bashrc file, written for a Linux system. He welcomes reader feedback on it.

Study the file carefully, and feel free to reuse code snippets and functions from it in your own .bashrc file or even in your scripts.

Example M-1. Sample .bashrc file

```
1 # ===== #
2 #
3 # PERSONAL $HOME/.bashrc FILE for bash-3.0 (or later)
4 # By Emmanuel Rouat [no-email]
5 #
6 # Last modified: Tue Nov 20 22:04:47 CET 2012
7
8 # This file is normally read by interactive shells only.
9 #+ Here is the place to define your aliases, functions and
10 #+ other interactive features like your prompt.
11 #
12 # The majority of the code here assumes you are on a GNU
13 #+ system (most likely a Linux box) and is often based on code
14 #+ found on Usenet or Internet.
15 #
16 # See for instance:
17 # http://tldp.org/LDP/abs/html/index.html
18 # http://www.caliban.org/bash
19 # http://www.shellorado.com/scripts/categories.html
20 # http://www.dotfiles.org
21 #
22 # The choice of colors was done for a shell with a dark background
23 #+ (white on black), and this is usually also suited for pure text-mode
24 #+ consoles (no X server available). If you use a white background,
25 #+ you'll have to do some other choices for readability.
26 #
27 # This bashrc file is a bit overcrowded.
28 # Remember, it is just just an example.
29 # Tailor it to your needs.
30 #
31 # ===== #
32
33 # --> Comments added by HOWTO author.
34
35 # If not running interactively, don't do anything
36 [ -z "$PS1" ] && return
37
38
39 #-----
40 # Source global definitions (if any)
41 #-----
42
43
44 if [ -f /etc/bashrc ]; then
45     . /etc/bashrc # --> Read /etc/bashrc, if present.
46 fi
```

```

47
48
49 #-----
50 # Automatic setting of $DISPLAY (if not set already).
51 # This works for me - your mileage may vary. . . .
52 # The problem is that different types of terminals give
53 #+ different answers to 'who am i' (rxvt in particular can be
54 #+ troublesome) - however this code seems to work in a majority
55 #+ of cases.
56 #-----
57
58 function get_xserver ()
59 {
60     case $TERM in
61         xterm )
62             XSERVER=$(who am i | awk '{print $NF}' | tr -d ' ' )
63             # Ane-Pieter Wieringa suggests the following alternative:
64             # I_AM=$(who am i)
65             # SERVER=${I_AM#* }
66             # SERVER=${SERVER%*}
67             XSERVER=${XSERVER%:*}
68             ;;
69         aterm | rxvt)
70             # Find some code that works here. ...
71             ;;
72     esac
73 }
74
75 if [ -z ${DISPLAY:=} ]; then
76     get_xserver
77     if [[ -z ${XSERVER} || ${XSERVER} == $(hostname) ||
78         ${XSERVER} == "unix" ]]; then
79         DISPLAY=":0.0"           # Display on local host.
80     else
81         DISPLAY=${XSERVER}:0.0  # Display on remote host.
82     fi
83 fi
84
85 export DISPLAY
86
87 #-----
88 # Some settings
89 #-----
90
91 #set -o nounset      # These two options are useful for debugging.
92 #set -o xtrace
93 alias debug="set -o nounset; set -o xtrace"
94
95 ulimit -S -c 0      # Don't want core dumps.
96 set -o notify
97 set -o noclobber
98 set -o ignoreeof
99
100
101 # Enable options:
102 shopt -s cdspell
103 shopt -s cdable_vars
104 shopt -s checkhash
105 shopt -s checkwinsize
106 shopt -s sourcepath
107 shopt -s no_empty_cmd_completion
108 shopt -s cmdhist
109 shopt -s histappend histreedit histverify
110 shopt -s extglob      # Necessary for programmable completion.
111
112 # Disable options:

```

```

113 shopt -u mailwarn
114 unset MAILCHECK          # Don't want my shell to warn me of incoming mail.
115
116
117 #-----
118 # Greeting, motd etc. ...
119 #-----
120
121 # Color definitions (taken from Color Bash Prompt HowTo).
122 # Some colors might look different of some terminals.
123 # For example, I see 'Bold Red' as 'orange' on my screen,
124 # hence the 'Green' 'BRed' 'Red' sequence I often use in my prompt.
125
126
127 # Normal Colors
128 Black='\e[0;30m'          # Black
129 Red='\e[0;31m'           # Red
130 Green='\e[0;32m'         # Green
131 Yellow='\e[0;33m'        # Yellow
132 Blue='\e[0;34m'         # Blue
133 Purple='\e[0;35m'        # Purple
134 Cyan='\e[0;36m'         # Cyan
135 White='\e[0;37m'        # White
136
137 # Bold
138 BBlack='\e[1;30m'        # Black
139 BRed='\e[1;31m'          # Red
140 BGreen='\e[1;32m'        # Green
141 BYellow='\e[1;33m'       # Yellow
142 BBlue='\e[1;34m'        # Blue
143 BPurple='\e[1;35m'       # Purple
144 BCyan='\e[1;36m'        # Cyan
145 BWhite='\e[1;37m'       # White
146
147 # Background
148 On_Black='\e[40m'        # Black
149 On_Red='\e[41m'         # Red
150 On_Green='\e[42m'       # Green
151 On_Yellow='\e[43m'      # Yellow
152 On_Blue='\e[44m'        # Blue
153 On_Purple='\e[45m'      # Purple
154 On_Cyan='\e[46m'        # Cyan
155 On_White='\e[47m'      # White
156
157 NC="\e[m"                # Color Reset
158
159
160 ALERT=${BWhite}${On_Red} # Bold White on red background
161
162
163
164 echo -e "${BCyan}This is BASH ${BRed}${BASH_VERSION%.*}${BCyan}\
165 - DISPLAY on ${BRed}$DISPLAY${NC}\n"
166 date
167 if [ -x /usr/games/fortune ]; then
168     /usr/games/fortune -s      # Makes our day a bit more fun.... :-)
169 fi
170
171 function _exit()            # Function to run upon exit of shell.
172 {
173     echo -e "${BRed}Hasta la vista, baby${NC}"
174 }
175 trap _exit EXIT
176
177 #-----
178 # Shell Prompt - for many examples, see:

```

```

179 #      http://www.debian-administration.org/articles/205
180 #      http://www.askapache.com/linux/bash-power-prompt.html
181 #      http://tldp.org/HOWTO/Bash-Prompt-HOWTO
182 #      https://github.com/nojhan/liquidprompt
183 #-----
184 # Current Format: [TIME USER@HOST PWD] >
185 # TIME:
186 #   Green      == machine load is low
187 #   Orange     == machine load is medium
188 #   Red        == machine load is high
189 #   ALERT      == machine load is very high
190 # USER:
191 #   Cyan       == normal user
192 #   Orange     == SU to user
193 #   Red        == root
194 # HOST:
195 #   Cyan       == local session
196 #   Green      == secured remote connection (via ssh)
197 #   Red        == unsecured remote connection
198 # PWD:
199 #   Green      == more than 10% free disk space
200 #   Orange     == less than 10% free disk space
201 #   ALERT      == less than 5% free disk space
202 #   Red        == current user does not have write privileges
203 #   Cyan       == current filesystem is size zero (like /proc)
204 # >:
205 #   White      == no background or suspended jobs in this shell
206 #   Cyan       == at least one background job in this shell
207 #   Orange     == at least one suspended job in this shell
208 #
209 #   Command is added to the history file each time you hit enter,
210 #   so it's available to all shells (using 'history -a').
211
212
213 # Test connection type:
214 if [ -n "${SSH_CONNECTION}" ]; then
215     CNX=${Green}          # Connected on remote machine, via ssh (good).
216 elif [[ "${DISPLAY%:*}" != "" ]]; then
217     CNX=${ALERT}         # Connected on remote machine, not via ssh (bad).
218 else
219     CNX=${BCyan}         # Connected on local machine.
220 fi
221
222 # Test user type:
223 if [[ ${USER} == "root" ]]; then
224     SU=${Red}            # User is root.
225 elif [[ ${USER} != $(logname) ]]; then
226     SU=${BRed}          # User is not login user.
227 else
228     SU=${BCyan}         # User is normal (well ... most of us are).
229 fi
230
231
232
233 NCPU=$(grep -c 'processor' /proc/cpuinfo)    # Number of CPUs
234 SLOAD=$(( 100*${NCPU} ))                    # Small load
235 MLOAD=$(( 200*${NCPU} ))                    # Medium load
236 XLOAD=$(( 400*${NCPU} ))                    # Xlarge load
237
238 # Returns system load as percentage, i.e., '40' rather than '0.40'.
239 function load()
240 {
241     local SYSLOAD=$(cut -d " " -f1 /proc/loadavg | tr -d '.')
242     # System load of the current host.
243     echo $((10#SYSLOAD))                    # Convert to decimal.
244 }

```

```

245
246 # Returns a color indicating system load.
247 function load_color()
248 {
249     local SYSLOAD=$(load)
250     if [ ${SYSLOAD} -gt ${XLOAD} ]; then
251         echo -en ${ALERT}
252     elif [ ${SYSLOAD} -gt ${MLOAD} ]; then
253         echo -en ${Red}
254     elif [ ${SYSLOAD} -gt ${SLOAD} ]; then
255         echo -en ${BRed}
256     else
257         echo -en ${Green}
258     fi
259 }
260
261 # Returns a color according to free disk space in $PWD.
262 function disk_color()
263 {
264     if [ ! -w "${PWD}" ] ; then
265         echo -en ${Red}
266         # No 'write' privilege in the current directory.
267     elif [ -s "${PWD}" ] ; then
268         local used=$(command df -P "$PWD" |
269             awk 'END {print $5} {sub(/%/,"")}')
270         if [ ${used} -gt 95 ]; then
271             echo -en ${ALERT}           # Disk almost full (>95%).
272         elif [ ${used} -gt 90 ]; then
273             echo -en ${BRed}           # Free disk space almost gone.
274         else
275             echo -en ${Green}          # Free disk space is ok.
276         fi
277     else
278         echo -en ${Cyan}
279         # Current directory is size '0' (like /proc, /sys etc).
280     fi
281 }
282
283 # Returns a color according to running/suspended jobs.
284 function job_color()
285 {
286     if [ $(jobs -s | wc -l) -gt "0" ]; then
287         echo -en ${BRed}
288     elif [ $(jobs -r | wc -l) -gt "0" ] ; then
289         echo -en ${BCyan}
290     fi
291 }
292
293 # Adds some text in the terminal frame (if applicable).
294
295
296 # Now we construct the prompt.
297 PROMPT_COMMAND="history -a"
298 case ${TERM} in
299     *term | rxvt | linux)
300         PS1="\[\$(load_color)\][\A\[$NC]\] "
301         # Time of day (with load info):
302         PS1="\[\$(load_color)\][\A\[$NC]\] "
303         # User@Host (with connection type info):
304         PS1=${PS1}"\[$SU\]\u\[$NC\]\@\[$CNX\]\h\[$NC]\] "
305         # PWD (with 'disk space' info):
306         PS1=${PS1}"\[\$(disk_color)\]\W\[$NC]\] "
307         # Prompt (with 'job' info):
308         PS1=${PS1}"\[\$(job_color)\]>\[$NC]\] "
309         # Set title of current xterm:
310         PS1=${PS1}"\[\e]0;[\u@\h] \w\a\"

```

```

311     ;;
312 *)
313     PS1="(A \u@\h \w) > " # --> PS1="(A \u@\h \w) > "
314                             # --> Shows full pathname of current dir.
315     ;;
316 esac
317
318
319
320 export TIMEFORMAT=$'\nreal %3R\tuser %3U\tsys %3S\tpcpu %P\n'
321 export HISTIGNORE="&:bg:fg:ll:h"
322 export HISTTIMEFORMAT="$ (echo -e ${BCyan}) [%d/%m %H:%M:%S]$(echo -e ${NC}) "
323 export HISTCONTROL=ignoredups
324 export HOSTFILE=$HOME/.hosts # Put a list of remote hosts in ~/.hosts
325
326
327 #=====
328 #
329 # ALIASES AND FUNCTIONS
330 #
331 # Arguably, some functions defined here are quite big.
332 # If you want to make this file smaller, these functions can
333 #+ be converted into scripts and removed from here.
334 #
335 #=====
336
337 #-----
338 # Personal Aliases
339 #-----
340
341 alias rm='rm -i'
342 alias cp='cp -i'
343 alias mv='mv -i'
344 # -> Prevents accidentally clobbering files.
345 alias mkdir='mkdir -p'
346
347 alias h='history'
348 alias j='jobs -l'
349 alias which='type -a'
350 alias ..='cd ..'
351
352 # Pretty-print of some PATH variables:
353 alias path='echo -e ${PATH//:/\\n}'
354 alias libpath='echo -e ${LD_LIBRARY_PATH//:/\\n}'
355
356
357 alias du='du -kh' # Makes a more readable output.
358 alias df='df -kTh'
359
360 #-----
361 # The 'ls' family (this assumes you use a recent GNU ls).
362 #-----
363 # Add colors for filetype and human-readable sizes by default on 'ls':
364 alias ls='ls -h --color'
365 alias lx='ls -lXB' # Sort by extension.
366 alias lk='ls -lSr' # Sort by size, biggest last.
367 alias lt='ls -ltr' # Sort by date, most recent last.
368 alias lc='ls -ltcr' # Sort by/show change time,most recent last.
369 alias lu='ls -ltur' # Sort by/show access time,most recent last.
370
371 # The ubiquitous 'll': directories first, with alphanumeric sorting:
372 alias ll="ls -lv --group-directories-first"
373 alias lm='ll |more' # Pipe through 'more'
374 alias lr='ll -R' # Recursive ls.
375 alias la='ll -A' # Show hidden files.
376 alias tree='tree -Csh' # Nice alternative to 'recursive ls' ...

```

```

377
378
379 #-----
380 # Tailoring 'less'
381 #-----
382
383 alias more='less'
384 export PAGER=less
385 export LESSCHARSET='latin1'
386 export LESSOPEN='|/usr/bin/lesspipe.sh %s 2>&-'
387         # Use this if lesspipe.sh exists.
388 export LESS='-i -N -w -z-4 -g -e -M -X -F -R -P%t?f%f \
389 :stdin .?pb%pb\%:?lbLine %lb:?bbByte %bb:-... '
390
391 # LESS man page colors (makes Man pages more readable).
392 export LESS_TERMCAP_mb=$'\E[01;31m'
393 export LESS_TERMCAP_md=$'\E[01;31m'
394 export LESS_TERMCAP_me=$'\E[0m'
395 export LESS_TERMCAP_se=$'\E[0m'
396 export LESS_TERMCAP_so=$'\E[01;44;33m'
397 export LESS_TERMCAP_ue=$'\E[0m'
398 export LESS_TERMCAP_us=$'\E[01;32m'
399
400
401 #-----
402 # Spelling typos - highly personnal and keyboard-dependent :- )
403 #-----
404
405 alias xs='cd'
406 alias vf='cd'
407 alias moer='more'
408 alias moew='more'
409 alias kk='ll'
410
411
412 #-----
413 # A few fun ones
414 #-----
415
416 # Adds some text in the terminal frame (if applicable).
417
418 function xtitle()
419 {
420     case "$TERM" in
421         *term* | rxvt)
422             echo -en "\e]0;$*\a" ;;
423         *) ;;
424         esac
425 }
426
427
428 # Aliases that use xtitle
429 alias top='xtitle Processes on $HOST && top'
430 alias make='xtitle Making $(basename $PWD) ; make'
431
432 # .. and functions
433 function man()
434 {
435     for i ; do
436         xtitle The $(basename $1|tr -d .[:digit:]) manual
437         command man -a "$i"
438     done
439 }
440
441
442 #-----

```

```

443 # Make the following commands run in background automatically:
444 #-----
445
446 function te() # wrapper around xemacs/gnuserv
447 {
448     if [ "$(gnuclient -batch -eval t 2>&-)" == "t" ]; then
449         gnuclient -q "$@";
450     else
451         ( xemacs "$@" & );
452     fi
453 }
454
455 function soffice() { command soffice "$@" & }
456 function firefox() { command firefox "$@" & }
457 function xpdf() { command xpdf "$@" & }
458
459
460 #-----
461 # File & strings related functions:
462 #-----
463
464
465 # Find a file with a pattern in name:
466 function ff() { find . -type f -iname '*"$@"*' -ls ; }
467
468 # Find a file with pattern $1 in name and Execute $2 on it:
469 function fe() { find . -type f -iname '*"$1;-"' '*' \
470 -exec ${2:-file} {} \; ; }
471
472 # Find a pattern in a set of files and highlight them:
473 #+ (needs a recent version of egrep).
474 function fstr()
475 {
476     OPTIND=1
477     local mycase=""
478     local usage="fstr: find string in files.
479 Usage: fstr [-i] \"pattern\" [\"filename pattern\"] "
480     while getopts :it opt
481     do
482         case "$opt" in
483             i) mycase="-i " ;;
484             *) echo "$usage"; return ;;
485         esac
486     done
487     shift $(( OPTIND - 1 ))
488     if [ "$#" -lt 1 ]; then
489         echo "$usage"
490         return;
491     fi
492     find . -type f -name "${2:-*}" -print0 | \
493 xargs -0 egrep --color=always -sn ${case} "$1" 2>&- | more
494
495 }
496
497
498 function swap()
499 { # Swap 2 filenames around, if they exist (from Uzi's bashrc).
500     local TMPFILE=tmp.$$
501
502     [ $# -ne 2 ] && echo "swap: 2 arguments needed" && return 1
503     [ ! -e $1 ] && echo "swap: $1 does not exist" && return 1
504     [ ! -e $2 ] && echo "swap: $2 does not exist" && return 1
505
506     mv "$1" $TMPFILE
507     mv "$2" "$1"
508     mv $TMPFILE "$2"

```



```

509 }
510
511 function extract()      # Handy Extract Program
512 {
513     if [ -f $1 ] ; then
514         case $1 in
515             *.tar.bz2) tar xvjf $1      ;;
516             *.tar.gz) tar xvzf $1      ;;
517             *.bz2)   bunzip2 $1        ;;
518             *.rar)   unrar x $1        ;;
519             *.gz)    gunzip $1         ;;
520             *.tar)   tar xvf $1        ;;
521             *.tbz2) tar xvjf $1        ;;
522             *.tgz)   tar xvzf $1        ;;
523             *.zip)   unzip $1          ;;
524             *.Z)     uncompress $1     ;;
525             *.7z)    7z x $1           ;;
526             *)       echo "'$1' cannot be extracted via >extract<" ;;
527         esac
528     else
529         echo "'$1' is not a valid file!"
530     fi
531 }
532
533
534 # Creates an archive (*.tar.gz) from given directory.
535 function maketar() { tar cvzf "${1%}/.tar.gz" "${1%}/" ; }
536
537 # Create a ZIP archive of a file or folder.
538 function makezip() { zip -r "${1%}/.zip" "$1" ; }
539
540 # Make your directories and files access rights sane.
541 function sanitize() { chmod -R u=rwX,g=rX,o= "$@" ; }
542
543 #-----
544 # Process/system related functions:
545 #-----
546
547
548 function my_ps() { ps $@ -u $USER -o pid,%cpu,%mem,bsdtime,command ; }
549 function pp() { my_ps f | awk '!/awk/ && $0~var' var=${1:-".*"} ; }
550
551
552 function killps() # kill by process name
553 {
554     local pid pname sig="-TERM" # default signal
555     if [ "$#" -lt 1 ] || [ "$#" -gt 2 ] ; then
556         echo "Usage: killps [-SIGNAL] pattern"
557         return ;
558     fi
559     if [ $# = 2 ] ; then sig=$1 ; fi
560     for pid in $(my_ps | awk '!/awk/ && $0~pat { print $1 }' pat=${!#} )
561     do
562         pname=$(my_ps | awk '$1~var { print $5 }' var=$pid )
563         if ask "Kill process $pid <$pname> with signal $sig?"
564             then kill $sig $pid
565         fi
566     done
567 }
568
569 function mydf() # Pretty-print of 'df' output.
570 { # Inspired by 'dfc' utility.
571     for fs ; do
572
573         if [ ! -d $fs ]
574         then

```

```

575         echo -e $fs" :No such file or directory" ; continue
576     fi
577
578     local info=( $(command df -P $fs | awk 'END{ print $2,$3,$5 }') )
579     local free=( $(command df -Pkh $fs | awk 'END{ print $4 }') )
580     local nbstars=$(( 20 * ${info[1]} / ${info[0]} ) )
581     local out=""
582     for ((j=0;j<20;j++)); do
583         if [ ${j} -lt ${nbstars} ]; then
584             out=$out"*"
585         else
586             out=$out "-"
587         fi
588     done
589     out=${info[2]} " "$out " ($free" free on "$fs)"
590     echo -e $out
591 done
592 }
593
594
595 function my_ip() # Get IP adress on ethernet.
596 {
597     MY_IP=$(/sbin/ifconfig eth0 | awk '/inet/ { print $2 } ' |
598     sed -e s/addr://)
599     echo ${MY_IP:-"Not connected"}
600 }
601
602 function ii() # Get current host related info.
603 {
604     echo -e "\nYou are logged on ${BRed}$HOST"
605     echo -e "\n${BRed}Additionnal information:$NC " ; uname -a
606     echo -e "\n${BRed}Users logged on:$NC " ; w -hs |
607         cut -d " " -f1 | sort | uniq
608     echo -e "\n${BRed}Current date :$NC " ; date
609     echo -e "\n${BRed}Machine stats :$NC " ; uptime
610     echo -e "\n${BRed}Memory stats :$NC " ; free
611     echo -e "\n${BRed}Diskspace :$NC " ; mydf / $HOME
612     echo -e "\n${BRed}Local IP Address :$NC" ; my_ip
613     echo -e "\n${BRed}Open connections :$NC " ; netstat -pan --inet;
614     echo
615 }
616
617 #-----
618 # Misc utilities:
619 #-----
620
621 function repeat() # Repeat n times command.
622 {
623     local i max
624     max=$1; shift;
625     for ((i=1; i <= max ; i++)); do # --> C-like syntax
626         eval "$@";
627     done
628 }
629
630
631 function ask() # See 'killps' for example of use.
632 {
633     echo -n "$@" '[y/n] ' ; read ans
634     case "$ans" in
635         y*|Y*) return 0 ;;
636         *) return 1 ;;
637     esac
638 }
639
640 function corename() # Get name of app that created a corefile.

```

```

641 {
642     for file ; do
643         echo -n $file : ; gdb --core=$file --batch | head -1
644     done
645 }
646
647
648
649 #=====
650 #
651 # PROGRAMMABLE COMPLETION SECTION
652 # Most are taken from the bash 2.05 documentation and from Ian McDonald's
653 # 'Bash completion' package (http://www.caliban.org/bash/#completion)
654 # You will in fact need bash more recent than 3.0 for some features.
655 #
656 # Note that most linux distributions now provide many completions
657 # 'out of the box' - however, you might need to make your own one day,
658 # so I kept those here as examples.
659 #=====
660
661 if [ "${BASH_VERSION%.*}" \< "3.0" ]; then
662     echo "You will need to upgrade to version 3.0 for full \
663         programmable completion features"
664     return
665 fi
666
667 shopt -s extglob          # Necessary.
668
669 complete -A hostname    rsh rcp telnet rlogin ftp ping disk
670 complete -A export      printenv
671 complete -A variable    export local readonly unset
672 complete -A enabled     builtin
673 complete -A alias       alias unalias
674 complete -A function    function
675 complete -A user        su mail finger
676
677 complete -A helptopic   help      # Currently same as builtins.
678 complete -A shopt       shopt
679 complete -A stopped -P '%' bg
680 complete -A job -P '%'  fg jobs disown
681
682 complete -A directory   mkdir rmdir
683 complete -A directory   -o default cd
684
685 # Compression
686 complete -f -o default -X '*.+(zip|ZIP)' zip
687 complete -f -o default -X '!*.*(zip|ZIP)' unzip
688 complete -f -o default -X '*.+(z|Z)' compress
689 complete -f -o default -X '!*.*(z|Z)' uncompress
690 complete -f -o default -X '*.+(gz|GZ)' gzip
691 complete -f -o default -X '!*.*(gz|GZ)' gunzip
692 complete -f -o default -X '*.+(bz2|BZ2)' bzip2
693 complete -f -o default -X '!*.*(bz2|BZ2)' bunzip2
694 complete -f -o default -X '!*.*(zip|ZIP|z|Z|gz|GZ|bz2|BZ2)' extract
695
696
697 # Documents - Postscript, pdf, dvi.....
698 complete -f -o default -X '!*.*(ps|PS)' gs ghostview ps2pdf ps2ascii
699 complete -f -o default -X \
700 '!*.*(dvi|DVI)' dvips dvi2pdf xdvi dviselect dvitype
701 complete -f -o default -X '!*.*(pdf|PDF)' acroread pdf2ps
702 complete -f -o default -X '!*.@(?(e)ps|?(E)PS|pdf|PDF)?\
703 (.gz|.GZ|.bz2|.BZ2|.Z))' gv ggv
704 complete -f -o default -X '!*.texi*' makeinfo texi2dvi texi2html texi2pdf
705 complete -f -o default -X '!*.tex' tex latex slitex
706 complete -f -o default -X '!*.lyx' lyx

```

```

707 complete -f -o default -X '!*.+(htm*|HTM*)' lynx html2ps
708 complete -f -o default -X \
709 '!*.+(doc|DOC|xls|XLS|ppt|PPT|sx?|SX?|csv|CSV|od?|OD?|ott|OTT)' soffice
710
711 # Multimedia
712 complete -f -o default -X \
713 '!*.+(gif|GIF|jpg*g|JP*G|bmp|BMP|xpm|XPM|png|PNG)' xv gimp ee gqview
714 complete -f -o default -X '!*.+(mp3|MP3)' mpg123 mpg321
715 complete -f -o default -X '!*.+(ogg|OGG)' ogg123
716 complete -f -o default -X \
717 '!*.@(mp[23]|MP[23]|ogg|OGG|wav|WAV|pls|\
718 m3u|xm|mod|s[3t]m|it|mtm|ult|flac)' xmms
719 complete -f -o default -X '!*.@(mp?(e)g|MP?(E)G|wma|avi|AVI|\
720 asf|vob|VOB|bin|dat|vcd|ps|pes|fli|viv|rm|ram|yuv|mov|MOV|qt|\
721 QT|wmv|mp3|MP3|ogg|OGG|ogm|OGM|mp4|MP4|wav|WAV|asx|ASX)' xine
722
723
724
725 complete -f -o default -X '!*.pl' perl perl5
726
727
728 # This is a 'universal' completion function - it works when commands have
729 #+ a so-called 'long options' mode , ie: 'ls --all' instead of 'ls -a'
730 # Needs the '-o' option of grep
731 #+ (try the commented-out version if not available).
732
733 # First, remove '=' from completion word separators
734 #+ (this will allow completions like 'ls --color=auto' to work correctly).
735
736 COMP_WORDBREAKS=${COMP_WORDBREAKS/=/}
737
738
739 _get_longopts()
740 {
741     # $1 --help | sed -e '/--/!d' -e 's/.*--\([^[:space:].,]*\)*/--\1/' | \
742     #grep ^"$2" |sort -u ;
743     $1 --help | grep -o -e "--^[[:space:].,]*" | grep -e "$2" |sort -u
744 }
745
746 _longopts()
747 {
748     local cur
749     cur=${COMP_WORDS[COMP_CWORD]}
750
751     case "${cur:-*}" in
752         -*)      ;;
753         *)      return ;;
754     esac
755
756     case "$1" in
757         \~*)    eval cmd="$1" ;;
758         *)      cmd="$1" ;;
759     esac
760     COMPREPLY=( $( _get_longopts $1 ${cur} ) )
761 }
762 complete -o default -F _longopts configure bash
763 complete -o default -F _longopts wget id info a2ps ls recode
764
765 _tar()
766 {
767     local cur ext regex tar untar
768
769     COMPREPLY=()
770     cur=${COMP_WORDS[COMP_CWORD]}
771
772     # If we want an option, return the possible long options.

```

```

773     case "$cur" in
774         -*)      COMPREPLY=( $( _get_longopts $1 $cur ) ); return 0;;
775     esac
776
777     if [ $COMP_CWORD -eq 1 ]; then
778         COMPREPLY=( $( compgen -W 'c t x u r d A' -- $cur ) )
779         return 0
780     fi
781
782     case "${COMP_WORDS[1]}" in
783         ?(-)c*f)
784             COMPREPLY=( $( compgen -f $cur ) )
785             return 0
786             ;;
787         +([Izjy])f)
788             ext='tar'
789             regex=$ext
790             ;;
791         *z*f)
792             ext='tar.gz'
793             regex='t\(ar\.\)\(gz\|Z\)'
794             ;;
795         *[Ijy]*f)
796             ext='t?(ar.)bz?(2)'
797             regex='t\(ar\.\)bz2\?'
798             ;;
799         *)
800             COMPREPLY=( $( compgen -f $cur ) )
801             return 0
802             ;;
803     esac
804
805     if [[ "$COMP_LINE" == tar*.$ext' '* ]]; then
806         # Complete on files in tar file.
807         #
808         # Get name of tar file from command line.
809         tar=$( echo "$COMP_LINE" | \
810             sed -e 's|^.* \([^ ]*$regex\) .*$|\1|' )
811         # Devise how to untar and list it.
812         untar=t${COMP_WORDS[1]//[Izjy]f}/
813
814         COMPREPLY=( $( compgen -W "$( echo $( tar $untar $tar \
815             2>/dev/null ) )" -- "$cur" ) )
816         return 0
817     else
818         # File completion on relevant files.
819         COMPREPLY=( $( compgen -G $cur*.$ext ) )
820     fi
821
822     return 0
823 }
824
825 complete -F _tar -o default tar
826
827 _make()
828 {
829     local mdef makef makef_dir="." makef_inc gcmd cur prev i;
830     COMPREPLY=();
831     cur=${COMP_WORDS[COMP_CWORD]};
832     prev=${COMP_WORDS[COMP_CWORD-1]};
833     case "$prev" in
834         -*)

```

```

839         COMPREPLY=$(compgen -f $cur );
840         return 0
841         ;;
842     esac;
843     case "$cur" in
844         -*)
845             COMPREPLY=$( _get_longopts $1 $cur );
846             return 0
847             ;;
848     esac;
849
850     # ... make reads
851     #     GNUmakefile,
852     #     then makefile
853     #     then Makefile ...
854     if [ -f ${makef_dir}/GNUmakefile ]; then
855         makef=${makef_dir}/GNUmakefile
856     elif [ -f ${makef_dir}/makefile ]; then
857         makef=${makef_dir}/makefile
858     elif [ -f ${makef_dir}/Makefile ]; then
859         makef=${makef_dir}/Makefile
860     else
861         makef=${makef_dir}/*.mk           # Local convention.
862     fi
863
864
865     # Before we scan for targets, see if a Makefile name was
866     #+ specified with -f.
867     for (( i=0; i < ${#COMP_WORDS[@]}; i++ )); do
868         if [[ ${COMP_WORDS[i]} == -f ]]; then
869             # eval for tilde expansion
870             eval makef=${COMP_WORDS[i+1]}
871             break
872         fi
873     done
874     [ ! -f $makef ] && return 0
875
876     # Deal with included Makefiles.
877     makef_inc=$( grep -E '^-?include' $makef |
878                 sed -e "s,^.* ,"$makef_dir"/," )
879     for file in $makef_inc; do
880         [ -f $file ] && makef="$makef $file"
881     done
882
883
884     # If we have a partial word to complete, restrict completions
885     #+ to matches of that word.
886     if [ -n "$cur" ]; then gcmd='grep "^$cur"' ; else gcmd=cat ; fi
887
888     COMPREPLY=( $( awk -F': ' '/^[a-zA-Z0-9][^#\|\\t]*:([^\=]|$)/ \
889                 {split($1,A,/ /);for(i in A)print A[i]}' \
890                 $makef 2>/dev/null | eval $gcmd ) )
891
892 }
893
894 complete -F _make -X '+(${*}|*.[cho])' make gmake pmake
895
896
897
898
899 _killall()
900 {
901     local cur prev
902     COMPREPLY=()
903     cur=${COMP_WORDS[COMP_CWORD]}
904

```

```

905 # Get a list of processes
906 #+ (the first sed evaluation
907 #+ takes care of swapped out processes, the second
908 #+ takes care of getting the basename of the process).
909 COMPREPLY=( $( ps -u $USER -o comm | \
910     sed -e '1,1d' -e 's#[]\[]##g' -e 's#^.*/##' | \
911     awk '{if ($0 ~ /^$cur/) print $0}' )
912
913     return 0
914 }
915
916 complete -F _killall killall killps
917
918
919
920 # Local Variables:
921 # mode:shell-script
922 # sh-shell:bash
923 # End:

```

And, here is a snippet from Andrzej Szelachowski's instructive `.bash_profile` file.

Example M-2. `.bash_profile` file

```

1 # From Andrzej Szelachowski's ~/.bash_profile:
2
3
4 # Note that a variable may require special treatment
5 #+ if it will be exported.
6
7 DARKGRAY='\e[1;30m'
8 LIGHTRED='\e[1;31m'
9 GREEN='\e[32m'
10 YELLOW='\e[1;33m'
11 LIGHTBLUE='\e[1;34m'
12 NC='\e[m'
13
14 PCT="\`if [[ \${EUID} -eq 0 ]]; then T='${LIGHTRED}'; else T='${LIGHTBLUE}'; fi;
15 echo \${T} \`"
16
17 # For "literal" command substitution to be assigned to a variable,
18 #+ use escapes and double quotes:
19 #+     PCT="\` ... \`" . . .
20 # Otherwise, the value of PCT variable is assigned only once,
21 #+ when the variable is exported/read from .bash_profile,
22 #+ and it will not change afterwards even if the user ID changes.
23
24
25 PS1="\n${GREEN}[w] \n${DARKGRAY}(${PCT}\t${DARKGRAY})-(${PCT}\u${DARKGRAY})-(${PCT}\!
26 ${DARKGRAY})${YELLOW}-> ${NC}"
27
28 # Escape a variables whose value changes:
29 #     if [[ \${EUID} -eq 0 ]],
30 # Otherwise the value of the EUID variable will be assigned only once,
31 #+ as above.
32
33 # When a variable is assigned, it should be called escaped:
34 #+     echo \${T},
35 # Otherwise the value of the T variable is taken from the moment the PCT
36 #+ variable is exported/read from .bash_profile.
37 # So, in this example it would be null.
38
39 # When a variable's value contains a semicolon it should be strong quoted:

```

```
40 #           T='$LIGHTRED',
41 # Otherwise, the semicolon will be interpreted as a command separator.
42
43
44 # Variables PCT and PS1 can be merged into a new PS1 variable:
45
46 PS1="\`if [[ \${EUID} -eq 0 ]]; then PCT='$LIGHTRED';
47 else PCT='$LIGHTBLUE'; fi;
48 echo '\n${GREEN}[w] \n${DARKGRAY}('\`$PCT'\t${DARKGRAY})-\`
49 ('\`$PCT'\u${DARKGRAY})-('\`$PCT'\!${DARKGRAY})$YELLOW-> $NC'\`"
50
51 # The trick is to use strong quoting for parts of old PS1 variable.
```

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Appendix N. Converting DOS Batch Files to Shell Scripts

Quite a number of programmers learned scripting on a PC running DOS. Even the crippled DOS batch file language allowed writing some fairly powerful scripts and applications, though they often required extensive kludges and workarounds. Occasionally, the need still arises to convert an old DOS batch file to a UNIX shell script. This is generally not difficult, as DOS batch file operators are only a limited subset of the equivalent shell scripting ones.

Table N-1. Batch file keywords / variables / operators, and their shell equivalents

Batch File Operator	Shell Script Equivalent	Meaning
%	\$	command-line parameter prefix
/	-	command option flag
\	/	directory path separator
==	=	(equal-to) string comparison test
!==!	!=	(not equal-to) string comparison test
		pipe
@	set +v	do not echo current command
*	*	filename "wild card"
>	>	file redirection (overwrite)
>>	>>	file redirection (append)
<	<	redirect stdin
%VAR%	\$VAR	environmental variable
REM	#	comment
NOT	!	negate following test
NUL	/dev/null	"black hole" for burying command output
ECHO	echo	echo (many more option in Bash)
ECHO.	echo	echo blank line
ECHO OFF	set +v	do not echo command(s) following
FOR %%VAR IN (LIST) DO	for var in [list]; do	"for" loop
:LABEL	none (unnecessary)	label
GOTO	none (use a function)	jump to another location in the script
PAUSE	sleep	pause or wait an interval
CHOICE	case or select	menu choice
IF	if	if-test
IF EXIST <i>FILENAME</i>	if [-e filename]	test if file exists
IF !%N==!	if [-z "\$N"]	if replaceable parameter "N" not present
CALL	source or . (dot operator)	"include" another script
COMMAND /C	source or . (dot operator)	"include" another script (same as CALL)
SET	export	set an environmental variable
SHIFT	shift	left shift command-line argument list
SGN	-lt or -gt	sign (of integer)

ERRORLEVEL	\$?	exit status
CON	stdin	"console" (stdin)
PRN	/dev/lp0	(generic) printer device
LPT1	/dev/lp0	first printer device
COM1	/dev/ttyS0	first serial port

Batch files usually contain DOS commands. These must be translated into their UNIX equivalents in order to convert a batch file into a shell script.

Table N-2. DOS commands and their UNIX equivalents

DOS Command	UNIX Equivalent	Effect
ASSIGN	ln	link file or directory
ATTRIB	chmod	change file permissions
CD	cd	change directory
CHDIR	cd	change directory
CLS	clear	clear screen
COMP	diff, comm, cmp	file compare
COPY	cp	file copy
Ctl-C	Ctl-C	break (signal)
Ctl-Z	Ctl-D	EOF (end-of-file)
DEL	rm	delete file(s)
DELTREE	rm -rf	delete directory recursively
DIR	ls -l	directory listing
ERASE	rm	delete file(s)
EXIT	exit	exit current process
FC	comm, cmp	file compare
FIND	grep	find strings in files
MD	mkdir	make directory
MKDIR	mkdir	make directory
MORE	more	text file paging filter
MOVE	mv	move
PATH	\$PATH	path to executables
REN	mv	rename (move)
RENAME	mv	rename (move)
RD	rmdir	remove directory
RMDIR	rmdir	remove directory
SORT	sort	sort file
TIME	date	display system time
TYPE	cat	output file to stdout
XCOPY	cp	(extended) file copy



Virtually all UNIX and shell operators and commands have many more options and enhancements than their DOS and batch file counterparts. Many DOS batch files rely on auxiliary utilities, such as **ask.com**,

a crippled counterpart to [read](#).

DOS supports only a very limited and incompatible subset of filename [wild-card expansion](#), recognizing just the * and ? characters.

Converting a DOS batch file into a shell script is generally straightforward, and the result oftentimes reads better than the original.

Example N-1. VIEWDATA.BAT: DOS Batch File

```
1 REM VIEWDATA
2
3 REM INSPIRED BY AN EXAMPLE IN "DOS POWERTOOLS"
4 REM                               BY PAUL SOMERSON
5
6
7 @ECHO OFF
8
9 IF !%1==! GOTO VIEWDATA
10 REM IF NO COMMAND-LINE ARG...
11 FIND "%1" C:\BOZO\BOOKLIST.TXT
12 GOTO EXIT0
13 REM PRINT LINE WITH STRING MATCH, THEN EXIT.
14
15 :VIEWDATA
16 TYPE C:\BOZO\BOOKLIST.TXT | MORE
17 REM SHOW ENTIRE FILE, 1 PAGE AT A TIME.
18
19 :EXIT0
```

The script conversion is somewhat of an improvement. [\[1\]](#)

Example N-2. *viewdata.sh*: Shell Script Conversion of VIEWDATA.BAT

```
1 #!/bin/bash
2 # viewdata.sh
3 # Conversion of VIEWDATA.BAT to shell script.
4
5 DATAFILE=/home/bozo/datafiles/book-collection.data
6 ARGNO=1
7
8 # @ECHO OFF                Command unnecessary here.
9
10 if [ $# -lt "$ARGNO" ]    # IF !%1==! GOTO VIEWDATA
11 then
12     less $DATAFILE        # TYPE C:\MYDIR\BOOKLIST.TXT | MORE
13 else
14     grep "$1" $DATAFILE   # FIND "%1" C:\MYDIR\BOOKLIST.TXT
15 fi
16
17 exit 0                    # :EXIT0
18
19 # GOTOs, labels, smoke-and-mirrors, and flimflam unnecessary.
20 # The converted script is short, sweet, and clean,
21 #+ which is more than can be said for the original.
```

Ted Davis' [Shell Scripts on the PC](#) site had a set of comprehensive tutorials on the old-fashioned art of batch file programming. Unfortunately the page has vanished without a trace.

Notes

- [1] Various readers have suggested modifications of the above batch file to prettify it and make it more compact and efficient. In the opinion of the *ABS Guide* author, this is wasted effort. A Bash script can access a DOS filesystem, or even an NTFS partition (with the help of [ntfs-3g](#)) to do batch or scripted operations.

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Appendix O. Exercises

The exercises that follow test and extend your knowledge of scripting. Think of them as a challenge, as an entertaining way to take you further along the stony path toward UNIX wizardry.

On a dingy side street in a run-down section of Hoboken, New Jersey, there sits a nondescript squat two-story brick building with an inscription incised on a marble plate in its wall:

```
Bash Scripting Hall of Fame.
```

Inside, among various dusty uninteresting exhibits is a corroding, cobweb-festooned brass plaque inscribed with a short, very short list of those few persons who have successfully mastered the material in the *Advanced Bash Scripting Guide*, as evidenced by their performance on the following Exercise sections.

(Alas, the author of the *ABS Guide* is not represented among the exhibits. This is possibly due to malicious rumors about [lack of credentials](#) and [deficient scripting skills](#).)

O.1. Analyzing Scripts

Examine the following script. Run it, then explain what it does. Annotate the script and rewrite it in a more compact and elegant manner.

```
1 #!/bin/bash
2
3 MAX=10000
4
5
6 for((nr=1; nr<$MAX; nr++))
7 do
8
9     let "t1 = nr % 5"
10    if [ "$t1" -ne 3 ]
11    then
12        continue
13    fi
14
15    let "t2 = nr % 7"
16    if [ "$t2" -ne 4 ]
17    then
18        continue
19    fi
20
21    let "t3 = nr % 9"
22    if [ "$t3" -ne 5 ]
23    then
24        continue
25    fi
26
27    break    # What happens when you comment out this line? Why?
28
29 done
30
31 echo "Number = $nr"
32
33
34 exit 0
```

Explain what the following script does. It is really just a parameterized command-line pipe.

```
1 #!/bin/bash
2
3 DIRNAME=/usr/bin
4 FILETYPE="shell script"
5 LOGFILE=logfile
6
7 file "$DIRNAME"/* | fgrep "$FILETYPE" | tee $LOGFILE | wc -l
8
9 exit 0
```

Examine and explain the following script. For hints, you might refer to the listings for [find](#) and [stat](#).

```
1 #!/bin/bash
2
3 # Author:  Nathan Coulter
4 # This code is released to the public domain.
5 # The author gave permission to use this code snippet in the ABS Guide.
6
```

```
7 find -maxdepth 1 -type f -printf '%f\000' | {
8   while read -d $'\000'; do
9     mv "$REPLY" "$(date -d "$(stat -c '%y' "$REPLY")" "+%Y%m%d%H%M%S"
10    )-$REPLY"
11   done
12 }
13
14 # Warning: Test-drive this script in a "scratch" directory.
15 # It will somehow affect all the files there.
```

A reader sent in the following code snippet.

```
1 while read LINE
2 do
3   echo $LINE
4 done < `tail -f /var/log/messages`
```

He wished to write a script tracking changes to the system log file, `/var/log/messages`. Unfortunately, the above code block hangs and does nothing useful. Why? Fix this so it does work. (Hint: rather than [redirecting the stdin of the loop](#), try a [pipe](#).)

Analyze the following "one-liner" (here split into two lines for clarity) contributed by Rory Winston:

```
1 export SUM=0; for f in $(find src -name "*.java");
2 do export SUM=$((SUM + $(wc -l $f | awk '{ print $1 }'))); done; echo $SUM
```

Hint: First, break the script up into bite-sized sections. Then, carefully examine its use of [double-parentheses](#) arithmetic, the [export](#) command, the [find](#) command, the [wc](#) command, and [awk](#).

Analyze [Example A-10](#), and reorganize it in a simplified and more logical style. See how many of the variables can be eliminated, and try to optimize the script to speed up its execution time.

Alter the script so that it accepts any ordinary ASCII text file as input for its initial "generation". The script will read the first `$ROW*$COL` characters, and set the occurrences of vowels as "living" cells. Hint: be sure to translate the spaces in the input file to underscore characters.

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O.2. Writing Scripts

Write a script to carry out each of the following tasks.

EASY

Self-reproducing Script

Write a script that backs itself up, that is, copies itself to a file named `backup.sh`.

Hint: Use the `cat` command and the appropriate [positional parameter](#).

Home Directory Listing

Perform a recursive directory listing on the user's home directory and save the information to a file. Compress the file, have the script prompt the user to insert a USB flash drive, then press **ENTER**. Finally, save the file to the flash drive after making certain the flash drive has properly mounted by parsing the output of `df`. Note that the flash drive must be *unmounted* before it is removed.

Converting `for` loops to `while` and `until` loops

Convert the *for loops* in [Example 11-1](#) to *while loops*. Hint: store the data in an [array](#) and step through the array elements.

Having already done the "heavy lifting," now convert the loops in the example to *until loops*.

Changing the line spacing of a text file

Write a script that reads each line of a target file, then writes the line back to `stdout`, but with an extra blank line following. This has the effect of *double-spacing* the file.

Include all necessary code to check whether the script gets the necessary command-line argument (a filename), and whether the specified file exists.

When the script runs correctly, modify it to *triple-space* the target file.

Finally, write a script to remove all blank lines from the target file, *single-spacing* it.

Backwards Listing

Write a script that echoes itself to `stdout`, but *backwards*.

Automatically Decompressing Files

Given a list of filenames as input, this script queries each target file (parsing the output of the `file` command) for the type of compression used on it. Then the script automatically invokes the appropriate decompression command (`gunzip`, `bunzip2`, `unzip`, `uncompress`, or whatever). If a target file is not compressed, the script emits a warning message, but takes no other action on that particular file.

Unique System ID

Generate a "unique" 6-digit hexadecimal identifier for your computer. Do *not* use the flawed `hostid` command. Hint: `md5sum /etc/passwd`, then select the first 6 digits of output.

Backup

Archive as a "tarball" (`*.tar.gz` file) all the files in your home directory tree (`/home/your-name`) that have been modified in the last 24 hours. Hint: use `find`.

Optional: you may use this as the basis of a *backup* script.

Checking whether a process is still running

Given a [process ID](#) (*PID*) as an argument, this script will check, at user-specified intervals, whether the given process is still running. You may use the `ps` and `sleep` commands.

Primes

Print (to `stdout`) all prime numbers between 60000 and 63000. The output should be nicely formatted in columns (hint: use `printf`).

Lottery Numbers

One type of lottery involves picking five different numbers, in the range of 1 - 50. Write a script that generates five pseudorandom numbers in this range, *with no duplicates*. The script will give the option of echoing the numbers to `stdout` or saving them to a file, along with the date and time the particular number set was generated. (If your script consistently generates *winning* lottery numbers, then you can retire on the proceeds and leave shell scripting to those of us who have to work for a living.)

INTERMEDIATE

Integer or String

Write a script [function](#) that determines if an argument passed to it is an integer or a string. The function will return TRUE (0) if passed an integer, and FALSE (1) if passed a string.

Hint: What does the following expression return when `$1` is *not* an integer?

```
expr $1 + 0
```

ASCII to Integer

The `atoi` function in **C** converts a string character to an integer. Write a shell script function that performs the same operation. Likewise, write a shell script function that does the inverse, mirroring the `C` `itoa` function which converts an integer into an ASCII character.

Managing Disk Space

List, one at a time, all files larger than 100K in the `/home/username` directory tree. Give the user the option to delete or compress the file, then proceed to show the next one. Write to a logfile the names of all deleted files and the deletion times.

Banner

Simulate the functionality of the deprecated [banner](#) command in a script.

Removing Inactive Accounts

Inactive accounts on a network server waste disk space and may become a security risk. Write an administrative script (to be invoked by `root` or the [cron daemon](#)) that checks for and deletes user accounts that have not been accessed within the last 90 days.

Enforcing Disk Quotas

Write a script for a multi-user system that checks users' disk usage. If a user surpasses a preset limit (500 MB, for example) in her `/home/username` directory, then the script automatically sends her a "pigout" warning e-mail.

The script will use the [du](#) and [mail](#) commands. As an option, it will allow setting and enforcing quotas using the [quota](#) and [setquota](#) commands.

Logged in User Information

For all logged in users, show their real names and the time and date of their last login.

Hint: use [who](#), [lastlog](#), and parse [/etc/passwd](#).

Safe Delete

Implement, as a script, a "safe" delete command, `sdel.sh`. Filenames passed as command-line arguments to this script are not deleted, but instead [gzipped](#) if not already compressed (use [file](#) to check), then moved to a `~/TRASH` directory. Upon invocation, the script checks the `~/TRASH` directory for files older than 48 hours and [permanently deletes](#) them. (An better alternative might be to have a second script handle this, periodically invoked by the [cron daemon](#).)

Extra credit: Write the script so it can handle files and directories [recursively](#). This would give it the capability of "safely deleting" entire directory structures.

Making Change

What is the most efficient way to make change for \$1.68, using only coins in common circulations (up to 25c)? It's 6 quarters, 1 dime, a nickel, and three cents.

Given any arbitrary command-line input in dollars and cents (\$*.??), calculate the change, using the minimum number of coins. If your home country is not the United States, you may use your local currency units instead. The script will need to parse the command-line input, then change it to multiples of the smallest monetary unit (cents or whatever). Hint: look at [Example 24-8](#).

Quadratic Equations

Solve a *quadratic* equation of the form $Ax^2 + Bx + C = 0$. Have a script take as arguments the coefficients, **A**, **B**, and **C**, and return the solutions to five decimal places.

Hint: pipe the coefficients to [bc](#), using the well-known formula, $x = (-B +/- \text{sqrt} (B^2 - 4AC)) / 2A$.

Table of Logarithms

Using the [bc](#) and [printf](#) commands, print out a nicely-formatted table of eight-place natural logarithms in the interval between 0.00 and 100.00, in steps of .01.

Hint: *bc* requires the `-l` option to load the math library.

Unicode Table

Using [Example T-1](#) as a template, write a script that prints to a file a complete [Unicode](#) table.

Hint: Use the `-e` option to [echo](#): `echo -e '\uXXXX'`, where *XXXX* is the Unicode numerical character designation. This requires [version 4.2](#) or later of Bash.

Sum of Matching Numbers

Find the sum of all five-digit numbers (in the range 10000 - 99999) containing *exactly two* out of the following set of digits: { 4, 5, 6 }. These may repeat within the same number, and if so, they count once for each occurrence.

Some examples of *matching numbers* are 42057, 74638, and 89515.

Lucky Numbers

A *lucky number* is one whose individual digits add up to 7, in successive additions. For example, 62431 is a *lucky number* ($6 + 2 + 4 + 3 + 1 = 16$, $1 + 6 = 7$). Find all the *lucky numbers* between 1000 and 10000.

Craps

Borrowing the ASCII graphics from [Example A-40](#), write a script that plays the well-known gambling game of *craps*. The script will accept bets from one or more players, roll the dice, and keep track of wins and losses, as well as of each player's bankroll.

Tic-tac-toe

Write a script that plays the child's game of *tic-tac-toe* against a human player. The script will let the human choose whether to take the first move. The script will follow an optimal strategy, and therefore never lose. To simplify matters, you may use ASCII graphics:

```
1  o | x |
2  -----
3  | x |
4  -----
5  | o |
6
7  Your move, human (row, column)?
```

Alphabetizing a String

Alphabetize (in ASCII order) an arbitrary string read from the command-line.

Parsing

Parse [/etc/passwd](#), and output its contents in nice, easy-to-read tabular form.

Logging Logins

Parse [/var/log/messages](#) to produce a nicely formatted file of user logins and login times. The script may need to run as *root*. (Hint: Search for the string "LOGIN.")

Pretty-Printing a Data File

Certain database and spreadsheet packages use save-files with the fields separated by commas, commonly referred to as *comma-separated values* or CSVs. Other applications often need to parse these files.

Given a data file with comma-separated [fields](#), of the form:

```
1 Jones,Bill,235 S. Williams St.,Denver,CO,80221,(303) 244-7989
2 Smith,Tom,404 Polk Ave.,Los Angeles,CA,90003,(213) 879-5612
3 ...
```

Reformat the data and print it out to `stdout` in labeled, evenly-spaced columns.

Justification

Given ASCII text input either from `stdin` or a file, adjust the word spacing to right-justify each line to a user-specified line-width, then send the output to `stdout`.

Mailing List

Using the [mail](#) command, write a script that manages a simple mailing list. The script automatically e-mails the monthly company newsletter, read from a specified text file, and sends it to all the addresses on the mailing list, which the script reads from another specified file.

Generating Passwords

Generate pseudorandom 8-character passwords, using characters in the ranges [0-9], [A-Z], [a-z]. Each password must contain at least two digits.

Monitoring a User

You suspect that one particular user on the network has been abusing her privileges and possibly attempting to hack the system. Write a script to automatically monitor and log her activities when she's signed on. The log file will save entries for the previous week, and delete those entries more than seven days old.

You may use [last](#), [lastlog](#), and [lastcomm](#) to aid your surveillance of the suspected fiend.

Checking for Broken Links

Using [lynx](#) with the `-traversal` option, write a script that checks a Web site for broken links.

DIFFICULT

Testing Passwords

Write a script to check and validate passwords. The object is to flag "weak" or easily guessed password candidates.

A trial password will be input to the script as a command-line parameter. To be considered acceptable, a password must meet the following minimum qualifications:

- ◇ Minimum length of 8 characters
- ◇ Must contain at least one numeric character
- ◇ Must contain at least one of the following non-alphabetic characters: @, #, \$, %, &, *, +, -, =

Optional:

- ◇ Do a dictionary check on every sequence of at least four consecutive alphabetic characters in the password under test. This will eliminate passwords containing embedded "words" found in a standard dictionary.
- ◇ Enable the script to check all the passwords on your system. These do not reside in [/etc/passwd](#).

This exercise tests mastery of [Regular Expressions](#).

Cross Reference

Write a script that generates a *cross-reference* (*concordance*) on a target file. The output will be a listing of all word occurrences in the target file, along with the line numbers in which each word occurs. Traditionally, *linked list* constructs would be used in such applications. Therefore, you should

investigate [arrays](#) in the course of this exercise. [Example 16-12](#) is probably *not* a good place to start.

Square Root

Write a script to calculate square roots of numbers using *Newton's Method*.

The algorithm for this, expressed as a snippet of Bash [pseudo-code](#) is:

```
1 # (Isaac) Newton's Method for speedy extraction
2 #+ of square roots.
3
4 guess = $argument
5 # $argument is the number to find the square root of.
6 # $guess is each successive calculated "guess" -- or trial solution --
7 #+ of the square root.
8 # Our first "guess" at a square root is the argument itself.
9
10 oldguess = 0
11 # $oldguess is the previous $guess.
12
13 tolerance = .000001
14 # To how close a tolerance we wish to calculate.
15
16 loopcnt = 0
17 # Let's keep track of how many times through the loop.
18 # Some arguments will require more loop iterations than others.
19
20
21 while [ ABS( $guess $oldguess ) -gt $tolerance ]
22 #     ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^ Fix up syntax, of course.
23
24 #     "ABS" is a (floating point) function to find the absolute value
25 #+   of the difference between the two terms.
26 #           So, as long as difference between current and previous
27 #+         trial solution (guess) exceeds the tolerance, keep looping.
28
29 do
30     oldguess = $guess # Update $oldguess to previous $guess.
31
32 # =====
33     guess = ( $oldguess + ( $argument / $oldguess ) ) / 2.0
34 #     = 1/2 ( ($oldguess **2 + $argument) / $oldguess )
35 # equivalent to:
36 #     = 1/2 ( $oldguess + $argument / $oldguess )
37 # that is, "averaging out" the trial solution and
38 #+ the proportion of argument deviation
39 #+ (in effect, splitting the error in half).
40 # This converges on an accurate solution
41 #+ with surprisingly few loop iterations . . .
42 #+ for arguments > $tolerance, of course.
43 # =====
44
45     (( loopcnt++ )) # Update loop counter.
46 done
```

It's a simple enough recipe, and *seems* at first glance easy enough to convert into a working Bash script. The problem, though, is that Bash has [no native support for floating point numbers](#). So, the script writer needs to use [bc](#) or possibly [awk](#) to convert the numbers and do the calculations. It could get rather messy . . .

Logging File Accesses

Log all accesses to the files in `/etc` during the course of a single day. This information should include the filename, user name, and access time. If any alterations to the files take place, that will be flagged. Write this data as tabular (tab-separated) formatted records in a logfile.

Monitoring Processes

Write a script to continually monitor all running processes and to keep track of how many child processes each parent spawns. If a process spawns more than five children, then the script sends an e-mail to the system administrator (or *root*) with all relevant information, including the time, PID of the parent, PIDs of the children, etc. The script appends a report to a log file every ten minutes.

Strip Comments

Strip all comments from a shell script whose name is specified on the command-line. Note that the initial [#! line](#) must not be stripped out.

Strip HTML Tags

Strip all the HTML tags from a specified HTML file, then reformat it into lines between 60 and 75 characters in length. Reset paragraph and block spacing, as appropriate, and convert HTML tables to their approximate text equivalent.

XML Conversion

Convert an XML file to both HTML and text format.

Optional: A script that converts Docbook/SGML to XML.

Chasing Spammers

Write a script that analyzes a spam e-mail by doing DNS lookups on the IP addresses in the headers to identify the relay hosts as well as the originating ISP. The script will forward the unaltered spam message to the responsible ISPs. Of course, it will be necessary to filter out *your own ISP's IP address*, so you don't end up complaining about yourself.

As necessary, use the appropriate [network analysis commands](#).

For some ideas, see [Example 16-41](#) and [Example A-28](#).

Optional: Write a script that searches through a list of e-mail messages and deletes the spam according to specified filters.

Creating man pages

Write a script that automates the process of creating [man pages](#).

Given a text file which contains information to be formatted into a *man page*, the script will read the file, then invoke the appropriate [groff](#) commands to output the corresponding *man page* to `stdout`. The text file contains blocks of information under the standard *man page* headings, i.e., NAME, SYNOPSIS, DESCRIPTION, etc.

[Example A-39](#) is an instructive first step.

Hex Dump

Do a hex(adecimal) dump on a binary file specified as an argument to the script. The output should be in neat tabular [fields](#), with the first field showing the address, each of the next 8 fields a 4-byte hex number, and the final field the ASCII equivalent of the previous 8 fields.

The obvious followup to this is to extend the hex dump script into a disassembler. Using a lookup table, or some other clever gimmick, convert the hex values into 80x86 op codes.

Emulating a Shift Register

Using [Example 27-15](#) as an inspiration, write a script that emulates a 64-bit shift register as an [array](#). Implement functions to *load* the register, *shift left*, *shift right*, and *rotate* it. Finally, write a function that interprets the register contents as eight 8-bit ASCII characters.

Calculating Determinants

Write a script that calculates determinants [\[1\]](#) by [recursively](#) expanding the *minors*. Use a 4 x 4 determinant as a test case.

Hidden Words

Write a "word-find" puzzle generator, a script that hides 10 input words in a 10 x 10 array of random letters. The words may be hidden across, down, or diagonally.

Optional: Write a script that *solves* word-find puzzles. To keep this from becoming too difficult, the solution script will find only horizontal and vertical words. (Hint: Treat each row and column as a string, and search for substrings.)

Anagramming

Anagram 4-letter input. For example, the anagrams of *word* are: *do or rod row word*. You may use `/usr/share/dict/linux.words` as the reference list.

Word Ladders

A "word ladder" is a sequence of words, with each successive word in the sequence differing from the previous one by a single letter.

For example, to "ladder" from *mark* to *vase*:

```
1 mark --> park --> part --> past --> vast --> vase
2      ^      ^      ^      ^      ^      ^
```

Write a script that solves word ladder puzzles. Given a starting and an ending word, the script will list all intermediate steps in the "ladder." Note that *all* words in the sequence must be legitimate dictionary words.

Fog Index

The "fog index" of a passage of text estimates its reading difficulty, as a number corresponding roughly to a school grade level. For example, a passage with a fog index of 12 should be comprehensible to anyone with 12 years of schooling.

The Gunning version of the fog index uses the following algorithm.

1. Choose a section of the text at least 100 words in length.
2. Count the number of sentences (a portion of a sentence truncated by the boundary of the text section counts as one).
3. Find the average number of words per sentence.

$$\text{AVE_WDS_SEN} = \text{TOTAL_WORDS} / \text{SENTENCES}$$

4. Count the number of "difficult" words in the segment -- those containing at least 3 syllables. Divide this quantity by total words to get the proportion of difficult words.

$$\text{PRO_DIFF_WORDS} = \text{LONG_WORDS} / \text{TOTAL_WORDS}$$

5. The Gunning fog index is the sum of the above two quantities, multiplied by 0.4, then rounded to the nearest integer.

$$\text{G_FOG_INDEX} = \text{int} (0.4 * (\text{AVE_WDS_SEN} + \text{PRO_DIFF_WORDS}))$$

Step 4 is by far the most difficult portion of the exercise. There exist various algorithms for estimating the syllable count of a word. A rule-of-thumb formula might consider the number of letters in a word and the vowel-consonant mix.

A strict interpretation of the Gunning fog index does not count compound words and proper nouns as "difficult" words, but this would enormously complicate the script.

Calculating PI using Buffon's Needle

The Eighteenth Century French mathematician de Buffon came up with a novel experiment. Repeatedly drop a needle of length n onto a wooden floor composed of long and narrow parallel boards. The cracks separating the equal-width floorboards are a fixed distance d apart. Keep track of the total drops and the number of times the needle intersects a crack on the floor. The ratio of these two quantities turns out to be a fractional multiple of PI.

In the spirit of [Example 16-50](#), write a script that runs a Monte Carlo simulation of *Buffon's Needle*. To simplify matters, set the needle length equal to the distance between the cracks, $n = d$.

Hint: there are actually two critical variables: the distance from the center of the needle to the nearest crack, and the inclination angle of the needle to that crack. You may use [bc](#) to handle the calculations.

Playfair Cipher

Implement the Playfair (Wheatstone) Cipher in a script.

The Playfair Cipher encrypts text by substitution of *digrams* (2-letter groupings). It is traditional to use a 5 x 5 letter scrambled-alphabet *key square* for the encryption and decryption.

```
1   C O D E S
2   A B F G H
3   I K L M N
4   P Q R T U
5   V W X Y Z
6
7 Each letter of the alphabet appears once, except "I" also represents
8 "J". The arbitrarily chosen key word, "CODES" comes first, then all
9 the rest of the alphabet, in order from left to right, skipping letters
10 already used.
11
12 To encrypt, separate the plaintext message into digrams (2-letter
13 groups). If a group has two identical letters, delete the second, and
14 form a new group. If there is a single letter left over at the end,
15 insert a "null" character, typically an "X."
16
17 THIS IS A TOP SECRET MESSAGE
18
19 TH IS IS AT OP SE CR ET ME SA GE
20
21
22
23 For each digram, there are three possibilities.
24 -----
25
26 1) Both letters will be on the same row of the key square:
27     For each letter, substitute the one immediately to the right, in that
28     row. If necessary, wrap around left to the beginning of the row.
29
30 or
31
32 2) Both letters will be in the same column of the key square:
33     For each letter, substitute the one immediately below it, in that
34     row. If necessary, wrap around to the top of the column.
35
36 or
37
38 3) Both letters will form the corners of a rectangle within the key square:
39     For each letter, substitute the one on the other corner the rectangle
40     which lies on the same row.
41
42
43 The "TH" digram falls under case #3.
44 G H
45 M N
46 T U          (Rectangle with "T" and "H" at corners)
47
48 T --> U
49 H --> G
50
51
52 The "SE" digram falls under case #1.
53 C O D E S      (Row containing "S" and "E")
54
55 S --> C      (wraps around left to beginning of row)
56 E --> S
```



```
57
58 =====
59
60 To decrypt encrypted text, reverse the above procedure under cases #1
61 and #2 (move in opposite direction for substitution). Under case #3,
62 just take the remaining two corners of the rectangle.
63
64
65 Helen Fouche Gaines' classic work, ELEMENTARY CRYPTANALYSIS (1939), gives a
66 fairly detailed description of the Playfair Cipher and its solution methods.
```

This script will have three main sections

- I. Generating the *key square*, based on a user-input keyword.
- II. Encrypting a *plaintext* message.
- III. Decrypting encrypted text.

The script will make extensive use of [arrays](#) and [functions](#). You may use [Example A-56](#) as an inspiration.

--

Please do not send the author your solutions to these exercises. There are more appropriate ways to impress him with your cleverness, such as submitting bugfixes and suggestions for improving the book.

Notes

- [1] For all you clever types who failed intermediate algebra, a *determinant* is a numerical value associated with a multidimensional *matrix* ([array](#) of numbers).

```
1 For the simple case of a 2 x 2 determinant:
2
3 |a  b|
4 |b  a|
5
6 The solution is a*a - b*b, where "a" and "b" represent numbers.
```

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Appendix P. Revision History

This document first appeared as a 60-page HOWTO in the late spring of 2000. Since then, it has gone through quite a number of updates and revisions. This book could not have been written without the assistance of the Linux community, and especially of the volunteers of the [Linux Documentation Project](#).

Here is the e-mail to the LDP requesting permission to submit version 0.1.

```
1 From thegrendel@theriver.com Sat Jun 10 09:05:33 2000 -0700
2 Date: Sat, 10 Jun 2000 09:05:28 -0700 (MST)
3 From: "M. Leo Cooper" <thegrendel@theriver.com>
4 X-Sender: thegrendel@localhost
5 To: ldp-discuss@lists.linuxdoc.org
6 Subject: Permission to submit HOWTO
7
8 Dear HOWTO Coordinator,
9
10 I am working on and would like to submit to the LDP a HOWTO on the subject
11 of "Bash Scripting" (shell scripting, using 'bash'). As it happens,
12 I have been writing this document, off and on, for about the last eight
13 months or so, and I could produce a first draft in ASCII text format in
14 a matter of just a few more days.
15
16 I began writing this out of frustration at being unable to find a
17 decent book on shell scripting. I managed to locate some pretty good
18 articles on various aspects of scripting, but nothing like a complete,
19 beginning-to-end tutorial. Well, in keeping with my philosophy, if all
20 else fails, do it yourself.
21
22 As it stands, this proposed "Bash-Scripting HOWTO" would serve as a
23 combination tutorial and reference, with the heavier emphasis on the
24 tutorial. It assumes Linux experience, but only a very basic level
25 of programming skills. Interspersed with the text are 79 illustrative
26 example scripts of varying complexity, all liberally commented. There
27 are even exercises for the reader.
28
29 At this stage, I'm up to 18,000+ words (124k), and that's over 50 pages of
30 text (whew!).
31
32
33 I haven't mentioned that I've previously authored an LDP HOWTO, the
34 "Software-Building HOWTO", which I wrote in Linuxdoc/SGML. I don't know
35 if I could handle Docbook/SGML, and I'm glad you have volunteers to do
36 the conversion. You people seem to have gotten on a more organized basis
37 these last few months. Working with Greg Hankins and Tim Bynum was nice,
38 but a professional team is even nicer.
39
40 Anyhow, please advise.
41
42
43 Mendel Cooper
44 thegrendel@theriver.com
```

Table P-1. Revision History

Release Date	Comments
0.1 14 Jun 2000	Initial release.
0.2 30 Oct 2000	Bugs fixed, plus much additional material and more example scripts.

- 0.3 12 Feb 2001 Major update.
- 0.4 08 Jul 2001 Complete revision and expansion of the book.
- 0.5 03 Sep 2001 Major update: Bugfixes, material added, sections reorganized.
- 1.0 14 Oct 2001 Stable release: Bugfixes, reorganization, material added.
- 1.1 06 Jan 2002 Bugfixes, material and scripts added.
- 1.2 31 Mar 2002 Bugfixes, material and scripts added.
- 1.3 02 Jun 2002 TANGERINE release: A few bugfixes, much more material and scripts added.
- 1.4 16 Jun 2002 MANGO release: A number of typos fixed, more material and scripts.
- 1.5 13 Jul 2002 PAPAYA release: A few bugfixes, much more material and scripts added.
- 1.6 29 Sep 2002 POMEGRANATE release: Bugfixes, more material, one more script.
- 1.7 05 Jan 2003 COCONUT release: A couple of bugfixes, more material, one more script.
- 1.8 10 May 2003 BREADFRUIT release: A number of bugfixes, more scripts and material.
- 1.9 21 Jun 2003 PERSIMMON release: Bugfixes, and more material.
- 2.0 24 Aug 2003 GOOSEBERRY release: Major update.
- 2.1 14 Sep 2003 HUCKLEBERRY release: Bugfixes, and more material.
- 2.2 31 Oct 2003 CRANBERRY release: Major update.
- 2.3 03 Jan 2004 STRAWBERRY release: Bugfixes and more material.
- 2.4 25 Jan 2004 MUSKMELON release: Bugfixes.
- 2.5 15 Feb 2004 STARFRUIT release: Bugfixes and more material.
- 2.6 15 Mar 2004 SALAL release: Minor update.
- 2.7 18 Apr 2004 MULBERRY release: Minor update.
- 2.8 11 Jul 2004 ELDERBERRY release: Minor update.
- 3.0 03 Oct 2004 LOGANBERRY release: Major update.
- 3.1 14 Nov 2004 BAYBERRY release: Bugfix update.
- 3.2 06 Feb 2005 BLUEBERRY release: Minor update.
- 3.3 20 Mar 2005 RASPBERRY release: Bugfixes, much material added.
- 3.4 08 May 2005 TEABERRY release: Bugfixes, stylistic revisions.
- 3.5 05 Jun 2005 BOXBERRY release: Bugfixes, some material added.
- 3.6 28 Aug 2005 POKEBERRY release: Bugfixes, some material added.
- 3.7 23 Oct 2005 WHORTLEBERRY release: Bugfixes, some material added.
- 3.8 26 Feb 2006 BLAEBERRY release: Bugfixes, some material added.
- 3.9 15 May 2006 SPICEBERRY release: Bugfixes, some material added.
- 4.0 18 Jun 2006 WINTERBERRY release: Major reorganization.
- 4.1 08 Oct 2006 WAXBERRY release: Minor update.
- 4.2 10 Dec 2006 SPARKLEBERRY release: Important update.
- 4.3 29 Apr 2007 INKBERRY release: Bugfixes, material added.
- 5.0 24 Jun 2007 SERVICEBERRY release: Major update.
- 5.1 10 Nov 2007 LINGONBERRY release: Minor update.
- 5.2 16 Mar 2008 SILVERBERRY release: Important update.
- 5.3 11 May 2008 GOLDENBERRY release: Minor update.
- 5.4 21 Jul 2008 ANGLEBERRY release: Major update.
- 5.5 23 Nov 2008 FARKLEBERRY release: Minor update.
- 5.6 26 Jan 2009 WORCESTERBERRY release: Minor update.
- 6.0 23 Mar 2009 THIMBLEBERRY release: Major update.

- 6.1 30 Sep 2009 BUFFALOBERRY release: Minor update.
 - 6.2 17 Mar 2010 ROWANBERRY release: Minor update.
 - 6.3 30 Apr 2011 SWOZZLEBERRY release: Major update.
 - 6.4 30 Aug 2011 VORTEXBERRY release: Minor update.
 - 6.5 05 Apr 2012 TUNGSTENBERRY release: Minor update.
 - 6.6 27 Nov 2012 YTTERBIUMBERRY release: Minor update.
 - 10 10 Mar 2014 YTTERBIUMBERRY release: License change.
-
-

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Appendix Q. Download and Mirror Sites

The latest update of this document, as an archived, [bzip2-ed](#) "tarball" including both the SGML source and rendered HTML, may be downloaded from the [author's home site](#). A [pdf version](#) is also available ([mirror site](#)). There is likewise an [epub version](#), courtesy of Craig Barnes and Michael Satke. The [change log](#) gives a detailed revision history. The *ABS Guide* even has [its own freshmeat.net/freecode page](#) to keep track of major updates, user comments, and popularity ratings for the project.

The legacy hosting site for this document is the [Linux Documentation Project](#), which maintains many other Guides and HOWTOs as well.

Many thanks to Ronny Bangsund for donating [server space](#) to host this project.

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Appendix R. To Do List

- A comprehensive survey of [incompatibilities](#) between Bash and the classic [Bourne shell](#).
- Same as above, but for the Korn shell (*ksh*).

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Those generous readers desiring to make a donation to the author may contribute a small amount via Paypal to my e-mail address, <thegrendel.abs@gmail.com>. (An **Honor Roll of Supporters** is given at the beginning of the [Change Log](#).) This is *not* a requirement. The *ABS Guide* is a free and freely distributed document for the use and enjoyment of the Linux community. However, in these difficult times, showing support for voluntary projects and especially to authors of limited means is more critically important than ever.

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ASCII Table

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Appendix T. ASCII Table

Traditionally, a book of this sort has an [ASCII Table](#) appendix. This book does not. Instead, here are several short scripts, each of which generates a complete ASCII table.

Example T-1. A script that generates an ASCII table

```
1 #!/bin/bash
2 # ascii.sh
3 # ver. 0.2, reldate 26 Aug 2008
4 # Patched by ABS Guide author.
5
6 # Original script by Sebastian Arming.
7 # Used with permission (thanks!).
8
9 exec >ASCII.txt          # Save stdout to file,
10                        #+ as in the example scripts
11                        #+ reassign-stdout.sh and upperconv.sh.
12
13 MAXNUM=256
14 COLUMNS=5
15 OCT=8
16 OCTSQU=64
17 LITTLESPACE=-3
18 BIGSPACE=-5
19
20 i=1 # Decimal counter
21 o=1 # Octal counter
22
23 while [ "$i" -lt "$MAXNUM" ]; do # We don't have to count past 400 octal.
24     paddi="$i"
25     echo -n "${paddi: $BIGSPACE} " # Column spacing.
26     paddo="00$o"
27 #     echo -ne "\\${paddo: $LITTLESPACE}" # Original.
28     echo -ne "\\0${paddo: $LITTLESPACE}" # Fixup.
29 #           ^
30     echo -n "    "
31     if (( i % COLUMNS == 0 )); then # New line.
32         echo
33     fi
34     ((i++, o++))
35     # The octal notation for 8 is 10, and 64 decimal is 100 octal.
36     (( i % OCT == 0 )) && ((o+=2))
37     (( i % OCTSQU == 0 )) && ((o+=20))
38 done
39
40 exit $?
41
42 # Compare this script with the "pr-asc.sh" example.
43 # This one handles "unprintable" characters.
44
45 # Exercise:
46 # Rewrite this script to use decimal numbers, rather than octal.
```

Example T-2. Another ASCII table script

```
1 #!/bin/bash
2 # Script author: Joseph Steinhauser
```

```

3 # Lightly edited by ABS Guide author, but not commented.
4 # Used in ABS Guide with permission.
5
6 #-----
7 #-- File:  ascii.sh      Print ASCII chart, base 10/8/16          (JETS-2012)
8 #-----
9 #-- Usage:  ascii [oct|dec|hex|help|8|10|16]
10 #--
11 #-- This script prints out a summary of ASCII char codes from Zero to 127.
12 #-- Numeric values may be printed in Base10, Octal, or Hex.
13 #--
14 #-- Format Based on: /usr/share/lib/pub/ascii with base-10 as default.
15 #-- For more detail, man ascii . . .
16 #-----
17
18 [ -n "$BASH_VERSION" ] && shopt -s extglob
19
20 case "$1" in
21   oct|[Oo]?([Cc][Tt])|8)      Obase=Octal;  Numy=3o;;
22   hex|[Hh]?([Ee][Xx])|16|[Xx]) Obase=Hex;    Numy=2X;;
23   help|?(-)[h?])              sed -n '2,/^[ ]*$\p' $0;exit;;
24   code|[Cc][Oo][Dd][Ee])sed -n '/case/, $p'  $0;exit;;
25   *) Obase=Decimal
26 esac # CODE is actually shorter than the chart!
27
28 printf "\t\t## $Obase ASCII Chart ##\n\n"; FM1="|%0${Numy:-3d}"; LD=-1
29
30 AB="nul soh stx etx eot enq ack bel bs tab nl vt np cr so si dle"
31 AD="dc1 dc2 dc3 dc4 nak syn etb can em sub esc fs gs rs us sp"
32
33 for TOK in $AB $AD; do ABR[${LD+=1}]=$TOK; done;
34 ABR[127]=del
35
36 IDX=0
37 while [ $IDX -le 127 ] && CHR="${ABR[$IDX]}"
38 do ((${#CHR}))&& FM2='%-3s' || FM2=`printf '\\\%o ' $IDX`
39 printf "$FM1 $FM2" "$IDX" $CHR; (( (IDX+=1)%8))||echo '|'
40 done
41
42 exit $?

```

Example T-3. A third ASCII table script, using *awk*

```

1 #!/bin/bash
2 # ASCII table script, using awk.
3 # Author: Joseph Steinhauser
4 # Used in ABS Guide with permission.
5
6
7 #-----
8 #-- File:  ascii      Print ASCII chart, base 10/8/16          (JETS-2010)
9 #-----
10 #-- Usage:  ascii [oct|dec|hex|help|8|10|16]
11 #--
12 #-- This script prints a summary of ASCII char codes from Zero to 127.
13 #-- Numeric values may be printed in Base10, Octal, or Hex (Base16).
14 #--
15 #-- Format Based on: /usr/share/lib/pub/ascii with base-10 as default.
16 #-- For more detail, man ascii
17 #-----
18
19 [ -n "$BASH_VERSION" ] && shopt -s extglob

```

```
20
21 case "$1" in
22   oct|[Oo]?([Cc][Tt])|8)      Obase=Octal;  Numy=3o;;
23   hex|[Hh]?([Ee][Xx])|16|[Xx]) Obase=Hex;    Numy=2X;;
24   help|?(-)[h?])             sed -n '2,/^[ ]*$/p' $0;exit;;
25   code|[Cc][Oo][Dd][Ee])sed -n '/case/, $p'  $0;exit;;
26   *) Obase=Decimal
27 esac
28 export Obase # CODE is actually shorter than the chart!
29
30 awk 'BEGIN{print "\n\t\t\t## "ENVIRON["Obase"]" ASCII Chart ##\n"
31         ab="soh, stx, etx, eot, enq, ack, bel, bs, tab, nl, vt, np, cr, so, si, dle, "
32         ad="dc1, dc2, dc3, dc4, nak, syn, etb, can, em, sub, esc, fs, gs, rs, us, sp"
33         split(ab ad, abr, ",");abr[0]="nul";abr[127]="del";
34         fm1="%0"${Numy:- 4d}"' %-3s"
35         for(idx=0;idx<128;idx++){fmt=fm1 (++colz%8?" ":"|\n")
36         printf(fmt,idx,(idx in abr)?abr[idx]:sprintf("%c",idx))} }'
37
38 exit $?
```

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>&j Redirect `stdout` to *file descriptor j*

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2>&1 Redirect `stderr` to `stdout`

&> Redirect *both `stdout` and `stderr`* of a command to a file

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