Advanced Bash-Scripting Guide

A complete guide to shell scripting, using Bash

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This is an major update of version 0.4. The main feature of this release is a major reorganization of the document into parts and chapters (just like a "real" book). Of course, more bugs have been swatted, and additional material and example scripts added. This project has now reached the equivalent of a 360-page book. See the `Change.log` file for a revision history.

This document is both a tutorial and a reference on shell scripting with Bash. It assumes no previous knowledge of scripting or programming, but progresses rapidly toward an intermediate/advanced level of instruction. [1] The exercises and heavily-commented examples invite active reader participation.

This project has evolved into a comprehensive book that compares favorably with any of the shell scripting manuals in print. It may serve as a textbook, a manual for self-study, and a reference and source of knowledge on shell scripting techniques.

The latest version of this document, as an archived "tarball" including both the SGML source and rendered HTML, may be downloaded from the author's home site.

Dedication

For Anita, the source of all the magic

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Notes

[1] ...all the while sneaking in little snippets of UNIX wisdom and lore.

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Introduction

Part 1. Introduction

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, give additional power and flexibility to scripts. Shell scripts lend themselves exceptionally well to to administrative system tasks and other routine repetitive jobs not requiring the bells and whistles of a full-blown tightly structured programming language.

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Chapter 1. Why Shell Programming?

A working knowledge of shell scripting is essential to everyone wishing to become reasonably adept 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.

Writing shell scripts is not hard to learn, since the 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 and straightforward, similar to that of invoking and chaining together utilities at the command line, and there are only a few "rules" to learn. Most short scripts work right the first time, and debugging even the longer ones is straightforward.

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 shell script, even if slowly, is often a useful first stage in project development. This way, the structure of the application can be tested and played with, and the major pitfalls found before proceeding to the final coding in C, C++, Java, or Perl.

Shell scripting hearkens back to the classical 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.

When not to use shell scripts

- resource-intensive tasks, especially where speed is a factor (sorting, hashing, etc.)
- 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 instead)
- complex applications, where structured programming is a necessity (need typechecking of variables, function prototypes, etc.)
- mission-critical applications upon which you are betting the ranch, or the future of the company
- situations where security is important, where you need to protect against hacking

- 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 multi-dimensional arrays
- need data structures, such as linked lists or trees
- need to generate or manipulate graphics or GUIs
- need direct access to system hardware
- need port or socket I/O
- need to use libraries or interface with legacy code
- proprietary, closed-source applications (shell scripts are necessarily Open Source)

If any of the above applies, consider a more powerful scripting language, perhaps Perl, Tcl, Python, or possibly a high-level 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 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 all flavors of UNIX. Most of the principles dealt with in this document apply equally well to scripting with other shells, such as the Korn Shell, from which Bash derives some of its features, [2] and the C Shell and its variants. (Note that C Shell programming is not recommended due to certain inherent problems, as pointed out in a news group posting by Tom Christiansen in October of 1993).

The following is a tutorial in shell scripting. It relies heavily on examples to illustrate features of the shell. As far as possible, the example scripts have been tested, and some of them may actually be useful in real life. The reader should use the actual examples in the the source archive (`something-or-other.sh`), [3] 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, pdf, or text rendered versions. Be aware that some of the scripts below 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 document wrote the example scripts that follow.

Notes

[1] These are referred to as builtins, features internal to the shell.

[2] Many of the features of *ksh88*, and even a few from the updated *ksh93* have been merged into Bash.

[3] 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 follow this guideline.

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Chapter 2. Starting Off With a Sha-Bang

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 the 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 "Logs cleaned up."
```

There is nothing unusual here, just a set of commands that could just as easily be invoked one by one from the command line on the console or in an xterm. The advantages of placing the commands in a script go beyond not having to retype them time and again. The script can easily be modified, customized, or generalized for a particular application.

Example 2-2. cleanup: An enhanced and generalized version of above script.

```
 1 #!/bin/bash
 2 # cleanup, version 2
 3 # Run as root, of course.
 4
 5 LOG_DIR=/var/log
 6 ROOT_UID=0     # Only users with $UID 0 have root privileges.
 7 LINES=50      # Default number of lines saved.
 8 E_XCD=66      # Can't change directory?
 9 E_NOTROOT=67  # Non-root exit error.
10
11
12 if [ "$UID" -ne "$ROOT_UID" ]
13 then
14   echo "Must be root to run this script."
15   exit $E_NOTROOT
16 fi
17
```

```
18 if [ -n "$1" ]
19 # Test if command line argument present (non-empty).
20 then
21   lines=$1
22 else
23   lines=$LINES # Default, if not specified on command line.
24 fi
25
26
27 #  Stephane Chazelas suggests the following,
28 #+ as a better way of checking command line arguments,
29 #+ but this is still a bit advanced for this stage of the tutorial.
30 #
31 #    E_WRONGARGS=65  # Non-numerical argument (bad arg format)
32 #
33 #    case "$1" in
34 #    ""      ) lines=50;;
35 #    *[!0-9]*) echo "Usage: `basename $0` file-to-cleanup"; exit $E_WRONGARGS;;
36 #    *       ) lines=$1;;
37 #    esac
38 #
39 #* Skip ahead to "Loops" to understand this.
40
41
42 cd $LOG_DIR
43
44 if [ `pwd` != "$LOG_DIR" ]  # or   if [ "$PWD" != "LOG_DIR" ]
45                             # Not in /var/log?
46 then
47   echo "Can't change to $LOG_DIR."
48   exit $E_XCD
49 fi  # Doublecheck if in right directory, before messing with log file.
50
51 # far better is:
52 # ---
53 # cd /var/log || {
54 #   echo "Cannot change to necessary directory." >&2
55 #   exit $E_XCD;
56 # }
57
58
59
60
61 tail -$lines messages > mesg.temp # Saves last section of message log file.
62 mv mesg.temp messages             # Becomes new log directory.
63
64
65 # cat /dev/null > messages
66 #* No longer needed, as the above method is safer.
67
68 cat /dev/null > wtmp  # > wtemp   has the same effect.
69 echo "Logs cleaned up."
```

```
70
71 exit 0
72 #  A zero return value from the script upon exit
73 #+ indicates success to the shell.
```

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

The *sha-bang* (#!) 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 [1] "magic number", a special marker that designates a file type, or in this case an executable shell script (see **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 (line 1 of the script), ignoring comments. [2]

```
1 #!/bin/sh
2 #!/bin/bash
3 #!/usr/bin/perl
4 #!/bin/tcl
5 #!/bin/sed -f
6 #!/usr/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. [3] Using **#!/bin/sh**, the default Bourne Shell in most commercial variants of UNIX, makes the script portable to non-Linux machines, though you may have to sacrifice a few Bash-specific features (the script will conform to the POSIX [4] **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.

#! can be omitted if the script consists only of a set of generic system commands, using no internal shell directives. Example 2, above, requires the initial #!, since the variable assignment line, **lines=50**, uses a shell-specific construct. Note that **#!/bin/sh** invokes the default shell interpreter, which defaults to `/bin/bash` on a Linux machine.

Important 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 can build a quite 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 if [ $# -ne Number_of_expected_args ]
2 then
3   echo "Usage: `basename $0` whatever"
4   exit $WRONG_ARGS
5 fi
```

2.1. Invoking the script

Having written the script, you can invoke it by **sh scriptname**, [5] or alternately **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) [6]

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**. [7] 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 system-wide executable. The script could then be invoked by simply typing **scriptname [ENTER]** from the command line.

Notes

[1] Some flavors of UNIX take a four-byte magic number, requiring a blank after the !, **#! bin/sh**.

[2] 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.

[3] 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=65
  7
  8 echo "This line will never print (betcha!)."
  9
 10 exit $WHATEVER  # Doesn't matter. The script will not exit here.
```

Also, try starting a README file with a **#!/bin/more**, and making it executable. The result is a self-listing documentation file.

[4] *P*ortable *O*perating *S*ystem *I*nterface, an attempt to standardize UNIX-like OSes.

[5] Caution: invoking a Bash script by **sh scriptname** turns off Bash-specific extensions, and the script may therefore fail to execute.

[6] A script needs *read*, as well as execute permission for it to run, since the shell needs to be able to read it.

[7] 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 included in a user's $PATH. It is therefore necessary to explicitly invoke the script in the current directory with a **./scriptname**.

2.2. Shell wrapper, self-executing script

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 2-3. shell wrapper

```
 1 #!/bin/bash
 2
 3 # This is a simple script that removes blank lines from a file.
 4 # No argument checking.
 5
 6 # Same as
 7 #    sed -e '/^$/d' filename
 8 # invoked from the command line.
 9
10 sed -e /^$/d "$1"
11 # The '-e' means an "editing" command follows (optional here).
12 # '^' is the beginning of line, '$' is the end.
13 # This match lines with nothing between the beginning and the end,
14 # blank lines.
15 # The 'd' is the delete command.
16
17 # Quoting the command-line arg permits
18 # whitespace and special characters in the filename.
19
20 exit 0
```

Example 2-4. A slightly more complex shell wrapper

```
 1 #!/bin/bash
 2
 3 # "subst", a script that substitutes one pattern for
 4 # another in a file,
 5 # i.e., "subst Smith Jones letter.txt".
 6
 7 ARGS=3
 8 E_BADARGS=65   # Wrong number of arguments passed to script.
 9
10 if [ $# -ne "$ARGS" ]
11 # Test number of arguments to script (always a good idea).
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 $E_BADARGS
26 fi
27
28 # Here is where the heavy work gets done.
29 sed -e "s/$old_pattern/$new_pattern/g" $file_name
30 # 's' is, of course, the substitute command in sed,
31 # and /pattern/ invokes address matching.
32 # The "g", or global flag causes substitution for *every*
33 # occurence of $old_pattern on each line, not just the first.
34 # Read the literature on 'sed' for a more in-depth explanation.
35
36 exit 0    # Successful invocation of the script returns 0.
```

Example 2-5. A shell wrapper around an awk script

```
 1 #!/bin/bash
 2
 3 # Adds up a specified column (of numbers) in the target file.
 4
 5 ARGS=2
 6 E_WRONGARGS=65
 7
 8 if [ $# -ne "$ARGS" ] # Check for proper no. of command line args.
 9 then
10    echo "Usage: `basename $0` filename column-number"
11    exit $E_WRONGARGS
12 fi
13
14 filename=$1
15 column_number=$2
16
17 # Passing shell variables to the awk part of the script is a bit tricky.
18 # See the awk documentation for more details.
19
20 # A multi-line awk script is invoked by   awk ' ..... '
21
22
23 # Begin awk script.
24 # ------------------------------
25 awk '
26
27 { total += $'"${column_number}"'
28 }
29 END {
30      print total
31 }
32
33 ' "$filename"
34 # ------------------------------
35 # End awk script.
36
37
38 #   It may not be safe to pass shell variables to an embedded awk script,
39 #   so Stephane Chazelas proposes the following alternative:
40 #   ---------------------------------------
41 #   awk -v column_number="$column_number" '
42 #   { total += $column_number
43 #   }
44 #   END {
45 #       print total
46 #   }' "$filename"
47 #   ---------------------------------------
48
```

```
49
50 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 can be effectively embedded in shell scripts, and there may even be some substance to the claim that Perl can totally replace shell scripting (though the author of this document remains skeptical).

Example 2-6. Perl embedded in a bash script

```
 1 #!/bin/bash
 2
 3 # Shell commands may precede the Perl script.
 4
 5 perl -e 'print "This is an embedded Perl script\n"'
 6 # Like sed, Perl also uses the "-e" option.
 7
 8 # Shell commands may follow.
 9
10 exit 0
```

Exercise. Write a shell script that performs a simple task.

Part 2. Basics

Table of Contents

3. Exit and Exit Status
4. Special Characters
5. Introduction to Variables and Parameters
6. Quoting
7. Tests
8. Operations and Related Topics

Chapter 3. Exit and Exit Status

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

Chet Ramey

The **exit** command may be used to terminate 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*). A successful command returns a 0, while an unsuccessful one returns a non-zero value that usually may 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`** *nn* command may be used to deliver an *nn* exit status to the shell (*nn* must be a decimal number in the 0 - 255 range).

Note 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 (*not* counting the **exit**).

$? 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". 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 3-1. exit / exit status

```
 1 #!/bin/bash
 2
 3 echo hello
 4 echo $?    # Exit status 0 returned because command successful.
 5
 6 lskdf      # Unrecognized command.
 7 echo $?    # Non-zero exit status returned.
 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.
```

$? is especially useful for testing the result of a command in a script (see Example 12-7 and Example 12-11).

Note The !, the logical "not" qualifier, reverses the outcome of a test or command, and this affects its exit status.

Example 3-2. 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.
 7 #    !true   leads to a "command not found" error
 8
 9 # Thanks, S.C.
```

Caution Certain exit status codes have reserved meanings and should not be user-specified in a script.

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Chapter 4. Special Characters

Special Characters Found In Scripts and Elsewhere

#

Comments. Lines beginning with a # (with the exception of #!) are comments.

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

Comments may also occur at the end of a command.

```
1 echo "A comment will follow." # Comment here.
```

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

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

Caution 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.

Note Of course, 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
```

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

.

"dot" command. [period] Equivalent to source (see Example 11-14). This is a bash builtin.

In a different context, as part of a regular expression, a "dot" matches a single character.

In yet another context, a dot is the filename 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
```

"

partial quoting. [double quote] *"STRING"* preserves (from interpretation) most of the special characters within *STRING*. See also Chapter 6.

'

full quoting. [single quote] *'STRING'* preserves all special characters within *STRING*. This is a stronger form of quoting than using ". See also Chapter 6.

,

comma operator. The **comma operator** links together a series of arithmetic operations. All are evaluated, but only the last one is returned.

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

\

escape. [backslash] **\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 6 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. [backticks] `*command*` makes available the output of *command* for setting a variable. This is also known as backticks or backquotes.

:

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 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
  4    take-some-action
  5 fi
```

Provide a placeholder where a binary operation is expected, see Example 8-1 and default parameters.

```
  1 : ${username=`whoami`}
  2 # ${username=`whoami`}   without the leading : gives an error
  3 #                        unless "username" is a command or builtin...
```

Provide a placeholder where a command is expected in a here document. See Example 17-8.

Evaluate string of variables using parameter substitution (as in Example 9-9).

```
  1 : ${HOSTNAME?} ${USER?} ${MAIL?}
  2 #Prints error message 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 12-9.

In combination with the >> redirection operator, updates a file access/modification time (**: >> new_file**). If the file did not previously exist, creates it. This is equivalent to touch.

Note 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 be appear in a comment. However, this is not the case with :.

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

!

reverse (or negate) the sense of a test or exit status. The ! operator inverts the exit status of the command to which it is applied (see Example 3-2). 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.

*

wild card. [asterisk] The * character serves as a "wild card" for filename expansion in globbing, as well as representing any number (or zero) characters in a regular expression.

A double asterisk, **, is the exponentiation operator.

$

Variable substitution.

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

In a regular expression, a $ matches the end of a line.

${}

Parameter substitution.

$*, $@

positional parameters.

()

command group.

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

Important 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 grep Linux file*.{txt,htm*}
2 # Finds all instances of the work "Linux"
3 # in the files "fileA.txt", "file2.txt", "fileR.html", "file-87.htm", etc.
```

A command may act upon a comma-separated list of file specs within *braces*. [1] Filename expansion (globbing) applies to the file specs between the braces.

Caution 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
```

{}

Block of code. [curly brackets] Also referred to as an "inline group", this construct, in effect, creates an anonymous function. However, unlike a function, the variables in 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 4-1. 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
```

Example 4-2. Saving the results of a code block to a file

```
 1 #!/bin/bash
 2 # rpm-check.sh
 3
 4 # Queries an rpm file for description, listing, and whether it can be installed.
 5 # Saves output to a file.
 6 #
 7 # This script illustrates using a code block.
 8
 9 E_NOARGS=65
10
11 if [ -z "$1" ]
12 then
13   echo "Usage: `basename $0` rpm-file"
14   exit $E_NOARGS
15 fi
```

```
 16
 17 {
 18   echo
 19   echo "Archive Description:"
 20   rpm -qpi $1       # Query description.
 21   echo
 22   echo "Archive Listing:"
 23   rpm -qpl $1       # Query listing.
 24   echo
 25   rpm -i --test $1  # Query whether rpm file can be installed.
 26   if [ ! $? ]
 27   then
 28     echo "$1 can be installed."
 29   else
 30     echo "$1 cannot be installed."
 31   fi
 32   echo
 33 } > "$1.test"       # Redirects output of everything in block to file.
 34
 35 echo "Results of rpm test in file $1.test"
 36
 37 # See rpm man page for explanation of options.
 38
 39 exit 0
```

Note Unlike a command group within (parentheses), as above, a code block enclosed by {braces} will *not* normally launch a subshell. [2]

{} \;

pathname. Mostly used in find constructs. This is *not* a shell builtin.

Note 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 [[ ]] (shell keyword).

See the discussion on the [[...]] construct for more details.

> >& >> <

redirection.

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

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

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

process substitution.

`(command)>`

`<(command)`

In a different context, the "<" and ">" characters act as string comparison operators.

<<

redirection used in a here document.

|

pipe. Passes the output of previous command to next one, or to 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 # Sorts the output of all ".lst" files and deletes duplicate lines.
```

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
-RW-R--R--    1 BOZO  BOZO       725 APR 20 20:56 DATA-FILE
```

Note 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.

&

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

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

-

redirection from/to `stdin` or `stdout`. [dash]

```
   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    Source directory, where the files to be moved are.
   6 # 2) &&                     "And-list": if the 'cd' operation successful, then
execute the next command.
   7 # 3) tar cf - .             The 'c' option 'tar' archiving command creates a
new archive,
   8 #                           the 'f' (file) option, followed by '-' designates
the target file as stdout,
   9 #                           and do it in current directory tree ('.').
  10 # 4) |                      Piped to...
  11 # 5) ( ... )                a subshell
  12 # 6) cd /dest/directory     Change to the destination directory.
  13 # 7) &&                     "And-list", as above
  14 # 8) tar xpvf -             Unarchive ('x'), preserve ownership and file
permissions ('p'),
  15 #                           and send verbose messages to stdout ('v'),
  16 #                           reading data from stdin ('f' followed by '-').
  17 #
  18 #                           Note that 'x' is a command, and 'p', 'v', 'f' are
options.
```

```
# Whew!



# More elegant than, but equivalent to:
#   cd source-directory
#   tar cf - . | (cd ../target-directory; tar xzf -)
#
# cp -a /source/directory /dest     also has same effect.
```

```
bunzip2 linux-2.4.3.tar.bz2 | tar xvf -
# --uncompress tar file--    | --then pass it to "tar"--
# If "tar" has not been patched to handle "bunzip2",
# this needs to be done in two discrete steps, using a pipe.
# 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.

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.

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

This time, it accepts input from `stdin` and filters it.

Try using diff to compare a file with a *section* of another.

```
grep bash file1 | diff file2 -
```

Finally, a real-world example using `-` with tar.

Example 4-3. 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 NOARGS=0
 7 E_BADARGS=65
 8
 9 if [ $# = $NOARGS ]
10 then
11   echo "Usage: `basename $0` filename"
12   exit $E_BADARGS
13 fi
14
15 tar cvf - `find . -mtime -1 -type f -print` > $1.tar
16 gzip $1.tar
17
18
19 # Stephane Chazelas points out that the above code will fail
20 # if there are too many files found
21 # or if any filenames contain blank characters.
22
23 # He suggests the following alternatives:
24 # -------------------------------------------------------------
25 #   find . -mtime -1 -type f -print0 | xargs -0 tar rvf "$1.tar"
26 #      using the GNU version of "find".
27
28 #   find . -mtime -1 -type f -exec tar rvf "$1.tar" '{}' \;
29 #      portable to other UNIX flavors, but much slower.
30
31
32 exit 0
```

Caution

Filenames beginning with `-` may cause problems when coupled with the `-` redirection operator. A script should check for this and pass such filenames as *`./-FILENAME`* or *`$PWD/-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. [dash] **cd -** changes to previous working directory. This uses the $OLDPWD environmental variable.

Caution This is not to be confused 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.

%

modulo. Modulo (remainder of a division) arithmetic operation.

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.

Control Characters

change the behavior of the terminal or text display. A control character is a **CONTROL** + **key** combination.

- **Ctl-C**

  Terminate a foreground job.
- **Ctl-D**

  Log out from a shell (similar to exit).
- **Ctl-G**

  "BEL" (beep).
- **Ctl-H**

  Backspace.
- **Ctl-J**

  Carriage return.
- **Ctl-L**

  Formfeed (clear the terminal screen). This has the same effect as the clear command.
- **Ctl-M**

  Newline.
- **Ctl-U**

  Erase a line of input.
- **Ctl-Z**

  Pause a foreground job.

Whitespace

functions as a separator, separating commands or variables. Whitespace consists of either spaces, tabs, blank lines, or any combination thereof. 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, defaults to whitespace.

Notes

[1] The shell does the *brace expansion*. The command itself acts upon the *result* of the expansion.

[2] Exception: a code block in braces as part of a pipe *may* be 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"  # Will not work.
5
6 # Thanks, S.C.
```

Chapter 5. Introduction to Variables and Parameters

Variables are at the heart of every programming and scripting language. They appear in arithmetic operations and manipulation of quantities, string parsing, and are indispensable for working in the abstract with symbols - tokens that represent something else. A variable is nothing more than a location or set of locations in computer memory that holds an item of data.

5.1. Variable Substitution

The *name* of a variable is a placeholder for its *value*, the data it holds. Referencing 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. The only time a variable appears "naked", without the $ prefix, is when declared or assigned, when *unset*, or when exported. 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 6 for a detailed discussion.

Note that **`$variable`** is actually a simplified alternate form of **`${variable}`**. In contexts where the **`$variable`** syntax causes an error, the longer form may work (see Section 9.2, below).

Example 5-1. Variable assignment and substitution

```
 1 #!/bin/bash
 2
 3 # Variables: assignment and substitution
 4
 5 a=37.5
 6 hello=$a
 7
 8 #-------------------------------------------------------------------------
 9 # No space permitted on either side of = sign when initializing variables.
10
11 # If "VARIABLE =value",
12 # script tries to run "VARIABLE" command with one argument, "=value".
13
14 # If "VARIABLE= value",
15 # script tries to run "value" command with
16 # the environmental variable "VARIABLE" set to "".
17 #-------------------------------------------------------------------------
18
19
20 echo hello    # Not a variable reference, just the string "hello".
21
22 echo $hello
23 echo ${hello} #Identical to above.
24
25 echo "$hello"
26 echo "${hello}"
27
28 # hello="A B  C   D"
29 # Now,   echo $hello   and   echo "$hello"   give different results.
30 # Quoting variable preserves whitespace.
31
32 echo '$hello'
33 # Variable referencing disabled by single quotes,
34 # which causes the "$" to be interpreted literally.
35
36 # Notice the effect of different types of quoting.
37
38
39 # Now *unsetting* $hello.
40 hello=
41 echo "\$hello (unset) = $hello"
42 # Unsetting a variable means setting it to a null value.
43
44 # ------------------------------------------------------------
45
46 # It is permissible to set multiple variables on the same line,
47 # if separated by white space.
48 # Caution, this may reduce legibility, and may not be portable.
49
```

```
var1=variable1  var2=variable2  var3=variable3
echo
echo "var1=$var1   var2=$var2  var3=$var3"

# May cause problems with older versions of "sh".

# -----------------------------------------------------------------

echo; echo

numbers="one two three"
other_numbers="1 2 3"
# If whitespace within a variable, then quotes necessary.
echo "numbers = $numbers"
echo "other_numbers = $other_numbers"
echo

echo "uninitialized variable = $uninitialized_variable"
# Uninitialized variable has null value (no value at all).
uninitialized_variable=
# Declaring, but not initializing it (same as unsetting it, as above).
echo "uninitialized variable = $uninitialized_variable"
# It still has a null value.

echo

exit 0
```

Warning An uninitialized variable has a "null" value - no assigned value at all (not zero!). Using a variable before assigning a value to it will inevitably cause problems.

5.2. Variable Assignment

=

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

Caution 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 5-2. Plain Variable Assignment

```
 1 #!/bin/bash
 2
 3 echo
 4
 5 # When is a variable "naked", i.e., lacking the '$' in front?
 6 # When it is being assigned, rather than referenced.
 7
 8 # Assignment
 9 a=879
10 echo "The value of \"a\" is $a"
11
12 # Assignment using 'let'
13 let a=16+5
14 echo "The value of \"a\" is now $a"
15
16 echo
17
18 # In a 'for' loop (really, a type of disguised assignment)
19 echo -n "The values of \"a\" in the loop are "
20 for a in 7 8 9 11
21 do
22   echo -n "$a "
23 done
24
```

```
25 echo
26 echo
27
28 # In a 'read' statement (also a type of assignment)
29 echo -n "Enter \"a\" "
30 read a
31 echo "The value of \"a\" is now $a"
32
33 echo
34
35 exit 0
```

Example 5-3. 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...
 9
10 a=`echo Hello!`   # Assigns result of 'echo' command to 'a'
11 echo $a
12
13 a=`ls -l`         # Assigns result of 'ls -l' command to 'a'
14 echo $a
15
16 exit 0
```

Variable assignment using the $(...) mechanism (a newer method than backquotes)

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

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5.3. 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

Note In a more general context, each process has an "environment", that is, a group of variables that hold information 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 shell variables causes the shell to update its environment, and all the shell's child processes (the commands it executes) inherit this environment.

Caution 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&=ZZZZZZZZZZZZZ/'`"

bash$ du
bash: /usr/bin/du: Argument list too long
```

(Thank you, S. C. 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.

Note 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.

---

positional parameters

arguments passed to the script from the command line - $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. [1] After $9, the arguments must

be enclosed in brackets, for example, ${10}, ${11}, ${12}.

Example 5-4. 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
 6 echo
 7
 8 echo "The name of this script is \"$0\"."
 9 # Adds ./ for current directory
10 echo "The name of this script is \"`basename $0`\"."
11 # Strips out path name info (see 'basename')
12
13 echo
14
15 if [ -n "$1" ]              # Tested variable is quoted.
16 then
17  echo "Parameter #1 is $1"  # Need quotes to escape #
18 fi
19
20 if [ -n "$2" ]
21 then
22  echo "Parameter #2 is $2"
23 fi
24
25 if [ -n "$3" ]
26 then
27  echo "Parameter #3 is $3"
28 fi
29
30 # ...
31
32 if [ -n "${10}" ]  # Parameters > $9 must be enclosed in {brackets}.
33 then
34  echo "Parameter #10 is ${10}"
35 fi
36
37 echo
38
39 exit 0
```

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. There must also exist symbolic links to all the alternate names of the script.

Tip 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 variable1x=$1x
 2 # This will prevent an error, even if positional parameter is absent.
 3
 4 critical_argument01=$variable1x
 5
 6 # The extra character can be stripped off later, if desired, like so.
 7 variable1=${variable1x/x/}    # It works even if variable1x contains an 'x'.
 8 # This uses one of the parameter substitution templates previously discussed.
 9 # Leaving out the replacement pattern results in a deletion.
10
11 # A more straightforward way of dealing with this is to simply test
12 # to simply test whether expected positional parameters have been passed.
13 if [ -z $1 ]
14 then
15   exit $POS_PARAMS_MISSING
16 fi
```

Example 5-5. wh, whois domain name lookup

```
 1 #!/bin/bash
 2
 3 # Does a 'whois domain-name' lookup on any of 3 alternate servers:
 4 #                    ripe.net, cw.net, radb.net
 5
 6 # Place this script, named 'wh' in /usr/local/bin
 7
 8 # Requires symbolic links:
 9 # ln -s /usr/local/bin/wh /usr/local/bin/wh-ripe
10 # ln -s /usr/local/bin/wh /usr/local/bin/wh-cw
11 # ln -s /usr/local/bin/wh /usr/local/bin/wh-radb
12
13
14 if [ -z "$1" ]
15 then
16   echo "Usage: `basename $0` [domain-name]"
17   exit 65
18 fi
19
20 case `basename $0` in
```

```
21 # Checks script name and calls proper server
22     "wh"     ) whois $1@whois.ripe.net;;
23     "wh-ripe") whois $1@whois.ripe.net;;
24     "wh-radb") whois $1@whois.radb.net;;
25     "wh-cw"  ) whois $1@whois.cw.net;;
26     *        ) echo "Usage: `basename $0` [domain-name]";;
27 esac
28
29 exit 0
```

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 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 (see Example 5-4).

Example 5-6. Using shift

```
 1 #!/bin/bash
 2 # Using 'shift' to step through all the positional parameters.
 3
 4 # Name this script something like shft,
 5 # and invoke it with some parameters, for example
 6 # ./shft a b c def 23 skidoo
 7
 8 until [ -z "$1" ]  # Until all parameters used up...
 9 do
10   echo -n "$1 "
11   shift
12 done
13
14 echo   # Extra line feed.
15
16 exit 0
```

Notes

[1] The process calling the script sets the *$0* parameter. By convention, this parameter is the name of the script. See the manpage for **execv**.

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Chapter 6. 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, such as the wild card character, *.)

```
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
```

Note Certain programs and utilities can still reinterpret or expand special characters in a quoted string. This is an important use of quoting, 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.
```

Of course, **grep [Ff]irst *.txt** would not work.

When referencing a variable, it is generally advisable in enclose it in double quotes (" "). This preserves all special characters within the variable name, except $, ` (backquote), and \ (escape). Keeping $ as a special character permits referencing a quoted variable (*"$variable"*), that is, replacing the variable with its value (see Example 5-1, above).

Use double quotes to prevent word splitting. [1] An argument enclosed in double quotes presents itself as a single word, even if it contains whitespace separators.

```
  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 $variable2        # Executes COMMAND with no
arguments.
 12 COMMAND "$variable2" "$variable2" "$variable2"  # Executes COMMAND with 3 empty
```

```
arguments.
  13 COMMAND "$variable2 $variable2 $variable2"      # Executes COMMAND with 1
argument (2 spaces).
  14
  15 # Thanks, S.C.
```

Tip Enclosing the arguments to an **echo** statement in double quotes is necessary only when word splitting is an issue.

Example 6-1. Echoing Weird Variables

```
   1 #!/bin/bash
   2 # weirdvars.sh: Echoing weird variables.
   3
   4 var="'(]\\{}\$\""
   5 echo $var        # '(]\{}$"
   6 echo "$var"      # '(]\{}$"     Doesn't make a difference.
   7
   8 IFS='\'
   9 echo $var        # '(]\{}$"     \ converted to space.
  10 echo "$var"      # '(] {}$"
  11
  12 # Examples above supplied by S.C.
  13
  14 exit 0
```

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").

Note 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
  10 # This example courtesy of Stephane Chazelas.
```

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

Caution 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 *0xx*

Example 6-2. Escaped Characters

```
 1 #!/bin/bash
 2 # escaped.sh: escaped characters
 3
 4 echo; echo
 5
 6 echo "\v\v\v\v"      # Prints \v\v\v\v
 7 # Must use the -e option with 'echo' to print escaped characters.
 8 echo -e "\v\v\v\v"   # Prints 4 vertical tabs.
 9 echo -e "\042"       # Prints " (quote, octal ASCII character 42).
10
11
12 # Bash, version 2 and later, permits using the $'\xxx' construct.
13 echo $'\n'
14 echo $'\a'
15 echo $'\t \042 \t'   # Quote (") framed by tabs.
16
17 # Assigning ASCII characters to a variable.
18 # ---------------------------------------
19 quote=$'\042'        # " assigned to a variable.
```

```
 20 echo "$quote This is a quoted string, $quote and this lies outside the quotes."
 21
 22 echo
 23
 24 # Concatenating ASCII chars in a variable.
 25 triple_underline=$'\137\137\137'  # 137 is octal ASCII code for "_".
 26 echo "$triple_underline UNDERLINE $triple_underline"
 27
 28 ABC=$'\101\102\103\010'           # 101, 102, 103 are octal A, B, C.
 29 echo $ABC
 30
 31 echo; echo
 32
 33 escape=$'\033'                   # 033 is octal for escape.
 34 echo "\"escape\" echoes as $escape"
 35
 36 echo; echo
 37
 38 exit 0
```

See Example 35-1 for another example of the **$' '** string expansion construct.

\"

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"  # results in $variable01
```

\\

gives the backslash its literal meaning

```
1 echo "\\"  # results in \
```

Note The behavior of \ depends on whether it is itself escaped, quoted, or appearing within a here document.

```
  1 echo \z               #  z
  2 echo \\z              # \z
  3 echo '\z'             # \z
  4 echo '\\z'            # \\z
  5 echo "\z"             # \z
  6 echo "\\z"            # \z
  7 echo `echo \z`        #  z
  8 echo `echo \\z`       #  z
  9 echo `echo \\\z`      # \z
 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
 16 cat <<EOF
 17 \z
 18 EOF                  # \z
 19
 20 cat <<EOF
 21 \\z
 22 EOF                  # \z
 23
 24 # These examples supplied by Stephane Chazelas.
```

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.

```
(cd /source/directory && tar cf - . ) | \
(cd /dest/directory && tar xpvf -)
# Repeating Alan Cox's directory tree copy command,
# but split into two lines for increased legibility.

# As an alternative:
tar cf - -C /source/directory |
tar xpvf - -C /dest/directory
# See note below.
# (Thanks, Stephane Chazelas.)
```

Note 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.

```
echo "foo
bar"
#foo
#bar

echo

echo 'foo
bar'    # No difference yet.
#foo
#bar

echo

echo foo\
bar     # Newline escaped.
#foobar

echo

echo "foo\
bar"     # Same here, as \ still interpreted as escape within weak quotes.
#foobar

echo

echo 'foo\
bar'     # Escape character \ taken literally because of strong quoting.
#foor\
#bar

# Examples suggested by Stephane Chazelas.
```

Notes

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

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Tests

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 also return an exit status of 0 if the arithmetic expressions they evaluate expand to a non-zero value. These arithmetic expansion constructs may therefore be used to perform arithmetic comparisons.

```
1 let "1<2" returns 0 (as "1<2" expands to "1")
2 (( 0 && 1 )) returns 1 (as "0 && 1" expands to "0")
```

- 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 if grep -q Bash file
 7 then echo "File contains at least one occurrence of Bash."
 8 fi
 9
10 if COMMAND_WHOSE_EXIT_STATUS_IS_0_UNLESS_ERROR_OCCURRED
11 then echo "Command succeeded."
12 else echo "Command failed."
13 fi
```

```
```

- An **if/then** construct can contain nested comparisons and tests.

```
  1 if echo "Next *if* is part of the comparison for the first *if*."
  2
  3   if [[ $comparison = "integer" ]]
  4     then (( a < b ))
  5   else
  6     [[ $a < $b ]]
  7   fi
  8
  9 then
 10   echo '$a is less than $b'
 11 fi
```

This detailed "if-test" explanation courtesy of Stephane Chazelas.

Example 7-1. What is truth?

```
  1 #!/bin/bash
  2
  3 echo
  4
  5 echo "Testing \"0\""
  6 if [ 0 ]      # zero
  7 then
  8   echo "0 is true."
  9 else
 10   echo "0 is false."
 11 fi
 12
 13 echo
 14
 15 echo "Testing \"NULL\""
 16 if [ ]        # NULL (empty condition)
 17 then
 18   echo "NULL is true."
 19 else
 20   echo "NULL is false."
 21 fi
 22
 23 echo
 24
 25 echo "Testing \"xyz\""
```

```
if [ xyz ]    # string
then
  echo "Random string is true."
else
  echo "Random string is false."
fi

echo

echo "Testing \"\$xyz\""
if [ $xyz ]   # Tests if $xyz is null, but...
              # it's only an uninitialized variable.
then
  echo "Uninitialized variable is true."
else
  echo "Uninitialized variable is false."
fi

echo

echo "Testing \"-n \$xyz\""
if [ -n "$xyz" ]            # More pedantically correct.
then
  echo "Uninitialized variable is true."
else
  echo "Uninitialized variable is false."
fi

echo


# When is "false" true?

echo "Testing \"false\""
if [ "false" ]
then
  echo "\"false\" is true."
else
  echo "\"false\" is false."
fi

echo

echo "Testing \"\$false\""  # Again, uninitialized variable.
if [ "$false" ]
then
  echo "\"\$false\" is true."
else
  echo "\"\$false\" is false."
fi
```

```
 76
 77
 78 echo
 79
 80 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
  7    # Optional (may be left out if not needed).
  8    # Adds default code block executing if original condition tests false.
  9    command 3
 10    command 4
 11    ...
 12 fi
```

Add a semicolon when 'if' and 'then' are on same line.

```
  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 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.

Note 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
```

Example 7-2. Equivalence of [ ] and test

```
 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 # Both code blocks are functionally identical.
13
14 if [ -z "$1" ]   # if [ -z "$1"   should work, but...
15 # Bash responds to a missing close bracket with an error message.
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 exit 0
```

The [[ ]] construct is the shell equivalent of [ ]. This is the *extended test command*, adopted from *ksh88*.

Note 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
```

Tip 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.

Note 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 # Arithmetic tests.
 3
 4 # The (( ... )) construct evaluates and tests numerical expressions.
 5
 6 (( 0 ))
 7 echo "Exit status of \"(( 0 ))\" is $?."
 8
 9 (( 1 ))
10 echo "Exit status of \"(( 1 ))\" is $?."
11
12 exit 0
```

Prev Quoting | Home | Up | Next File test operators

7.2. File test operators

Returns true if...

-e

file exists

-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 (floppy, cdrom, etc.)

-c

file is a character device (keyboard, modem, sound card, etc.)

-p

file is a pipe

-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. [1] 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. [2] 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.

```
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, he can only delete files in it that he owns. This keeps users from inadvertently overwriting or deleting each other's files in a publicly accessible directory, such as `/tmp`.

-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 29-1, Example 10-7, Example 10-3, and Example A-2 illustrate uses of the file test operators.

Notes

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

[2] On modern UNIX systems, the sticky bit is no longer used for files, only on directories.

7.3. Comparison operators (binary)

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" ]
```

string comparison

=

is equal to

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

==

is equal to

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

This is a synonym for =.

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

!=

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 26-4 for an application of this comparison operator.

-z

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

-n

string is not "null".

Caution The **-n** test absolutely 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 7-5) normally works, however, this is an unsafe practice. *Always* quote a tested string. [1]

Example 7-4. 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 # Caution advised.
 9
10 if [ "$a" -ne "$b" ]
11 then
12   echo "$a is not equal to $b"
13   echo "(arithmetic comparison)"
14 fi
15
16 echo
17
18 if [ "$a" != "$b" ]
19 then
20   echo "$a is not equal to $b."
21   echo "(string comparison)"
22 fi
23
24 # In this instance, both "-ne" and "!=" work.
25
26 echo
27
28 exit 0
```

Example 7-5. 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
 8 # If a string has not been initialized, it has no defined value.
 9 # This state is called "null" (not the same as zero).
10
11 if [ -n $string1 ]    # $string1 has not been declared or initialized.
12 then
13   echo "String \"string1\" is not null."
14 else
15   echo "String \"string1\" is null."
16 fi
17 # Wrong result.
18 # Shows $string1 as not null, although it was not initialized.
19
20
21 echo
22
23
24 # Lets try it again.
25
26 if [ -n "$string1" ]  # This time, $string1 is quoted.
27 then
28   echo "String \"string1\" is not null."
29 else
30   echo "String \"string1\" is null."
31 fi      # Quote strings within test brackets!
32
33
34 echo
35
36
37 if [ $string1 ]       # This time, $string1 stands naked.
38 then
39   echo "String \"string1\" is not null."
40 else
41   echo "String \"string1\" is null."
42 fi
43 # This works fine.
44 # The [ ] test operator alone detects whether the string is null.
45 # However it is good practice to quote it ("$string1").
46 #
```

```
47 # As Stephane Chazelas points out,
48 #    if [ $string 1 ]   has one argument, "]"
49 #    if [ "$string 1" ]  has two arguments, the empty "$string1" and "]"
50
51
52
53 echo
54
55
56
57 string1=initialized
58
59 if [ $string1 ]       # Again, $string1 stands naked.
60 then
61   echo "String \"string1\" is not null."
62 else
63   echo "String \"string1\" is null."
64 fi
65 # Again, gives correct result.
66 # Still, it is better to quote it ("$string1"), because...
67
68
69 string1="a = b"
70
71 if [ $string1 ]       # Again, $string1 stands naked.
72 then
73   echo "String \"string1\" is not null."
74 else
75   echo "String \"string1\" is null."
76 fi
77 # Not quoting "$string1" now gives wrong result!
78
79 exit 0
80 # Also, thank you, Florian Wisser, for the "heads-up".
```

Example 7-6. zmost

```
 1 #!/bin/bash
 2
 3 #View gzipped files with 'most'
 4
 5 NOARGS=65
 6 NOTFOUND=66
 7 NOTGZIP=67
 8
 9 if [ $# -eq 0 ] # same effect as:  if [ -z "$1" ]
10 # $1 can exist, but be empty:  zmost "" arg2 arg3
11 then
12   echo "Usage: `basename $0` filename" >&2
13   # Error message to stderr.
14   exit $NOARGS
15   # Returns 65 as exit status of script (error code).
16 fi
17
18 filename=$1
19
20 if [ ! -f "$filename" ]   # Quoting $filename allows for possible spaces.
21 then
22   echo "File $filename not found!" >&2
23   # Error message to stderr.
24   exit $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 $NOTGZIP
32 fi
33
34 zcat $1 | most
35
36 # Uses the file viewer 'most' (similar to 'less').
37 # Later versions of 'most' have file decompression capabilities.
38 # May substitute 'more' or 'less', if desired.
39
40
41 exit $?   # Script returns exit status of pipe.
42 # Actually "exit $?" unnecessary, as the script will, in any case,
43 # 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 are 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 [ "$exp1" -a "$exp2" ]
```

Refer to Example 8-2 and Example 26-7 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).

7.4. Nested if/then Condition Tests

Condition tests using the **if/then** construct may be nested. The net result is identical to using the **&&** compound comparison operator above.

```
1 if [ condition1 ]
2 then
3   if [ condition2 ]
4   then
5     do-something  # But only if both "condition1" and "condition2" valid.
6   fi
7 fi
```

See Example 35-3 for an example of nested *if/then* condition tests.

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 "=".
```

Caution Do not confuse the "=" assignment operator with the = test operator.

```
1 #    = as a test operator
2
3 if [ "$string1" = "$string2" ]
4 # if [ "Xstring1" = "Xstring2" ] is safer,
5 # to prevent an error message should one of the variables be empty.
6 # (The prepended "X" characters cancel out.)
7 then
8    command
9 fi
```

arithmetic operators

+

plus

-

minus

*

multiplication

/

division

**

exponentiation

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

%

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

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

This operator finds use in, among other things, generating numbers within a specific range (see Example 9-18 and Example 9-19) and formatting program output (see Example 26-6). It can even be used to generate prime numbers, (see Example A-11).

+=

"plus-equal" (increment variable by a constant)

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 8-1. Using Arithmetic Operations

```
 1 #!/bin/bash
 2 # Counting to 6 in 5 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 : $((n = $n + 1))
10 #  ":" necessary because otherwise Bash attempts
11 #+ to interpret "$((n = $n + 1))" as a command.
12 echo -n "$n "
13
14 n=$(($n + 1))
15 echo -n "$n "
16
17 : $[ n = $n + 1 ]
18 #  ":" necessary because otherwise Bash attempts
19 #+ to interpret "$((n = $n + 1))" as a command.
20 # Works even if "n" was initialized as a string.
21 echo -n "$n "
22
23 n=$[ $n + 1 ]
24 #  Works even if "n" was initialized as a string.
25 #* Avoid this type of construct, since it is obsolete and nonportable.
26 echo -n "$n "; echo
27
28 # Thanks, Stephane Chazelas.
29
30 exit 0
```

Note Integer variables in Bash are actually signed *long* (32-bit) integers, in the range of -2147483648 to 2147483647. An operation that takes a variable outside these limits will give an erroneous result.

```
1 a=2147483646
2 echo "a = $a"      # a = 2147483646
3 let "a+=1"         # Increment "a".
4 echo "a = $a"      # a = 2147483647
5 let "a+=1"         # increment "a" again, past the limit.
6 echo "a = $a"      # a = -2147483648
7                    #      ERROR (out of range)
```

Caution 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 (error token is ".5 +
1.3")
   5
   6 echo "b = $b"       # b=1
```

Use bc in scripts that 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 run fast enough to permit its use on the fly.

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 negate

!

bitwise NOT

^

bitwise XOR

^=

"bitwise XOR-equal"

logical operators

&&

and (logical)

```
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 within [ ... ] construct.
```

Note && may also, depending on context, be used in an and list to concatenate commands.

||

or (logical)

```
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 within [ ... ] construct.
```

Note Bash tests the exit status of each statement linked with a logical operator.

Example 8-2. 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 ']'.
```

```
#
#    if [[ $a -eq 24 && $b -eq 24 ]]   works
#    (The "&&" has a different meaning in line 17 than in line 6.)
#    Thanks, Stephane Chazelas.


if [ "$a" -eq 98 ] || [ "$b" -eq 47 ]
then
  echo "Test #2 succeeds."
else
  echo "Test #2 fails."
fi


#  The -a and -o options provide
#+ an alternative compound condition test.
#  Thanks to Patrick Callahan for pointing this out.


if [ "$a" -eq 24 -a "$b" -eq 47 ]
then
  echo "Test #3 succeeds."
else
  echo "Test #3 fails."
fi


if [ "$a" -eq 98 -o "$b" -eq 47 ]
then
  echo "Test #4 succeeds."
else
  echo "Test #4 fails."
fi


a=rhino
b=crocodile
if [ "$a" = rhino ] && [ "$b" = crocodile ]
then
  echo "Test #5 succeeds."
else
  echo "Test #5 fails."
fi

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*, but only the last operation is returned.

```
1 let "t1 = ((5 + 3, 7 - 1, 15 - 4))"
2 echo "t1 = $t1"               # t1 = 11
3
4 let "t2 = ((a = 9, 15 / 3))"  # Set "a" and calculate "t2".
5 echo "t2 = $t2    a = $a"     # t2 = 5    a = 9
```

The comma operator finds use mainly in for loops. See Example 10-10.

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 *#* is evaluated as *BASE#NUMBER* (this option is of limited usefulness because of range restrictions).

Example 8-3. Representation of numerical constants:

```
 1 #!/bin/bash
 2 # numbers.sh: Representation of numbers.
 3
 4 # Decimal
 5 let "d = 32"
 6 echo "d = $d"
 7 # Nothing out of the ordinary here.
 8
 9
10 # Octal: numbers preceded by '0' (zero)
11 let "o = 071"
12 echo "o = $o"
13 # Expresses result in decimal.
14
15 # Hexadecimal: numbers preceded by '0x' or '0X'
16 let "h = 0x7a"
17 echo "h = $h"
18 # Expresses result in decimal.
19
20 # Other bases: BASE#NUMBER
21 # BASE between 2 and 36.
22 let "b = 32#77"
23 echo "b = $b"
24 # This notation only works for a limited range (2 - 36)
25             # ... 10 digits + 26 alpha characters = 36.
26 let "c = 2#47"  # Error: out of range.
```

```
27 echo "c = $c"
28
29 echo
30
31 echo $((36#zz)) $((2#10101010)) $((16#AF16))
32
33 exit 0
34 # Thanks, S.C., for clarification.
```

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Chapter 9. Variables Revisited

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, usually `/bin/bash`

`$BASH_ENV`

an environmental variable pointing to a Bash startup file to be read when a script is invoked

`$BASH_VERSION`

the version of Bash installed on the system

```
bash$ echo $BASH_VERSION
2.04.12(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.

`$DIRSTACK`

contents of the directory stack (affected by pushd and popd)

This builtin variable is the counterpart to the dirs command.

`$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.

Caution 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.
```

`$GROUPS`

groups current user belongs to

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

`$HOME`

home directory of the user, usually `/home/username` (see Example 9-9)

`$HOSTNAME`

The hostname command assigns the system name at bootup in an init script. However, the `gethostname()` function sets the Bash internal variable `$HOSTNAME`. See also Example 9-9.

`$HOSTTYPE`

host type

Like $MACHTYPE, identifies the system hardware.

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

`$IFS`

input field separator

This 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 6-1.

```
bash$ echo $IFS | cat -vte
$


bash$ bash -c 'set w x y z; IFS=":-;"; echo "$*"'
w:x:y:z
```

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

Example 9-1. $IFS and whitespace

```
 1 #!/bin/bash
 2 # $IFS treats whitespace differently than other characters.
 3
 4 output_args_one_per_line()
 5 {
 6   for arg
 7   do echo "[$arg]"
 8   done
 9 }
10
11 echo; echo "IFS=\" \""
12 echo "-------"
13
14 IFS=" "
15 var=" a  b c   "
16 output_args_one_per_line $var  # output_args_one_per_line `echo " a  b c   "`
17 #
18 # [a]
19 # [b]
20 # [c]
21
22
23 echo; echo "IFS=:"
24 echo "-----"
25
26 IFS=:
27 var=":a::b:c:::"               # Same as above, but substitute ":" for " ".
28 output_args_one_per_line $var
29 #
30 # []
31 # [a]
32 # []
33 # [b]
34 # [c]
35 # []
36 # []
37 # []
38
39 # The same thing happens with the "FS" field separator in awk.
40
41 # Thank you, Stephane Chazelas.
42
43 echo
44
45 exit 0
```

(Thanks, S. C., for clarification and examples.)

$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.

Note 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`.

`$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 last_cmd_arg=$_  # Save it.
  2
  3 echo "At line number $LINENO, variable \"v1\" = $v1"
  4 echo "Last command argument processed = $last_cmd_arg"
```

`$MACHTYPE`

machine type

Identifies the system hardware.

```
bash$ echo $MACHTYPE
i686-debian-linux-gnu
```

`$OLDPWD`

old working directory ("OLD-print-working-directory", previous directory you were in)

`$OSTYPE`

operating system type

```
bash$ echo $OSTYPE
linux-gnu
```

`$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 Chapter 27).

```
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).

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

`$PPID`

The `$PPID` of a process is the process id (`pid`) of its parent process. [1]

Compare this with the pidof command.

`$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 10-25).

`$PS4`

The quartenary prompt, shown at the beginning of each line of output when invoking a script with the -x option. It displays as "+".

`$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=73
 4
 5 clear # Clear 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 # Filenames may contain all characters in the 0 - 255 range, except "/".
27 # Deleting files beginning with weird characters is left as an exercise.
28
29 # Various other operations here, as necessary.
30
31 echo
```

```
32 echo "Done."
33 echo "Old files deleted in $TargetDirectory."
34 echo
35
36
37 exit 0
```

$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
 3 echo
 4 echo -n "What is your favorite vegetable? "
 5 read
 6
 7 echo "Your favorite vegetable is $REPLY."
 8 # REPLY holds the value of last "read" if and only if
 9 # no variable supplied.
10
11 echo
12 echo -n "What is your favorite fruit? "
13 read fruit
14 echo "Your favorite fruit is $fruit."
15 echo "but..."
16 echo "Value of \$REPLY is still $REPLY."
17 # $REPLY is still set to its previous value because
18 # the variable $fruit absorbed the new "read" value.
19
20 echo
21
22 exit 0
```

$SECONDS

The number of seconds the script has been running.

```
 1 #!/bin/bash
 2
 3 ENDLESS_LOOP=1
 4 INTERVAL=1
 5
 6 echo
 7 echo "Hit Control-C to exit this script."
 8 echo
 9
10 while [ $ENDLESS_LOOP ]
11 do
12   if [ "$SECONDS" -eq 1 ]
13   then
14     units=second
15   else
16     units=seconds
```

```
  fi

  echo "This script has been running $SECONDS $units."
  sleep $INTERVAL
done


exit 0
```

$SHELLOPTS

the list of enabled shell options, a readonly variable

$SHLVL

Shell level, how deeply Bash is nested. If, at the command line, $SHLVL is 1, then in a script it will increment to 2.

$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.

Note Unfortunately, this works only while waiting for input at the shell prompt console or in an xterm. While it would be nice to speculate on the uses of this internal variable for timed input, for example in combination with read, *$TMOUT* does not work in that context and is virtually useless for shell scripting. (Reportedly the *ksh* version of a timed **read** does work).

Implementing timed input in a script is certainly possible, but hardly seems worth the effort. One method 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 30-3) the interrupt generated by the timing loop (whew!).

Example 9-2. Timed Input

```
#!/bin/bash
# timed-input.sh

# TMOUT=3            useless in a script

TIMELIMIT=3  # Three seconds in this instance, may be set to different value.

PrintAnswer()
{
  if [ "$answer" = TIMEOUT ]
  then
    echo $answer
  else       # Don't want to mix up the two instances.
    echo "Your favorite veggie is $answer"
    kill $!  # Kills no longer needed TimerOn function running in background.
             # $! is PID of last job running in background.
  fi

}


TimerOn()
{
```

```
  sleep $TIMELIMIT && kill -s 14 $$ &
  # Waits 3 seconds, then sends sigalarm to script.
}

Int14Vector()
{
  answer="TIMEOUT"
  PrintAnswer
  exit 14
}

trap Int14Vector 14   # Timer interrupt (14) subverted for our purposes.

echo "What is your favorite vegetable "
TimerOn
read answer
PrintAnswer


# Admittedly, this is a kludgy implementation of timed input,
# but pretty much as good as can be done with Bash.
# (Challenge to reader: come up with something better.)

# If you need something a bit more elegant...
# consider writing the application in C or C++,
# using appropriate library functions, such as 'alarm' and 'setitimer'.

exit 0
```

An alternative is using stty.

Example 9-3. Once more, timed input

```
#!/bin/bash
# timeout.sh

# Written by Stephane Chazelas,
# and modified by the document author.

INTERVAL=5                # timeout interval

timedout_read() {
  timeout=$1
  varname=$2
  old_tty_settings=`stty -g`
  stty -icanon min 0 time ${timeout}0
  eval read $varname      # or just    read $varname
  stty "$old_tty_settings"
  # See man page for "stty".
}

echo; echo -n "What's your name? Quick! "
timedout_read $INTERVAL your_name

```

```
 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
```

`$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 9-4. 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 "$ROOT_UID" ]  # Will the real "root" please stand up?
  7 then
  8   echo "You are root."
  9 else
 10   echo "You are just an ordinary user (but mom loves you just the same)."
 11 fi
 12
 13 exit 0
 14
 15
 16 # ================================================================ #
 17 # Code below will not execute, because the script already exited.
 18
 19 # An alternate method of getting to the root of matters:
 20
 21 ROOTUSER_NAME=root
 22
 23 username=`id -nu`
 24 if [ "$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
 30
 31 exit 0
```

See also Example 2-2.

Note The variables $USER, $USERNAME, $LOGNAME, $MAIL, and $ENV are *not* Bash builtins. These are, however, often set as environmental variables in one of the Bash 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.

$-

Flags passed to script

Caution 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

$_

Special variable set to last argument of previous command executed.

Example 9-5. underscore variable

```
  1 #!/bin/bash
  2
  3 echo $_         # /bin/bash
  4 # Just called /bin/bash to run the script.
  5
  6 du >/dev/null   # So no output from command.
  7 echo $_         # du
  8
  9 ls -al          # So no output from command.
 10 echo $_         # -al  (last argument)
 11
 12 :
 13 echo $_         # :
```

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 5-4 and Example 11-10)

$#

number of command line arguments [2] or positional parameters (see Example 2-4)

$$

process id of script, often used in scripts to construct temp file names (see Example A-8, Example 30-4, and Example 12-21)

$?

exit status of a command, function, or the script itself (see Example 23-3)

$*

All of the positional parameters, seen as a single word

$@

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.

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

```
 1 #!/bin/bash
 2 # Invoke this script with several arguments, such as "one two three".
 3
 4 E_BADARGS=65
 5
 6 if [ ! -n "$1" ]
 7 then
 8   echo "Usage: `basename $0` argument1 argument2 etc."
 9   exit $E_BADARGS
10 fi
11
12 echo
13
14 index=1
15
16 echo "Listing args with \"\$*\":"
17 for arg in "$*"  # Doesn't work properly if "$*" isn't quoted.
18 do
19   echo "Arg #$index = $arg"
20   let "index+=1"
21 done             # $* sees all arguments as single word.
22 echo "Entire arg list seen as single word."
23
24 echo
25
26 index=1
27
28 echo "Listing args with \"\$@\":"
29 for arg in "$@"
30 do
31   echo "Arg #$index = $arg"
32   let "index+=1"
33 done             # $@ sees arguments as separate words.
34 echo "Arg list seen as separate words."
35
36 echo
37
38 exit 0
```

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 12-15 and Example 12-16.

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

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

```
 1 #!/bin/bash
 2
 3 # Erratic behavior of the "$*" and "$@" internal Bash variables,
 4 # depending on whether these are quoted or not.
 5 # Word splitting and linefeeds handled inconsistently.
 6
 7 # This example script by Stephane Chazelas,
 8 # and slightly modified by the document author.
 9
10
11 set -- "First one" "second" "third:one" "" "Fifth: :one"
12 # Setting the script arguments, $1, $2, etc.
13
14 echo
15
16 echo 'IFS unchanged, using "$*"'
17 c=0
18 for i in "$*"               # quoted
19 do echo "$((c+=1)): [$i]"   # This line remains the same in every instance.
20                             # Echo args.
21 done
22 echo ---
23
24 echo 'IFS unchanged, using $*'
25 c=0
26 for i in $*                 # unquoted
27 do echo "$((c+=1)): [$i]"
28 done
29 echo ---
30
31 echo 'IFS unchanged, using "$@"'
32 c=0
33 for i in "$@"
34 do echo "$((c+=1)): [$i]"
35 done
36 echo ---
37
38 echo 'IFS unchanged, using $@'
39 c=0
40 for i in $@
41 do echo "$((c+=1)): [$i]"
42 done
43 echo ---
44
45 IFS=:
46 echo 'IFS=":", using "$*"'
47 c=0
```

```
 48 for i in "$*"
 49 do echo "$((c+=1)): [$i]"
 50 done
 51 echo ---
 52
 53 echo 'IFS=":", using $*'
 54 c=0
 55 for i in $*
 56 do echo "$((c+=1)): [$i]"
 57 done
 58 echo ---
 59
 60 var=$*
 61 echo 'IFS=":", using "$var" (var=$*)'
 62 c=0
 63 for i in "$var"
 64 do echo "$((c+=1)): [$i]"
 65 done
 66 echo ---
 67
 68 echo 'IFS=":", using $var (var=$*)'
 69 c=0
 70 for i in $var
 71 do echo "$((c+=1)): [$i]"
 72 done
 73 echo ---
 74
 75 var="$*"
 76 echo 'IFS=":", using $var (var="$*")'
 77 c=0
 78 for i in $var
 79 do echo "$((c+=1)): [$i]"
 80 done
 81 echo ---
 82
 83 echo 'IFS=":", using "$var" (var="$*")'
 84 c=0
 85 for i in "$var"
 86 do echo "$((c+=1)): [$i]"
 87 done
 88 echo ---
 89
 90 echo 'IFS=":", using "$@"'
 91 c=0
 92 for i in "$@"
 93 do echo "$((c+=1)): [$i]"
 94 done
 95 echo ---
 96
 97 echo 'IFS=":", using $@'
 98 c=0
 99 for i in $@
100 do echo "$((c+=1)): [$i]"
101 done
102 echo ---
103
104 var=$@
105 echo 'IFS=":", using $var (var=$@)'
106 c=0
```

```
107 for i in $var
108 do echo "$((c+=1)): [$i]"
109 done
110 echo ---
111
112 echo 'IFS=":", using "$var" (var=$@)'
113 c=0
114 for i in "$var"
115 do echo "$((c+=1)): [$i]"
116 done
117 echo ---
118
119 var="$@"
120 echo 'IFS=":", using "$var" (var="$@")'
121 c=0
122 for i in "$var"
123 do echo "$((c+=1)): [$i]"
124 done
125 echo ---
126
127 echo 'IFS=":", using $var (var="$@")'
128 c=0
129 for i in $var
130 do echo "$((c+=1)): [$i]"
131 done
132
133 echo
134
135 # Try this script with ksh or zsh -y.
136
137 exit 0
```

Note 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 mecho $*       # a,b,c
 17
 18 mecho $@       # a,b,c
 19 mecho "$@"     # a,b,c
 20
```

```
21 # The behavior of $* and $@ when $IFS is empty depends
22 # on whatever Bash or sh version being run.
23 # It is therefore inadvisable to depend on this "feature" in a script.
24
25
26 # Thanks, S.C.
27
28 exit 0
```

Notes

[1] The pid of the currently running script is $$, of course.

[2] The words "argument" and "parameter" are often used interchangeably. In the context of this document, they have the same precise meaning, that of a variable passed to a script or function.

9.2. 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 \$PATH = $PATH"
 5 PATH=${PATH}:/opt/bin  #Add /opt/bin to $PATH for duration of script.
 6 echo "New \$PATH = $PATH"
```

`${parameter-default}`

If parameter not set, use default.

```
 1 echo ${username-`whoami`}
 2 # Echoes the result of `whoami`, if variable $username is still unset.
```

Note This is almost equivalent to *`${parameter:-default}`*. The extra : makes a difference only when *parameter* has been declared, but is null.

```
 1 #!/bin/bash
 2
 3 username0=
 4 # username0 has been declared, but is set to null.
 5 echo "username0 = ${username0-`whoami`}"
 6 # Will not echo.
 7
 8 echo "username1 = ${username1-`whoami`}"
 9 # username1 has not been declared.
10 # Will echo.
11
12 username2=
13 # username2 has been declared, but is set to null.
14 echo "username2 = ${username2:-`whoami`}"
15 # Will echo because of :- rather than just - in condition test.
16
```

```
 17 exit 0
```

${parameter=default}**, **${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 ${username=`whoami`}
  2 # Variable "username" is now set to `whoami`.
```

${parameter+alt_value}**, **${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.

Both forms nearly equivalent. The : makes a difference only when *parameter* has been declared and is null, as above.

Example 9-9. Using param substitution and :

```
  1 #!/bin/bash
  2
  3 # Check some of the system's environmental variables.
  4 # If, for example, $USER, the name of the person at the console, is not set,
  5 # the machine will not recognize you.
  6
  7 : ${HOSTNAME?} ${USER?} ${HOME?} ${MAIL?}
  8   echo
  9   echo "Name of the machine is $HOSTNAME."
 10   echo "You are $USER."
 11   echo "Your home directory is $HOME."
 12   echo "Your mail INBOX is located in $MAIL."
 13   echo
 14   echo "If you are reading this message,"
 15   echo "critical environmental variables have been set."
 16   echo
 17   echo
 18
 19 # ------------------------------------------------------
 20
 21 # The ${variablename?} construction can also check
 22 # for variables set within the script.
 23
 24 ThisVariable=Value-of-ThisVariable
 25 # Note, by the way, that string variables may be set
 26 # to characters disallowed in their names.
 27 : ${ThisVariable?}
 28 echo "Value of ThisVariable is $ThisVariable".
 29 echo
 30 echo
 31
 32
 33 : ${ZZXy23AB?"ZZXy23AB has not been set."}
 34 # If ZZXy23AB has not been set, then the script terminates with an error
message.
 35
 36 # You can specify the error message.
 37 # : ${ZZXy23AB?"ZZXy23AB has not been set."}
 38
 39
 40 # Same result with:    dummy_variable=${ZZXy23AB?}
 41 #                      dummy_variable=${ZZXy23AB?"ZXy23AB has not been set."}
```

```
 42 #
 43 #                     echo ${ZZXy23AB?} >/dev/null
 44
 45
 46
 47 echo "You will not see this message, because script terminated above."
 48
 49 HERE=0
 50 exit $HERE   # Will *not* exit here.
```

Parameter substitution and/or expansion. The following expressions are the complement to the **match** *in* **expr** string operations (see Example 12-5). 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.

Note Exceptions:

- **${#*}** and **${#@}** give the *number of positional parameters*.
- For an array, **${#array[*]}** and **${#array[@]}** give the number of elements in the array.

Example 9-10. 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 "Invoke this script with one or more command-line arguments."
  9   exit $E_NO_ARGS
 10 fi
 11
 12 var01=abcdEFGH28ij
 13
 14 echo "var01 = ${var01}"
 15 echo "Length of var01 = ${#var01}"
 16
 17 echo "Number of command-line arguments passed to script = ${#@}"
 18 echo "Number of command-line arguments passed to script = ${#*}"
 19
 20 exit 0
```

${var#pattern}**, **${var##pattern}

Remove from $var the shortest/longest part of $pattern that matches the *front end* of $var.

A usage illustration from Example A-6:

```
1 # Function from "days-between.sh" example.
2 # Strips leading zero(s) from argument passed.
3
4 strip_leading_zero () # Better to strip possible leading zero(s)
5 {                    # from day and/or month
6   val=${1#0}         # since otherwise Bash will interpret them
7   return $val        # as octal values (POSIX.2, sect 2.9.2.1).
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.
```

${var%pattern}**, **${var%%pattern}

Remove from $var the shortest/longest part of $pattern that matches the *back end* of $var.

Version 2 of Bash adds additional options.

Example 9-11. Pattern matching in parameter substitution

```
 1 #!/bin/bash
 2 # Pattern matching  using the # ## % %% parameter substitution operators.
 3
 4 var1=abcd12345abc6789
 5 pattern1=a*c  # * (wild card) matches everything between a - c.
 6
 7 echo
 8 echo "var1 = $var1"           # abcd12345abc6789
 9 echo "var1 = ${var1}"         # abcd12345abc6789   (alternate form)
10 echo "Number of characters in ${var1} = ${#var1}"
11 echo "pattern1 = $pattern1"   # a*c  (everything between 'a' and 'c')
12 echo
13
14
15 echo '${var1#$pattern1}  =' "${var1#$pattern1}"    #         d12345abc6789
```

```
# Shortest possible match, strips out first 3 characters  abcd12345abc6789
#                                  ^^^^^                  |-|
echo '${var1##$pattern1} =' "${var1##$pattern1}"   #                  6789
# Longest possible match, strips out first 12 characters  abcd12345abc6789
#                                  ^^^^^                  |----------|

echo; echo

pattern2=b*9            # everything between 'b' and '9'
echo "var1 = $var1"     # Still  abcd12345abc6789
echo "pattern2 = $pattern2"
echo

echo '${var1%pattern2}  =' "${var1%$pattern2}"     #     abcd12345a
# Shortest possible match, strips out last 6 characters  abcd12345abc6789
#                                   ^^^^                           |----|
echo '${var1%%pattern2} =' "${var1%%$pattern2}"    #     a
# Longest possible match, strips out last 12 characters  abcd12345abc6789
#                                   ^^^^                  |-------------|

# Remember, # and ## work from the left end of string,
#           % and %% work from the right end.

echo

exit 0
```

Example 9-12. Renaming file extensions:

```
#!/bin/bash

#                rfe
#                ---

# Renaming file extensions.
#
#         rfe old_extension new_extension
#
# Example:
# To rename all *.gif files in working directory to *.jpg,
#          rfe gif jpg

ARGS=2
E_BADARGS=65

if [ $# -ne $ARGS ]
then
  echo "Usage: `basename $0` old_file_suffix new_file_suffix"
  exit $E_BADARGS
fi

```

```
 23 for filename in *.$1
 24 # Traverse list of files ending with 1st argument.
 25 do
 26   mv $filename ${filename%$1}$2
 27   # Strip off part of filename matching 1st argument,
 28   # then append 2nd argument.
 29 done
 30
 31 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-9 for an example of the creative use of this operator.

${var/patt/replacement}

First match of *patt*, within *var* replaced with *replacement*.

If *replacement* is omitted, then the first match of *patt* is replaced by *nothing*, that is, deleted.

${var//patt/replacement}

Global replacement. All matches of *patt*, within *var* replaced with *replacement*.

As above, if *replacement* is omitted, then all occurrences of *patt* are replaced by *nothing*, that is, deleted.

Example 9-13. 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, S. C. 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/#patt/replacement}

If *prefix* of *var* matches *replacement*, then substitute *replacement* for *patt*.

${var/%patt/replacement}

If *suffix* of *var* matches *replacement*, then substitute *replacement* for *patt*.

Example 9-14. Matching patterns at prefix or suffix of string

```
 1 #!/bin/bash
 2 # Pattern replacement at prefix / suffix of string.
 3
 4 v0=abc1234zip1234abc    # Original variable.
 5 echo "v0 = $v0"         # abc1234zip1234abc
 6 echo
 7
 8 # Match at prefix (beginning) of string.
 9 v1=${v0/#abc/ABCDEF}    # abc1234zip1234abc
10                         # |-|
11 echo "v1 = $v1"         # ABCDE1234zip1234abc
12                         # |---|
13
14 # Match at suffix (end) of string.
15 v2=${v0/%abc/ABCDEF}    # abc1234zip123abc
16                         #              |-|
17 echo "v2 = $v2"         # abc1234zip1234ABCDEF
18                         #               |----|
19
20 echo
21
22 #  --------------------------------------------------
23 #  Must match at beginning / end of string,
24 #+ otherwise no replacement results.
25 #  --------------------------------------------------
26 v3=${v0/#123/000}       # Matches, but not at beginning.
27 echo "v3 = $v3"         # abc1234zip1234abc
28                         # NO REPLACEMENT.
29 v4=${v0/%123/000}       # Matches, but not at end.
30 echo "v4 = $v4"         # abc1234zip1234abc
31                         # NO REPLACEMENT.
32
33 exit 0
```

${!varprefix*}**, **${!varprefix@}

Matches all previously declared variables beginning with *varprefix*.

```
1 xyz23=whatever
2 xyz24=
3
4 a=${!xyz*}      # Expands to names of declared variables beginning with "xyz".
5 echo "a = $a"   # a = xyz23 xyz24
6 a=${!xyz@}      # Same as above.
7 echo "a = $a"   # a = xyz23 xyz24
8
9 # Bash, version 2.04, adds this feature.
```

Notes

[1] If $parameter is null in a non-interactive script, it will terminate with a 127 exit status (the Bash error code code for "command not found").

9.3. Typing variables: declare or typeset

The **declare** or **typeset** builtins (they are exact synonyms) permit restricting the properties of variables. This is a very weak form of the typing 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*

```
1 declare -r var1
```

(**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.

-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 "three" as an integer.
```

Note that certain arithmetic operations are permitted for declared integer variables without the need for expr or let.

-a *array*

```
1 declare -a indices
```

The variable `indices` will be treated as an array.

-f *functions*

```
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.

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 9-15. 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.
```

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9.4. Indirect References to Variables

Assume that the value of a variable is the name of a second variable. Is it somehow possible to retrieve the value of this second variable from the first one? For example, if *a=letter_of_alphabet* and *letter_of_alphabet=z*, can a reference to *a* return *z*? This can indeed be done, and it is called an *indirect reference*. It uses the unusual *eval var1=\$$var2* notation.

Example 9-16. Indirect References

```
 1 #!/bin/bash
 2 # Indirect variable referencing.
 3
 4 a=letter_of_alphabet
 5 letter_of_alphabet=z
 6
 7 echo
 8
 9 # Direct reference.
10 echo "a = $a"
11
12 # Indirect reference.
13 eval a=\$$a
14 echo "Now a = $a"
15
16 echo
17
18
19 # Now, let's try changing the second order reference.
20
21 t=table_cell_3
22 table_cell_3=24
23 echo "\"table_cell_3\" = $table_cell_3"
24 echo -n "dereferenced \"t\" = "; eval echo \$$t
25 # In this simple case,
26 #   eval t=\$$t; echo "\"t\" = $t"
27 # also works (why?).
28
29 echo
30
31 t=table_cell_3
32 NEW_VAL=387
33 table_cell_3=$NEW_VAL
34 echo "Changing value of \"table_cell_3\" to $NEW_VAL."
35 echo "\"table_cell_3\" now $table_cell_3"
```

```
36 echo -n "dereferenced \"t\" now "; eval echo \$$t
37 # "eval" takes the two arguments "echo" and "\$$t" (set equal to $table_cell_3)
38 echo
39
40 # (Thanks, S.C., for clearing up the above behavior.)
41
42
43 # Another method is the ${!t} notation, discussed in "Bash, version 2" section.
44 # See also example "ex78.sh".
45
46 exit 0
```

Example 9-17. 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 uses indirect references.
 6
 7 ARGS=2
 8 E_WRONGARGS=65
 9
10 if [ $# -ne "$ARGS" ] # Check for proper no. of command line args.
11 then
12    echo "Usage: `basename $0` filename column-number"
13    exit $E_WRONGARGS
14 fi
15
16 filename=$1
17 column_number=$2
18
19 #===== Same as original script, up to this point =====#
20
21
22 # A multi-line awk script is invoked by   awk ' ..... '
23
24
25 # Begin awk script.
26 # ------------------------------------------------
27 awk "
28
29 { total += \$${column_number} # indirect reference
30 }
31 END {
32      print total
33      }
34
```

```
 35      " "$filename"
 36 # ----------------------------------------------
 37 # End awk script.
 38
 39 # Indirect variable reference avoids the hassles
 40 # of referencing a shell variable within the embedded awk script.
 41 # Thanks, Stephane Chazelas.
 42
 43
 44 exit 0
```

Caution This method of indirect referencing is a bit tricky. If the second order variable changes its value, then the 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 35-2) makes indirect referencing more intuitive.

9.5. $RANDOM: generate random integer

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

Example 9-18. 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 echo "Random number less than $RANGE  ---  $number"
30
31 echo
32
33 # If you need a random int greater than a lower bound,
34 # then set up a test to discard all numbers below that.
35
36 FLOOR=200
37
38 number=0   #initialize
```

```
while [ "$number" -le $FLOOR ]
do
  number=$RANDOM
done
echo "Random number greater than $FLOOR ---  $number"
echo


# May combine above two techniques to retrieve random number between two limits.
number=0   #initialize
while [ "$number" -le $FLOOR ]
do
  number=$RANDOM
  let "number %= $RANGE"  # Scales $number down within $RANGE.
done
echo "Random number between $FLOOR and $RANGE ---  $number"
echo


# Generate binary choice, that is, "true" or "false" value.
BINARY=2
number=$RANDOM
T=1

let "number %= $BINARY"
# let "number >>= 14"    gives a better random distribution
# (right shifts out everything except last binary digit).
if [ "$number" -eq $T ]
then
  echo "TRUE"
else
  echo "FALSE"
fi

echo


# May generate toss of the dice.
SPOTS=7   # Modulo 7 gives range 0 - 6.
DICE=2
ZERO=0
die1=0
die2=0

# Tosses each die separately, and so gives correct odds.

  while [ "$die1" -eq $ZERO ]     # Can't have a zero come up.
  do
    let "die1 = $RANDOM % $SPOTS" # Roll first one.
  done

  while [ "$die2" -eq $ZERO ]
  do
```

```
 92     let "die2 = $RANDOM % $SPOTS" # Roll second one.
 93   done
 94
 95 let "throw = $die1 + $die2"
 96 echo "Throw of the dice = $throw"
 97 echo
 98
 99
100 exit 0
```

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 9-19. Rolling the 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         # Throw count.
  9
 10 zeroes=0        # Must initialize counts to zero.
 11 ones=0          # since an uninitialized variable is null, not zero.
 12 twos=0
 13 threes=0
 14 fours=0
 15 fives=0
 16 sixes=0
 17
 18 print_result ()
 19 {
 20 echo
 21 echo "ones =   $ones"
 22 echo "twos =   $twos"
 23 echo "threes = $threes"
 24 echo "fours =  $fours"
 25 echo "fives =  $fives"
 26 echo "sixes =  $sixes"
 27 echo
 28 }
 29
 30 update_count()
 31 {
```

```
 32 case "$1" in
 33   0) let "ones += 1";;   # Since die has no "zero", this corresponds to 1.
 34   1) let "twos += 1";;   # And this to 2, etc.
 35   2) let "threes += 1";;
 36   3) let "fours += 1";;
 37   4) let "fives += 1";;
 38   5) let "sixes += 1";;
 39 esac
 40 }
 41
 42 echo
 43
 44
 45 while [ "$throw" -lt "$MAXTHROWS" ]
 46 do
 47   let "die1 = RANDOM % $PIPS"
 48   update_count $die1
 49   let "throw += 1"
 50 done
 51
 52 print_result
 53
 54 # The scores should distribute fairly evenly, assuming RANDOM is fairly random.
 55 # With $MAXTHROWS at 600, all should cluster around 100, plus-or-minus 20 or so.
 56 #
 57 # Keep in mind that RANDOM is a pseudorandom generator,
 58 # and not a spectacularly good one at that.
 59
 60 # Exercise for the reader (easy):
 61 # Rewrite this script to flip a coin 1000 times.
 62 # Choices are "HEADS" or "TAILS".
 63
 64 exit 0
```

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. (This mirrors the behavior of the *random()* function in C.)

Example 9-20. Reseeding RANDOM

```
  1 #!/bin/bash
  2 # seeding-random.sh: Seeding the RANDOM variable.
  3
  4 MAXCOUNT=25       # How many numbers to generate.
  5
  6 random_numbers ()
  7 {
  8 count=0
  9 while [ "$count" -lt "$MAXCOUNT" ]
 10 do
 11   number=$RANDOM
 12   echo -n "$number "
 13   let "count += 1"
 14 done
 15 }
 16
 17 echo; echo
 18
 19 RANDOM=1          # Setting RANDOM seeds the random number generator.
 20 random_numbers
 21
 22 echo; echo
 23
 24 RANDOM=1          # Same seed for RANDOM...
 25 random_numbers    # ...reproduces the exact same number series.
 26
 27 echo; echo
 28
 29 RANDOM=2          # Trying again, but with a different seen...
 30 random_numbers    # gives a different number series.
 31
 32 echo; echo
 33
 34 # RANDOM=$$  seeds RANDOM from process id of script.
 35 # It is also possible to seed RANDOM from 'time' or 'date'.
 36
 37 # Getting fancy...
 38 SEED=$(head -1 /dev/urandom | od -N 1 | awk '{ print $2 }')
 39 # Pseudo-random output fetched from /dev/urandom (system pseudo-random
"device"),
 40 # then converted to line of printable (octal) numbers by "od",
 41 # finally "awk" retrieves just one number for SEED.
 42 RANDOM=$SEED
 43 random_numbers
 44
 45 echo; echo
 46
 47 exit 0
```

Note The `/dev/urandom` device/file provides a means 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) or using dd (see Example 12-30).

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The Double Parentheses Construct

9.6. 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-type manipulation of variables in Bash.

Example 9-21. C-type manipulation of variables

```
  1 #!/bin/bash
  2 # Manipulating a variable, C-style, using the ((...)) construct.
  3
  4
  5 echo
  6
  7 (( a = 23 ))  # Setting a value, C-style, with spaces on both sides of the "=".
  8 echo "a (initial value) = $a"
  9
 10 (( a++ ))     # Post-increment 'a', C-style.
 11 echo "a (after a++) = $a"
 12
 13 (( a-- ))     # Post-decrement 'a', C-style.
 14 echo "a (after a--) = $a"
 15
 16
 17 (( ++a ))     # Pre-increment 'a', C-style.
 18 echo "a (after ++a) = $a"
 19
 20 (( --a ))     # Pre-decrement 'a', C-style.
 21 echo "a (after --a) = $a"
 22
 23 echo
 24
 25 (( t = a<45?7:11 ))   # C-style trinary operator.
 26 echo "If a < 45, then t = 7, else t = 11."
 27 echo "t = $t "  # Yes!
 28
 29 echo
 30
 31
 32 # -----------------
 33 # Easter Egg alert!
 34 # -----------------
 35 # Chet Ramey apparently snuck a bunch of undocumented C-style constructs into
Bash.
```

```
  36 # In the Bash docs, Ramey calls ((...)) shell arithmetic, but it goes far beyond
that.
  37 # Sorry, Chet, the secret is now out.
  38
  39 # See also "for" and "while" loops using the ((...)) construct.
  40
  41 # These work only with Bash, version 2.04 or later.
  42
  43 exit 0
```

See also Example 10-10.

Chapter 10. Loops and Branches

Operations on code blocks are the key to structured, organized shell scripts. Looping and branching constructs provide the tools for accomplishing this.

10.1. Loops

A *loop* is a block of code that iterates (repeats) a list of commands as long as the loop control condition is true.

for loops

for (in)

This is the basic looping construct. It differs significantly from its C counterpart.

for *arg* in [*list*]
do
  command...
done

Note During each pass through the loop, *arg* takes on the value of each 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 10-1. Simple for loops

```
 1 #!/bin/bash
 2
 3 for planet in Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto
 4 do
 5   echo $planet
 6 done
 7
 8 echo
 9
10 # Entire 'list' enclosed in quotes creates a single variable.
11 for planet in "Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto"
12 do
13   echo $planet
14 done
15
16 exit 0
```

Note

Each **[list]** element may contain multiple parameters. This is useful when processing parameters in groups. In such cases, use the **set** command (see Example 11-10) to force parsing of each **[list]** element and assignment of each component to the positional parameters.

Example 10-2. 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" and sets positional parameters.
 9   # the "--" prevents nasty surprises if $planet is null or begins with a dash.
10
11   # May need to save original positional parameters, since they get overwritten.
12   # One way of doing this is to use an array,
13   #        original_params=("$@")
14
15   echo "$1         $2,000,000 miles from the sun"
16   #-------two  tabs---concatenate zeroes onto parameter $2
17 done
18
19 # (Thanks, S.C., for additional clarification.)
20
21 exit 0
```

A variable may supply the **[list]** in a **for** loop.

Example 10-3. *Fileinfo:* operating on a file list contained in a variable

```
 1 #!/bin/bash
 2 # fileinfo.sh
 3
 4 FILES="/usr/sbin/privatepw
 5 /usr/sbin/pwck
 6 /usr/sbin/go500gw
 7 /usr/bin/fakefile
 8 /sbin/mkreiserfs
 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 $9 "         file size: " $5 }'  # Print 2 fields.
24   whatis `basename $file`   # File info.
25   echo
26 done
27
28 exit 0
```

The **[list]** in a **for** loop may contain filename globbing, that is, using wildcards for filename expansion.

Example 10-4. Operating on files with a for loop

```
 1 #!/bin/bash
 2 # list-glob.sh: Generating [list] in a for-loop using "globbing".
 3
 4 echo
 5
 6 for file in *
 7 do
 8   ls -l "$file"  # Lists all files in $PWD (current directory).
 9   # Recall that the wild card character "*" matches everything,
10   # however, in "globbing", it doesn't match dot-files.
11
12   # If the pattern matches no file, it is expanded to itself.
13   # To prevent this, set the nullglob option
14   # (shopt -s nullglob).
15   # Thanks, S.C.
16 done
17
18 echo; echo
19
20 for file in [jx]*
21 do
22   rm -f $file    # Removes only files beginning with "j" or "x" in $PWD.
23   echo "Removed file \"$file\"".
24 done
25
26 echo
27
28 exit 0
```

Omitting the **in [list]** part of a **for** loop causes the loop to operate on $@, the list of arguments given on the command line to the script.

Example 10-5. Missing `in [list]` in a for loop

```
 1 #!/bin/bash
 2
 3 # Invoke both with and without arguments, and see what happens.
 4
 5 for a
 6 do
 7  echo -n "$a "
 8 done
 9
10 # The 'in list' missing, therefore the loop operates on '$@'
11 # (command-line argument list, including whitespace).
12
13 echo
14
```

```
15 exit 0
```

It is possible to use command substitution to generate the **[list]** in a **for** loop. See also Example 12-28, Example 10-9 and Example 12-27.

Example 10-6. Generating the [list] in a for loop with command substitution

```
 1 #!/bin/bash
 2 # A for-loop with [list] generated by command substitution.
 3
 4 NUMBERS="9 7 3 8 37.53"
 5
 6 for number in `echo $NUMBERS`  # for number in 9 7 3 8 37.53
 7 do
 8   echo -n "$number "
 9 done
10
11 echo
12 exit 0
```

This is a somewhat more complex example of using command substitution to create the [list].

Example 10-7. 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` 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 for word in $( strings "$2" | grep "$1" )
 24 # The "strings" command lists strings in binary files.
 25 # Output then piped to "grep", which tests for desired string.
 26 do
 27   echo $word
 28 done
 29
 30 # As S.C. points out, the above for-loop could be replaced with the simpler
 31 #    strings "$2" | grep "$1" | tr -s "$IFS" '[\n*]'
 32
 33
 34 # Try something like  "./bin-grep mem /bin/ls"  to exercise this script.
 35
 36 exit 0
```

Here is yet another example of the [list] resulting from command substitution.

Example 10-8. Checking all the binaries in a directory for authorship

```
  1 #!/bin/bash
  2 # findstring.sh: Find a particular string in binaries in a specified directory.
  3
  4 directory=/usr/bin/
  5 fstring="Free Software Foundation"  # See which files come from the FSF.
  6
  7 for file in $( find $directory -type f -name '*' | sort )
  8 do
  9   strings -f $file | grep "$fstring" | sed -e "s%$directory%%"
 10   # In the "sed" expression, it is necessary to substitute for the normal "/"
delimiter
 11   # because "/" happens to be one of the characters filtered out.
 12   # Failure to do so gives an error message (try it).
 13 done
 14
 15 exit 0
 16
 17 # Exercise for the reader (easy):
 18 # Convert this script to taking command-line parameters for $directory and
$fstring.
```

The output of a **for** loop may be piped to a command or commands.

Example 10-9. Listing the symbolic links in a directory

```
 1 #!/bin/bash
 2 # symlinks.sh: Lists symbolic links in a directory.
 3
 4 ARGS=1                 # Expect one command-line argument.
 5
 6 if [ $# -ne "$ARGS" ]  # If not 1 arg...
 7 then
 8   directory=`pwd`      # current working directory.
 9 else
10   directory=$1
11 fi
12
13 echo "symbolic links in directory \"$directory\""
14
15 for file in $( find $directory -type l )   # "-type l" = symbolic links
16 do
17   echo $file
18 done | sort                               # Otherwise file list is unsorted.
19
20 exit 0
```

There is an alternative syntax to a **for** loop that will look very familiar to C programmers. This requires double parentheses.

Example 10-10. A C-like for loop

```
 1 #!/bin/bash
 2 # Two 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 # Now, let's do the same, using C-like syntax.
17
18 LIMIT=10
19
```

```
for ((a=1; a <= LIMIT ; a++))  # Double parentheses, and "LIMIT" with no "$".
do
  echo -n "$a "
done                           # A construct borrowed from 'ksh93'.

echo; echo

# +=========================================================================+

# Let's use the C "comma operator" to increment two variables simultaneously.

for ((a=1, b=1; a <= LIMIT ; a++, b++))  # The comma chains together operations.
do
  echo -n "$a-$b "
done

echo; echo

exit 0
```

See also Example 26-6 and Example 26-7.

Now, for an example from "real life".

Example 10-11. Using efax in batch mode

```
#!/bin/bash

EXPECTED_ARGS=2
E_BADARGS=65

if [ $# -ne $EXPECTED_ARGS ]
# Check for proper no. of command line args.
then
   echo "Usage: `basename $0` phone# text-file"
   exit $E_BADARGS
fi


if [ ! -f "$2" ]
then
  echo "File $2 is not a text file"
  exit $E_BADARGS
fi


```

```
fax make $2              # Create fax formatted files from text files.

for file in $(ls $2.0*)  # Concatenate the converted files.
                         # Uses wild card in variable list.
do
  fil="$fil $file"
done

efax -d /dev/ttyS3 -o1 -t "T$1" $fil   # Do the work.


# As S.C. points out, the for-loop can be eliminated with
#    efax -d /dev/ttyS3 -o1 -t "T$1" $2.0*
# but it's not quite as instructive [grin].

exit 0
```

---

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).

while [*condition*]
do
  command...
done

As is the case with for/in loops, placing the **do** on the same line as the condition test requires a semicolon.

while [*condition*] ; do

Note that certain specialized **while** loops, as, for example, a getopts construct, deviate somewhat from the standard template given here.

Example 10-12. Simple while loop

```
#!/bin/bash

var0=0
LIMIT=10

while [ "$var0" -lt "$LIMIT" ]
do
  echo -n "$var0 "        # -n suppresses newline.
  var0=`expr $var0 + 1`   # var0=$(($var0+1)) also works.
done

echo

```

```
14 exit 0
```

Example 10-13. Another while loop

```
 1 #!/bin/bash
 2
 3 echo
 4
 5 while [ "$var1" != "end" ]     # while test "$var1" != "end"
 6 do                             # also works.
 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 10-14. 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 last 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-like syntax by using the double parentheses construct (see also Example 9-21).

Example 10-15. C-like syntax in a while loop

```
 1 #!/bin/bash
 2 # wh-loopc.sh: Count to 10 in a "while" loop.
 3
 4 LIMIT=10
 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, 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, and no "$" preceding variables.
23 do
24   echo -n "$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 # Now, C programmers can feel right at home in Bash.
33
34 exit 0
```

Note A **while** loop may have its `stdin` redirected to a file by a < at its end.

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...
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/in loops, placing the **do** on the same line as the condition test requires a semicolon.

until [*condition-is-true*] ; do

Example 10-16. until loop

```
 1 #!/bin/bash
 2
 3 until [ "$var1" = end ] # Tests condition here, at top of loop.
 4 do
 5   echo "Input variable #1 "
 6   echo "(end to exit)"
 7   read var1
 8   echo "variable #1 = $var1"
 9 done
10
11 exit 0
```

10.2. Nested Loops

A nested loop is a loop within a loop, an inner loop within the body of an outer one. What happens 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 may interrupt this process.

Example 10-17. Nested Loop

```
 1 #!/bin/bash
 2 # 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   # Beginning of inner loop.
14   for b in 1 2 3 4 5
15   do
16     echo "Pass $inner in inner loop."
17     let "inner+=1"  # Increment inner loop counter.
18   done
19   # End of inner loop.
20
21   let "outer+=1"    # Increment outer loop counter.
22   echo              # Space between output in pass of outer loop.
23 done
24 # End of outer loop.
25
```

```
  26 exit 0
```

See Example 26-4 for an illustration of nested "while" loops, and Example 26-5 to see a "while" loop nested inside an "until" loop.

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10.3. Loop Control

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 10-18. 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)."
 7
 8 a=0
 9
10 while [ $a -le "$LIMIT" ]
11 do
12  a=$(($a+1))
13
14  if [ "$a" -eq 3 ] || [ "$a" -eq 11 ]  # Excludes 3 and 11
15  then
16    continue  # Skip rest of this particular loop iteration.
17  fi
18
19  echo -n "$a "
20 done
21
22 # Exercise for the reader:
23 # Why does loop print up to 20?
24
25 echo; echo
26
27 echo Printing Numbers 1 through 20, but something happens after 2.
```

```
28
29 ######################################################################
30
31 # Same loop, but substituting 'break' for 'continue'.
32
33 a=0
34
35 while [ "$a" -le "$LIMIT" ]
36 do
37  a=$(($a+1))
38
39  if [ "$a" -gt 2 ]
40  then
41    break  # Skip entire rest of loop.
42  fi
43
44  echo -n "$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 10-19. 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 $outerloop:   "
 9
10   for innerloop in 1 2 3 4 5
11   do
12     echo -n "$innerloop "
13
14     if [ "$innerloop" -eq 3 ]
15     then
```

```
      break  # Try   break 2   to see what happens.
             # ("Breaks" out of both inner and outer loops.)
    fi
  done

  echo
done

echo

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 10-20. Continuing at a higher loop level

```
#!/bin/bash
# The "continue N" command, continuing at the Nth level loop.

for outer in I II III IV V           # outer loop
do
  echo; echo -n "Group $outer: "

  for inner in 1 2 3 4 5 6 7 8 9 10  # inner loop
  do

    if [ "$inner" -eq 7 ]
    then
      continue 2  # Continue at loop on 2nd level, that is "outer loop".
                  # Replace above line with a simple "continue"
                  # to see normal loop behavior.
    fi

    echo -n "$inner "  # 8 9 10 will never echo.
  done

done

echo; echo

# Exercise for the reader:
```

```
26 # Come up with a meaningful use for "continue N" in a script.
27
28 exit 0
```

Caution 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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10.4. 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 equivalent of **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

Note

- Quoting the variables is not mandatory, since word splitting does not take place.
- Each test line ends with a right paren).
- Each condition block ends with a *double* semicolon ;;.
- The entire **case** block terminates with an **esac** (*case* spelled backwards).

Example 10-21. Using case

```
 1 #!/bin/bash
 2
 3 echo; echo "Hit a key, then hit return."
 4 read Keypress
 5
 6 case "$Keypress" in
 7   [a-z]   ) echo "Lowercase letter";;
 8   [A-Z]   ) echo "Uppercase letter";;
 9   [0-9]   ) echo "Digit";;
10   *       ) echo "Punctuation, whitespace, or other";;
11 esac  # Allows ranges of characters in [square brackets].
12
13 # Exercise for the reader:
14 # As the script stands, # it accepts a single keystroke, then terminates.
15 # Change the script so it accepts continuous input,
16 # reports on each keystroke, and terminates only when "X" is hit.
17 # Hint: enclose everything in a "while" loop.
18
19 exit 0
```

Example 10-22. 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 Floppy 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
 34 # each option.
 35
 36   "J" | "j" )
 37   echo
 38   echo "Mildred Jones"
 39   echo "249 E. 7th St., Apt. 19"
 40   echo "New York, NY 10009"
 41   echo "(212) 533-2814"
 42   echo "(212) 533-9972 fax"
 43   echo "milliej@loisaida.com"
 44   echo "Girlfriend"
 45   echo "Birthday: Feb. 11"
 46   ;;
 47
 48 # Add info for Smith & Zane later.
 49
 50           * )
 51    # Default option.
 52    # Empty input (hitting RETURN) fits here, too.
 53    echo
 54    echo "Not yet in database."
 55   ;;
 56
 57 esac
 58
 59 echo
 60
 61 # Exercise for the reader:
 62 # Change the script so it accepts continuous input,
 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 65;;  # No command-line parameters,
 5                                                   # or first parameter empty.
 6 # Note that ${0##*/} is ${var##pattern} param substitution. Net result is $0.
 7
 8 -*) FILENAME=./$1;;   # If filename passed as argument ($1) starts with a dash,
 9                       # replace it with ./$1
10                       # so further commands don't interpret it as an option.
11
12 * ) FILENAME=$1;;     # Otherwise, $1.
13 esac
```

Example 10-23. Using command substitution to generate the case variable

```
 1 #!/bin/bash
 2 # Using command substitution to generate a "case" variable.
 3
 4 case $( arch ) in   # "arch" returns machine architecture.
 5 i386 ) echo "80386-based machine";;
 6 i486 ) echo "80486-based machine";;
 7 i586 ) echo "Pentium-based machine";;
 8 i686 ) echo "Pentium2+-based machine";;
 9 *    ) echo "Other type of machine";;
10 esac
11
12 exit 0
```

A **case** construct can filter strings for globbing patterns.

Example 10-24. Checking for alphabetic input

```
#!/bin/bash
# Using "case" structure to filter a string.

SUCCESS=0
FAILURE=-1

isalpha ()  # Tests whether *first character* of input string is alphabetic.
{
if [ -z "$1" ]               # No argument passed?
then
  return $FAILURE
fi

case "$1" in
[a-zA-Z]*) return $SUCCESS;;  # Begins with a letter?
*        ) return $FAILURE;;
esac
}             # Compare this with "isalpha ()" function in C.


isalpha2 ()   # Tests whether *entire string* is alphabetic.
{
  [ $# -eq 1 ] || return $FAILURE

  case $1 in
  *[!a-zA-Z]*|"") return $FAILURE;;
               *) return $SUCCESS;;
  esac
}



check_var ()  # Front-end to isalpha().
{
if isalpha "$@"
then
  echo "$* = alpha"
else
  echo "$* = non-alpha"  # Also "non-alpha" if no argument passed.
fi
}

a=23skidoo
b=H3llo
c=-What?
d=`echo $b`   # Command substitution.

check_var $a
check_var $b
check_var $c
check_var $d
check_var     # No argument passed, so what happens?
```

```
53
54
55 # Script improved by S.C.
56
57 exit 0
```

---

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 that this may be changed.

Example 10-25. Creating menus using select

```
 1 #!/bin/bash
 2
 3 PS3='Choose your favorite vegetable: ' # Sets the prompt string.
 4
 5 echo
 6
 7 select vegetable in "beans" "carrots" "potatoes" "onions" "rutabagas"
 8 do
 9   echo
10   echo "Your favorite veggie is $vegetable."
11   echo "Yuck!"
12   echo
13   break  # if no 'break' here, keeps looping forever.
14 done
15
16 exit 0
```

If **in** *list* is omitted, then **select** uses the list of command line arguments ($@) passed to the script or to the function in which the **select** construct is embedded.

Compare this to the behavior of a

for *variable* [in *list*]

construct with the **in** *list* omitted.

Example 10-26. 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 tomatoes spinach
21 #         $1    $2   $3      $4       $5       $6
22 #         passed to choice_of() function
23
24 exit 0
```

Chapter 11. Internal Commands and Builtins

A *builtin* is a command contained within the Bash tool set, literally *built in*. A builtin may be a synonym to a system command of the same name, but Bash reimplements it internally. [1] For example, the Bash **echo** command is not the same as `/bin/echo`, although their behavior is almost identical.

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" and "!" are keywords. Similar to a *builtin*, a keyword is hard-coded into Bash.

I/O

echo

prints (to `stdout`) an expression or variable (see Example 5-1).

```
1 echo Hello
2 echo $a
```

An **echo** requires the `-e` option to print escaped characters. See Example 6-2.

Normally, each **echo** command prints a terminal newline, but the `-n` option suppresses this.

Note 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
```

Note An **echo**, in combination with command substitution can set a variable.

```
a=`echo "HELLO" | tr A-Z a-z`
```

See also Example 12-13, Example 12-2, Example 12-26, and Example 12-27.

Caution Be aware that **echo `command`** deletes any linefeeds that the output of *command* generates. Since $IFS normally contains \n as one of its set of whitespace characters, Bash segments the output of *command* at linefeeds into arguments to **echo**, which then emits these arguments separated by spaces.

```
bash$  printf '\n\n1\n2\n3\n\n\n\n'


1
2
3



bash $



bash$ echo "`printf '\n\n1\n2\n3\n\n\n\n'`"

1
2
3
bash $
```

Note 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, and the 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.

Caution Older versions of Bash may not support **printf**.

Example 11-1. printf in action

```
 1 #!/bin/bash
 2 # printf demo
 3
 4 PI=3.14159265358979
 5 DecimalConstant=31373
 6 Message1="Greetings,"
 7 Message2="Earthling."
 8
 9 echo
10
11 printf "Pi to 2 decimal places = %1.2f" $PI
12 echo
13 printf "Pi to 9 decimal places = %1.9f" $PI  # It even rounds off correctly.
14
15 printf "\n"                                  # Prints a line feed,
16                                              # equivalent to 'echo'.
17
18 printf "Constant = \t%d\n" $DecimalConstant  # Inserts tab (\t)
19
20 printf "%s %s \n" $Message1 $Message2
21
22 echo
23
24 # ============================================#
25 # Simulation of C function, 'sprintf'.
26 # Loading a variable with a formatted string.
27
28 echo
29
30 Pi12=$(printf "%1.12f" $PI)
31 echo "Pi to 12 decimal places = $Pi12"
32
33 Msg=`printf "%s %s \n" $Message1 $Message2`
34 echo $Msg; echo $Msg
35
36 # As it happens, the 'sprintf' function can now be accessed
37 # as a loadable module to Bash, but this is not portable.
38
39 exit 0
```

Formatting error messages is a useful application of **printf**

```
  1 E_BADDIR=65
  2
  3 var=nonexistent_directory
  4
  5 error()
  6 {
  7   printf "$@" >&2
  8   # Formats positional params passed, and sents 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.
```

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 26-2).

Example 11-2. Variable assignment, using read

```
  1 #!/bin/bash
  2
  3 echo -n "Enter the value of variable 'var1': "
  4 # The -n option to echo suppresses newline.
  5
  6 read var1
  7 # Note no '$' in front of var1, since it is being set.
  8
  9 echo "var1 = $var1"
 10
 11
 12 echo
 13
 14 # A single 'read' statement can set multiple variables.
 15 echo -n "Enter the values of variables 'var2' and 'var3' (separated by a space
or tab): "
 16 read var2 var3
 17 echo "var2 = $var2      var3 = $var3"
 18 # If you input only one value, the other variable(s) will remain unset (null).
 19
 20 exit 0
```

Normally, inputting a `\` suppresses a newline during input to a **read**. The `-r` option causes an inputted `\` to be

interpreted literally.

Example 11-3. 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, and again press <ENTER>."
 7 read var1     # The "\" suppresses the newline, when reading "var1".
 8               #     first line \
 9               #     second line
10
11 echo "var1 = $var1"
12 #     var1 = first line second line
13
14 # For each line terminated by a "\",
15 # you get a prompt on the next line to continue feeding characters into var1.
16
17 echo; echo
18
19 echo "Enter another string terminated by a \\ , then press <ENTER>."
20 read -r var2  # The -r option causes the "\" to be read literally.
21               #     first line \
22
23 echo "var2 = $var2"
24 #     var2 = first line \
25
26 # Data entry terminates with the first <ENTER>.
27
28 echo
29
30 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 **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 11-4. 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 File 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 originial $IFS.
 38 # This code snippet also by Heiner Steven.
 39
 40 exit 0
```

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.

pwd

Print Working Directory. This gives the user's (or script's) current directory (see Example 11-5). 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 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 that directory popped from the stack.

dirs lists the contents of the directory stack (counterpart to $DIRSTACK) 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 11-5. 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
```

Variables

let

The **let** command carries out arithmetic operations on variables. In many cases, it functions as a less complex version of expr.

Example 11-6. Letting let do some 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"
 9
10 let "a <<= 3"     # Equivalent to  let "a = a << 3"
11 echo "\"\$a\" (=16) left-shifted 3 places = $a"
12
13 let "a /= 4"      # Equivalent to  let "a = a / 4"
14 echo "128 / 4 = $a"
15
16 let "a -= 5"      # Equivalent to  let "a = a - 5"
17 echo "32 - 5 = $a"
18
19 let "a = a * 10"  # Equivalent to  let "a = a * 10"
20 echo "27 * 10 = $a"
21
22 let "a %= 8"      # Equivalent to  let "a = a % 8"
23 echo "270 modulo 8 = $a  (270 / 8 = 33, remainder $a)"
24
25 echo
26
27 exit 0
```

---

eval

`eval arg1, arg2, ...`

Translates into commands the arguments in a list (useful for code generation within a script).

Example 11-7. Showing the effect of eval

```
 1 #!/bin/bash
 2
 3 y=`eval ls -l`   # Similar to y=`ls -l`
 4 echo $y          # but linefeeds removed.
 5
 6 y=`eval df`      # Similar to y=`df`
 7 echo $y          # but linefeeds removed.
 8
 9 # Since LF's not preserved, it may make it easier to parse output.
10
11 exit 0
```

Example 11-8. Forcing a log-off

```
 1 #!/bin/bash
 2
 3 y=`eval ps ax | sed -n '/ppp/p' | awk '{ print $1 }'`
 4 # Finding the process number of 'ppp'.
 5
 6 kill -9 $y   # Killing it
 7
 8 # Above lines may be replaced by
 9 #  kill -9 `ps ax | awk '/ppp/ { print $1 }'
10
11
12 chmod 666 /dev/ttyS3
13 # Doing a SIGKILL on ppp changes the permissions
14 # on the serial port. Restore them to previous state.
15
16 rm /var/lock/LCK..ttyS3   # Remove the serial port lock file.
17
18 exit 0
```

Example 11-9. 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 echo $var | tr a-z n-za-m    # foobar
16                              # Back to original variable.
17
18 # This example by Stephane Chazelas.
19
20 exit 0
```

Caution 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. 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 11-10. Using set with positional parameters

```
 1 #!/bin/bash
 2
 3 # script "set-test"
 4
 5 # Invoke this script with three command line parameters,
 6 # for example, "./set-test 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 echo
15
16 set `uname -a` # Sets the positional parameters to the output
17               # of the command `uname -a`
18
19 echo "Positional parameters after  set \`uname -a\` :"
20 # $1, $2, $3, etc. reinitialized to result of `uname -a`
21 echo "Field #1 of 'uname -a' = $1"
22 echo "Field #2 of 'uname -a' = $2"
23 echo "Field #3 of 'uname -a' = $3"
24 echo
25
26 exit 0
```

See also Example 10-2.

unset

The **unset** command deletes a shell variable. Note that this command does not affect positional parameters.

```
bash$ unset PATH

bash$ echo $PATH


bash$
```

Example 11-11. "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                        # Uninitialized.
 8 echo "(unset) variable = $variable"  # $variable is null.
 9
10 exit 0
```

---

export

The **export** command makes available variables to all child processes of the running script or shell. Unfortunately, there is no way to **export** variables back to the parent process, to the process that called or invoked the script or shell. One important use of **export** command is in startup files, to initialize and make accessible environmental variables to subsequent user processes.

Example 11-12. 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
 7 ARGS=2
 8 E_WRONGARGS=65
 9
10 if [ $# -ne "$ARGS" ] # Check for proper no. of command line args.
11 then
12    echo "Usage: `basename $0` filename column-number"
13    exit $E_WRONGARGS
14 fi
15
16 filename=$1
```

```
 17 column_number=$2
 18
 19 #===== Same as original script, up to this point =====#
 20
 21 export column_number
 22 # Export column number to environment, so it's available for retrieval.
 23
 24
 25 # Begin awk script.
 26 # ------------------------------------------------
 27 awk '{ total += $ENVIRON["column_number"]
 28 }
 29 END { print total }' $filename
 30 # ------------------------------------------------
 31 # End awk script.
 32
 33
 34 # Thanks, Stephane Chazelas.
 35
 36 exit 0
```

Tip It is possible to initialize and export variables in the same operation, as in **export var1=xxx**.

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** library function familiar to C programmers. It permits passing and concatenating multiple options [2] 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 decrements the implicit `$OPTIND` variable to step to the next.

Note

1. The arguments must be passed from the command line to the script preceded by a minus (-) or a plus (+). It is the prefixed - or + that lets **getopts** recognize command-line arguments as *options*. In fact, **getopts** will not process arguments without the prefixed - or +, 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 replaces the obsolete **getopt** 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>.
20
```

Example 11-13. Using getopts to read the options/arguments passed to a script

```
 1 #!/bin/bash
 2
 3 # 'getopts' processes command line arguments to script.
 4 # The arguments are parsed as "options" (flags) and associated arguments.
 5
 6 # Try invoking this script with
 7 # 'scriptname -mn'
 8 # 'scriptname -oq qOption' (qOption can be some arbitrary string.)
 9 # 'scriptname -qXXX -r'
10 #
11 # 'scriptname -qr'    - Unexpected result, takes "r" as the argument to option
"q"
12 # 'scriptname -q -r'  - Unexpected result, same as above
13 #  If an option expects an argument ("flag:"), then it will grab
```

```
#  whatever is next on the command line.

NO_ARGS=0
OPTERROR=65

if [ $# -eq "$NO_ARGS" ]  # Script invoked with no command-line args?
then
  echo "Usage: `basename $0` options (-mnopqrs)"
  exit $OPTERROR          # Exit and explain usage, if no argument(s) given.
fi
# Usage: scriptname -options
# Note: dash (-) necessary


while getopts ":mnopq:rs" Option
do
  case $Option in
    m     ) echo "Scenario #1: option -m-";;
    n | o ) echo "Scenario #2: option -$Option-";;
    p     ) echo "Scenario #3: option -p-";;
    q     ) echo "Scenario #4: option -q-, with argument \"$OPTARG\"";;
    # Note that option 'q' must have an associated argument,
    # otherwise it falls through to the default.
    r | s ) echo "Scenario #5: option -$Option-"'';;
    *     ) echo "Unimplemented option chosen.";;   # DEFAULT
  esac
done

shift $(($OPTIND - 1))
# Decrements the argument pointer so it points to next argument.

exit 0
```

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`. This is the shell scripting equivalent of a C/C++ **`#include`** directive. It is useful in situations when multiple scripts use a common data file or function library.

Example 11-14. "Including" a data file

```
 1 #!/bin/bash
 2
 3 . data-file    # Load a data file.
 4 # Same effect as "source data-file", but more portable.
 5
 6 # The file "data-file" must be present in current working directory,
 7 # since it is referred to by its 'basename'.
 8
 9 # Now, reference some data from that file.
10
11 echo "variable1 (from data-file) = $variable1"
12 echo "variable3 (from data-file) = $variable3"
13
14 let "sum = $variable2 + $variable4"
15 echo "Sum of variable2 + variable4 (from data-file) = $sum"
16 echo "message1 (from data-file) is \"$message1\""
17 # Note:                            escaped quotes
18
19 print_message This is the message-print function in the data-file.
20
21
22 exit 0
```

File `data-file` for Example 11-14, 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 may be loaded with a 'source' or '.' command by a shell script.
 4
 5 # Let's initialize some variables.
 6
 7 variable1=22
 8 variable2=474
 9 variable3=5
10 variable4=97
11
12 message1="Hello, how are you?"
13 message2="Enough for now. Goodbye."
14
15 print_message ()
16 {
17 # Echoes any message passed to it.
18
19   if [ -z "$1" ]
20   then
21     return 1
22     # Error, if argument missing.
23   fi
24
25   echo
```

```
26
27   until [ -z "$1" ]
28   do
29     # Step through arguments passed to function.
30     echo -n "$1"
31     # Echo args one at a time, suppressing line feeds.
32     echo -n " "
33     # Insert spaces between words.
34     shift
35     # Next one.
36   done
37
38   echo
39
40   return 0
41 }
```

---

exit

Unconditionally terminates a script. The **exit** command may optionally take an integer argument, which is returned to the shell as the exit status of the script. It is a good practice to end all but the simplest scripts with an **exit 0**, indicating a successful run.

Note 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**.

exec

This shell builtin replaces the current process with a specified command. Normally, when the shell encounters a command, it forks off [3] 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. For this reason, if an **exec** appears in a script, it would probably be the final command.

An **exec** also serves to reassign file descriptors. **exec <zzz-file** replaces `stdin` with the file `zzz-file` (see Example 16-1).

Example 11-15. Effects of exec

```
1 #!/bin/bash
2
3 exec echo "Exiting \"$0\"."   # Exit from script.
4
5 # The following lines never execute.
6
7 echo "This will never echo."
8
9 exit 0  # Will not exit here.
```

Note 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 24-1 and Example 24-2). 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 directory names with 'cd'
3 command.
```

Commands

true

A command that returns a successful (zero) exit status, but does nothing else.

```
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.
9 done
```

false

A command that returns an unsuccessful exit status, but does nothing else.

```
 1 # Null loop
 2 while false
 3 do
 4    # The following code will not execute.
 5    operation-1
 6    operation-2
 7    ...
 8    operation-n
 9    # Nothing happens!
10 done
```

type [cmd]

Similar to the which external command, **type cmd** gives the full pathname to "cmd". Unlike **which**, **type** is a Bash builtin. The useful `-a` option to **type** accesses 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/[
```

hash [cmds]

Record the path name of specified commands (in the shell hash table), 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.

help

help COMMAND looks up a short usage summary of the shell builtin COMMAND. This is the counterpart to whatis, but for builtins.

```
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.
```

11.1. 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.

ps

*P*rocess *S*tatistics: lists currently executing processes by owner and PID (process id). This is usually invoked with `ax` options, and may be piped to grep or sed to search for a specific process (see Example 11-8 and Example 28-1).

```
bash$  ps ax | grep sendmail
295 ?     S      0:00 sendmail: accepting connections on port 25
```

pstree

Lists currently executing processes in "tree" format. The `-p` option shows the PIDs, as well as the process names.

jobs

Lists the jobs running in the background, giving the job number. Not as useful as **ps**.

Note 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), and "1384" is the process 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

Stop 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 11-16. 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**. See the job id table.

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 used in executing commands, in the following form:

```
0m0.020s 0m0.020s
```

This capability is of very limited value, since it is uncommon to profile and benchmark shell scripts.

kill

Forcibly terminate a process by sending it an appropriate *terminate* signal (see Example 13-4).

Note **`kill -l`** lists all the signals. 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 process whose parent has terminated, cannot be killed (you can't kill something that is already dead), but **init** will usually clean it up sooner or later.

command

The **command COMMAND** directive disables aliases and functions for the command "COMMAND".

Note 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 `/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. [4].

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. [5] 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 11-1. Job Identifiers

Notation	Meaning
%N	Job number [N]
%S	Invocation (command line) of job begins with string *S*
%?S	Invocation (command line) of job contains within it string *S*
%%	"current" job (last job stopped in foreground or started in background)
%+	"current" job (last job stopped in foreground or started in background)
%-	Last job
$!	Last background process

Notes

[1] This is either for performance reasons (builtins execute much faster than external commands, which usually require *forking* off a process) or because a particular builtin needs direct access to the shell internals.

[2] A 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.

[3] 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 running.

[4] This is not portable to all systems.

[5] The same effect as **autoload** can be achieved with typeset -fu.

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Chapter 12. 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.

12.1. Basic Commands

Command Listing

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 interesting options are `-S`, sort listing by file size, and `-t`, sort by file modification time.

Example 12-1. Using ls to create a table of contents for burning a CDR disk

```
 1 #!/bin/bash
 2
 3 SPEED=2    # May use higher speed if supported.
 4 IMAGEFILE=cdimage.iso
 5 CONTENTSFILE=contents
 6 DEFAULTDIR=/opt
 7
 8 # Script to automate burning a CDR.
 9
10 # Uses Joerg Schilling's "cdrecord" package.
11 # (http://www.fokus.gmd.de/nthp/employees/schilling/cdrecord.html)
12
13 # If this script invoked as an ordinary user, need to suid cdrecord
14 # (chmod u+s /usr/bin/cdrecord, as root).
15
16 if [ -z "$1" ]
17 then
18   IMAGE_DIRECTORY=$DEFAULTDIR
19   # Default directory, if not specified on command line.
20 else
21     IMAGE_DIRECTORY=$1
22 fi
23
24 ls -lRF $IMAGE_DIRECTORY > $IMAGE_DIRECTORY/$CONTENTSFILE
25 # The "l" option gives a "long" file listing.
```

```
 26 # The "R" option makes the listing recursive.
 27 # The "F" option marks the file types (directories get a trailing /).
 28 echo "Creating table of contents."
 29
 30 mkisofs -r -o $IMAGFILE $IMAGE_DIRECTORY
 31 echo "Creating ISO9660 file system image ($IMAGEFILE)."
 32
 33 cdrecord -v -isosize speed=$SPEED dev=0,0 $IMAGEFILE
 34 echo "Burning the disk."
 35 echo "Please be patient, this will take a while."
 36
 37 exit 0
```

---

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 cat filename cat file.1 file.2 file.3 > file.123
```

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.

See also Example 12-19 and Example 12-15.

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 is not the same effect as **tac**, as it preserves the order of the lines, but flips each one around.

```
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 12-4).

Tip Particularly useful are the `-a` archive flag (for copying an entire directory tree) and the `-r` and `-R` recursive flags.

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. For some examples of using **mv** in a script, see Example 9-12 and Example A-3.

rm

Delete (remove) a file or files. The `-f` forces removal of even readonly files.

Warning When used with the recursive flag `-r`, this command removes files all the way down the directory tree.

rmdir

Remove directory. The directory must be empty of all files, including invisible "dotfiles", [1] for this command to succeed.

mkdir

Make directory, creates a new directory. **`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 (see Example 11-8).

```
   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
   3 # others
   4 # (octal mode).
```

```
   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.
```

chattr

Change file attributes. This has the same effect as **chmod** above, but with a different invocation syntax, and it works only on an *ext2* filesystem.

ln

Creates links to pre-existings files. Most often used with the `-s`, symbolic or "soft" link flag. This permits referencing the linked file by more than one name and is a superior alternative to aliasing (see Example 5-5).

`ln -s oldfile newfile` links the previously existing `oldfile` to the newly created link, `newfile`.

Notes

[1] These are files whose names begin with a dot, such as `~/.Xdefaults`. Such filenames do not show up in a normal **ls** listing, 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.

12.2. Complex Commands

Command Listing

find

-exec *COMMAND* \;

Carries out *COMMAND* on each file that **find** scores a hit on. *COMMAND* terminates with \; (the ; is escaped to make certain the shell passes it to **find** literally, which concludes the command sequence). If *COMMAND* contains {}, then **find** substitutes the full path name of the selected file.

```
bash$ find ~/ -name '*.txt'
/home/bozo/.kde/share/apps/karm/karmdata.txt
/home/bozo/misc/irmeyc.txt
/home/bozo/test-scripts/1.txt
```

```
  1 find /home/bozo/projects -mtime 1
  2 # Lists all files in /home/bozo/projects directory tree
  3 # that were modified within the last day.
```

```
  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 - how can they be filtered out?
  5
  6 # Perhaps by:
  7
  8 find /etc -type f -exec cat '{}' \; | tr -c '.[:digit:]' '\n' \
  9  | grep '^[^.][^.]*\.[^.][^.]*\.[^.][^.]*\.[^.][^.]*$'
 10 # [:digit:] is one of the character classes
 11 # introduced with the POSIX 1003.2 standard.
 12
 13 # Thanks, S.C.
```

Caution The `-exec` option to **find** should not be confused with the exec shell builtin.

Example 12-2. Badname, eliminate file names in current directory containing bad characters and whitespace.

```
 1 #!/bin/bash
 2
 3 # Delete filenames in current directory containing bad characters.
 4
 5 for filename in *
 6 do
 7 badname=`echo "$filename" | sed -n /[\+\{\;\"\\\=\?~\(\)\<\>\&\*\|\$]/p`
 8 # Files containing those nasties:     + { ; " \ = ? ~ ( ) < > & * | $
 9 rm $badname 2>/dev/null    # So error messages deep-sixed.
10 done
11
12 # Now, take care of files containing all manner of whitespace.
13 find . -name "* *" -exec rm -f {} \;
14 # The path name of the file that "find" finds replaces the "{}".
15 # The '\' ensures that the ';' is interpreted literally, as end of command.
16
17 exit 0
18
19 #-----------------------------------------------------------------------
20 # Commands below this line will not execute because of "exit" command.
21
22 # An alternative to the above script:
23 find . -name '*[+{;"\\=?~()<>&*|$ ]*' -exec rm -f '{}' \;
24 exit 0
25 # (Thanks, S.C.)
```

See Example 12-20, Example 4-3, and Example 10-8 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 backquotes fail with a too many arguments error, substituting **xargs** often works. 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.

`ls | xargs -p -l gzip` gzips every file in current directory, one at a time, prompting before each operation.

Tip An interesting **xargs** option is `-n` *XX*, which limits the number of arguments passed to *XX*.

`ls | xargs -n 8 echo` lists the files in the current directory in 8 columns.

Tip 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.)*

Example 12-3. Log file 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 -$LINES /var/log/messages | xargs |  fmt -s >>logfile
 16 echo >>logfile
 17 echo >>logfile
 18
 19 exit 0
```

Example 12-4. copydir, copying files in current directory to another, using xargs

```
  1 #!/bin/bash
  2
  3 # Copy (verbose) all files in current directory
  4 # to directory specified on command line.
  5
  6 if [ -z "$1" ]   # Exit if no argument given.
  7 then
  8   echo "Usage: `basename $0` directory-to-copy-to"
  9   exit 65
 10 fi
 11
 12 ls . | xargs -i -t cp ./{} $1
 13 # This is the exact equivalent of
 14 #    cp * $1
 15 # unless any of the filenames has "whitespace" characters.
 16
 17 exit 0
```

---

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

```
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 $string28 $position $length`
```

External programs, such as sed and **Perl** have far superior string parsing facilities, and it might well be advisable to use these rather than the built-in Bash ones.

Example 12-5. Using expr

```
 1 #!/bin/bash
 2
 3 # Demonstrating some of the uses of 'expr'
 4 # =======================================
 5
 6 echo
 7
 8 # Arithmetic Operators
 9
10 echo "Arithmetic Operators"
11 echo
12 a=`expr 5 + 3`
13 echo "5 + 3 = $a"
14
15 a=`expr $a + 1`
16 echo
17 echo "a + 1 = $a"
18 echo "(incrementing a variable)"
19
20 a=`expr 5 % 3`
21 # modulo
22 echo
23 echo "5 mod 3 = $a"
24
25 echo
26 echo
27
28 # Logical Operators
29
30 echo "Logical Operators"
31 echo
32
33 a=3
34 echo "a = $a"
35 b=`expr $a \> 10`
36 echo 'b=`expr $a \> 10`, therefore...'
37 echo "If a > 10, b = 0 (false)"
38 echo "b = $b"
39
40 b=`expr $a \< 10`
41 echo "If a < 10, b = 1 (true)"
42 echo "b = $b"
```

```
43
44
45 echo
46 echo
47
48 # Comparison Operators
49
50 echo "Comparison Operators"
51 echo
52 a=zipper
53 echo "a is $a"
54 if [ `expr $a = snap` ]
55 # Force re-evaluation of variable 'a'
56 then
57    echo "a is not zipper"
58 fi
59
60 echo
61 echo
62
63
64
65 # String Operators
66
67 echo "String Operators"
68 echo
69
70 a=1234zipper43231
71 echo "The string being operated upon is \"$a\"."
72
73 # index: position of substring
74 b=`expr index $a 23`
75 echo "Numerical position of first \"23\" in \"$a\" is \"$b\"."
76
77 # substr: print substring, starting position & length specified
78 b=`expr substr $a 2 6`
79 echo "Substring of \"$a\", starting at position 2, and 6 chars long is \"$b\"."
80
81 # length: length of string
82 b=`expr length $a`
83 echo "Length of \"$a\" is $b."
84
85
86 # 'match' operations similarly to 'grep'
87 #      uses Regular expressions
88 b=`expr match "$a" '[0-9]*'`
89 echo Number of digits at the beginning of \"$a\" is $b.
90 b=`expr match "$a" '\([0-9]*\)'`                    # Note escaped parentheses.
91 echo "The digits at the beginning of \"$a\" are \"$b\"."
92
93 echo
94
95 exit 0
```

Important The : 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 $string :\" construct"
 5 echo "-----------------------------------------"
 6 echo
 7
 8 a=1234zipper43231
 9 echo "The string being operated upon is \"`expr "$a" : '\(.*\)'`\"."
10 #       Escaped parentheses.
11 #       Regular expression parsing.
12
13 echo "Length of \"$a\" is `expr "$a" : '.*'`."   # Length of string
14
15 echo "Number of digits at the beginning of \"$a\" is `expr "$a" : '[0-9]*'`."
16
17 echo "The digits at the beginning of \"$a\" are `expr "$a" : '\([0-9]*\)'`."
18
19 echo
20
21 exit 0
```

12.3. Time / Date Commands

Command Listing

date

Simply invoked, **date** prints the date and time to `stdout`. Where this command gets interesting is in its formatting and parsing options.

Example 12-6. 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=`eval date +%s`
14 filename=$prefix.$suffix
15 echo $filename
16 # It's great for creating "unique" temp filenames,
17 # even better than using $$.
18
19 # Read the 'date' man page for more formatting options.
20
21 exit 0
22 # Note that the "+%s" option to 'date' is GNU-specific.
```

---

time

Outputs very verbose timing statistics for executing a command.

`time ls -l /` gives something like this:

```
0.00user 0.01system 0:00.05elapsed 16%CPU (0avgtext+0avgdata 0maxresident)k
0inputs+0outputs (149major+27minor)pagefaults 0swaps
```

See also the very similar times command in the previous section.

Note 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`** (for ordinary files).

at

The **at** job control command executes a given set of commands at a specified time. This is a user version of cron.

`at 2pm January 15` prompts for a set of commands to execute at that time. These commands may include executable shell scripts.

Using either the `-f` option or input redirection (<), **at** reads a command list from a file. This file can include shell scripts, though they should, of course, be noninteractive. Particularly clever is including the run-parts command in the file to execute a 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.

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. This can be useful for timing or in processes running in the background, checking for a specific event every so often (see Example 30-4).

```
1 sleep 3
2 # Pauses 3 seconds.
```

Note The **sleep** command defaults to seconds, but minute, hours, or days may also be specified.

```
1 sleep 3 h
2 # Pauses 3 hours!
```

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. This can be used for fine-grain timing, or for polling an ongoing process at very frequent intervals.

```
1 usleep 30
2 # Pauses 30 microseconds.
```

Caution 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**.

12.4. Text Processing Commands

Command Listing

sort

File sorter, often used as a filter in a pipe. This command can sort a text stream or file forwards or backwards, or according to various keys or character positions. The *info page* lists its many options. See Example 10-8 and Example 10-9.

tsort

Topological sort, reading in pairs of whitespace-separated strings and sorting according to input patterns.

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.

There are available various fancy frontends for **diff**, such as **spiff**, **wdiff**, **xdiff**, and **mgdiff**.

Tip The **diff** command returns an exit status of 0 if the compared files are identical, and 1 if they differ. 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:

```
cd /usr/src
gzip -cd patchXX.gz | patch -p0
# Upgrading kernel source using 'patch'.
# From the Linux kernel docs "README",
# by anonymous author (Alan Cox?).
```

Note The **diff** command can also recursively compare directories (for the filenames present).

```
bash$ diff ~/notes1 ~/notes2
Only in /home/bozo/notes1: file02
Only in /home/bozo/notes1: file03
Only in /home/bozo/notes2: file04
```

diff3

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.

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.

Note 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 12-7. Using cmp to compare two files within a script.

```
#!/bin/bash

ARGS=2  # Two args to script expected.
E_BADARGS=65

if [ $# -ne "$ARGS" ]
then
  echo "Usage: `basename $0` file1 file2"
  exit $E_BADARGS
fi


cmp $1 $2 > /dev/null  # /dev/null buries the output of the "cmp" command.
# Also works with 'diff', i.e.,   diff $1 $2 > /dev/null

if [ $? -eq 0 ]        # Test exit status of "cmp" command.
then
  echo "File \"$1\" is identical to file \"$2\"."
else
```

```
  echo "File \"$1\" differs from file \"$2\"."
fi

exit 0
```

---

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.

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 the number of occurrences.

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 cat /etc/mtab | cut -d ' ' -f1,2
```

Using **cut** to list the OS and kernel version:

```
  1 uname -a | cut -d" " -f1,3,11,12
```

`cut -d ' ' -f2,3 filename` is equivalent to **`awk -F'[ ]' '{ print $2, $3 }' filename`**

See also Example 12-27.

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`.

Warning 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**.

paste

Tool for merging together different files into a single, multi-column file. In combination with **cut**, useful for creating system log files.

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
```

Note The tagged field appears only once in the output.

head

lists the beginning of a file to `stdout` (the default is `10` lines, but this can be changed). It has a number of interesting options.

Example 12-8. 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 from the "p"
command).
  47
  48 # sed is now ready to continue reading its input. (Note that before
  49 # continuing, if -n option had not been passed, sed would have printed
  50 # the line once again).
  51
  52 # Now, sed reads the remainder of the characters, and finds the end of the file.
  53 # It is now ready to process its 2nd line (which is also numbered '$' as
  54 # it's the last one).
  55 # It sees it is not matched by any <range>, so its job is done.
  56
  57 # In few word this sed commmand means:
  58 # "On the first line only, remove any character up to the right-most space,
  59 # then print it."
  60
  61 # A better way to do this would have been:
  62 #           sed -e 's/.* //;q'
  63
  64 # Here, two <range><action>s (could have been written
  65 #           sed -e 's/.* //' -e q):
  66
  67 #   range                    action
  68 #   nothing (matches line)   s/.* //
  69 #   nothing (matches line)   q (quit)
  70
  71 # Here, sed only reads its first line of input.
  72 # It performs both actions, and prints the line (substituted) before quitting
  73 # (because of the "q" action) since the "-n" option is not passed.
  74
  75 # ============================================================== #
  76
  77 # A simpler altenative to the above 1-line script would be:
  78 #           head -c4 /dev/urandom| od -An -tu4
  79
  80 exit 0
```

See also Example 12-25.

tail

lists the end of a file to `stdout` (the default is `10` lines). Commonly used to keep track of changes to a system logfile, using the `-f` option, which outputs lines appended to the file.

Example 12-9. 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 file if it does not already exist,
 7 # and truncates it to zero length if it does.
 8 # : > filename   also works.
 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
```

See also Example 12-3, Example 12-25 and Example 30-4.

grep

A multi-purpose file search tool that uses regular expressions. Originally a command/filter in the ancient **ed** line editor, **g/re/p**, or *global - regular expression - print*.

grep *pattern* [*file*...]

search the files `file`, etc. for occurrences of *pattern*.

ls -l | grep '\.txt$' has the same effect as **ls -l *.txt** (although symbolic links may cause problems).

The `-i` option causes a case-insensitive search.

The `-l` option lists only the files in which matches were found, but not the matching lines.

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.

```
grep -c txt *.sgml   # (number of occurrences of "txt" in "*.sgml" files)


#   grep -cz .
#            ^ dot
# means count (-c) zero-separated (-z) items matching "."
# that is, non-empty ones (containing at least 1 character).
#
printf 'a b\nc  d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -cz .     # 4
printf 'a b\nc  d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -cz '$'   # 5
printf 'a b\nc  d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -cz '^'   # 5
#
printf 'a b\nc  d\n\n\n\n\n\000\n\000e\000\000\nf' | grep -c '$'    # 9
# By default, newline chars (\n) separate items to match.

# Note that the -z option is GNU "grep" specific.


# Thanks, S.C.
```

Example 30-4 demonstrates how to use **grep** to search for a word pattern in a system log file.

If there is a successful match, **grep** returns an exit status of 0, which makes it useful in a condition test in a script.

Example 12-10. Emulating "grep" in a script

```
#!/bin/bash
# grp.sh: Very crude reimplementation of 'grep'.

E_BADARGS=65

if [ -z "$1" ]    # Check for argument to script.
then
  echo "Usage: `basename $0` pattern"
  exit $E_BADARGS
fi

echo

for file in *     # Traverse all files in $PWD.
do
  output=$(sed -n /"$1"/p $file)  # Command substitution.

  if [ ! -z "$output" ]           # What happens if "$output" is not quoted?
  then
    echo -n "$file: "
    echo $output
  fi              #  sed -ne "/$1/s|^|${file}: |p"  is equivalent to above.

  echo
done

```

```
echo

exit 0

# Exercises for reader:
# --------------------
# 1) Add newlines to output, if more than one match in any given file.
# 2) Add features.
```

Note **egrep** is the same as **grep -E**. This uses a somewhat different, extended set of regular expressions, which can make the search somewhat more flexible.

Note **fgrep** is the same as **grep -F**. It does a literal string search (no regular expressions), which generally speeds things up quite a bit.

Tip To search compressed files, use **zgrep**. It also works on non-compressed files, though slower than plain **grep**. This is handy for searching through a mixed set of files, some of them compressed, some not.

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 12-11. Checking words in a list for validity

```
#!/bin/bash
# lookup: Does a dictionary lookup on each word in a data file.

file=words.data  # Data file from which to read words to test.

echo

while [ "$word" != end ]  # Last word in data file.
do
  read word      # From data file, because of redirection at end of loop.
  look $word > /dev/null  # Don't want to display lines in dictionary file.
  lookup=$?      # Exit status of 'look' command.

  if [ "$lookup" -eq 0 ]
  then
    echo "\"$word\" is valid."
  else
    echo "\"$word\" is invalid."
  fi

done <"$file"    # Redirects stdin to $file, so "reads" come from there.

echo

exit 0

# ------------------------------------------------------------------
# Code below line will not execute because of "exit" command above.
```

```
 29
 30
 31 # Stephane Chazelas proposes the following, more concise alternative:
 32
 33 while read word && [[ $word != end ]]
 34 do if look "$word" > /dev/null
 35    then echo "\"$word\" is valid."
 36    else echo "\"$word\" is invalid."
 37    fi
 38 done <"$file"
 39
 40 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/doc/sed-3.02/README
20     127     838 /usr/doc/sed-3.02/README
[20 lines  127 words  838 characters]
```

wc -w gives only the word count.

wc -l gives only the line count.

wc -c 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 have a linefeed in their name.
3
4 # Alternative ways of doing this are:
5 #      find . -maxdepth 1 -name \*.txt -print0 | grep -cz .
6 #      (shopt -s nullglob; set -- *.txt; echo $#)
7
8 # 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
```

See also Example 12-25 and Example 16-5.

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.

Caution 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 tr -d 0-9 <filename
2 # 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
```

Example 12-12. toupper: Transforms a file to all uppercase.

```
 1 #!/bin/bash
 2 # Changes a file to all uppercase.
 3
 4 E_BADARGS=65
 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 exit 0
```

Example 12-13. 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 into Bash by Chet Ramey,
 7 # and considerably simplified by Mendel Cooper, author of this document.
 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 0
21
22
```

```
# Code below this line will not execute because of "exit".
#--------------------------------------------------------#
# To run it, delete script above line.

# The above script will not work on filenames containing blanks or newlines.

# Stephane Chazelas therefore suggests the following alternative:


for filename in *    # Not necessary to use basename,
                     # since "*" won't return any file containing "/".
do n=`echo "$filename/" | tr '[:upper:]' '[:lower:]'`
#                            POSIX char set notation.
#                    Slash added so that trailing newlines are not
#                    removed by command substitution.
   # Variable substitution:
   n=${n%/}          # Removes trailing slash, added above, from filename.
   [[ $filename == $n ]] || mv "$filename" "$n"
                     # Checks if filename already lowercase.
done

exit 0
```

Example 12-14. du: DOS to UNIX text file conversion.

```
#!/bin/bash
# du.sh: DOS to UNIX text file converter.

E_WRONGARGS=65

if [ -z "$1" ]
then
  echo "Usage: `basename $0` filename-to-convert"
  exit $E_WRONGARGS
fi

NEWFILENAME=$1.unx

CR='\015'  # Carriage return.
# Lines in a DOS text file end in a CR-LF.

tr -d $CR < $1 > $NEWFILENAME
# Delete CR and write to new file.

echo "Original DOS text file is \"$1\"."
echo "Converted UNIX text file is \"$NEWFILENAME\"."

exit 0
```

Example 12-15. rot13: rot13, ultra-weak encryption.

```
 1 #!/bin/bash
 2 # rot13.sh: Classic rot13 algorithm, encryption that might fool a 3-year old.
 3
 4 # Usage: ./rot13.sh filename
 5 # or     ./rot13.sh <filename
 6 # or     ./rot13.sh and supply keyboard input (stdin)
 7
 8 cat "$@" | tr 'a-zA-Z' 'n-za-mN-ZA-M'   # "a" goes to "n", "b" to "o", etc.
 9 # The 'cat "$@"' construction
10 # permits getting input either from stdin or from files.
11
12 exit 0
```

Example 12-16. 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" "$key"
18 #        |  to uppercase  |     encrypt
19 # Will work on lowercase, uppercase, or mixed-case quotes.
20 # Passes non-alphabetic characters through unchanged.
21
22
23 # Try this script with something like
24 # "Nothing so needs reforming as other people's habits."
25 # --Mark Twain
26 #
27 # Output is:
28 # "CFPHRCS QF CIIOQ MINFMBRCS EQ FPHIM GIFGUI'Q HETRPQ."
29 # --BEML PZERC
30
31 # To reverse the encryption:
32 # cat "$@" | 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
```

---

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, so quoting letter ranges within brackets is mandatory.

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 12-17 and Example A-2).

fmt

Simple-minded file formatter, used as a filter in a pipe to "wrap" long lines of text output.

Example 12-17. Formatted file listing.

```
  1 #!/bin/bash
  2
  3 # Get a file listing...
  4
  5 b=`ls /usr/local/bin`
  6
  7 echo $b | fmt -w 40   # ...40 columns wide.
  8
  9 # Could also have been done by
 10 #  echo $b | fold - -s -w 40
 11
 12 exit 0
```

See also Example 12-3.

Tip A powerful alternative to **fmt** is Kamil Toman's **par** utility, available from http://www.cs.berkeley.edu/~amc/Par/.

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.

column

Column formatter. This filter transforms list-type text output into a "pretty-printed" table by inserting tabs at appropriate places.

Example 12-18. Using column to format a directory listing

```
 1 #!/bin/bash
 2 # This is a slight modification of the example file in the "column" man page.
 3
 4
 5 (printf "PERMISSIONS LINKS OWNER GROUP SIZE MONTH DAY HH:MM PROG-NAME\n" \
 6 ; ls -l | sed 1d) | column -t
 7
 8 # The "sed 1d" in the pipe deletes the first line of output,
 9 # which would be "total        N",
10 # where "N" is the total number of files found by "ls -l".
11
12 # The -t option to "column" pretty-prints a table.
13
14 exit 0
```

---

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`.

Example 12-19. nl: A self-numbering script.

```
 1 #!/bin/bash
 2
 3 # This script echoes itself twice to stdout with its lines numbered.
 4
 5 # 'nl' sees this as line 3 since it does not number blank lines.
 6 # 'cat -n' sees the above line as number 5.
 7
 8 nl `basename $0`
 9
10 echo; echo  # Now, let's try it with 'cat -n'
11
12 cat -n `basename $0`
13 # The difference is that 'cat -n' numbers the blank lines.
14 # Note that 'nl -ba' will also do so.
15
16 exit 0
```

---

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

A GNU utility for localization and translating the text output of programs into foreign languages. While primarily intended for C programs, **gettext** also finds use in shell scripts. See the *info page*.

iconv

A utility for converting file(s) to a different encoding (character set). Its chief use is for localization.

groff, **gs**, **TeX**

Groff, TeX, and Postscript are text markup languages used for preparing copy for printing or formatted video display.

Manpages use **groff** (see Example A-1). *Ghostscript* (**gs**) is a GPL Postscript interpreter. **TeX** is Donald Knuth's elaborate typsetting system. It is often convenient to write a shell script encapsulating all the options and arguments passed to one of these markup languages.

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.

12.5. File and Archiving Commands

Archiving

tar

The standard UNIX archiving utility. 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 4-3). GNU tar has long since been patched to accept gzip compression options, such as **tar czvf archive-name.tar.gz ***, which recursively archives and compresses all files (except dotfiles) in a directory tree.

Some useful **tar** options:

1. `-c` create (a new archive)
2. `--delete` delete (files from the archive)
3. `-r` append (files to the archive)
4. `-t` list (archive contents)
5. `-u` update archive
6. `-x` extract (files from the archive)
7. `-z` gzip the archive

Caution 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 files in a shell archive are concatenated without compression, and the resultant archive is essentially a shell script, complete with #!/bin/sh header, and containing all the necessary unarchiving commands. Shar archives still show up in Internet newsgroups, but otherwise **shar** has been pretty well replaced by **tar**/**gzip**. The **unshar** command unpacks **shar** archives.

ar

Creation and manipulation utility for archives, mainly used for binary object file libraries.

cpio

This specialized archiving copy command is rarely seen any more, having been supplanted by **tar**/**gzip**. It still has its uses, such as moving a directory tree.

Example 12-20. Using cpio to move a directory tree

```
 1 #!/bin/bash
 2
 3 # Copying a directory tree using cpio.
 4
 5 ARGS=2
 6 E_BADARGS=65
 7
 8 if [ $# -ne "$ARGS" ]
 9 then
10   echo Usage: `basename $0` source destination
11   exit $E_BADARGS
12 fi
13
14 source=$1
15 destination=$2
16
17 find "$source" -depth | cpio -admvp "$destination"
18 # Read the man page to decipher these cpio options.
19
20 exit 0
```

Example 12-21. Unpacking an *rpm* archive

```
 1 #!/bin/bash
 2 # de-rpm.sh: Unpack an 'rpm' archive
 3
 4 E_NO_ARGS=65
 5 TEMPFILE=$$.cpio                          # Tempfile with "unique" name.
 6                                           # $$ is process ID of script.
 7
 8 if [ -z "$1" ]
 9 then
10   echo "Usage: `basename $0` filename"
11 exit $E_NO_ARGS
12 fi
13
14
15 rpm2cpio < $1 > $TEMPFILE                 # Converts rpm archive into cpio
archive.
16 cpio --make-directories -F $TEMPFILE -i  # Unpacks cpio archive.
17 rm -f $TEMPFILE                           # Deletes cpio archive.
18
19 exit 0
```

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 **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**.

Caution On some commercial UNIX systems, **zcat** is a synonym for **uncompress -c**, and will not work on *gzipped* files.

See also Example 7-6.

bzip2

An alternate compression utility, usually more efficient than **gzip**, especially on large files. The corresponding decompression command is **bunzip2**.

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**.

sq

Yet another compression 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**.

Tip The output of **sq** may be piped to **gzip** for further compression.

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.

Example 12-22. 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=65
 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=`eval file $1 | awk '{ print $2, $3, $4, $5 }'`
16 # "file $1" echoes file type...
17 # then awk removes the first field of this, the filename...
18 # then the result is fed into the variable "type".
19 correct_type="ASCII C program text"
20
21 if [ "$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 for the reader.
43
44 # Also, the above code deletes lines with a "*/" or "/*",
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 \", \\" ...) the only way is to write a C parser
 77 # (lex or yacc perhaps?).
 78
 79 exit 0
```

---

which

which command-xxx gives the full path to "command-xxx". This is useful for finding out whether a particular command or utility is installed on the system.

$bash which rm

```
/usr/bin/rm
```

whereis

Similar to **which**, above, **whereis command-xxx** gives the full path to "command-xxx", but also to its *manpage*.

$bash whereis rm

```
rm: /bin/rm /usr/share/man/man1/rm.1.bz2
```

whatis

whatis filexxx looks up "filexxx" 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 12-23. 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 # You may wish to redirect output of this script, like so:
 15 # ./what.sh >>whatis.db
 16 # or view it a page at a time on stdout,
 17 # ./what.sh | less
```

See also Example 10-3.

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
```

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 10-7 and Example 10-8.

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.

Note **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-6).

Example 12-24. basename and dirname

```
 1 #!/bin/bash
 2
 3 a=/home/bozo/daily-journal.txt
 4
 5 echo "Basename of /home/bozo/daily-journal.txt = `basename $a`"
 6 echo "Dirname of /home/bozo/daily-journal.txt = `dirname $a`"
 7 echo
 8 echo "My own home is `basename ~/`."         # Also works with just ~.
 9 echo "The home of my home is `dirname ~/`."  # Also works with just ~.
10
11 exit 0
```

---

split

Utility for splitting a file into smaller chunks. Usually used for splitting up large files in order to back them up on floppies or preparatory to e-mailing or uploading them.

sum, **cksum**, **md5sum**

These are utilities for generating checksums. A *checksum* is a number 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. The **md5sum** command is the most appropriate of these in security applications.

Encoding and Encryption

uuencode

This utility encodes binary files into ASCII characters, making them suitable for transmission in the body of an e-mail message or in a newsgroup posting.

uudecode

This reverses the encoding, decoding uuencoded files back into the original binaries.

Example 12-25. uudecoding encoded files

```
 1 #!/bin/bash
 2
 3 lines=35        # Allow 35 lines for the header (very generous).
 4
 5 for File in *   # Test all the files in the current working directory...
 6 do
 7   search1=`head -$lines $File | grep begin | wc -w`
 8   search2=`tail -$lines $File | grep end | wc -w`
 9   # Uuencoded files have a "begin" near the beginning,
10   # and an "end" near the end.
11   if [ "$search1" -gt 0 ]
12   then
13     if [ "$search2" -gt 0 ]
14     then
15       echo "uudecoding - $File -"
16       uudecode $File
17     fi
18   fi
19 done
20
21 # Note that running this script upon itself fools it
22 # into thinking it is a uuencoded file,
23 # because it contains both "begin" and "end".
24
25 # Exercise to the reader:
26 # Modify this script to check for a newsgroup header.
```

```
27
28 exit 0
```

Tip The fold -s command may be useful (possibly in a pipe) to process long uudecoded text messages downloaded from Usenet newsgroups.

crypt

At one time, this was the standard UNIX file encryption utility. [1] 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).

Miscellaneous

install

Special purpose file copying command, similar to **cp**, but capable of setting permissions and attributes of the copied files. This command seems tailormade for installing software packages, and as such it shows up frequently in `Makefiles` (in the *`make install :`* section). It could likewise find use in installation scripts.

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 a script.

Notes

[1] 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.

12.6. Communications Commands

Information and Statistics

host

Searches for information about an Internet host by name or IP address, using DNS.

vrfy

Verify an Internet e-mail address.

nslookup

Do an Internet "name server lookup" on a host by IP address. This may be run either interactively or noninteractively, i.e., from within a script.

dig

Similar to **nslookup**, do an Internet "name server lookup" on a host. May be run either interactively or noninteractively, i.e., from within a script.

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.

ping

Broadcast an "ICMP ECHO_REQUEST" packet to other machines, either on a local or remote network. This is a diagnostic tool for testing network connections, and it should be used with caution.

A successful **ping** returns an exit status of 0. This can be tested for in a script.

```
bash$ ping localhost
PING localhost.localdomain (127.0.0.1) from 127.0.0.1 : 56(84) bytes of data.
Warning: time of day goes back, taking countermeasures.
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
```

whois

Perform a DNS (Domain Name System) lookup. The `-h` option permits specifying which *whois* server to query. See Example 5-5.

finger

Retrieve information about a particular user on a network. Optionally, this command can display the user's `~/.plan`, `~/.project`, and `~/.forward` files, if present.

```
bash$ finger bozo
Login: bozo                             Name: Bozo Bozeman
Directory: /home/bozo                   Shell: /bin/bash
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
No mail.
No Plan.
```

Out of security considerations, many networks disable **finger** and its associated daemon. [1]

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 greater 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 / from a remote host. An ftp session can be automated in a script (see Example 17-7, Example A-4, and Example A-8).

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.

telnet

Utility and protocol for connecting to a remote host.

Caution The telnet protocol contains security holes and should therefore probably be avoided.

rlogin

`Remote login`, initates 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. Using **rcp** and similar utilities with security implications in a shell script may not be advisable. Consider, instead, using **ssh** 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.

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.

Mail

vacation

This utility automatically replies to e-mails that the intended recipient is on vacation and temporarily unavailable. This 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 silently wander about behind the scenes, carrying out their appointed tasks.

12.7. Terminal Control Commands

Command Listing

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**, below. **tput reset** is the equivalent of **reset**, below.

```
bash$ tput longname
xterm terminal emulator (XFree86 4.0 Window System)
```

Note that stty offers a more powerful command set for controlling a terminal.

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 10-22.

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, create a record of a session.

12.8. Math Commands

Command Listing

factor

Factor an integer into prime factors.

```
bash$ factor 27417
27417: 3 13 19 37
```

bc, dc

These are flexible, arbitrary precision calculation utilities.

bc has a syntax vaguely resembling C.

dc uses RPN ("Reverse Polish Notation").

Of the two, **bc** seems more useful in scripting. It is a fairly well-behaved UNIX utility, and may therefore be used in a pipe.

Bash can't handle floating point calculations, and it lacks operators for certain important mathematical functions. Fortunately, **bc** comes to the rescue.

Here is a simple template for using **bc** to calculate a script variable.

```
variable=$(echo "OPTIONS; OPERATIONS" | bc)
```

Example 12-26. 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 "mcalc" (mortgage calculator) package,
 6 # by Jeff Schmidt and Mendel Cooper (yours truly, the author of this document).
 7 #   http://www.ibiblio.org/pub/Linux/apps/financial/mcalc-1.6.tar.gz  [15k]
 8
 9 echo
10 echo "Given the principal, interest rate, and term of a mortgage,"
11 echo "calculate the monthly payment."
12
13 bottom=1.0
14
15 echo
16 echo -n "Enter principal (no commas) "
17 read principal
18 echo -n "Enter interest rate (percent) "  # If 12%, enter "12", not ".12".
19 read interest_r
20 echo -n "Enter term (months) "
21 read term
22
23
24  interest_r=$(echo "scale=9; $interest_r/100.0" | bc) # Convert to decimal.
25                  # "scale" determines how many decimal places.
26
27
28  interest_rate=$(echo "scale=9; $interest_r/12 + 1.0" | bc)
29
30
31  top=$(echo "scale=9; $principal*$interest_rate^$term" | bc)
32
33  echo; echo "Please be patient. This may take a while."
34
35  let "months = $term - 1"
36  for ((x=$months; x > 0; x--))
37  do
38    bot=$(echo "scale=9; $interest_rate^$x" | bc)
39    bottom=$(echo "scale=9; $bottom+$bot" | bc)
40 #  bottom = $(($bottom + $bot"))
41  done
42
43  # let "payment = $top/$bottom"
44  payment=$(echo "scale=2; $top/$bottom" | bc)
45  # Use two decimal places for dollars and cents.
46
47  echo
48  echo "monthly payment = \$$payment"  # Echo a dollar sign in front of amount.
49  echo
50
51
52  exit 0
53
54  # Exercises:
55  #   1) Filter input to permit commas in principal amount.
```

```
  56  #   2) Filter input to permit interest to be entered as percent or decimal.
  57  #   3) If you are really ambitious,
  58  #      expand this script to print complete amortization tables.
```

Example 12-27. Base Conversion

```
  1 :
  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 ##########################################################################
  9 # Description
 10 #
 11 # Changes
 12 # 21-03-95 stv     fixed error occuring with 0xb as input (0.2)
 13 ##########################################################################
 14
 15 # ==> Used in this document with the script author's permission.
 16 # ==> Comments added by document author.
 17
 18 NOARGS=65
 19 PN=`basename "$0"`                        # Program name
 20 VER=`echo '$Revision: 1.2 $' | cut -d' ' -f2`  # ==> VER=1.2
 21
 22 Usage () {
 23     echo "$PN - print number to different bases, $VER (stv '95)
 24 usage: $PN [number ...]
 25
 26 If no number is given, the numbers are read from standard input.
 27 A number may be
 28     binary (base 2)               starting with 0b (i.e. 0b1100)
 29     octal (base 8)         starting with 0  (i.e. 014)
 30     hexadecimal (base 16)  starting with 0x (i.e. 0xc)
 31     decimal                       otherwise (i.e. 12)" >&2
 32     exit $NOARGS
 33 }   # ==> Function to print usage message.
 34
 35 Msg () {
 36     for i   # ==> in [list] missing.
 37     do echo "$PN: $i" >&2
 38     done
 39 }
 40
 41 Fatal () { Msg "$@"; exit 66; }
 42
 43 PrintBases () {
 44     # Determine base of the number
 45     for i      # ==> in [list] missing...
```

```
 46     do         # ==> so operates on command line arg(s).
 47    case "$i" in
 48        0b*)                ibase=2;;       # binary
 49        0x*|[a-f]*|[A-F]*)  ibase=16;;      # hexadecimal
 50        0*)                 ibase=8;;       # octal
 51        [1-9]*)             ibase=10;;      # decimal
 52        *)
 53            Msg "illegal number $i - ignored"
 54            continue;;
 55    esac
 56
 57    # Remove prefix, convert hex digits to uppercase (bc needs this)
 58    number=`echo "$i" | sed -e 's:^0[bBxX]::' | tr '[a-f]' '[A-F]'`
 59    # ==> Uses ":" as sed separator, rather than "/".
 60
 61    # Convert number to decimal
 62    dec=`echo "ibase=$ibase; $number" | bc`  # ==> 'bc' is calculator utility.
 63    case "$dec" in
 64        [0-9]*)     ;;                      # number ok
 65        *)          continue;;              # error: ignore
 66    esac
 67
 68    # Print all conversions in one line.
 69    # ==> 'here document' feeds command list to 'bc'.
 70    echo `bc <<!
 71        obase=16; "hex="; $dec
 72        obase=10; "dec="; $dec
 73        obase=8;  "oct="; $dec
 74        obase=2;  "bin="; $dec
 75 !
 76     ` | sed -e 's: :       :g'
 77
 78     done
 79 }
 80
 81 while [ $# -gt 0 ]
 82 do
 83     case "$1" in
 84    --)     shift; break;;
 85    -h)     Usage;;                 # ==> Help message.
 86    -*)     Usage;;
 87    *)      break;;                 # first number
 88     esac   # ==> More error checking for illegal input would be useful.
 89     shift
 90 done
 91
 92 if [ $# -gt 0 ]
 93 then
 94     PrintBases "$@"
 95 else                                    # read from stdin
 96     while read line
 97     do
 98    PrintBases $line
 99     done
100 fi
```

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12.9. Miscellaneous Commands

Command Listing

jot, **seq**

These utilities emit a sequence of integers, with a user selected increment. This can be used to advantage in a for loop.

Example 12-28. Using seq to generate loop arguments

```
 1 #!/bin/bash
 2
 3 for a in `seq 80`  # or   for a in $( seq 80 )
 4 # Same as   for a in 1 2 3 4 5 ... 80   (saves much typing!).
 5 # May also use 'jot' (if present on system).
 6 do
 7   echo -n "$a "
 8 done
 9 # Example of using the output of a command to generate
10 # the [list] in a "for" loop.
11
12 echo; echo
13
14
15 COUNT=80  # Yes, 'seq' may also take a replaceable parameter.
16
17 for a in `seq $COUNT`  # or   for a in $( seq $COUNT )
18 do
19   echo -n "$a "
20 done
21
22 echo
23
24 exit 0
```

---

run-parts

The **run-parts** command [1] executes all the scripts in a target directory, sequentially in ASCII-sorted filename order. The cron command 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!).

Warning Be very cautious when piping **yes** to a potentially dangerous system command, such as fsck or fdisk.

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.

`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**.

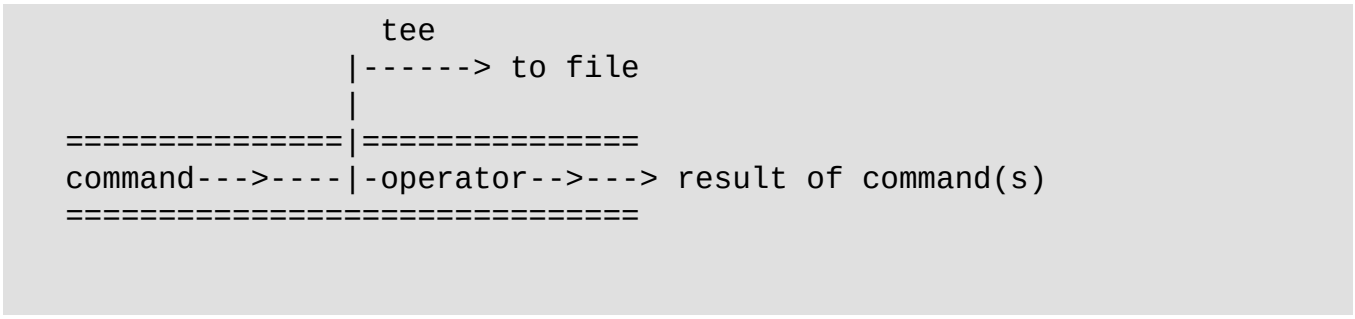
```
bash$ groff -Tascii file.tr | lp

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 here from the plumbing trade.]

This is a redirection operator, but with a difference. Like the plumber's *tee*, it permits "siponing off" 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.




```
   1 cat listfile* | sort | tee check.file | uniq > result.file
```

(The file `check.file` contains the concatenated sorted "listfiles", 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. [3] Typically, one process writes to the FIFO, and the other reads from it. See Example A-10.

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.

dd

This is the somewhat obscure and much feared "data duplicator" command. Originally a utility for exchanging data on magnetic tapes between UNIX minicomputers and IBM mainframes, this command still has its uses. The **dd** command simply copies a file (or `stdin/stdout`), but with conversions. Possible conversions are ASCII/EBCDIC, [4] upper/lower case, swapping of byte pairs between input and output, and skipping and/or truncating the head or tail of the input file. A **dd --help** lists the conversion and other options that this powerful utility takes.

```
   1 # Exercising 'dd'.
   2
   3 n=3
   4 p=5
   5 input_file=project.txt
   6 output_file=log.txt
   7
   8 dd if=$input_file of=$output_file bs=1 skip=$((n-1)) count=$((p-n+1)) 2>
/dev/null
   9 # Extracts characters n to p from file $input_file.
  10
  11
  12
  13
  14 echo -n "hello world" | dd cbs=1 conv=unblock 2> /dev/null
  15 # Echoes "hello world" vertically.
```

```
16
17
18 # Thanks, S.C.
```

To demonstrate just how versatile **dd** is, let's use it to capture keystrokes.

Example 12-29. Capturing Keystrokes

```
 1 #!/bin/bash
 2 # 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=$keypresses 2> /dev/null)
14 # 'dd' uses stdin, if "if" not specified.
15
16 stty "$old_tty_setting"           # Restore old terminal settings.
17
18 echo "You pressed the \"$keys\" keys."
19
20 # Thanks, S.C. 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 will not be truncated.
3
4 # 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.

```
1 dd if=kernel-image of=/dev/fd0H1440
```

One important use for **dd**is initializing temporary swap files (Example 29-2). 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 12-30. Securely deleting a file

```
 1 #!/bin/bash
 2 # blotout.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
 7 #+ will not reveal the original file data.
 8
 9 PASSES=7         # Number of file-shredding passes.
10 BLOCKSIZE=1      #  I/O with /dev/urandom requires unit block size,
11                  #+ otherwise you get weird results.
12 E_BADARGS=70
13 E_NOT_FOUND=71
14 E_CHANGED_MIND=72
15
16 if [ -z "$1" ]   # No filename specified.
17 then
18   echo "Usage: `basename $0` filename"
19   exit $E_BADARGS
20 fi
21
22 file=$1
23
24 if [ ! -e "$file" ]
25 then
26   echo "File \"$file\" not found."
27   exit $E_NOT_FOUND
28 fi
29
30 echo; echo -n "Are you absolutely sure you want to blot out \"$file\" (y/n)? "
31 read answer
32 case "$answer" in
33 [nN]) echo "Changed your mind, huh?"
34       exit $E_CHANGED_MIND
35       ;;
36 *)    echo "Blotting out file \"$file\".";;
37 esac
38
39
40 flength=$(ls -l "$file" | awk '{print $5}')  # Field 5 is file length.
41
42 pass_count=1
43
44 echo
45
46 while [ "$pass_count" -le "$PASSES" ]
```

```
do
  echo "Pass #$pass_count"
  sync         # Flush buffers.
  dd if=/dev/urandom of=$file bs=$BLOCKSIZE count=$flength
               # Fill with random bytes.
  sync         # Flush buffers again.
  dd if=/dev/zero of=$file bs=$BLOCKSIZE count=$flength
               # Fill with zeros.
  sync         # Flush buffers yet again.
  let "pass_count += 1"
  echo
done


rm -f $file    # Finally, delete scrambled and shredded file.
sync           # Flush buffers a final time.

echo "File \"$file\" blotted out and deleted."; echo


#  This is a fairly secure, if inefficient and slow method
#+ of thoroughly "shredding" a file.

# The file cannot not be "undeleted" or retrieved by normal methods.
#  However...
#+ this simple method will likely *not* withstand forensic analysis.


#  Tom Vier's "wipe" file-deletion package does a much more thorough job
#+ of file shredding than this simple script.
#     http://www.ibiblio.org/pub/Linux/utils/file/wipe-2.0.0.tar.bz2

#  For an in-depth analysis on the topic of file deletion and security,
#+ see Peter Gutmann's paper,
#+     "Secure Deletion of Data From Magnetic and Solid-State Memory".
#           http://www.cs.auckland.ac.nz/~pgut001/secure_del.html


exit 0
```

---

od

The **od**, or *octal dump* command 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. See Example 9-20 and Example 12-8.

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] For an excellent overview of this topic, see Andy Vaught's article, Introduction to Named Pipes, in the September, 1997 issue of Linux Journal.

[4] EBCDCIC (pronounced "ebb-sid-ic") is an acronym for Extended Binary Coded Decimal Interchange Code. This is an IBM data format no longer in much use. 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.
```

Chapter 13. System and Administrative Commands

The startup and shutdown scripts in `/etc/rc.d` illustrate the uses (and usefulness) of many of these comands. 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

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 # in 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.

Note The **adduser** command is a synonym for **useradd** and is usually a symbolic link to it.

id

The **id** command lists the real and effective user IDs and the group IDs of the current user. 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
```

Also see Example 9-4.

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
```

su

Runs a program or script as a substitute *u*ser. **su rjones** starts a shell as user *rjones*. A naked **su** defaults to *root*. See Example A-10.

users

Show all logged on users. This is the approximate equivalent of **who -q**.

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.

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
```

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 little use.

Terminals

tty

Echoes the name 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 13-1. 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 erase characters of input.
 6                                # Won't work.
 7 echo "Your name is $name."
 8
 9 stty erase '#'                 # Set "hashmark" (#) as erase character.
10 echo -n "What is your name? "
11 read name                      # Use # to erase last character typed.
12 echo "Your name is $name."
13
14 exit 0
```

Example 13-2. secret password: Turning off terminal echoing

```
 1 #!/bin/bash
 2
 3 echo
 4 echo -n "Enter password "
 5 read passwd
 6 echo "password is $passwd"
 7 echo -n "If someone had been looking over your shoulder, "
 8 echo "your password would have been compromised."
 9
10 echo && echo  # Two line-feeds in an "and list".
11
12 stty -echo    # Turns off screen echo.
13
14 echo -n "Enter password again "
15 read passwd
16 echo
17 echo "password is $passwd"
18 echo
19
20 stty echo     # Restores screen echo.
21
22 exit 0
```

A creative use of **stty** is detecting a user keypress (without hitting **ENTER**).

Example 13-3. Keypress detection

```
 1 #!/bin/bash
 2 # keypress.sh: Detect a user keypress ("hot keyboard").
 3
 4 echo
 5
 6 old_tty_settings=$(stty -g)   # Save old settings.
 7 stty -icanon
 8 Keypress=$(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.

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 iexten 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$ bash$ wc -c < file
13
```

The process controlling the terminal receives only 13 characters (12 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 begining of the line.

Stephane Chazelas

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).
```

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.

Tip It can be very 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 17-2).

```
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!
```

Note If write access to a particular terminal has been disabled with **mesg**, then **wall** cannot send a message to it.

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.

Information and Statistics

uname

Output system specifications (OS, kernel version, etc.) to `stdout`. Invoked with the `-a` option, gives verbose system info (see Example 12-3).

```
bash$ uname -a
Linux localhost.localdomain 2.2.15-2.5.0 #1 Sat Feb 5 00:13:43 EST 2000 i686 unknown
```

arch

Show system architecture. Equivalent to **uname -m**. See Example 10-23.

```
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.

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
...
```

strace

Diagnostic and debugging tool for tracing system calls and signals. The simplest way of invoking it is **strace COMMAND**.

```
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 **truss**.

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
```

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
```

stat

Gives detailed and verbose *stat*istics 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
```

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
```

netstat

Show current network information and statistics, such as routing tables and active connections. This utility accesses information in `/proc/net` (Chapter 28). See Example 28-2.

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
```

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
```

hostid

Echo a 32-bit hexadecimal numerical identifier for the host machine.

```
bash$ hostid
7f0100
```

Note 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*.

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 mailing them, as appropriate. 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.

Job Control

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**, **snice**, and **skill**.

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
880
```

Example 13-4. pidof helps kill a process

```
 1 #!/bin/bash
 2 # kill-process.sh
 3
 4 NOPROCESS=2
 5
 6 process=xxxyyyzzz  # 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` ".
27
28
29 # This entire script could be replaced by
30 #    kill $(pidof -x process_name)
31 # but it would not be as instructive.
32
33 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.

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`.

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.

Network

ifconfig

Network interface configuration and tuning utility. It 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 to "grep" means "quiet", i.e., producing no
output.
 17 # Redirecting output to /dev/null is therefore not strictly necessary.
 18
 19 # ...
 20
 21 echo "Currently active devices:"
 22 echo `/sbin/ifconfig | grep ^[a-z] | awk '{print $1}'`
 23 #                           ^^^^^  should be quoted to prevent globbing.
 24 #  The following also work.
 25 #    echo $(/sbin/ifconfig | awk '/^[a-z]/ { print $1 })'
 26 #    echo $(/sbin/ifconfig | sed -e 's/ .*//')
 27 #  Thanks, S.C., for additional comments.
```

See also Example 30-4.

route

Show info about or make changes to the kernel routing table.

```
bash$ route
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
127.0.0.0       *               255.0.0.0       U     0      0        0 lo
```

mknod

Creates block or character device files (may be necessary when installing new hardware on the system).

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 CDROM
3 mount /mnt/cdrom
4 # Shortcut, if /mnt/cdrom listed in /etc/fstab
```

This versatile command can even mount an ordinary file as if it were a filesystem on a block device. It accomplishes that by associating the file with a loopback device. One application of this is to mount and examine an ISO9660 image before burning it onto a CDR. [3]

Example 13-5. 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 #                  "-o loop" option equivalent to "losetup /dev/loop0"
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 **umount**ed, else filesystem corruption may result.

```
1 umount /mnt/cdrom
2 # You may now press the eject button and safely remove the disk.
```

Note The **automount** utility, if properly installed, can mount and unmount floppies or CDROM disks as they are accessed or removed. On laptops with swappable floppy and CDROM drives, this can cause problems, though.

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 12-30.

losetup

Sets up and configures loopback devices.

Example 13-6. 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, **swapoff**

Enable / disable swap partitition 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 13-7. 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 this document.
 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 0
```

---

tune2fs

Tune ext2 filesystem. May be used to change filesystem parameters, such as maximum mount count. This must be invoked as root.

Warning 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
```

fdisk

Create or change a partition table on a storage device, usually a hard drive. This command must be invoked as root.

Warning 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.

Caution All of these should be invoked as root, and they can damage or destroy a filesystem if misused.

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.

Caution 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 file that controls access to a file, device, or resource. The lock file serves as a flag that this particular file, device, or resource is in use by a particular process ("busy"), and this permits only restricted access (or no access) to other processes.

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 Netscape 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 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. 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
6   ...
```

Backup

dump, **restore**

The **dump** command is an elaborate filesystem backup utility, generally used on larger installations and networks. [4] 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.

System Resources

ulimit

Sets an *upper limit* on system resources. Usually invoked with the `-f` option, which sets a limit on file size (**ulimit -f 1000** limits files to 1 meg maximum). 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 Chapter 27).

umask

User file creation 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 the file permissions *disabled*. For example, **umask 022** ensures that new files will have at most 755 permissions (777 NAND 022). [5] 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 Chapter 27).

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 another 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]
```

insmod

Force insertion of a kernel module. Must be invoked as root.

modprobe

Module loader that is normally invoked automatically in a startup script.

depmod

Creates module dependency file, usually invoked from startup script.

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.

Note 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.
```

Tip 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.
```

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)
```

nm

List symbols in an unstripped compiled binary.

rdist

Remote distribution client: synchronizes, clones, or backs up a file system on a remote server.

Using our knowledge of administrative commands, let us examine a system script. One of the shortest and simplest to understand scripts is **killall**, used to suspend running processes at system shutdown.

Example 13-8. 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 specific
 9 # --> (may not be present in other distributions).
10
11 # Bring down all unneeded services that are still running (there shouldn't
12 # 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, and since if there
28    # --> is a lock file, that's proof the process has been running.
29    # --> See the "lockfile" entry, above.
30
31
```

```
 32    # Bring the subsystem down.
 33    if [ -f /etc/rc.d/init.d/$subsys.init ]; then
 34        /etc/rc.d/init.d/$subsys.init stop
 35    else
 36        /etc/rc.d/init.d/$subsys stop
 37    # --> Suspend running jobs and daemons
 38         # --> using the 'stop' shell builtin.
 39    fi
 40 done
```

That wasn't so bad. Aside from a little fancy footwork with variable matching, there is no new material there.

Exercise. 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 "action" commands to "echos".

Now, look at some of the more complex scripts in `/etc/rc.d/init.d`. See if you can understand parts of them. Follow the above procedure to analyze them. For some additional insight, you might also examine the file `sysvinitfiles` in `/usr/doc/initscripts-X.XX`, 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] Operators of single-user Linux systems generally prefer something simpler for backups, such as **tar**.

[5] NAND is the logical "not-and" operator. Its effect is somewhat similar to subtraction.

Chapter 14. Command Substitution

Command substitution reassigns the output of a command or even multiple commands; it literally plugs the command output into another context.

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`
 2 # "filename" contains a list of files to delete.
 3 #
 4 # S. C. points out that "arg list too long" error might result.
 5 # Better is              xargs rm -- < filename
 6 # ( -- covers those cases where "filename" begins with a "-" )
 7
 8 textfile_listing=`ls *.txt`
 9 # Variable contains names of all *.txt files in current working directory.
10 echo $textfile_listing
11
12 textfile_listing2=$(ls *.txt)   # The alternative form of command substitution.
13 echo $textfile_listing
14 # Same result.
15
16 # A possible problem with putting a list of files into a single string
17 # is that a newline may creep in.
18 #
19 # A safer way to assign a list of files to a parameter is with an array.
20 #      shopt -s nullglob    # If no match, filename expands to nothing.
21 #      textfile_listing=( *.txt )
22 #
23 # Thanks, S.C.
```

Caution

Command substitution may result in word splitting.

```
COMMAND `echo a b`     # 2 args: a and b

COMMAND "`echo a b`"   # 1 arg: "a b"

COMMAND `echo`         # no arg

COMMAND "`echo`"       # one empty arg


# Thanks, S.C.
```

Caution

Word splitting resulting from command substitution may remove trailing newlines characters from the output of the reassigned command(s). This can cause unpleasant surprises.

```
dir_listing=`ls -l`
echo $dirlisting

# Expecting a nicely ordered directory listing, such as:
# -rw-rw-r--    1 bozo       30 May 13 17:15 1.txt
# -rw-rw-r--    1 bozo       51 May 15 20:57 t2.sh
# -rwxr-xr-x    1 bozo      217 Mar  5 21:13 wi.sh

# However, what you get is:
# total 3 -rw-rw-r-- 1 bozo bozo 30 May 13 17:15 1.txt -rw-rw-r-- 1 bozo
# bozo 51 May 15 20:57 t2.sh -rwxr-xr-x 1 bozo bozo 217 Mar 5 21:13 wi.sh

# The newlines disappeared.
```

Even when there is no word splitting, command substitution can remove trailing newlines.

```
# cd "`pwd`"  # This should always work.
# However...

mkdir 'dir with trailing newline
'

cd 'dir with trailing newline
'

cd "`pwd`"  # Error message:
# bash: cd: /tmp/file with trailing newline: No such file or directory

cd "$PWD"   # Works fine.









old_tty_setting=$(stty -g)   # Save old terminal setting.
echo "Hit a key "
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 Thanks, S.C.
```

Note

The **$(COMMAND)** form has superseded backticks for command substitution.

```
1 output=$(sed -n /"$1"/p $file)
2 # From "grp.sh"    example.
```

Examples of command substitution in shell scripts:

1. Example 10-7
2. Example 10-23
3. Example 9-20
4. Example 12-2
5. Example 12-13
6. Example 12-10
7. Example 12-28
8. Example 10-11
9. Example 10-9
10. Example 12-22
11. Example 16-5
12. Example A-12
13. Example 28-1
14. Example 12-26
15. Example 12-27

Chapter 15. Arithmetic Expansion

Arithmetic expansion provides a powerful tool for performing 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`          # 'expr' does the expansion.
```

Arithmetic expansion with double parentheses, and using **let**

The use of backticks in arithmetic expansion has been superseded by double parentheses **$((...))** or the very convenient **let** construction.

```
1 z=$(($z+3))
2 # $((EXPRESSION)) is arithmetic expansion.  # Not to be confused with
3                                             # command substitution.
4
5 let z=z+3
6 let "z += 3"  #If quotes, then spaces and special operators allowed.
7 # 'let' is actually arithmetic evaluation, rather than expansion.
```

All the above are equivalent. You may use whichever one "rings your chimes".

Examples of arithmetic expansion in scripts:

1. Example 12-5
2. Example 10-12
3. Example 26-1
4. Example 26-4
5. Example A-12

Chapter 16. I/O Redirection

There are always three default "files" 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 4-1 and Example 4-2) and sending it as input to another file, command, program, or script.

Each open file gets assigned a file descriptor. [1] 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. [2] This simplifies restoration to normal after complex redirection and reshuffling (see Example 16-1).

```
 1    >
 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       # The : serves as a dummy placeholder, producing no output.
11
12    >>
13       # Redirect stdout to a file.
14       # Creates the file if not present, otherwise appends to it.
15
16    2>&1
17       # Redirects stderr to stdout.
18       # Error messages get sent to same place as standard output.
19
20    i>&j
21       # Redirects file descriptor i to j.
22       # All output of file pointed to by i gets sent to file pointed to by j.
23
24    >&j
25       # Redirects, by default, file descriptor 1 (stdout) to j.
26       # All stdout gets sent to file pointed to by j.
27
28    0<
29     <
30       # Accept input from a file.
31       # Companion command to ">", and often used in combination with it.
32       #
33       # grep search-word <filename
34
```

```
  35
  36    [j]<>filename
  37       # Open file "filename" for reading and writing, and assign file descriptor
"j" to it.
  38       # If "filename" does not exist, create it.
  39       # If file descriptor "j" is not specified, default to fd 0, stdin.
  40       #
  41       # An application of this is writing at a specified place in a file.
  42       echo 1234567890 > File    # Write string to "File".
  43       exec 3<> File             # Open "File" and assign fd 3 to it.
  44       read -n 4 <&3             # Read only 4 characters.
  45       echo -n . >&3             # Write a decimal point there.
  46       exec 3>&-                 # Close fd 3.
  47       cat File                  # ==> 1234.67890
  48       # Random access, by golly.
  49
  50
  51
  52    |
  53       # Pipe.
  54       # General purpose process and command chaining tool.
  55       # Similar to ">", but more general in effect.
  56       # Useful for chaining commands, scripts, files, and programs together.
  57       cat *.txt | sort | uniq > result-file
  58       # Sorts the output of all the .txt files and deletes duplicate lines,
  59       # 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
  3 command1 | command2 | command3 > output-file
```

See Example 12-21 and Example A-10.

Multiple output streams may be redirected to one file.

```
  1 ls -yz >> command.log 2>&1
  2 # Capture result of illegal options "yz" to "ls" in file "command.log".
  3 # Because stderr redirected to the file, any error messages will also be there.
```

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                                # Save current "value" of stdout.
  4 ls -l 2>&1 >&3 3>&- | grep bad 3>&-    # Close fd 3 for 'ls' and 'grep'.
  5 exec 3>&-                                # Now close it for the remainder of the
script.
  6
  7 # Thanks, S.C.
```

For a more detailed introduction to I/O redirection see Appendix D.

16.1. Using exec

The **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 16-1. 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
  7 exec < data-file   # stdin replaced by file "data-file"
  8
  9 read a1            # Reads first line of file "data-file".
 10 read a2            # Reads second line of file "data-file."
 11
 12 echo
 13 echo "Following lines read from file."
 14 echo "-------------------------------"
 15 echo $a1
 16 echo $a2
 17
```

```
 18 echo; echo; echo
 19
 20 exec 0<&6 6<&-
 21 # Now restore stdin from fd #6, where it had been saved,
 22 # and close fd #6 ( 6<&- ) to free it for other processes to use.
 23 # <&6 6<&-    also works.
 24
 25 echo -n "Enter data  "
 26 read b1  # Now "read" functions as expected, reading from normal stdin.
 27 echo "Input read from stdin."
 28 echo "----------------------"
 29 echo "b1 = $b1"
 30
 31 echo
 32
 33 exit 0
```

Notes

[1] 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 version of a file pointer. It is analogous to a *file handle* in C.

[2] 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.

Prev Arithmetic Expansion | Home Up | Next Redirecting Code Blocks

16.2. 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 23-7). The < operator at the the end of the code block accomplishes this.

Example 16-2. Redirected *while* loop

```
 1 #!/bin/bash
 2
 3 if [ -z "$1" ]
 4 then
 5   Filename=names.data  # Default, if no filename specified.
 6 else
 7   Filename=$1
 8 fi
 9 # Filename=${1:-names.data}
10 # can replace the above test (parameter substitution).
11
12 count=0
13
14 echo
15
16 while [ "$name" != Smith ]  # Why is variable $name in quotes?
17 do
18   read name                 # Reads from $Filename, rather than stdin.
19   echo $name
20   let "count += 1"
21 done <"$Filename"           # Redirects stdin to file $Filename.
22
23 echo; echo "$count names read"; echo
24
25 # Note that in some older shell scripting languages,
26 # the redirected loop would run as a subshell.
27 # Therefore, $count would return 0, the initialized value outside the loop.
28 # Bash and ksh avoid starting a subshell whenever possible,
29 # so that this script, for example, runs correctly.
30 # Thanks to Heiner Steven for pointing this out.
31
32 exit 0
```

Example 16-3. 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 $name
30   let "count += 1"
31 done <"$Filename"         # Loop reads from file $Filename.
32
33
34 exec 0<&3                # Restore old stdin.
35 exec 3<&-                # Close temporary fd 3.
36
37 echo; echo "$count names read"; echo
38
39 exit 0
```

Example 16-4. 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 # Same results as with "while" loop in previous example.
19
20 exit 0
```

Example 16-5. 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 $1 }'`  # Number of lines in target
file.
11 # Very contrived and kludgy, nevertheless shows that
12 # it's possible to redirect stdin within a "for" loop...
13 # if you're clever enough.
14 #
15 # More concise is     line_count=$(wc < "$Filename")
16
17
18 for name in `seq $line_count`  # Recall that "seq" prints sequence of numbers.
19 # while [ "$name" != Smith ]   --   more complicated than a "while" loop   --
20 do
21   read name                   # Reads from $Filename, rather than stdin.
22   echo $name
23   if [ "$name" = Smith ]      # Need all this extra baggage here.
```

```
  then
    break
  fi
done <"$Filename"              # Redirects stdin to file $Filename.

exit 0
```

Example 16-6. Redirected *if/then* test

```
#!/bin/bash

if [ -z "$1" ]
then
  Filename=names.data   # Default, if no filename specified.
else
  Filename=$1
fi

TRUE=1

if [ "$TRUE" ]          # if true    and   if :   also work.
then
 read name
 echo $name
fi <"$Filename"
# Reads only first line of file.
# An "if/then" test has no way of iterating unless embedded in a loop.

exit 0
```

Note Here documents are a special case of redirected code blocks.

16.3. Applications

Clever use of I/O redirection permits parsing and stitching together snippets of command output (see Example 11-4). This permits generating report and log files.

Example 16-7. Logging events

```
 1 #!/bin/bash
 2 # logevents.sh, by Stephane Chazelas.
 3
 4 # Event logging to a file.
 5 # Must be run as root (for write access in /var/log).
 6
 7 ROOT_UID=0     # Only users with $UID 0 have root privileges.
 8 E_NOTROOT=67   # Non-root exit error.
 9
10
11 if [ "$UID" -ne "$ROOT_UID" ]
12 then
13   echo "Must be root to run this script."
14   exit $E_NOTROOT
15 fi
16
17
18 FD_DEBUG1=3
19 FD_DEBUG2=4
20 FD_DEBUG3=5
21
22 # Uncomment one of the two lines below to activate script.
23 # LOG_EVENTS=1
24 # LOG_VARS=1
25
26
27 log()  # Writes time and date to log file.
28 {
29 echo "$(date)  $*" >&7     # This *appends* the date to the file.
30                            # See below.
31 }
32
33
34
```

```
case $LOG_LEVEL in
 1) exec 3>&2         4> /dev/null 5> /dev/null;;
 2) exec 3>&2         4>&2         5> /dev/null;;
 3) exec 3>&2         4>&2         5>&2;;
 *) exec 3> /dev/null 4> /dev/null 5> /dev/null;;
esac

FD_LOGVARS=6
if [[ $LOG_VARS ]]
then exec 6>> /var/log/vars.log
else exec 6> /dev/null               # Bury output.
fi

FD_LOGEVENTS=7
if [[ $LOG_EVENTS ]]
then
  # then exec 7 >(exec gawk '{print strftime(), $0}' >> /var/log/event.log)
  # Above line will not work in Bash, version 2.04.
  exec 7>> /var/log/event.log        # Append to "event.log".
  log                                      # Write time and date.
else exec 7> /dev/null                  # Bury output.
fi

echo "DEBUG3: beginning" >&${FD_DEBUG3}

ls -l >&5 2>&4                       # command1 >&5 2>&4

echo "Done"                                 # command2

echo "sending mail" >&${FD_LOGEVENTS}   # Writes "sending mail" to fd #7.


exit 0
```

Chapter 17. Here Documents

A *here document* uses a special form of I/O redirection to feed a command script to an interactive program, such as ftp, telnet, or **ex**. Typically, the script consists of a command list to the program, delineated by a limit string. The special symbol << precedes the limit string. This has the effect of redirecting the output of a file into the program, similar to **`interactive-program < command-file`**, where `command-file` contains

```
1 command #1
2 command #2
3 ...
```

The "here document" alternative looks like this:

```
1 #!/bin/bash
2 interactive-program <<LimitString
3 command #1
4 command #2
5 ...
6 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.

Example 17-1. dummyfile: Creates a 2-line dummy file

```
 1 #!/bin/bash
 2
 3 # Non-interactive use of 'vi' to edit a file.
 4 # (Will not work with 'vim', for some reason.)
 5 # Emulates 'sed'.
 6
 7 E_BADARGS=65
 8
 9 if [ -z "$1" ]
10 then
11   echo "Usage: `basename $0` filename"
12   exit $E_BADARGS
13 fi
14
```

```
15 TARGETFILE=$1
16
17 # Insert 2 lines in file, then save.
18 #--------Begin here document-----------#
19 vi $TARGETFILE <<x23LimitStringx23
20 i
21 This is line 1 of the example file.
22 This is line 2 of the example file.
23 ^[
24 ZZ
25 x23LimitStringx23
26 #----------End here document-----------#
27
28 # Note that ^[ above is a literal escape
29 # typed by Control-V Escape.
30
31 exit 0
```

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*.

Example 17-2. 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: Comment lines printed by 'wall'.
 8 zzz23EndOfMessagezzz23
 9
10 # Could have been done more efficiently by
11 #         wall <message-file
12 # However, saving a message template in a script saves work.
13
14 exit 0
```

Example 17-3. 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 exit 0
18
19
20 #-----------------------------------------
21 # Code below disabled, due to "exit 0" above.
22
23 # S.C. points out that the following also works.
24 echo "-----------------------------------
25 This is line 1 of the message.
26 This is line 2 of the message.
27 This is line 3 of the message.
28 This is line 4 of the message.
29 This is the last line of the message.
30 -----------------------------------"
31 # However, text may not include double quotes unless they are escaped.
```

The - option to mark a here document limit string (**<<-LimitString**) suppresses tabs (but not spaces) in the output. This may be useful in making a script more readable.

Example 17-4. 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 tabs in the body of the document, but *not* spaces.
 6
 7 cat <<-ENDOFMESSAGE
 8    This is line 1 of the message.
 9    This is line 2 of the message.
10    This is line 3 of the message.
11    This is line 4 of the message.
12    This is the last line of the message.
13 ENDOFMESSAGE
14 # The output of the script will be flush left.
15 # Leading tab in each line will not show.
16
17 # Above 5 lines of "message" prefaced by a tab, not spaces.
18 # Spaces not affected by   <<-  .
19
20
21 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 17-5. Here document with parameter substitution

```
 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 0
```

Quoting or escaping the "limit string" at the head of a here document disables parameter substitution within its body. This has very limited usefulness.

Example 17-6. 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 the same
effect.
 16 #  cat <<"Endofmessage"
 17 #  cat <<\Endofmessage
 18
 19 exit 0
```

This is a useful script containing a here document with parameter substitution.

Example 17-7. upload: Uploads 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 (metalab.unc.edu).
 6
 7 E_ARGERROR=65
 8
 9 if [ -z "$1" ]
10 then
11   echo "Usage: `basename $0` filename"
12   exit $E_ARGERROR
13 fi
14
15
16 Filename=`basename $1`           # Strips pathname out of file name.
17
18 Server="metalab.unc.edu"
19 Directory="/incoming/Linux"
20 # These need not be hard-coded into script,
21 # but may instead be changed to command line argument.
22
23 Password="your.e-mail.address"   # Change above to suit.
24
25 ftp -n $Server <<End-Of-Session
26 # -n option disables auto-logon
27
28 user anonymous "$Password"
29 binary
30 bell                # Ring 'bell' after each file transfer
31 cd $Directory
32 put "$Filename.lsm"
33 put "$Filename.tar.gz"
34 bye
35 End-Of-Session
36
37 exit 0
```

It is possible to use : as a dummy command accepting output from a here document. This, in effect, creates an "anonymous" here document.

Example 17-8. "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 0
```

Note 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)
```

Caution Some utilities will not work in a here document.

For those tasks too complex for a "here document", consider using the **expect** scripting language, which is specifically tailored for feeding input into interactive programs.

Chapter 18. 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 you make the copies, send a 100-line Bash script to the first person on the list given 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 *xbill*. 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

Part 4. Advanced Topics

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Chapter 19. Regular Expressions

To fully utilize the power of shell scripting, you need to master Regular Expressions. Certain commands and utilities commonly used in scripts, such as expr, sed and awk interpret and use REs.

19.1. A Brief Introduction to Regular Expressions

An expression is a string of characters. Those characters that have 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 for the symbols that follow. Regular Expressions are sets of characters and/or metacharacters that UNIX endows with special features. [1]

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 substring or an entire string).

- The asterisk * matches any number of repeats of the character string or RE preceding it, *including zero*.

  "1133*" matches *11 + one or more 3's + possibly other characters*: *113*, *1133*, *111312*, 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).
- 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.

  "^$" matches blank lines.

- Brackets [...] enclose a set of characters to match in a single RE.

  "[xyz]" matches the characters *x*, *y*, or *z*.

  "[c-n]" matches any of the characters in the range *c* to *n*.

  "[B-Pk-y]" matches any of the characters in the ranges *B* to *P* and *k* to *y*.

  "[a-z0-9]" matches any lowercase letter or any digit.

  "[^b-d]" matches all characters *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][0-9]" matches any Social Security number.
- The backslash \ escapes a special character, which means that character gets interpreted literally.

  A "\$" reverts back to its literal meaning of "$", rather than its RE meaning of end-of-line. Likewise a "\\" has the literal meaning of "\".

-

  Extended REs. 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).

  Caution Curly brackets are not available as an RE in the "classic" version of awk. However, **gawk** has the `--re-interval` option that permits them (without being escaped).

  ```
  bash$ echo 2222 | gawk --re-interval '/2{3}/'
  2222
  ```

- **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]**.

Important POSIX character classes generally require quoting or double brackets ([[ ]]).

```
bash$ grep [[:digit:]] test.file
abc=723
```

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
```

To see POSIX character classes used in scripts, refer to Example 12-12 and Example 12-13.

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-7 and Example A-12 for illustrations of this.

"Sed & Awk", by Dougherty and Robbins gives a very complete and lucid treatment of REs (see the *Bibliography*).

Notes

[1] The simplest type of Regular Expression is a character string that retains its literal meaning, not containing any metacharacters.

[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
```

19.2. Globbing

Bash itself cannot recognize Regular Expressions. In scripts, commands and utilities, such as sed and awk, interpret RE's.

Bash does carry out filename expansion, a process known as "globbing", but this does *not* use the standard RE set. Instead, globbing recognizes and expands wildcards. Globbing interprets the standard wildcard characters, * and ?, character lists in square brackets, and certain other special characters (such as ^ for negating the sense of a match). There are some important limitations on wildcard characters in globbing, however. Strings containing *. will not match filenames that start with a dot, as, for example, `.bashrc`. [1] 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
```

See also Example 10-4.

Notes

[1] Filename expansion *can* match dotfiles, but only if the pattern explicitly includes the dot.

```
  1 ~/[.]bashrc    # Will not expand to ~/.bashrc
  2 ~/?bashrc      # Neither will this.
  3                # Wild cards and metacharacters will not expand to a dot in
globbing.
  4
  5 ~/.[b]ashrc    # Will expand to ~./bashrc
  6 ~/.ba?hrc      # Likewise.
  7 ~/.bashr*      # Likewise.
  8
  9 # Setting the "dotglob" option turns this off.
 10
 11 # Thanks, S.C.
```

Chapter 20. Subshells

Running a shell script launches another instance of the command processor. Just as your commands are interpreted at the command line prompt, similarly does a script batch process a list of commands in a file. Each shell script running is, in effect, a subprocess of the parent shell, the one that gives you the prompt at the console or in an xterm window.

A shell script can also launch subprocesses. These *subshells* let the script do parallel processing, in effect executing multiple subtasks simultaneously.

Command List in Parentheses

(command1; command2; command3; ...)

A command list embedded between *parentheses* runs as a subshell.

Note 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, local variables.

Example 20-1. Variable scope in a subshell

```
 1 #!/bin/bash
 2 # subshell.sh
 3
 4 echo
 5
 6 outer_variable=Outer
 7
 8 (
 9 inner_variable=Inner
10 echo "From subshell, \"inner_variable\" = $inner_variable"
11 echo "From subshell, \"outer\" = $outer_variable"
12 )
13
14 echo
15
16 if [ -z "$inner_variable" ]
17 then
18   echo "inner_variable undefined in main body of shell"
19 else
20   echo "inner_variable defined in main body of shell"
21 fi
22
```

```
23 echo "From main body of shell, \"inner_variable\" = $inner_variable"
24 # $inner_variable will show as uninitialized because
25 # variables defined in a subshell are "local variables".
26
27 echo
28
29 exit 0
```

See also Example 32-1.

+

Directory changes made in a subshell do not carry over to the parent shell.

Example 20-2. 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
```

One application of this is testing whether a variable is defined.

```
1 if (set -u; : $variable) 2> /dev/null
2 then
3   echo "Variable is set."
4 fi
5
6 # Could also be written [[ ${variable-x} != x || ${variable-y} != y ]]
7 # or                   [[ ${variable-x} != x$variable ]]
8 # or                   [[ ${variable+x} = x ]])
```

Another application is checking for a lock file:

```
1 if (set -C; : > lock_file) 2> /dev/null
2 then
3   echo "Another user is already running that script."
4   exit 65
5 fi
6
7 # Thanks, S.C.
```

Processes may execute in parallel within different subshells. This permits breaking a complex task into subcomponents processed concurrently.

Example 20-3. 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)`**.

Note A command block between *`curly braces`* does *not* launch a subshell.

{ command1; command2; command3; ... }

Chapter 21. 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.

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 21-1. Running a script in restricted mode

```
 1 #!/bin/bash
 2 # Starting the script with "#!/bin/bash -r"
 3 # runs entire script in restricted mode.
 4
 5 echo
 6
 7 echo "Changing directory."
 8 cd /usr/local
 9 echo "Now in `pwd`"
10 echo "Coming back home."
11 cd
12 echo "Now in `pwd`"
13 echo
14
15 # Everything up to here in normal, unrestricted mode.
16
17 set -r
18 # set --restricted    has same effect.
19 echo "==> Now in restricted mode. <=="
20
21 echo
22 echo
23
24 echo "Attempting directory change in restricted mode."
25 cd ..
26 echo "Still in `pwd`"
27
28 echo
29 echo
30
31 echo "\$SHELL = $SHELL"
32 echo "Attempting to change shell in restricted mode."
33 SHELL="/bin/ash"
34 echo
35 echo "\$SHELL= $SHELL"
36
37 echo
38 echo
39
40 echo "Attempting to redirect output in restricted mode."
41 ls -l /usr/bin > bin.files
42 ls -l bin.files    # Try to list attempted file creation effort.
43
```

```
44 echo
45
46 exit 0
```

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Chapter 22. Process Substitution

Process substitution is the counterpart to command substitution. Command substitution sets a variable to the result of a command, as in **dir_contents=`ls -al`** or **xref=$(grep word datafile)**. Process substitution feeds the output of a process to another process (in other words, it sends the results of a command to another command).

Command substitution template

command within parentheses

>(command)

<(command)

These initiate process substitution. This uses `/dev/fd/<n>` files to send the results of the process within parentheses to another process. [1]

Note 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 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.)

```
 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) dir
12 # Calls "tar cf /dev/fd/?? dir", 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 dir
21 rm pipe
22 #        or
23 exec 3>&1
24 tar cf /dev/fd/4 dir 4>&1 >&3 3>&- | bzip2 -c > file.tar.bz2 3>&-
25 exec 3>&-
26
27
28 # Thanks, S.C.
```

A reader of this document sent in the following interesting example of process substitution.

```
 1 # Script fragment taken from SuSE distribution:
 2
 3 while read  des what mask iface; do
 4 # Some commands ...
 5 done < <(route -n)
 6
 7
 8 # To test it, let's make it do something.
 9 while read  des what mask iface; do
10   echo $des $what $mask $iface
11 done < <(route -n)
12
13 # Output:
14 # Kernel IP routing table
15 # Destination Gateway Genmask Flags Metric Ref Use Iface
16 # 127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo
17
18
19 # As S.C. points out, an easier-to-understand equivalent is:
20 route -n |
21   while read des what mask iface; do   # Variables set from output of pipe.
22     echo $des $what $mask $iface
23   done  # Same output as above.
```

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

Chapter 23. 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, 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...
}

Functions are called, *triggered*, simply by invoking their names.

Example 23-1. Simple function

```
 1 #!/bin/bash
 2
 3 funky ()
 4 {
 5   echo "This is a funky function."
 6   echo "Now exiting funky function."
 7 } # Function declaration must precede call.
 8
 9   # Now, call the function.
10
11 funky
12
13 exit 0
```

The function definition must precede the first call to it. There is no method of "declaring" the function, as, for example, in C.

```
# f1
# Will give an error message, since function "f1" not yet defined.

# However...


f1 ()
{
  echo "Calling function \"f2\" from within function \"f1\"."
  f2
}

f2 ()
{
  echo "Function \"f2\"."
}

f1  # Function "f2" is not actually called until this point,
    # although it is referenced before its definition.
    # This is permissable.

# Thanks, S.C.
```

It is even possible to nest a function within another function, although this is not very useful.

```
f1 ()
{

  f2 () # nested
  {
    echo "Function \"f2\", inside \"f1\"."
  }

}

# f2
# Gives an error message.

f1  # Does nothing, since calling "f1" does not automatically call "f2".
f2  # Now, it's all right to call "f2",
    # since its definition has been made visible by calling "f1".

# Thanks, S.C.
```

Function declarations can appear in unlikely places, even where a command would otherwise go.

```
ls -l | foo() { echo "foo"; }  # Permissable, but useless.



if [ "$USER" = bozo ]
then
  bozo_greet ()   # Function definition embedded in an if/then construct.
  {
    echo "Hello, Bozo."
  }
fi

bozo_greet        # Works only for Bozo, and other users get an error.



# Something like this might be useful in some contexts.
NO_EXIT=1   # Will enable function definition below.

[[ $NO_EXIT -eq 1 ]] && exit() { true; }     # Function definition in an "and-
list".
# If $NO_EXIT is 1, declares "exit ()".
# This disables the "exit" builtin by aliasing it to "true".

exit  # Invokes "exit ()" function, not "exit" builtin.

# Thanks, S.C.
```

23.1. Complex Functions and Function Complexities

Functions may process arguments passed to them and return an exit status to the script for further processing.

```
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 23-2. Function Taking Parameters

```
#!/bin/bash

func2 () {
   if [ -z "$1" ]                   # Checks if parameter #1 is zero length.
   then
     echo "-Parameter #1 is zero length.-"  # Also if no parameter is passed.
   else
     echo "-Param #1 is \"$1\".-"
   fi

   if [ "$2" ]
   then
```

```
 13      echo "-Parameter #2 is \"$2\".-"
 14    fi
 15
 16    return 0
 17 }
 18
 19 echo
 20
 21 echo "Nothing passed."
 22 func2                          # Called with no params
 23 echo
 24
 25
 26 echo "Zero-length parameter passed."
 27 func2 ""                       # Called with zero-length param
 28 echo
 29
 30 echo "Null parameter passed."
 31 func2 "$uninitialized_param"   # Called with uninitialized param
 32 echo
 33
 34 echo "One parameter passed."
 35 func2 first           # Called with one param
 36 echo
 37
 38 echo "Two parameters passed."
 39 func2 first second    # Called with two params
 40 echo
 41
 42 echo "\"\" \"second\" passed."
 43 func2 "" second       # Called with zero-length first parameter
 44 echo                  # and ASCII string as a second one.
 45
 46 exit 0
```

Note In contrast to certain other programming languages, shell scripts normally pass only value parameters to functions. [1] Variable names (which are actually pointers), if passed as parameters to functions, will be treated as string literals and cannot be dereferenced. *Functions interpret their arguments literally.*

Exit and Return

exit status

Functions return a value, called an *exit status*. 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 [2] 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 23-3. Maximum of two numbers

```
 1 #!/bin/bash
 2 # max.sh: Maximum of two integers.
 3
 4 E_PARAM_ERR=-198    # If less than 2 params passed to function.
 5 EQUAL=-199          # Return value if both params equal.
 6
 7 max2 ()             # Returns larger of two numbers.
 8 {                   # Note: numbers compared must be less than 257.
 9 if [ -z "$2" ]
10 then
11   return $E_PARAM_ERR
12 fi
13
14 if [ "$1" -eq "$2" ]
15 then
16   return $EQUAL
17 else
18   if [ "$1" -gt "$2" ]
19   then
20     return $1
21   else
22     return $2
23   fi
24 fi
25 }
26
27 max2 33 34
28 return_val=$?
29
30 if [ "$return_val" -eq $E_PARAM_ERR ]
31 then
32   echo "Need to pass two parameters to the function."
33 elif [ "$return_val" -eq $EQUAL ]
34   then
35     echo "The two numbers are equal."
36 else
37     echo "The larger of the two numbers is $return_val."
38 fi
39
40
41 exit 0
42
43 # Exercise for the reader (easy):
44 # Convert this to an interactive script,
45 # that is, have the script ask for input (two numbers).
```

Tip 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 }
 7
 8 if count_lines_in_etc_passwd
 9 then
10   echo "There are $REPLY lines in /etc/passwd."
11 else
12   echo "Cannot count lines in /etc/passwd."
13 fi
14
15 # Thanks, S.C.
```

Example 23-4. 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
 8 # is left as an exercise for the reader.
 9
10 # Usage: roman number-to-convert
11
12 LIMIT=200
13 E_ARG_ERR=65
14 E_OUT_OF_RANGE=66
15
16 if [ -z "$1" ]
17 then
18   echo "Usage: `basename $0` number-to-convert"
19   exit $E_ARG_ERR
20 fi
21
22 num=$1
23 if [ "$num" -gt $LIMIT ]
24 then
25   echo "Out of range!"
26   exit $E_OUT_OF_RANGE
27 fi
28
29 to_roman ()   # Must declare function before first call to it.
30 {
31 number=$1
32 factor=$2
33 rchar=$3
```

```
 34 let "remainder = number - factor"
 35 while [ "$remainder" -ge 0 ]
 36 do
 37   echo -n $rchar
 38   let "number -= factor"
 39   let "remainder = number - factor"
 40 done
 41
 42 return $number
 43       # Exercise for the reader:
 44       # Explain how this function works.
 45       # Hint: division by successive subtraction.
 46 }
 47
 48
 49 to_roman $num 100 C
 50 num=$?
 51 to_roman $num 90 LXXXX
 52 num=$?
 53 to_roman $num 50 L
 54 num=$?
 55 to_roman $num 40 XL
 56 num=$?
 57 to_roman $num 10 X
 58 num=$?
 59 to_roman $num 9 IX
 60 num=$?
 61 to_roman $num 5 V
 62 num=$?
 63 to_roman $num 4 IV
 64 num=$?
 65 to_roman $num 1 I
 66
 67 echo
 68
 69 exit 0
```

See also Example 10-24.

Important The largest positive integer a function can return is 256. The **return** command is closely tied to the concept of exit status, which accounts for this particular limitation. Fortunately, there are workarounds for those situations requiring a large integer return value from a function.

Example 23-5. 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 256.
 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 256        # Still o.k.
15 echo $?                # Returns 256.
16
17 return_test 257        # Error!
18 echo $?                # Returns 1 (return code for miscellaneous error).
19
20 return_test -151896    # However, large negative numbers work.
21 echo $?                # Returns -151896.
22
23 exit 0
```

As we have seen, a function can return a large negative value. This also permits returning large positive integer, using a bit of trickery.

Example 23-6. 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 MAXRETVAL=256       # Maximum positive return value from a function.
 9 E_PARAM_ERR=-99999  # Parameter error.
10 E_NPARAM_ERR=99999  # "Normalized" parameter error.
11
12 max2 ()             # Returns larger of two numbers.
13 {
14 if [ -z "$2" ]
15 then
16   return $E_PARAM_ERR
17 fi
18
19 if [ "$1" -eq "$2" ]
20 then
21   return $EQUAL
22 else
23   if [ "$1" -gt "$2" ]
```

```
  then
    retval=$1
  else
    retval=$2
  fi
fi

# ------------------------------------------------------------- #
# This is a workaround to enable returning a large integer
# from this function.
if [ "$retval" -gt "$MAXRETVAL" ]    # If out of range,
then                                 # then
  let "retval = (( 0 - $retval ))"   # adjust to a negative value.
  # (( 0 - $VALUE )) changes the sign of VALUE.
fi
# Large *negative* return values permitted, fortunately.
# ------------------------------------------------------------- #

return $retval
}

max2 33001 33997
return_val=$?

# ------------------------------------------------------------------------ #
if [ "$return_val" -lt 0 ]                 # If "adjusted" negative number,
then                                       # then
  let "return_val = (( 0 - $return_val ))"  # renormalize to positive.
fi                                         # "Absolute value" of $return_val.
# ------------------------------------------------------------------------ #


if [ "$return_val" -eq "$E_NPARAM_ERR" ]
then                   # Parameter error "flag" gets sign changed, too.
  echo "Error: Too few parameters."
elif [ "$return_val" -eq "$EQUAL" ]
  then
    echo "The two numbers are equal."
else
    echo "The larger of the two numbers is $return_val."
fi

exit 0
```

See also Example A-6.

Exercise for the reader: 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 4-1).

Example 23-7. Real name from username

```
  1 #!/bin/bash
  2
  3 # From username, gets "real name" from /etc/passwd.
  4
  5 ARGCOUNT=1  # Expect one arg.
  6 E_WRONGARGS=65
  7
  8 file=/etc/passwd
  9 pattern=$1
 10
 11 if [ $# -ne "$ARGCOUNT" ]
 12 then
 13   echo "Usage: `basename $0` USERNAME"
 14   exit $E_WRONGARGS
 15 fi
 16
 17 file_excerpt ()  # Scan file for pattern, the print relevant portion of line.
 18 {
 19 while read line  # while does not necessarily need "[ condition]"
 20 do
 21   echo "$line" | grep $1 | awk -F":" '{ print $5 }'  # Have awk use ":"
delimiter.
 22 done
 23 } <$file  # Redirect into function's stdin.
 24
 25 file_excerpt $pattern
 26
 27 # Yes, this entire script could be reduced to
 28 #       grep PATTERN /etc/passwd | awk -F":" '{ print $5 }'
 29 # or
 30 #       awk -F: '/PATTERN/ {print $5}'
 31 # or
 32 #       awk -F: '($1 == "username") { print $5 }' # real name from username
 33 # However, it might not be as instructive.
 34
 35 exit 0
```

There is an alternative, 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.

```
# Instead of:
Function ()
{
 ...
 } < file

# Try this:
Function ()
{
  {
    ...
   } < file
}

# Similarly,

Function ()  # This works.
{
  {
   echo $*
  } | tr a b
}

Function ()  # This doesn't work.
{
  echo $*
} | tr a b   # A nested code block is mandatory here.


# Thanks, S.C.
```

Notes

[1] Indirect variable references (see Example 35-2) provide a clumsy sort of mechanism for passing variable pointers to functions.

```
#!/bin/bash

ITERATIONS=3  # How many times to get input.
icount=1

my_read () {
  # Called with my_read varname,
  # outputs the previous value between brackets as the default value,
  # then asks for a new value.

  local local_var

  echo -n "Enter a value "
  eval 'echo -n "[$'$1'] "'  # Previous value.
  read local_var
  [ -n "$local_var" ] && eval $1=\$local_var

  # "And-list": if "local_var" then set "$1" to its value.
}
```

```
20
21 echo
22
23 while [ "$icount" -le "$ITERATIONS" ]
24 do
25   my_read var
26   echo "Entry #$icount = $var"
27   let "icount += 1"
28   echo
29 done
30
31
32 # Thanks to Stephane Chazelas for providing this instructive example.
33
34 exit 0
```

[2] The **return** command is a Bash builtin.

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23.2. Local Variables and Recursion

Local variables make recursion possible.

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.

Example 23-8. Local variable visibility

```
 1 #!/bin/bash
 2
 3 func ()
 4 {
 5   local a=23
 6   echo
 7   echo "a in function = $a"
 8   echo
 9 }
10
11 func
12
13 # Now, see if local 'a' exists outside function.
14
15 echo "a outside function = $a"  # Nope, 'a' not visible globally.
16 echo
17
18 exit 0
```

Local variables permit recursion (a recursive function is one that calls itself), but this practice generally involves much computational overhead and is definitely *not* recommended in a shell script. [1]

Example 23-9. Recursion, using a local variable

```
 1 #!/bin/bash
 2
 3 #              factorial
 4 #              ---------
 5
 6
 7 # Does bash permit recursion?
 8 # Well, yes, but...
 9 # You gotta have rocks in your head to try it.
10
11
12 MAX_ARG=5
13 E_WRONG_ARGS=65
14 E_RANGE_ERR=66
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 (5 is maximum)."
26   # Let's get real now.
27   # If you want greater range than this,
28   # rewrite it in a real programming language.
29   exit $E_RANGE_ERR
30 fi
31
32 fact ()
33 {
34   local number=$1
35   # Variable "number" must be declared as local,
36   # otherwise this doesn't work.
37   if [ "$number" -eq 0 ]
38   then
39     factorial=1    # Factorial of 0 = 1.
```

```
  else
    let "decrnum = number - 1"
    fact $decrnum  # Recursive function call.
    let "factorial = $number * $?"
  fi

  return $factorial
}

fact $1
echo "Factorial of $1 is $?."

exit 0
```

See also Example A-11 for an example of recursion in a script. Be aware that recursion is resource-intensive and executes slowly, especially in a script.

Notes

[1] Too many levels of recursion may crash a script with a segfault.

```
#!/bin/bash

recursive_function ()
{
(( $1 < $2 )) && f $(( $1 + 1 )) $2;
}

recursive_function 1 50000  # Segfaults.

# Recursion this deep might cause even a C program to segfault,
# by using up all the memory allotted to the stack.

# Thanks, S.C.

exit 0  # This script will not exit normally.
```

Functions Up Aliases

Chapter 24. 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 lm="ls -l | more"** in the ~/.bashrc file, then each **lm** 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 losing important files.

In a script, aliases have very limited usefulness. It would be quite 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. [1] 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 24-1. Aliases within a script

```
   1 #!/bin/bash
   2 # May need to be invoked with  #!/bin/bash2  on older systems.
   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 # Alias handles 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   let count+=1
59 done
60
61 echo; echo
62
63 alias xyz="cat $1"   # Try a positional parameter in an alias.
64 xyz                  # If you invoke the script with a filename as a parameter.
65 #  This seems to work,
66 #+ although the Bash documentation suggests that it shouldn't.
67
68 exit 0
```

Note — The **unalias** command removes a previously set *alias*.

Example 24-2. unalias: Setting and unsetting an alias

```
 1 #!/bin/bash
 2
 3 shopt -s expand_aliases  # Enables alias expansion.
 4
 5 alias llm='ls -al | more'
 6 llm
 7
 8 echo
 9
10 unalias llm              # Unset alias.
11 llm
12 # Error message results, since 'llm' no longer recognized.
13
14 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] However, aliases do seem to expand positional parameters.

Chapter 25. 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).

Example 25-1. 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" ] && echo "Argument
#2 = $2"
   5 then
   6   echo "At least 2 arguments passed to script."
   7   # All the chained commands return true.
   8 else
   9   echo "Less than 2 arguments passed to script."
  10   # At least one of the chained commands returns false.
  11 fi
  12 # Note that "if [ ! -z $1 ]" works, but its supposed equivalent,
  13 #  if [ -n $1 ] does not. However, quoting fixes this.
  14 #  if [ -n "$1" ] works.  Careful!
  15 # It is best to always quote tested variables.
  16
  17
  18 # This accomplishes the same thing, using "pure" if/then statements.
  19 if [ ! -z "$1" ]
  20 then
  21   echo "Argument #1 = $1"
  22 fi
  23 if [ ! -z "$2" ]
  24 then
  25   echo "Argument #2 = $2"
  26   echo "At least 2 arguments passed to script."
  27 else
```

```
  28   echo "Less than 2 arguments passed to script."
  29 fi
  30 # It's longer and less elegant than using an "and list".
  31
  32
  33 exit 0
```

Example 25-2. Another command-line arg test using an "and list"

```
   1 #!/bin/bash
   2
   3 ARGS=1        # Number of arguments expected.
   4 E_BADARGS=65  # Exit value if incorrect number of args passed.
   5
   6 test $# -ne $ARGS && echo "Usage: `basename $0` $ARGS argument(s)" && exit
$E_BADARGS
   7 # If condition-1 true (wrong number of args passed to script),
   8 # then the rest of the line executes, and script terminates.
   9
  10 # Line below executes only if the above test fails.
  11 echo "Correct number of arguments passed to this script."
  12
  13 exit 0
  14
  15 # To check exit value, do a "echo $?" after script termination.
```

---

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 25-3. Using "or lists" in combination with an "and list"

```
 1 #!/bin/bash
 2
 3 # "Delete", not-so-cunning file deletion utility.
 4 # Usage: delete filename
 5
 6 E_BADARGS=65
 7
 8 if [ -z "$1" ]
 9 then
10   echo "Usage: `basename $0` filename"
11   exit $E_BADARGS
12 fi
13
14
15 file=$1  # Set filename.
16
17 [ ! -f "$1" ] && echo "File \"$1\" 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 continued on to a second line with an escape.
21
22 [ ! -f "$1" ] || (rm -f $1; echo "File \"$file\" deleted.")
23 # OR LIST, to delete file if present.
24 # ( command1 ; command2 ) is, in effect, an AND LIST variant.
25
26 # Note logic inversion above.
27 # AND LIST executes on true, OR LIST on false.
28
29 exit 0
```

Caution If the first command in an "or list" returns true, it *will* execute.

Important 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 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 # since the logic operators "&&" and "||" have equal precedence.
10
11 # It's best to avoid such complexities, unless you know what you're doing.
12
13 # Thanks, S.C.
```

See Example A-6 for an illustration of using an **`and / or list`** to test variables.

Chapter 26. Arrays

Newer versions of **bash** support one-dimensional arrays. Arrays may be declared with the **variable[xx]** notation or explicitly by a **declare -a variable** statement. To dereference (find the contents of) an array variable, use *curly bracket* notation, that is, **${variable[xx]}**.

Example 26-1. 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 o.k.
12
13
14 echo -n "area[11] = "
15 echo ${area[11]}    #  {curly brackets} needed
16
17 echo -n "area[13] = "
18 echo ${area[13]}
19
20 echo "Contents of area[51] are ${area[51]}."
21
22 # Contents of uninitialized array variable print blank.
23 echo -n "area[43] = "
24 echo ${area[43]}
25 echo "(area[43] unassigned)"
26
27 echo
28
29 # Sum of two array variables assigned to third
30 area[5]=`expr ${area[11]} + ${area[13]}`
31 echo "area[5] = area[11] + area[13]"
32 echo -n "area[5] = "
33 echo ${area[5]}
34
35 area[6]=`expr ${area[11]} + ${area[51]}`
36 echo "area[6] = area[11] + area[51]"
```

```
 37 echo -n "area[6] = "
 38 echo ${area[6]}
 39 # This fails because adding an integer to a string is not permitted.
 40
 41 echo; echo; echo
 42
 43 # --------------------------------------------------------------
 44 # Another array, "area2".
 45 # Another way of assigning array variables...
 46 # array_name=( XXX YYY ZZZ ... )
 47
 48 area2=( zero one two three four )
 49
 50 echo -n "area2[0] = "
 51 echo ${area2[0]}
 52 # Aha, zero-based indexing (first element of array is [0], not [1]).
 53
 54 echo -n "area2[1] = "
 55 echo ${area2[1]}    # [1] is second element of array.
 56 # --------------------------------------------------------------
 57
 58 echo; echo; echo
 59
 60 # ------------------------------------------------
 61 # Yet another array, "area3".
 62 # Yet another way of assigning array variables...
 63 # array_name=([xx]=XXX [yy]=YYY ...)
 64
 65 area3=([17]=seventeen [24]=twenty-four)
 66
 67 echo -n "area3[17] = "
 68 echo ${area3[17]}
 69
 70 echo -n "area3[24] = "
 71 echo ${area3[24]}
 72 # ------------------------------------------------
 73
 74 exit 0
```

Arrays variables have a syntax all their own, and even standard Bash commands have special options adapted for array use.

Example 26-2. Some special properties of arrays

```
 1 #!/bin/bash
 2
 3 declare -a colors
 4 # Permits declaring an array without specifying its size.
 5
 6 echo "Enter your favorite colors (separated from each other by a space)."
 7
 8 read -a colors
 9 # Special option to 'read' command,
10 # allowing assignment of elements in an array.
11
12 echo
13
14 element_count=${#colors[@]}
15 # Special syntax to extract number of elements in array.
16 # element_count=${#colors[*]} works also.
17 #
18 # The "@" variable allows word splitting within quotes
19 # (extracts variables separated by whitespace).
20
21 index=0
22
23 while [ "$index" -lt "$element_count" ]
24 do    # List all the elements in the array.
25   echo ${colors[$index]}
26   let "index = $index + 1"
27 done
28 # Each array element listed on a separate line.
29 # If this is not desired, use  echo -n "${colors[$index]} "
30 #
31 # Doing it with a "for" loop instead:
32 #   for i in "${colors[@]}"
33 #   do
34 #     echo "$i"
35 #   done
36 # (Thanks, S.C.)
37
38 echo
39
40 # Again, list all the elements in the array, but using a more elegant method.
41   echo ${colors[@]}
42 # echo ${colors[*]} works also.
43
44 echo
45
46 exit 0
```

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 26-3. Of empty arrays and empty elements

```
 1 #!/bin/bash
 2 # empty-array.sh
 3
 4 # An empty array is not the same as an array with empty elements.
 5
 6 array0=( first second third )
 7 array1=( '' )   # "array1" has one empty element.
 8 array2=( )      # No elements... "array2" is empty.
 9
10 echo
11
12 echo "Elements in array0:  ${array0[@]}"
13 echo "Elements in array1:  ${array1[@]}"
14 echo "Elements in array2:  ${array2[@]}"
15 echo
16 echo "Length of first element in array0 = ${#array0}"
17 echo "Length of first element in array1 = ${#array1}"
18 echo "Length of first element in array2 = ${#array2}"
19 echo
20 echo "Number of elements in array0 = ${#array0[*]}"  # 3
21 echo "Number of elements in array1 = ${#array1[*]}"  # 1  (surprise!)
22 echo "Number of elements in array2 = ${#array2[*]}"  # 0
23
24 echo
25
26 exit 0  # Thanks, S.C.
```

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=( "${array1[@]}" )
 3
 4 # Adding an element to an array.
 5 array=( "${array[@]}" "new element" )
 6 # or
 7 array[${#array[*]}]="new element"
 8
 9 # Thanks, S.C.
```

--

Arrays permit deploying old familiar algorithms as shell scripts. Whether this is necessarily a good idea is left to the reader to decide.

Example 26-4. An old friend: *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 for element getting swapped
out.
 19   Countries[$1]=${Countries[$2]}
 20   Countries[$2]=$temp
 21
 22   return
 23 }
 24
 25 declare -a Countries  # Declare array, optional here since it's initialized
below.
 26
 27 Countries=(Netherlands Ukraine Zaire Turkey Russia Yemen Syria Brazil Argentina
Nicaragua Japan Mexico Venezuela Greece England Israel Peru Canada Oman Denmark Wales
France Kenya Qatar Liechtenstein Hungary)
 28 # Couldn't think of one starting with X (darn!).
 29
 30 clear                     # Clear the screen to start with.
 31
 32 echo "0: ${Countries[*]}"  # List entire array at pass 0.
 33
 34 number_of_elements=${#Countries[@]}
 35 let "comparisons = $number_of_elements - 1"
 36
 37 count=1 # Pass number.
 38
 39 while [ "$comparisons" -gt 0 ]          # Beginning of outer loop
 40 do
```

```
 41
 42   index=0  # Reset index to start of array after each pass.
 43
 44   while [ "$index" -lt "$comparisons" ] # Beginning of inner loop
 45   do
 46     if [ ${Countries[$index]} \> ${Countries[`expr $index + 1`]} ]
 47     # If out of order...
 48     # Recalling that \> is ASCII comparison operator.
 49
 50     # if [[ ${Countries[$index]} > ${Countries[`expr $index + 1`]} ]]
 51     # also works.
 52     then
 53       exchange $index `expr $index + 1`  # Swap.
 54     fi
 55     let "index += 1"
 56   done # End of inner loop
 57
 58
 59 let "comparisons -= 1" # Since "heaviest" element bubbles to bottom,
 60                        # we need do one less comparison each pass.
 61
 62 echo
 63 echo "$count: ${Countries[@]}"  # Print resultant array at end of each pass.
 64 echo
 65 let "count += 1"               # Increment pass count.
 66
 67 done                           # End of outer loop
 68
 69 # All done.
 70
 71 exit 0
```

--

Arrays enable implementing a shell script version of the *Sieve of Erastosthenes*. 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 26-5. Complex array application: *Sieve of Erastosthenes*

```
 1 #!/bin/bash
 2 # sieve.sh
 3
 4 # Sieve of Erastosthenes
 5 # Ancient algorithm for finding prime numbers.
 6
 7 # This runs a couple of orders of magnitude
 8 # slower than the equivalent C program.
 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.
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=$LOWER_LIMIT+1
 65 # We know 1 is prime, so let's start with 2.
 66
 67 until [ "$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 # Invoke the functions sequentially.
 93 initialize
 94 sift
 95 print_primes
 96 # This is what they call structured programming.
 97
 98 echo
 99
100 exit 0
101
102
103
104 # ----------------------------------------------- #
105 # Code below line will not execute.
```

```
106
107 # This improved version of the Sieve, by Stephane Chazelas,
108 # executes somewhat faster.
109
110 # Must invoke with command-line argument (limit of primes).
111
112 UPPER_LIMIT=$1                  # From command line.
113 let SPLIT=UPPER_LIMIT/2         # Halfway to max number.
114
115 Primes=( '' $(seq $UPPER_LIMIT) )
116
117 i=1
118 until (( ( i += 1 ) > SPLIT ))  # Need check only halfway.
119 do
120   if [[ -n $Primes[i] ]]
121   then
122     t=$i
123     until (( ( t += i ) > UPPER_LIMIT ))
124     do
125       Primes[t]=
126     done
127   fi
128 done
129 echo ${Primes[*]}
130
131 exit 0
```

Compare this array-based prime number generator with with an alternative that does not use arrays, Example A-11.

--

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 26-6. 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 and unpredictable behavior.
 9 # The first 20 terms of the series are:
10 # 1 1 2 3 3 4 5 5 6 6 6 8 8 8 10 9 10 11 11 12
11
12 # See Hofstadter's book, "Goedel, Escher, Bach: An Eternal Golden Braid",
13 # p. 137, ff.
14
15
16 LIMIT=100     # Number of terms to calculate
17 LINEWIDTH=20  # Number of terms printed per line
18
19 Q[1]=1        # First two terms of series are 1.
20 Q[2]=1
21
22 echo
23 echo "Q-series [$LIMIT terms]:"
24 echo -n "${Q[1]} "             # Output first two terms.
25 echo -n "${Q[2]} "
26
27 for ((n=3; n <= $LIMIT; n++))  # C-like loop conditions.
28 do   # Q[n] = Q[n - Q[n-1]] + Q[n - Q[n-2]]  for n>2
29 # Need to break the expression into intermediate terms,
30 # since Bash doesn't handle complex array arithmetic very well.
31
32   let "n1 = $n - 1"        # n-1
33   let "n2 = $n - 2"        # n-2
34
35   t0=`expr $n - ${Q[n1]}`  # n - Q[n-1]
36   t1=`expr $n - ${Q[n2]}`  # n - Q[n-2]
37
38   T0=${Q[t0]}              # Q[n - Q[n-1]]
39   T1=${Q[t1]}              # Q[n - Q[n-2]]
40
41 Q[n]=`expr $T0 + $T1`      # Q[n - Q[n-1]] + Q[n - ![n-2]]
42 echo -n "${Q[n]} "
43
44 if [ `expr $n % $LINEWIDTH` -eq 0 ]    # Format output.
45 then   #     mod
46   echo # Break lines into neat chunks.
47 fi
48
49 done
50
51 echo
52
```

```
 53 exit 0
 54
 55 # This is an iterative implementation of the Q-series.
 56 # The more intuitive recursive implementation
 57 # is left as an exercise for the reader.
 58 # Warning: calculating this series recursively takes a *very* long time.
```

--

Bash supports only one-dimensional arrays, however a little trickery permits simulating multi-dimensional ones.

Example 26-7. Simulating a two-dimensional array, then tilting it

```
  1 #!/bin/bash
  2 # Simulating a two-dimensional array.
  3
  4 # A two-dimensional array stores rows sequentially.
  5
  6 Rows=5
  7 Columns=5
  8
  9 declare -a alpha     # char alpha [Rows] [Columns];
 10                      # Unnecessary declaration.
 11
 12 load_alpha ()
 13 {
 14 local rc=0
 15 local index
 16
 17
 18 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
 19 do
 20   local row=`expr $rc / $Columns`
 21   local column=`expr $rc % $Rows`
 22   let "index = $row * $Rows + $column"
 23   alpha[$index]=$i   # alpha[$row][$column]
 24   let "rc += 1"
 25 done
 26
 27 # Simpler would be
 28 #   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 )
 29 # but this somehow lacks the "flavor" of a two-dimensional array.
 30 }
 31
 32 print_alpha ()
 33 {
 34 local row=0
```

```
local index

echo

while [ "$row" -lt "$Rows" ]   # Print out in "row major" order -
do                             # columns vary
                               # while row (outer loop) remains the same.
  local column=0

  while [ "$column" -lt "$Columns" ]
  do
    let "index = $row * $Rows + $column"
    echo -n "${alpha[index]} "  # alpha[$row][$column]
    let "column += 1"
  done

  let "row += 1"
  echo

done

# The simpler equivalent is
#   echo ${alpha[*]} | xargs -n $Columns

echo
}

filter ()     # Filter out negative array indices.
{

echo -n "  "  # Provides the tilt.

if [[ "$1" -ge 0 &&  "$1" -lt "$Rows" && "$2" -ge 0 && "$2" -lt "$Columns" ]]
then
    let "index = $1 * $Rows + $2"
    # Now, print it rotated.
    echo -n " ${alpha[index]}"  # alpha[$row][$column]
fi

}



rotate ()  # Rotate the array 45 degrees
{          # ("balance" it on its lower lefthand corner).
local row
local column

for (( row = Rows; row > -Rows; row-- ))  # Step through the array backwards.
do

  for (( column = 0; column < Columns; column++ ))
```

```
 88   do
 89
 90     if [ "$row" -ge 0 ]
 91     then
 92       let "t1 = $column - $row"
 93       let "t2 = $column"
 94     else
 95       let "t1 = $column"
 96       let "t2 = $column + $row"
 97     fi
 98
 99     filter $t1 $t2   # Filter out negative array indices.
100   done
101
102   echo; echo
103
104 done
105
106 # Array rotation inspired by examples (pp. 143-146) in
107 # "Advanced C Programming on the IBM PC", by Herbert Mayer
108 # (see bibliography).
109
110 }
111
112
113 #--------------------------------------------------#
114 load_alpha     # Load the array.
115 print_alpha    # Print it out.
116 rotate         # Rotate it 45 degrees counterclockwise.
117 #--------------------------------------------------#
118
119
120 # This is a rather contrived, not to mention kludgy simulation.
121 #
122 # Exercise #1 for the reader:
123 # Rewrite the array loading and printing functions
124 # in a more intuitive and elegant fashion.
125 #
126 # Exercise #2:
127 # Figure out how the array rotation functions work.
128 # Hint: think about the implications of backwards-indexing an array.
129
130 exit 0
```

Chapter 27. 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 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 F 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.

Notes

[1] This does not apply to **csh**, **tcsh**, and other shells not related to or descended from the classic Bourne shell (**sh**).

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/dev and /proc

Chapter 28. /dev and /proc

A Linux or UNIX machine typically has two special-purpose directories, `/dev` and `/proc`. The `/dev` directory contains entries for the physical *devices* that may or may not be present in the hardware. [1] The `/proc` directory is actually a pseudo-filesystem. The files in the `/proc` directory 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 ttyp
  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 /dev/sndstat | grep Audio
Audio devices:
0: ESS ES1688 AudioDrive (rev 11) (3.01)
```

Note As of the 2.3 (and 2.4) kernel, `/dev/sndstat` has been deprecated.

The `/dev` directory contains *loopback* devices, such as `/dev/loop0`. A loopback device is a gimmick allows an ordinary file to be accessed as if it were a block device. [2] This enables mounting an entire filesystem within a single large file. See Example 13-6 and Example 13-5.

Shell scripts may extract data from certain of the files in `/dev` and `/proc`. [3]

```
kernel_version=$( awk '{ print $3 }' /proc/version )
```

```
CPU=$( awk '/model name/ {print $4}' < /proc/cpuinfo )

if [ $CPU = Pentium ]
then
  run_some_commands
  ...
else
  run_different_commands
  ...
fi
```

A few of the pseudo-devices in `/dev` have other specialized uses, such as `/dev/zero`.

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 28-1. Finding the process associated with a PID

```
#!/bin/bash
# pid-identifier.sh: Gives complete path name to process associated with pid.

ARGNO=1  # Number of arguments the script expects.
E_WRONGARGS=65
E_BADPID=66
E_NOSUCHPROCESS=67
E_NOPERMISSION=68
PROCFILE=exe

if [ $# -ne $ARGNO ]
then
  echo "Usage: `basename $0` PID-number" >&2  # Error message >stderr.
  exit $E_WRONGARGS
fi

pidno=$( ps ax | grep $1 | awk '{ print $1 }' | grep $1 )
# Checks for pid in "ps" listing, field #1.
# Then makes sure it is the actual process, not the process invoked by this
script.
# The last "grep $1" filters out this possibility.
if [ -z "$pidno" ]  # If, after all the filtering, the result is a zero-length
```

```
string,
  22 then               # no running process corresponds to the pid given.
  23   echo "No such process running."
  24   exit $E_NOSUCHPROCESS
  25 fi
  26
  27 # Alternatively:
  28 #   if ! ps $1 > /dev/null 2>&1
  29 #   then               # no running process corresponds to the pid given.
  30 #     echo "No such process running."
  31 #     exit $E_NOSUCHPROCESS
  32 #    fi
  33
  34
  35 if [ ! -r "/proc/$1/$PROCFILE" ]  # Check for read permission.
  36 then
  37   echo "Process $1 running, but..."
  38   echo "Can't get read permission on /proc/$1/$PROCFILE."
  39   exit $E_NOPERMISSION  # Ordinary user can't access some files in /proc.
  40 fi
  41
  42 # The last two tests may be replaced by:
  43 #    if ! kill -0 $1 > /dev/null 2>&1 # '0' is not a signal, but
  44                                       # this will test whether it is possible
  45                                       # to send a signal to the process.
  46 #    then echo "PID doesn't exist or you're not its owner" >&2
  47 #    exit $E_BADPID
  48 #    fi
  49
  50
  51
  52 exe_file=$( ls -l /proc/$1 | grep "exe" | awk '{ print $11 }' )
  53 # Or       exe_file=$( ls -l /proc/$1/exe | awk '{print $11}' )
  54 #
  55 # /proc/pid-number/exe is a symbolic link
  56 # to the complete path name of the invoking process.
  57
  58 if [ -e "$exe_file" ]  # If /proc/pid-number/exe exists...
  59 then                 # the corresponding process exists.
  60   echo "Process #$1 invoked by $exe_file."
  61 else
  62   echo "No such process running."
  63 fi
  64
  65
  66 # This elaborate script can *almost* be replaced by
  67 # ps ax | grep $1 | awk '{ print $5 }'
  68 # However, this will not work...
  69 # because the fifth field of 'ps' is argv[0] of the process,
  70 # not the executable file path.
  71 #
  72 # However, either of the following would work.
```

```
 73 #       find /proc/$1/exe -printf '%l\n'
 74 #       lsof -aFn -p $1 -d txt | sed -ne 's/^n//p'
 75
 76 # Additional commentary by Stephane Chazelas.
 77
 78 exit 0
```

Example 28-2. On-line connect status

```
  1 #!/bin/bash
  2
  3 PROCNAME=pppd        # ppp daemon
  4 PROCFILENAME=status  # Where to look.
  5 NOTCONNECTED=65
  6 INTERVAL=2           # Update every 2 seconds.
  7
  8 pidno=$( ps ax | grep -v "ps ax" | grep -v grep | grep $PROCNAME | awk '{ print
$1 }' )
  9 # Finding the process number of 'pppd', the 'ppp daemon'.
 10 # Have to filter out the process lines generated by the search itself.
 11
 12
 13 if [ -z "$pidno" ]   # If no pid, then process is not running.
 14 then
 15   echo "Not connected."
 16   exit $NOTCONNECTED
 17 else
 18   echo "Connected."; echo
 19 fi
 20
 21 while [ true ]       # Endless loop, script can be improved here.
 22 do
 23
 24   if [ ! -e "/proc/$pidno/$PROCFILENAME" ]
 25   # While process running, then "status" file exists.
 26   then
 27     echo "Disconnected."
 28     exit $NOTCONNECTED
 29   fi
 30
 31 netstat -s | grep "packets received"  # Get some connect statistics.
 32 netstat -s | grep "packets delivered"
 33
 34
 35   sleep $INTERVAL
 36   echo; echo
 37
 38 done
```

```
39
40 exit 0
41
42 # As it stands, this script must be terminated with a Control-C.
43
44 #    Exercises for the reader:
45 #    Improve the script so it exits on a "q" keystroke.
46 #    Make the script more user-friendly in other ways.
```

Warning In general, it is dangerous to *write* to the files in `/proc`, as this can corrupt the filesystem or crash the machine.

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 acesses data in character units. Examples of block devices are a hard drive and CD ROM drive. An example of a character device is a keyboard.

[3] Certain system commands, such as procinfo, free, vmstat, and uptime do this as well.

Chapter 29. Of Zeros and Nulls

/dev/zero and /dev/null

Uses of /dev/null

Think of /dev/null as a "black hole". It is the nearest equivalent to a write-only file. Everything written to it disappears forever. Attempts to read or output from it result in nothing. Nevertheless, /dev/null can be quite useful from both the command line and in scripts.

Suppressing stdout or stderr (from Example 12-2):

```
1 rm $badname 2>/dev/null
2 #           So error messages [stderr] deep-sixed.
```

Deleting contents of a file, but preserving the file itself, with all attendant permissions (from Example 2-1 and Example 2-2):

```
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 log file (especially good for dealing with those nasty "cookies" sent by Web commercial sites):

Example 29-1. Hiding the cookie jar

```
1 if [ -f ~/.netscape/cookies ]  # Remove, if exists.
2 then
3   rm -f ~/.netscape/cookies
4 fi
5
6 ln -s /dev/null ~/.netscape/cookies
7 # 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 file, but it actually contains nulls (numerical zeros, not the ASCII kind). Output written to it disappears, and it is fairly difficult to actually read the nulls in /dev/zero, though it can be done with od or a hex editor. The chief use for /dev/zero is in creating an initialized dummy file of

specified length intended as a temporary swap file.

Example 29-2. Setting up a swapfile using `/dev/zero`

```
 1 #!/bin/bash
 2
 3 # Creating a swapfile.
 4 # This script must be run as root.
 5
 6 ROOT_UID=0         # Root has $UID 0.
 7 E_WRONG_USER=65    # Not root?
 8
 9 FILE=/swap
10 BLOCKSIZE=1024
11 MINBLOCKS=40
12 SUCCESS=0
13
14 if [ "$UID" -ne "$ROOT_UID" ]
15 then
16   echo; echo "You must be root to run this script."; echo
17   exit $E_WRONG_USER
18 fi
19
20
21 if [ -n "$1" ]
22 then
23   blocks=$1
24 else
25   blocks=$MINBLOCKS             # Set to default of 40 blocks
26 fi                             # if nothing specified on command line.
27
28 if [ "$blocks" -lt $MINBLOCKS ]
29 then
30   blocks=$MINBLOCKS             # Must be at least 40 blocks long.
31 fi
32
33
34 echo "Creating swap file of size $blocks blocks (KB)."
35 dd if=/dev/zero of=$FILE bs=$BLOCKSIZE count=$blocks  # Zero out file.
36
37 mkswap $FILE $blocks            # Designate it a swap file.
38 swapon $FILE                    # Activate swap file.
39
40 echo "Swap file created and activated."
41
42 exit $SUCCESS
```

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 13-6) or securely deleting a file (see Example 12-30).

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Chapter 30. Debugging

The Bash shell contains no debugger, nor even any debugging-specific commands or 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 30-1. test23, a buggy script

```
 1 #!/bin/bash
 2 # test23.sh
 3
 4 # This is a buggy script.
 5
 6 a=37
 7
 8 if [$a -gt 27 ]
 9 then
10   echo $a
11 fi
12
13 exit 0
```

Output from script:

```
./test23: [37: command not found
```

What's wrong with the above script (hint: after the **if**)?

What if the script executes, but does not work as expected? This is the all too familiar logic error.

Example 30-2. test24, another buggy script

```
 1 #!/bin/bash
 2
 3 # This is supposed to delete all filenames in current directory
 4 # containing embedded spaces.
 5 # It doesn't work.  Why not?
 6
 7
 8 badname=`ls | grep ' '`
 9
10 # echo "$badname"
11
12 rm "$badname"
13
14 exit 0
```

Try to find out what's wrong with Example 30-2 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 to 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 an error message syntax error, 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. echo statements at critical points in the script to trace the variables, and otherwise give a snapshot of what is going on.
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 at each attempt to use an undeclared variable.

4. 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.

Note A *signal* is simply 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.

```
1 trap '' 2
2 # Ignore interrupt 2 (Control-C), with no action specified.
3
4 trap 'echo "Control-C disabled."' 2
5 # Message when Control-C pressed.
```

Example 30-3. Trapping at exit

```
 1 #!/bin/bash
 2
 3 trap 'echo Variable Listing --- a = $a  b = $b' EXIT
 4 # EXIT is the name of the signal generated upon exit from a script.
 5
 6 a=39
 7
 8 b=36
 9
10 exit 0
11 # Note that commenting out the 'exit' command makes no difference,
12 # since the script exits in any case after running out of commands.
```

Example 30-4. 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
 5 TRUE=1
 6 LOGFILE=/var/log/messages
 7 # Note that $LOGFILE must be readable (chmod 644 /var/log/messages).
 8 TEMPFILE=temp.$$
 9 # Create a "unique" temp file name, using process id of the script.
10 KEYWORD=address
11 # At logon, the line "remote IP address xxx.xxx.xxx.xxx"
12 #                    appended to /var/log/messages.
13 ONLINE=22
14 USER_INTERRUPT=13
15
16 trap 'rm -f $TEMPFILE; exit $USER_INTERRUPT' TERM INT
17 # Cleans up the temp file if script interrupted by control-c.
18
19 echo
20
21 while [ $TRUE ]  #Endless loop.
22 do
23   tail -1 $LOGFILE> $TEMPFILE
24   # Saves last line of system log file as temp file.
25   search=`grep $KEYWORD $TEMPFILE`
26   # Checks for presence of the "IP address" phrase,
27   # indicating a successful logon.
28
29   if [ ! -z "$search" ] # Quotes necessary because of possible spaces.
30   then
31      echo "On-line"
```

```
32      rm -f $TEMPFILE    # Clean up temp file.
33      exit $ONLINE
34    else
35      echo -n "."        # -n option to echo suppresses newline,
36                         # so you get continuous rows of dots.
37    fi
38
39    sleep 1
40  done
41
42
43  # Note: if you change the KEYWORD variable to "Exit",
44  # this script can be used while on-line to check for an unexpected logoff.
45
46  # Exercise: Change the script, as per the above note,
47  #           and prettify it.
48
49  exit 0
50
51
52  # Nick Drage suggests an alternate method:
53
54  while true
55    do ifconfig ppp0 | grep UP 1> /dev/null && echo "connected" && exit 0
56    echo -n "."   # Prints dots (.....) until connected.
57    sleep 2
58  done
59
60  # Problem: Hitting Control-C to terminate this process may be insufficient.
61  #          (Dots may keep on echoing.)
62  # Exercise: Fix this.
63
64
65
66  # Stephane Chazelas has yet another alternative:
67
68  CHECK_INTERVAL=1
69
70  while ! tail -1 "$LOGFILE" | grep -q "$KEYWORD"
71  do echo -n .
72     sleep $CHECK_INTERVAL
73  done
74  echo "On-line"
75
76  # Exercise: Consider the strengths and weaknesses
77  #           of each of these approaches.
```

Note The DEBUG argument to **trap** causes a specified action to execute after every command in a script. This permits tracing variables, for example.

Example 30-5. 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
 7
 8 echo "Just initialized \"\$variable\" to $variable."
 9
10 let "variable *= 3"
11 echo "Just multiplied \"\$variable\" by 3."
12
13 # The "trap 'commands' DEBUG" construct would be more useful
14 # in the context of a complex script,
15 # where placing multiple "echo $variable" statements might be
16 # clumsy and time-consuming.
17
18 # Thanks, Stephane Chazelas for the pointer.
19
20 exit 0
```

Note **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
```

Notes

[1] By convention, *signal 0* is assigned to exit.

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Options

Chapter 31. 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
```

Note 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 or by complete name.

Table 31-1. bash options

Abbreviation	Name	Effect
`-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 **...**
`-f`	noglob	Filename expansion (globbing) disabled
`-i`	interactive	Script runs in *interactive* mode
`-p`	privileged	Script runs as "suid" (caution!)
`-r`	restricted	Script runs in *restricted* mode (see Chapter 21).
`-u`	nounset	Attempt to use undefined variable outputs error message, and forces an exit
`-v`	verbose	Print each command to `stdout` before executing it
`-x`	xtrace	Similar to `-v`, but expands commands
`-e`	errexit	Abort script at first error (when a command exits with non-zero status)
`-n`	noexec	Read commands in script, but do not execute them (syntax check)
`-s`	stdin	Read commands from `stdin`
`-t`	(none)	Exit after first command
`-`	(none)	End of options flag. All other arguments are positional parameters.
`--`	(none)	Unset positional parameters. If arguments given (`-- arg1 arg2`), positional parameters set to arguments.

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Chapter 32. Gotchas

Turandot: Gli enigmi sono tre, la morte una!

Caleph: No, no! Gli enigmi sono tre, una la vita!

Puccini

Assigning reserved words or characters to variable names.

```
case=value0       # Causes problems.
23skidoo=value1   # Also problems.
# Variable names starting with a digit are reserved by the shell.
# Try _23skidoo=value1. Starting variables with an underscore is o.k.

# However...      using just the underscore will not work.
_=25
echo $_           # $_ is a special variable set to last arg of last command.

xyz((!*=value2    # Causes severe problems.
```

Using a hyphen or other reserved characters in a variable name.

```
var-1=23
# Use 'var_1' instead.
```

Using the same name for a variable and a function. This can make a script difficult to understand.

```
do_something ()
{
  echo "This function does something with \"$1\"."
}

do_something=do_something

do_something do_something

# All this is legal, but highly confusing.
```

Using whitespace inappropriately (in contrast to other programming languages, Bash can be quite finicky about

whitespace).

```
var1 = 23   # 'var1=23' is correct.
# On line above, Bash attempts to execute command "var1"
# with the arguments "=" and "23".

let c = $a - $b   # 'let c=$a-$b' or 'let "c = $a - $b"' are correct.

if [ $a -le 5]    # if [ $a -le 5 ]   is correct.
# if [ "$a" -le 5 ]   is even better.
# [[ $a -le 5 ]] also works.
```

Assuming uninitialized variables (variables before a value is assigned to them) are "zeroed out". An uninitialized variable has a value of "null", *not* zero.

Mixing up = and *-eq* in a test. Remember, = is for comparing literal variables and *-eq* for integers.

```
if [ "$a" = 273 ]      # Is $a an integer or string?
if [ "$a" -eq 273 ]    # If $a is an integer.

# Sometimes you can mix up -eq and = without adverse consequences.
# However...


a=273.0   # Not an integer.

if [ "$a" = 273 ]
then
  echo "Comparison works."
else
  echo "Comparison does not work."
fi    # Comparison does not work.

# Same with   a=" 273"  and a="0273".


# Likewise, problems trying to use "-eq" with non-integer values.

if [ "$a" -eq 273.0 ]
then
  echo "a = $a'
fi  # Aborts with an error message.
# test.sh: [: 273.0: integer expression expected
```

Sometimes variables within "test" brackets ([ ]) need to be quoted (double quotes). Failure to do so may cause unexpected behavior. See Example 7-5, Example 16-2, and Example 9-6.

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  # Trying to redirect error output of command1 into a
pipe...
   2 #    ...will not work.
   3
   4 command1 2>& - | command2  # Also futile.
   5
   6 Thanks, S.C.
```

Using Bash version 2 functionality in a script headed with **#!/bin/bash** may cause a bailout with error messages. Older Linux machines may have version 1.x of Bash as the default installation (**echo $BASH_VERSION**). Try changing the header of the script to **#!/bin/bash2**.

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.

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.

A shell script headed by **#!/bin/sh** may 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**.

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 32-1. 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 # End subshell
19 )
20
21 echo
22 echo "inner_variable outside subshell = $inner_variable"  # Unset.
23 echo "outer_variable outside subshell = $outer_variable"  # Unchanged.
24 echo
25
26 exit 0
```

Using "suid" commands in 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 "hacker-proof" shell scripts.

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 a script has no effect.

Chapter 33. 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 intended as an *Official Shell Scripting Stylesheet*.

33.1. 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, but now it's a complete
mystery.
  3 # (From Antek Sawicki's "pw.sh" script.)
```

  Add descriptive headers to your scripts and functions.

```
  1 #!/bin/bash
  2
  3 #***********************************************#
  4 #                   xyz.sh
  5 #           written by Bozo Bozeman
  6 #                July 05, 2001
  7
  8 #           Clean up project files.
  9 #***********************************************#
 10
 11 BADDIR=65                        # 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, $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 $BADDIR
 26   fi
```

```
27
28   rm -f "$1"/*
29   return 0   # Success.
30 }
31
32 cleanup_pfiles $projectdir
33
34 exit 0
```

Be sure to put the *#!/bin/bash* at the beginning of the first line of the script, preceding any comment headers.

- 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   ...
14 fi
```

- 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 "$MAXVAL" ]
 7 ...
 8
 9
10 E_NOTFOUND=75                        # Uppercase for an errorcode,
11                                      # and name begins with "E_".
12 if [ ! -e "$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 variable.
20 export MAIL_DIRECTORY
```

```
21
22
23 GetAnswer ()                          # Mixed case works well for a function.
24 {
25   prompt=$1
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                      # Permissable, 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=65
2 ...
3 ...
4 exit $E_WRONG_ARGS
```

See also Appendix C.

- Break complex scripts into simpler modules. Use functions where appropriate. See Example 35-3.
- 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).
```

Notes

[1] In this context, " magic numbers" have an entirely different meaning than the magic numbers used to designate file types.

Chapter 34. Miscellany

Nobody really knows what the Bourne shell's grammar is. Even examination of the source code is little help.

Tom Duff

34.1. 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 # Stephane Chazelas (thanks again).
```

Let us consider an *interactive* script to be one that requires input from the user, usually with read statements (see Example 11-2). "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 then
3   # non-interactive
4   ...
5 else
6   # interactive
7   ...
8 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 # (Thanks to "UNIX F.A.Q.", 1993)
```

Note 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.

34.2. Tests and Comparisons

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 $city"  # Greater
ASCII order.
 13 /bin/test "$city" \< Paris && echo "Yes, Paris is greater than $city"
 14 [ "$city" \< Paris ] && echo "Yes, Paris is greater than $city"
 15 [[ $city < Paris ]] && echo "Yes, Paris is greater than $city"    # Need not
quote $city.
 16
 17 # Thank you, S.C.
```

34.3. 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. 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.

Try to write your scripts in a structured, coherent form, 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.

34.4. Assorted Tips

- To keep a record of which user scripts have run during a particular sesssion 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 date>> $SAVE_FILE      #Date and time.
  4 echo $0>> $SAVE_FILE   #Script name.
  5 echo>> $SAVE_FILE      #Blank line as separator.
  6
  7 # Of course, SAVE_FILE defined and exported as environmental variable in
~/.bashrc
  8 # (something like ~/.scripts-run)
```

- 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 as an external shell command in a C program using the *`system()`* call, i.e., *`system("script_name");`*.
- 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=256          # Maximum (positive) return value of a function.
 14 SUCCESS=0
 15 FAILURE=-1
 16
 17
 18
 19 # Functions
 20
 21 Usage ()               # "Usage:" message.
 22 {
```

```
  if [ -z "$1" ]       # No arg passed.
  then
    msg=filename
  else
    msg=$@
  fi

  echo "Usage: `basename $0` "$msg""
}


Check_if_root ()       # Check if root running script.
{                      # From "ex39.sh" example.
  if [ "$UID" -ne "$ROOT_UID" ]
  then
    echo "Must be root to run this script."
    exit $E_NOTROOT
  fi
}


CreateTempfileName ()  # Creates a "unique" temp filename.
{                      # From "ex51.sh" example.
  prefix=temp
  suffix=`eval date +%s`
  Tempfilename=$prefix.$suffix
}


isalpha2 ()            # Tests whether *entire string* is alphabetic.
{                      # From "isalpha.sh" example.
  [ $# -eq 1 ] || return $FAILURE

  case $1 in
  *[!a-zA-Z]*|"") return $FAILURE;;
  *) return $SUCCESS;;
  esac                 # Thanks, S.C.
}


abs ()                           # Absolute value.
{                                # Caution: Max return value = 256.
  E_ARGERR=-999999

  if [ -z "$1" ]                 # Need arg passed.
  then
    return $E_ARGERR             # Obvious error value returned.
  fi

  if [ "$1" -ge 0 ]              # If non-negative,
  then                           #
    absval=$1                    # stays as-is.
```

```
  else                            # Otherwise,
    let "absval = (( 0 - $1 ))"   # change sign.
  fi

  return $absval
}
```

- Use special-purpose comment headers to increase clarity and legibility in scripts.

```
## Caution.
rm -rf *.zzy   ##  The "-rf" options to "rm" are very dangerous,
               ##+ especially with wildcards.

#+ Line continuation.
#  This is line 1
#+ of a multi-line comment,
#+ and this is the final line.

#* Note.

#o List item.

#> Another point of view.
while [ "$var1" != "end" ]    #> while test "$var1" != "end"
```

- Using the $? exit status variable, a script may test if a parameter contains only digits, so it can be treated as an integer.

```
#!/bin/bash

SUCCESS=0
E_BADINPUT=65

test "$1" -ne 0 -o "$1" -eq 0 2>/dev/null
# An integer is either equal to 0 or not equal to 0.
# 2>/dev/null suppresses error message.

if [ $? -ne "$SUCCESS" ]
then
  echo "Usage: `basename $0` integer-input"
  exit $E_BADINPUT
fi

let "sum = $1 + 25"             # Would give error if $1 not integer.
echo "Sum = $sum"

# Any variable, not just a command line parameter, can be tested this way.

```

```
21 exit 0
```

- Using the double parentheses construct, it is possible to use C-like syntax for setting and incrementing variables and in for and while loops. See Example 10-10 and Example 10-15.
- The run-parts command is handy for running a set of command scripts in sequence, particularly in combination with cron or at.
- 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.

  Caution 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).

  For more effective 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).

34.5. Portability Issues

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. Even lacking this measure, 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 recent release of the source to many of the original UNIX utilities will only accelerate the trend.

Chapter 35. Bash, version 2

The current version of *Bash*, the one you have running on your machine, is actually version 2. This update of the classic Bash scripting language added array variables, [1] string and parameter expansion, and a better method of indirect variable references, among other features.

Example 35-1. 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 echo $'Three form feeds \f \f \f'
11 echo $'10 newlines \n\n\n\n\n\n\n\n\n\n'
12
13 exit 0
```

Example 35-2. 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 ${!variable} notation is greatly superior to the old "eval var1=\$$var2"
14
15 echo
16
```

```
17 t=table_cell_3
18 table_cell_3=24
19 echo "t = ${!t}"        # t = 24
20 table_cell_3=387
21 echo "Value of t changed to ${!t}"    # 387
22
23 # This is useful for referencing members of an array or table,
24 # or for simulating a multi-dimensional array.
25 # An indexing option would have been nice (sigh).
26
27 exit 0
```

Example 35-3. Using arrays and other miscellaneous trickery to deal four random hands from a deck of cards

```
 1 #!/bin/bash
 2 # May need to be invoked with  #!/bin/bash2  on older machines.
 3
 4 # Cards:
 5 # deals four random hands from a deck of cards.
 6
 7 UNPICKED=0
 8 PICKED=1
 9
10 DUPE_CARD=99
11
12 LOWER_LIMIT=0
13 UPPER_LIMIT=51
14 CARDS_IN_SUIT=13
15 CARDS=52
16
17 declare -a Deck
18 declare -a Suits
19 declare -a Cards
20 # It would have been easier and more intuitive
21 # with a single, 3-dimensional array.
22 # Perhaps a future version of Bash will support multidimensional arrays.
23
24
25 initialize_Deck ()
26 {
27 i=$LOWER_LIMIT
28 until [ "$i" -gt $UPPER_LIMIT ]
29 do
30   Deck[i]=$UNPICKED   # Set each card of "Deck" as unpicked.
31   let "i += 1"
32 done
```

```
 33 echo
 34 }
 35
 36 initialize_Suits ()
 37 {
 38 Suits[0]=C #Clubs
 39 Suits[1]=D #Diamonds
 40 Suits[2]=H #Hearts
 41 Suits[3]=S #Spades
 42 }
 43
 44 initialize_Cards ()
 45 {
 46 Cards=(2 3 4 5 6 7 8 9 10 J Q K A)
 47 # Alternate method of initializing an array.
 48 }
 49
 50 pick_a_card ()
 51 {
 52 card_number=$RANDOM
 53 let "card_number %= $CARDS"
 54 if [ "${Deck[card_number]}" -eq $UNPICKED ]
 55 then
 56   Deck[card_number]=$PICKED
 57   return $card_number
 58 else
 59   return $DUPE_CARD
 60 fi
 61 }
 62
 63 parse_card ()
 64 {
 65 number=$1
 66 let "suit_number = number / CARDS_IN_SUIT"
 67 suit=${Suits[suit_number]}
 68 echo -n "$suit-"
 69 let "card_no = number % CARDS_IN_SUIT"
 70 Card=${Cards[card_no]}
 71 printf %-4s $Card
 72 # Print cards in neat columns.
 73 }
 74
 75 seed_random ()  # Seed random number generator.
 76 {
 77 seed=`eval date +%s`
 78 let "seed %= 32766"
 79 RANDOM=$seed
 80 }
 81
 82 deal_cards ()
 83 {
```

```
 84 echo
 85
 86 cards_picked=0
 87 while [ "$cards_picked" -le $UPPER_LIMIT ]
 88 do
 89   pick_a_card
 90   t=$?
 91
 92   if [ "$t" -ne $DUPE_CARD ]
 93   then
 94     parse_card $t
 95
 96     u=$cards_picked+1
 97     # Change back to 1-based indexing (temporarily).
 98     let "u %= $CARDS_IN_SUIT"
 99     if [ "$u" -eq 0 ]   # Nested if/then condition test.
100     then
101      echo
102      echo
103     fi
104     # Separate hands.
105
106     let "cards_picked += 1"
107   fi
108 done
109
110 echo
111
112 return 0
113 }
114
115
116 # Structured programming:
117 # entire program logic modularized in functions.
118
119 #================
120 seed_random
121 initialize_Deck
122 initialize_Suits
123 initialize_Cards
124 deal_cards
125
126 exit 0
127 #================
128
129
130
131 # Exercise 1:
132 # Add comments to thoroughly document this script.
133
134 # Exercise 2:
```

```
135 # Revise the script to print out each hand sorted in suits.
136 # You may add other bells and whistles if you like.
137
138 # Exercise 3:
139 # Simplify and streamline the logic of the script.
```

Notes

[1] Chet Ramey promises associative arrays (a Perl feature) in a future Bash release.

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Chapter 36. Credits

Philippe Martin translated 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 email him at feloy@free.fr.

Philippe Martin also pointed out that positional parameters past $9 are possible using {bracket} notation, see Example 5-4.

Stephane Chazelas sent a long list of corrections, additions, and example scripts. More than a contributor, he has, in effect, taken on the role of **editor** for this document. Merci beaucoup !

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. 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-12).

Kudos to Noah Friedman for permission to use his string function script (Example A-13).

Emmanuel Rouat suggested corrections and additions on command substitution and aliases. He also contributed a very nice sample `.bashrc` file (Appendix F).

Heiner Steven kindly gave permission to use his base conversion script, Example 12-27. He also made a number of corrections and many helpful suggestions. Special thanks.

Florian Wisser enlightened me on some of the fine points of testing strings (see Example 7-5), and on other matters.

Marc-Jano Knopp sent corrections 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.

Others making helpful suggestions and pointing out errors were Gabor Kiss, Leopold Toetsch, and Nick Drage (script ideas!).

My gratitude to Chet Ramey and Brian Fox for writing **Bash**, an elegant and powerful scripting tool.

Thanks most of all to my wife, Anita, for her encouragement and emotional support.

Chapter 37. Endnotes

37.1. Author's Note

How did I come to write a Bash scripting book? It's a strange tale. It seems that a couple of 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 scripting. In fact, I was looking for this very book, or something much like it. Unfortunately, it didn't exist, so if I wanted it, I had to write it. And so, here we are, folks.

This reminds me of the apocryphal story about the 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 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 driven by it, and I can't help admiring the old coot...

37.2. About the Author

Who is this guy anyhow?

The author claims no credentials or special qualifications, other than a compulsion to write. [1] This book is somewhat of a departure from his other major work, HOW-2 Meet Women: The Shy Man's Guide to Relationships.

A Linux user since 1995 (Slackware 2.2, kernel 1.2.1), the author has written a few software truffles, including the cruft one-time pad encryption utility, the mcalc mortgage calculator, the judge Scrabble® adjudicator, and the yawl word gaming list package. He got his start in programming using FORTRAN IV on a CDC 3800, but is not the least bit nostalgic for those days.

Living in a secluded desert community with wife and dog, he cherishes human frailty.

Notes

[1] Those who can, do. Those who can't... get an MCSE.

37.3. Tools Used to Produce This Book

37.3.1. 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 Muellner (O'Reilly, ISBN 1-56592-580-7). This is the standard reference for anyone attempting to write a document in Docbook SGML format.

Bibliography

Dale Dougherty and Arnold Robbins, *Sed and Awk*, 2nd edition, O'Reilly and Associates, 1997, 1-156592-225-5.

To unfold the full power of shell scripting, you need at least a passing familiarity with **sed** and **awk**. This is the standard tutorial. It includes an excellent introduction to "regular expressions". Read this book.

*

Aeleen Frisch, *Essential System Administration*, 2nd edition, O'Reilly and Associates, 1995, 1-56592-127-5.

This excellent sys admin manual has a decent introduction to shell scripting for sys administrators and does a nice job of explaining the startup and initialization scripts. The book is long overdue for a third edition (are you listening, Tim O'Reilly?).

*

Stephen Kochan and Patrick Woods, *Unix Shell Programming*, Hayden, 1990, 067248448X.

The standard reference, though a bit dated by now.

*

Neil Matthew and Richard Stones, *Beginning Linux Programming*, Wrox Press, 1996, 1874416680.

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.

*

David Medinets, *Unix Shell Programming Tools*, McGraw-Hill, 1999, 0070397333.

Good info on 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 somewhat deficient in coverage on programming topics 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*, 2nd edition, O'Reilly and Associates, Random House, 1997, 1-56592-260-3.

Contains a couple of sections of very informative in-depth articles on shell programming, but falls short of being a tutorial. It reproduces much of the regular expressions tutorial from the Dougherty and Robbins book, above.

*

Arnold Robbins, *Bash Reference Card*, SSC, 1998, 1-58731-010-5.

Excellent Bash pocket reference (don't leave home without it). A bargain at $4.95, but also available for free download on-line in pdf format.

*

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 has served as an inspiration for the author of this document.

*

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 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, even has a Bash section.

*

The UNIX CD Bookshelf, 2nd edition, O'Reilly and Associates, 2000, 1-56592-815-6.

An array of six 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 $70. Buy this one, even if it means going into debt and not paying the rent.

Unfortunately, out of print at present.

*

The O'Reilly books on Perl. (Actually, any O'Reilly books.)

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 F.A.Q.

Example shell scripts at Lucc's Shell Scripts .

Example shell scripts at SHELLdorado .

Example shell scripts at Noah Friedman's script site.

Example shell scripts at SourceForge Snippet Library - shell scrips.

Giles Orr's Bash-Prompt HOWTO.

The sed F.A.Q.

Carlos Duarte's instructive "Do It With Sed" tutorial.

The GNU **gawk** reference manual (**gawk** is the extended GNU version of **awk** available on Linux and BSD systems).

Trent Fisher's groff tutorial.

Mark Komarinski's Printing-Usage HOWTO.

There is some nice material on I/O redirection (Chapter 16) 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.

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.

The manpages for **bash** and **bash2**, **date**, **expect**, **expr**, **find**, **grep**, **gzip**, **ln**, **patch**, **tar**, **tr**, **bc**, **xargs**. The texinfo documentation on **bash**, **dd**, **gawk**, and **sed**.

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Contributed Scripts

Appendix A. Contributed Scripts

These scripts, while not fitting into the text of this document, do illustrate some interesting shell programming techniques. They are useful, too. Have fun analyzing and running them.

Example A-1. manview: Viewing formatted manpages

```
 1 #!/bin/bash
 2 # manview.sh: Formats the source of a man page for viewing.
 3
 4 # This is useful when writing man page source and you want to
 5 # look at the intermediate results on the fly while working on it.
 6
 7 E_WRONGARGS=65
 8
 9 if [ -z "$1" ]
10 then
11   echo "Usage: `basename $0` [filename]"
12   exit $E_WRONGARGS
13 fi
14
15 groff -Tascii -man $1 | less
16 # From the man page for groff.
17
18 # If the man page includes tables and/or equations,
19 # then the above code will barf.
20 # The following line can handle such cases.
21 #
22 #   gtbl < "$1" | geqn -Tlatin1 | groff -Tlatin1 -mtty-char -man
23 #
24 #   Thanks, S.C.
25
26 exit 0
```

Example A-2. mailformat: Formatting an e-mail message

```
 1 #!/bin/bash
 2 # mail-format.sh: Format e-mail messages.
 3
 4 # Gets rid of carets, tabs, also fold excessively long lines.
 5
 6 ARGS=1
 7 E_BADARGS=65
 8 E_NOFILE=66
 9
10 if [ $# -ne $ARGS ]  # Correct number of arguments passed to script?
11 then
12   echo "Usage: `basename $0` filename"
13   exit $E_BADARGS
14 fi
15
16 if [ -f "$1" ]       # Check if file exists.
17 then
18     file_name=$1
19 else
20     echo "File \"$1\" does not exist."
21     exit $E_NOFILE
22 fi
23
24 MAXWIDTH=70          # Width to fold long lines to.
25
26 sed '
27 s/^>//
28 s/^  *>//
29 s/^  *//
30 s/         *//
31 ' $1 | fold -s --width=$MAXWIDTH
32           # -s option to "fold" breaks lines at whitespace, if possible.
33
34 # This script was inspired by an article in a well-known trade journal
35 # extolling a 164K Windows utility with similar functionality.
36
37 exit 0
```

Example A-3. rn: A simple-minded file rename utility

This script is a modification of Example 12-13.

```
 1 #! /bin/bash
 2 #
 3 # Very simpleminded filename "rename" utility (based on "lowercase.sh").
 4 #
 5 # The "ren" utility, by Vladimir Lanin (lanin@csd2.nyu.edu),
 6 # does a much better job of this.
 7
 8
 9 ARGS=2
10 E_BADARGS=65
11 ONE=1                     # For getting singular/plural right (see below).
12
13 if [ $# -ne "$ARGS" ]
14 then
15   echo "Usage: `basename $0` old-pattern new-pattern"
16   # As in "rn gif jpg", which renames all gif files in working directory to jpg.
17   exit $E_BADARGS
18 fi
19
20 number=0                   # Keeps track of how many files actually renamed.
21
22
23 for filename in *$1*       #Traverse all matching files in directory.
24 do
25    if [ -f "$filename" ]  # If finds match...
26    then
27      fname=`basename $filename`            # Strip off path.
28      n=`echo $fname | sed -e "s/$1/$2/"`   # Substitute new for old in filename.
29      mv $fname $n                          # Rename.
30      let "number += 1"
31    fi
32 done
33
34 if [ "$number" -eq "$ONE" ]                # For correct grammar.
35 then
36  echo "$number file renamed."
37 else
38  echo "$number files renamed."
39 fi
40
41 exit 0
42
43
44 # Exercise for reader:
45 # What type of files will this not work on?
46 # How to fix this?
```

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 E_BADARGS=65
 6
 7 if [ -z "$1" ]
 8 then
 9   echo "Usage: `basename $0` filename"
10   exit $E_BADARGS
11 fi
12
13 Username=bozo           # Change to suit.
14
15 Filename=`basename $1`  # Strips pathname out of file name
16
17 Server="XXX"
18 Directory="YYY"         # Change above to actual server name & directory.
19
20
21 password=`cruft <pword`
22 # "pword" is the file containing encrypted password.
23 # Uses the author's own "cruft" file encryption package,
24 # based on the classic "onetime pad" algorithm,
25 # and obtainable from:
26 # Primary-site:   ftp://metalab.unc.edu /pub/Linux/utils/file
27 #                 cruft-0.2.tar.gz [16k]
28
29
30 ftp -n $Server <<End-Of-Session
31 user $Username $Password
32 binary
33 bell
34 cd $Directory
35 put $Filename
36 bye
37 End-Of-Session
38 # -n option to "ftp" disables auto-logon.
39 # "bell" rings 'bell' after each file transfer.
40
41 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/xxxxxxx/                    Change to suit your system.
 7 BLOCKSIZE=2048
 8 SPEED=2                                   # May use higher speed if supported.
 9
10 echo; echo "Insert source CD, but do *not* mount it."
11 echo "Press ENTER when ready. "
12 read ready                                # Wait for input, $ready not used.
13
14 echo; echo "Copying the source CD to $OF."
15 echo "This may take a while. Please be patient."
16
17 dd if=$CDROM of=$OF bs=$BLOCKSIZE          # Raw device copy.
18
19
20 echo; echo "Remove data CD."
21 echo "Insert blank CDR."
22 echo "Press ENTER when ready. "
23 read ready                                # Wait for input, $ready not used.
24
25 echo "Copying $OF to CDR."
26
27 cdrecord -v -isosize speed=$SPEED dev=0,0 $OF
28 # Uses Joerg Schilling's "cdrecord" package (see its docs).
29 # http://www.fokus.gmd.de/nthp/employees/schilling/cdrecord.html
30
31
32 echo; echo "Done copying $OF to CDR on device $CDROM."
33
34 echo "Do you want to erase the image file (y/n)? "  # Probably a huge file.
35 read answer
36
37 case "$answer" in
38 [yY]) rm -f $OF
39       echo "$OF erased."
40       ;;
41 *)    echo "$OF not erased.";;
42 esac
43
44 echo
45
46 # Exercise for the reader:
47 # Change the above "case" statement to also accept "yes" and "Yes" as input.
48
49 exit 0
```

Example A-6. days-between: Calculate number of 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 ARGS=2                # Two command line parameters expected.
  6 E_PARAM_ERR=65        # Param error.
  7
  8 REFYR=1600            # Reference year.
  9 CENTURY=100
 10 DIY=365
 11 ADJ_DIY=367           # Adjusted for leap year + fraction.
 12 MIY=12
 13 DIM=31
 14 LEAPCYCLE=4
 15
 16 MAXRETVAL=256         # Largest permissable
 17                       # positive return value from a function.
 18
 19 diff=                    # Declare global variable for date difference.
 20 value=                # Declare global variable for absolute value.
 21 day=                  # Declare globals for day, month, year.
 22 month=
 23 year=
 24
 25
 26 Param_Error ()        # Command line parameters wrong.
 27 {
 28   echo "Usage: `basename $0` [M]M/[D]D/YYYY [M]M/[D]D/YYYY"
 29   echo "       (date must be after 1/3/1600)"
 30   exit $E_PARAM_ERR
 31 }
 32
 33
 34 Parse_Date ()                # Parse date from command line params.
 35 {
 36   month=${1%%/**}
 37   dm=${1%/**}                # Day and month.
 38   day=${dm#*/}
 39   let "year = `basename $1`"  # Not a filename, but works just the same.
 40 }
 41
 42
 43 check_date ()                # Checks for invalid date(s) passed.
 44 {
 45   [ "$day" -gt "$DIM" ] || [ "$month" -gt "$MIY" ] || [ "$year" -lt "$REFYR" ]
&& Param_Error
 46   # Exit script on bad value(s).
 47   # Uses "or-list / and-list".
 48   # Exercise for the reader: Implement more rigorous date checking.
 49 }
```

```
 50
 51
 52 strip_leading_zero () # Better to strip possible leading zero(s)
 53 {                    # from day and/or month
 54   val=${1#0}         # since otherwise Bash will interpret them
 55   return $val        # as octal values (POSIX.2, sect 2.9.2.1).
 56 }
 57
 58
 59 day_index ()         # Gauss' Formula:
 60 {                    # Days from Jan. 3, 1600 to date passed as param.
 61
 62   day=$1
 63   month=$2
 64   year=$3
 65
 66   let "month = $month - 2"
 67   if [ "$month" -le 0 ]
 68   then
 69     let "month += 12"
 70     let "year -= 1"
 71   fi
 72
 73   let "year -= $REFYR"
 74   let "indexyr = $year / $CENTURY"
 75
 76
 77   let "Days = $DIY*$year + $year/$LEAPCYCLE - $indexyr + $indexyr/$LEAPCYCLE +
$ADJ_DIY*$month/$MIY + $day - $DIM"
 78   # For an in-depth explanation of this algorithm, see
 79   # http://home.t-online.de/home/berndt.schwerdtfeger/cal.htm
 80
 81
 82   if [ "$Days" -gt "$MAXRETVAL" ]  # If greater than 256,
 83   then                             # then change to negative value
 84     let "dindex = 0 - $Days"       # which can be returned from function.
 85   else let "dindex = $Days"
 86   fi
 87
 88   return $dindex
 89
 90 }
 91
 92
 93 calculate_difference ()          # Difference between to day indices.
 94 {
 95   let "diff = $1 - $2"           # Global variable.
 96 }
 97
 98
 99 abs ()                           # Absolute value
100 {                                # Uses global "value" variable.
```

```
  if [ "$1" -lt 0 ]                # If negative
  then                             # then
    let "value = 0 - $1"           # change sign,
  else                             # else
    let "value = $1"               # leave it alone.
  fi
}



if [ $# -ne "$ARGS" ]              # Require two command line params.
then
  Param_Error
fi

Parse_Date $1
check_date $day $month $year      # See if valid date.

strip_leading_zero $day           # Remove any leading zeroes
day=$?                            # on day and/or month.
strip_leading_zero $month
month=$?

day_index $day $month $year
date1=$?

abs $date1                         # Make sure it's positive
date1=$value                       # by getting absolute value.

Parse_Date $2
check_date $day $month $year

strip_leading_zero $day
day=$?
strip_leading_zero $month
month=$?

day_index $day $month $year
date2=$?

abs $date2                         # Make sure it's positive.
date2=$value

calculate_difference $date1 $date2

abs $diff                          # Make sure it's positive.
diff=$value

echo $diff

exit 0
# Compare this script with the implementation of Gauss' Formula in C at
# http://buschencrew.hypermart.net/software/datedif
```

+

The following two scripts are by Mark Moraes of the University of Toronto. See the enclosed file "Moraes-COPYRIGHT" for permissions and restrictions.

Example A-7. 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 # 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 # ==> Exercise for the reader: Add error checking and other options.
22 # ==>
23 # ==> Note that the small sed script repeats, except for the arg passed.
24 # ==> Does it make sense to embed it in a function? Why or why not?
```

Example A-8. ftpget: Downloading files via ftp

```
#! /bin/sh
# $Id: ftpget,v 1.2 91/05/07 21:15:43 moraes Exp $
# Script to perform batch anonymous ftp. Essentially converts a list of
# of command line arguments into input to ftp.
# Simple, and quick - written as a companion to ftplist
# -h specifies the remote host (default prep.ai.mit.edu)
# -d specifies the remote directory to cd to - you can provide a sequence
# of -d options - they will be cd'ed to in turn. If the paths are relative,
# make sure you get the sequence right. Be careful with relative paths -
# there are far too many symlinks nowadays.
# (default is the ftp login directory)
# -v turns on the verbose option of ftp, and shows all responses from the
# ftp server.
# -f remotefile[:localfile] gets the remote file into localfile
# -m pattern does an mget with the specified pattern. Remember to quote
# shell characters.
# -c does a local cd to the specified directory
# For example,
#  ftpget -h expo.lcs.mit.edu -d contrib -f xplaces.shar:xplaces.sh \
#           -d ../pub/R3/fixes -c ~/fixes -m 'fix*'
# will get xplaces.shar from ~ftp/contrib on expo.lcs.mit.edu, and put it in
# xplaces.sh in the current working directory, and get all fixes from
# ~ftp/pub/R3/fixes and put them in the ~/fixes directory.
# Obviously, the sequence of the options is important, since the equivalent
# commands are executed by ftp in corresponding order
#
# Mark Moraes (moraes@csri.toronto.edu), Feb 1, 1989
# ==> Angle brackets changed to parens, so Docbook won't get indigestion.
#


# ==> These comments added by author of this document.

# PATH=/local/bin:/usr/ucb:/usr/bin:/bin
# export PATH
# ==> Above 2 lines from original script probably superfluous.

TMPFILE=/tmp/ftp.$$
# ==> Creates temp file, using process id of script ($$)
# ==> to construct filename.

SITE=`domainname`.toronto.edu
# ==> 'domainname' similar to 'hostname'
# ==> May rewrite this to parameterize this for general use.

usage="Usage: $0 [-h remotehost] [-d remotedirectory]... [-f
remfile:localfile]... \
           [-c localdirectory] [-m filepattern] [-v]"
ftpflags="-i -n"
verbflag=
set -f             # So we can use globbing in -m
set x `getopt vh:d:c:m:f: $*`
```

```
 52 if [ $? != 0 ]; then
 53    echo $usage
 54    exit 65
 55 fi
 56 shift
 57 trap 'rm -f ${TMPFILE} ; exit' 0 1 2 3 15
 58 echo "user anonymous ${USER-gnu}@${SITE} > ${TMPFILE}"
 59 # ==> Added quotes (recommended in complex echoes).
 60 echo binary >> ${TMPFILE}
 61 for i in $*   # ==> Parse command line args.
 62 do
 63    case $i in
 64    -v) verbflag=-v; echo hash >> ${TMPFILE}; shift;;
 65    -h) remhost=$2; shift 2;;
 66    -d) echo cd $2 >> ${TMPFILE};
 67        if [ x${verbflag} != x ]; then
 68            echo pwd >> ${TMPFILE};
 69        fi;
 70        shift 2;;
 71    -c) echo lcd $2 >> ${TMPFILE}; shift 2;;
 72    -m) echo mget "$2" >> ${TMPFILE}; shift 2;;
 73    -f) f1=`expr "$2" : "\([^:]*\).*"`; f2=`expr "$2" : "[^:]*:\(.*\)"`;
 74        echo get ${f1} ${f2} >> ${TMPFILE}; shift 2;;
 75    --) shift; break;;
 76    esac
 77 done
 78 if [ $# -ne 0 ]; then
 79    echo $usage
 80    exit 65   # ==> Changed from "exit 2" to conform with standard.
 81 fi
 82 if [ x${verbflag} != x ]; then
 83    ftpflags="${ftpflags} -v"
 84 fi
 85 if [ x${remhost} = x ]; then
 86    remhost=prep.ai.mit.edu
 87    # ==> Rewrite to match your favorite ftp site.
 88 fi
 89 echo quit >> ${TMPFILE}
 90 # ==> All commands saved in tempfile.
 91
 92 ftp ${ftpflags} ${remhost} < ${TMPFILE}
 93 # ==> Now, tempfile batch processed by ftp.
 94
 95 rm -f ${TMPFILE}
 96 # ==> Finally, tempfile deleted (you may wish to copy it to a logfile).
 97
 98
 99 # ==> Exercises for reader:
100 # ==> 1) Add error checking.
101 # ==> 2) Add bells & whistles.
```

+

Antek Sawicki contributed the following script, which makes very clever use of the parameter substitution operators discussed in Section 9.2.

Example A-9. password: Generating random 8-character passwords

```
 1 #!/bin/bash
 2 # May need to be invoked with  #!/bin/bash2  on older machines.
 3 #
 4 # Random password generator for bash 2.x by Antek Sawicki <tenox@tenox.tc>,
 5 # who generously gave permission to the document author to use it here.
 6 #
 7 # ==> Comments added by document author ==>
 8
 9
10 MATRIX="0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz"
11 LENGTH="8"
12 # ==> May change 'LENGTH' for longer password, of course.
13
14
15 while [ "${n:=1}" -le "$LENGTH" ]
16 # ==> Recall that := is "default substitution" operator.
17 # ==> So, if 'n' has not been initialized, set it to 1.
18 do
19    PASS="$PASS${MATRIX:$(($RANDOM%${#MATRIX})):1}"
20    # ==> Very clever, but tricky.
21
22    # ==> Starting from the innermost nesting...
23    # ==> ${#MATRIX} returns length of array MATRIX.
24
25    # ==> $RANDOM%${#MATRIX} returns random number between 1
26    # ==> and length of MATRIX - 1.
27
28    # ==> ${MATRIX:$(($RANDOM%${#MATRIX})):1}
29    # ==> returns expansion of MATRIX at random position, by length 1.
30    # ==> See {var:pos:len} parameter substitution in Section 3.3.1
31    # ==> and following examples.
32
33    # ==> PASS=... simply pastes this result onto previous PASS (concatenation).
34
35    # ==> To visualize this more clearly, uncomment the following line
36    # ==>             echo "$PASS"
37    # ==> to see PASS being built up,
38    # ==> one character at a time, each iteration of the loop.
39
40    let n+=1
41    # ==> Increment 'n' for next pass.
42 done
```

```
43
44 echo "$PASS"      # ==> Or, redirect to file, as desired.
45
46 exit 0
```

+

James R. Van Zandt contributed this script, which uses named pipes and, in his words, "really exercises quoting and escaping".

Example A-10. 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
31   exit 0
```

+

Stephane Chazelas contributed the following script to demonstrate that generating prime numbers does not require arrays.

Example A-11. Generating prime numbers using the modulo operator

```
#!/bin/bash
# primes.sh: Generate prime numbers, without using arrays.

# This does *not* use the classic "Sieve of Erastosthenes" algorithm,
# but instead uses the more intuitive method of testing each candidate number
# for factors (divisors) up to half its value, using the "%" modulo operator.
#
# Script contributed by Stephane Chazelas,


LIMIT=1000  # Primes 2 - 1000

Primes()
{
 (( n = $1 + 1 ))            # Bump to next integer.
 shift

 if (( n == LIMIT ))
 then echo $*
 return
 fi

 for i; do
   (( i * i > n )) && break   # Need check divisors only halfway to top.
   (( n % i )) && continue    # Sift out non-primes using modulo operator.
   Primes $n $@               # Recursion.
   return
   done

   Primes $n $@ $n            # Recursion.
}

Primes 1

exit 0

# Compare the speed of this algorithm for generating primes
# with the Sieve of Erastosthenes (ex68.sh).

# Exercise: Rewrite this script without recursion, for faster execution.
```

+

Jordi Sanfeliu gave permission to use his elegant *tree* script.

Example A-12. tree: Displaying a directory tree

```
  1 #!/bin/sh
  2 #         @(#) tree      1.1  30/11/95       by Jordi Sanfeliu
  3 #                                          email: mikaku@arrakis.es
  4 #
  5 #         Initial version:  1.0  30/11/95
  6 #         Next version   :  1.1  24/02/97   Now, with symbolic links
  7 #         Patch by       :  Ian Kjos, to support unsearchable dirs
  8 #                           email: beth13@mail.utexas.edu
  9 #
 10 #         Tree is a tool for view the directory tree (obvious :-) )
 11 #
 12
 13 # ==> 'Tree' script used here with the permission of its author, Jordi Sanfeliu.
 14 # ==> Comments added by the author of this document.
 15 # ==> Argument quoting added.
 16
 17
 18 search () {
 19    for dir in `echo *`
 20    # ==> `echo *` lists all the files in current working directory, without line
breaks.
 21    # ==> Similar effect to     for dir in *
 22    # ==> but "dir in `echo *`" will not handle filenames with blanks.
 23    do
 24       if [ -d "$dir" ] ; then   # ==> If it is a directory (-d)...
 25          zz=0   # ==> Temp variable, keeping track of directory level.
 26          while [ $zz != $deep ]    # Keep track of inner nested loop.
 27          do
 28             echo -n "|   "    # ==> Display vertical connector symbol,
 29                           # ==> with 2 spaces & no line feed in order to indent.
 30             zz=`expr $zz + 1` # ==> Increment zz.
 31          done
 32          if [ -L "$dir" ] ; then   # ==> If directory is a symbolic link...
 33             echo "+---$dir" `ls -l $dir | sed 's/^.*'$dir' //'`
 34        # ==> Display horiz. connector and list directory name, but...
 35        # ==> delete date/time part of long listing.
 36          else
 37             echo "+---$dir"      # ==> Display horizontal connector symbol...
 38                                  # ==> and print directory name.
 39             if cd "$dir" ; then  # ==> If can move to subdirectory...
 40                deep=`expr $deep + 1`   # ==> Increment depth.
 41                search     # with recursivity ;-)
 42                      # ==> Function calls itself.
 43                numdirs=`expr $numdirs + 1`   # ==> Increment directory count.
 44             fi
```

```
 45          fi
 46       fi
 47    done
 48    cd ..   # ==> Up one directory level.
 49    if [ "$deep" ] ; then  # ==> If depth = 0 (returns TRUE)...
 50       swfi=1              # ==> set flag showing that search is done.
 51    fi
 52    deep=`expr $deep - 1`  # ==> Decrement depth.
 53 }
 54
 55 # - Main -
 56 if [ $# = 0 ] ; then
 57    cd `pwd`    # ==> No args to script, then use current working directory.
 58 else
 59    cd $1       # ==> Otherwise, move to indicated directory.
 60 fi
 61 echo "Initial directory = `pwd`"
 62 swfi=0      # ==> Search finished flag.
 63 deep=0      # ==> Depth of listing.
 64 numdirs=0
 65 zz=0
 66
 67 while [ "$swfi" != 1 ]   # While flag not set...
 68 do
 69    search   # ==> Call function after initializing variables.
 70 done
 71 echo "Total directories = $numdirs"
 72
 73 exit 0
 74 # ==> Challenge to reader: try to figure out exactly how this script works.
```

Noah Friedman gave permission to use his *string function* script, which essentially reproduces some of the C-library string manipulation functions.

Example A-13. string functions: C-like 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 variabl 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 $s2
153 #
154 # Strcspn returns the length of the maximum initial segment of string s1,
155 # which consists entirely of characters not from string s2.
156 #:end docstring:
157
158 ###;;;autoload
159 function strcspn ()
160 {
161     # Unsetting IFS allows whitspace to be handled as normal chars.
162     local IFS=
163     local result="${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 for reader:
267 # Add code to test all the other string functions above.
268
269
270 exit 0
```

Stephane Chazelas demonstrates object-oriented programming a Bash script.

Example A-14. Object-oriented database

```
#!/bin/bash
# obj-oriented.sh: Object-oriented programming in a shell script.
# Script by Stephane Chazelas.


person.new()        # Looks almost like a class declaration in C++.
{
  local obj_name=$1 name=$2 firstname=$3 birthdate=$4

  eval "$obj_name.set_name() {
          eval \"$obj_name.get_name() {
                  echo \$1
                }\"
        }"

  eval "$obj_name.set_firstname() {
          eval \"$obj_name.get_firstname() {
                  echo \$1
                }\"
        }"

  eval "$obj_name.set_birthdate() {
          eval \"$obj_name.get_birthdate() {
            echo \$1
          }\"
          eval \"$obj_name.show_birthdate() {
            echo \$(date -d \"1/1/1970 0:0:\$1 GMT\")
          }\"
          eval \"$obj_name.get_age() {
            echo \$(( (\$(date +%s) - \$1) / 3600 / 24 / 365 ))
          }\"
        }"

  $obj_name.set_name $name
  $obj_name.set_firstname $firstname
  $obj_name.set_birthdate $birthdate
}

echo

person.new self Bozeman Bozo 101272413
# Create an instance of "person.new" (actually passing args to the function).

self.get_firstname      #   Bozo
self.get_name           #   Bozeman
self.get_age            #   28
self.get_birthdate      #   101272413
```

```
48 self.show_birthdate      #   Sat Mar 17 20:13:33 MST 1973
49
50 echo
51
52 # typeset -f
53 # to see the created functions (careful, it scrolls off the page).
54
55 exit 0
```

Appendix B. 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-like syntax

For all their differences, the two utilities share a similar invocation syntax, both use regular expressions , both read input by default from `stdin`, and both output to `stdout`. These are well-behaved UNIX tools, and they work together well. The output from one can be piped into the other, and their combined capabilities give shell scripts some of the power of Perl.

Note One important difference between the utilities is that while shell scripts can easily pass arguments to sed, it is more complicated for awk (see Example 2-5 and Example 9-17).

B.1. Sed

Sed is a non-interactive line 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. [1] 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 **p**rinting (to `stdout`), **d**eletion, and **s**ubstitution.

Table B-1. Basic sed operators

Operator	Name	Effect
`[address-range]/p`	print	Print [specified address range]

`[address-range]/d`	delete	Delete [specified address range]
`s/pattern1/pattern2/`	substitute	Substitute pattern2 for first instance of pattern1 in a line
`[address-range]/s/pattern1/pattern2/`	substitute	Substitute pattern2 for first instance of pattern1 in a line, over *`address-range`*
`[address-range]/y/pattern1/pattern2/`	transform	replace any character in pattern1 with the corresponding character in pattern2, over *`address-range`* (equivalent of **tr**)
g	global	Operate on *every* pattern match within each matched line of input

Note 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'
   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.)
```

Note Both sed and awk use 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 option may be omitted.

```
   1 sed -n '/xzy/p'
   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 B-2. Examples

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 -n 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.
`/GUI/d`	Delete all lines containing "GUI".
`s/GUI//g`	Delete all instances of "GUI", leaving the remainder of each line intact.

Note 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
```

Tip A quick way to double-space a text file is **`sed G filename`**.

For illustrative examples of sed within shell scripts, see:

1. Example 2-3
2. Example 2-4
3. Example 12-2
4. Example A-3
5. Example 12-10
6. Example 12-18
7. Example A-7
8. Example A-12
9. Example 12-22
10. Example 10-8
11. Example 12-27
12. Example A-2
13. Example 12-8

For a more extensive treatment of sed, check the appropriate references in the *Bibliography*.

Notes

[1] If no address range is specified, the default is *all* lines.

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B.2. Awk

Awk

Awk 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 couple of these here - the ones most useful for shell scripting.

Awk breaks each line of input passed to it into *fields*. By default, a field is a string of consecutive characters separated by whitespace, though there are options for changing the delimiter. Awk parses and operates on each separate field. This makes awk ideal for handling structured text files, especially tables, data organized into consistent chunks, such as rows and columns.

Strong quoting (single quotes) and curly brackets enclose segments of awk code within a shell script.

```
1 awk '{print $3}'
2 # Prints field #3 to stdout.
3
4 awk '{print $1 $5 $6}'
5 # Prints fields #1, #5, and #6.
```

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 needs to be an **END** command to terminate the processing.

```
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.

For examples of awk within shell scripts, see:

1. Example 11-8
2. Example 16-5
3. Example 12-22
4. Example 2-5
5. Example 9-17
6. Example 11-12
7. Example 28-1
8. Example 28-2
9. Example 10-3
10. Example 12-30
11. Example 9-20

That's all the awk we'll cover here, folks, but there's lots more to learn. See the appropriate references in the *Bibliography*.

Appendix C. Exit Codes With Special Meanings

Table C-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"
2	misuse of shell builtins, according to Bash documentation		Seldom seen, usually defaults to exit code 1
126	command invoked cannot execute		permission problem or command is not an executable
127	"command not found"		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
128+n	fatal error signal "n"	**kill -9** $PPIDof script	**$?** returns 137 (128 + 9)
130	script terminated by Control-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 table, exit codes 1 - 2, 126 - 165, and 255 have special meanings, and should therefore be avoided as user-specified exit parameters. Ending a script with **exit 127** would certainly cause confusion when troubleshooting (is the error 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, this might not add any additional ambiguity, but, on the other hand, it probably would not be very informative either.

There has been an attempt to systematize exit status numbers (see `/usr/include/sysexits.h`), but this is intended mostly for C and C++ programmers. It would be well to support a similar standard for scripts. 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 still leave 50 valid codes, and make troubleshooting scripts more straightforward.

All user-defined exit codes in the accompanying examples to this document now conform to this standard, except where overriding circumstances exist, as in Example 9-2.

Note 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.

Appendix D. A Detailed Introduction to I/O and I/O Redirection

written by Stephane 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 ouput 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 permissable). 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 &
  5 exec 7> /tmp/fifo1
  6 exec 8> >(while read a; do echo "FD8: $a, to fd7"; done >&7)
  7
  8 exec 3>&1
  9 (
 10  (
 11   (
 12    while read a; do echo "FIFO2: $a"; done < /tmp/fifo2 | tee /dev/stderr | tee
/dev/fd/4 | tee /dev/fd/5 | tee /dev/fd/6 >&7 &
 13    exec 3> /tmp/fifo2
 14
 15    echo 1st, to stdout
 16    sleep 1
 17    echo 2nd, to stderr >&2
 18    sleep 1
 19    echo 3rd, to fd 3 >&3
 20    sleep 1
 21    echo 4th, to fd 4 >&4
 22    sleep 1
 23    echo 5th, to fd 5 >&5
 24    sleep 1
 25    echo 6th, through a pipe | sed 's/.*/PIPE: &, to fd 5/' >&5
 26    sleep 1
 27    echo 7th, to fd 6 >&6
 28    sleep 1
 29    echo 8th, to fd 7 >&7
 30    sleep 1
 31    echo 9th, to fd 8 >&8
 32
 33   ) 4>&1 >&3 3>&- | while read a; do echo "FD4: $a"; done 1>&3 5>&- 6>&-
 34  ) 5>&1 >&3 | while read a; do echo "FD5: $a"; done 1>&3 6>&-
```

```
35 ) 6>&1 >&3 | while read a; do echo "FD6: $a"; done 3>&-
36
37 rm -f /tmp/fifo1 /tmp/fifo2
38
39
40 # For each command and subshell, figure out which fd points to what.
41
42 exit 0
```

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Appendix E. 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
 4 E_CDERROR=65
 5
 6 error()
 7 {
 8   printf "$@" >&2
 9   exit $E_CDERROR
10 }
11
12 cd $var || error $"Can't cd to %s." "$var"
13 read -p $"Enter the value: " var
14 # ...
```

```
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.

Now, build a `language.po` file for each language that the script will be translated into, specifying the *`msgstr`*. As an example:

fr.po:

```
1 #: a:6
2 msgid "Can't cd to %s."
3 msgstr "Impossible de se positionner dans le répertoire %s."
4 #: a:7
5 msgid "Enter the value: "
6 msgstr "Entrez la valeur : "
```

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.

Note 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 exported to the environment.

This appendix written by Stephane Chazelas.

Appendix F. A Sample .bashrc File

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. Study this file carefully, and feel free to reuse code snippets and functions from it in your own .bashrc file and even in your scripts.

Example F-1. Sample .bashrc file

```
  1 #=============================================================
  2 #
  3 # PERSONAL $HOME/.bashrc FILE for bash-2.04 (or later)
  4 #
  5 # This file is read (normally) by interactive shells only.
  6 # Here is the place to define your aliases, functions and
  7 # other interactive features like your prompt.
  8 #
  9 # This file was designed (originally) for Solaris.
 10 # --> Modified for Linux.
 11 #
 12 #=============================================================
 13
 14 # --> Comments added by HOWTO author.
 15
 16
 17 #-----------------------------------
 18 # Source global definitions (if any)
 19 #-----------------------------------
 20
 21 if [ -f /etc/bashrc ]; then
 22    . /etc/bashrc   # --> Read /etc/bashrc, if present.
 23 fi
 24
 25
 26 #--------------------------------------------------------------
 27 # Automatic setting of $DISPLAY (if not set already)
 28 # This works for linux and solaris - your mileage may vary....
 29 #--------------------------------------------------------------
 30
 31
 32 if [ -z ${DISPLAY:=""} ]; then
 33     DISPLAY=$(who am i)
```

```
 34     DISPLAY=${DISPLAY%%\!*}
 35     if [ -n "$DISPLAY" ]; then
 36    export DISPLAY=$DISPLAY:0.0
 37     else
 38    export DISPLAY=":0.0"  # fallback
 39     fi
 40 fi
 41
 42
 43 #---------------
 44 # Some settings
 45 #---------------
 46
 47 set -o notify
 48 set -o noclobber
 49 set -o ignoreeof
 50 set -o nounset
 51 #set -o xtrace             # useful for debuging
 52
 53 shopt -s cdspell
 54 shopt -s cdable_vars
 55 shopt -s checkhash
 56 shopt -s checkwinsize
 57 shopt -s mailwarn
 58 shopt -s sourcepath
 59 shopt -s no_empty_cmd_completion
 60 shopt -s histappend histreedit
 61 shopt -s extglob   # useful for programmable completion
 62
 63
 64
 65 #-----------------------
 66 # Greeting, motd etc...
 67 #-----------------------
 68
 69 # Define some colors first:
 70 red='\e[0;31m'
 71 RED='\e[1;31m'
 72 blue='\e[0;34m'
 73 BLUE='\e[1;34m'
 74 cyan='\e[0;36m'
 75 CYAN='\e[1;36m'
 76 NC='\e[0m'         # No Color
 77 # --> Nice. Has the same effect as using "ansi.sys" in DOS.
 78
 79 # Looks best on a black background.....
 80 echo -e "${CYAN}This is BASH ${RED}${BASH_VERSION%.*}${CYAN} - DISPLAY on
${RED}$DISPLAY${NC}\n"
 81 date
 82
 83
 84 function _exit()   # function to run upon exit of shell
 85 {
```

```
 86     echo -e "${RED}Hasta la vista, baby${NC}"
 87 }
 88 trap _exit 0
 89
 90 #---------------
 91 # Shell prompt
 92 #---------------
 93
 94
 95 function fastprompt()
 96 {
 97     unset PROMPT_COMMAND
 98     case $TERM in
 99    *term | rxvt )
100        PS1="[\h] \W > \[\033]0;[\u@\h] \w\007\]" ;;
101    *)
102        PS1="[\h] \W > " ;;
103     esac
104 }
105
106
107 function powerprompt()
108 {
109     _powerprompt()
110     {
111    LOAD=$(uptime|sed -e "s/.*: \([^,]*\).*/\1/" -e "s/ //g")
112    TIME=$(date +%H:%M)
113     }
114
115     PROMPT_COMMAND=_powerprompt
116     case $TERM in
117    *term | rxvt  )
118        PS1="${cyan}[\$TIME \$LOAD]$NC\n[\h \#] \W > \[\033]0;[\u@\h] \w\007\]"
;;
119    linux )
120        PS1="${cyan}[\$TIME - \$LOAD]$NC\n[\h \#] \w > " ;;
121    * )
122        PS1="[\$TIME - \$LOAD]\n[\h \#] \w > " ;;
123     esac
124 }
125
126 powerprompt        # this is the default prompt - might be slow
127            # If too slow, use fastprompt instead....
128
129
130
131 #================================================================
132 #
133 # ALIASES AND FUNCTIONS
134 #
135 # Arguably, some functions defined here are quite big
136 # (ie 'lowercase') but my workstation has 512Meg of RAM, so .....
```

```
137 # If you want to make this file smaller, these functions can
138 # be converted into scripts.
139 #
140 # Many functions were taken (almost) straight from the bash-2.04
141 # examples.
142 #
143 #============================================================
144
145 #------------------
146 # Personnal Aliases
147 #------------------
148
149 alias rm='rm -i'
150 alias cp='cp -i'
151 alias mv='mv -i'
152 # -> Prevents accidentally clobbering files.
153
154 alias h='history'
155 alias j='jobs -l'
156 alias r='rlogin'
157 alias which='type -a'
158 alias ..='cd ..'
159 alias path='echo -e ${PATH//:/\\n}'
160 alias print='/usr/bin/lp -o nobanner -d $LPDEST'
161 alias pjet='enscript -h -G -fCourier9 -d $LPDEST '
162 alias vi='vim'
163 alias du='du -h'
164 alias df='df -kh'
165
166 alias ls='ls -hF --color'
167 alias lx='ls -lXB'
168 alias lk='ls -lSr'
169 alias la='ls -Al'
170 alias lr='ls -lR'
171 alias lt='ls -ltr'
172 alias lm='ls -al |more'
173
174 alias background='xv -root -quit -max -rmode 5'
175
176 alias more='less'
177 export PAGER=less
178 export LESSCHARSET='latin1'
179 export LESSOPEN='|lesspipe.sh %s'  # Use this if lesspipe.sh exists
180 export LESS='-i -N -w  -z-4 -g -e -M -X -F -R -P%t?f%f \
181 :stdin .?pb%pb\%:?lbLine %lb:?bbByte %bb:-...'
182
183 # spelling typos
184
185 alias xs='cd'
186 alias vf='cd'
187 alias moer='more'
188 alias moew='more'
189 alias kk='ll'
```

```
190
191
192
193
194
195 #----------------
196 # a few fun ones
197 #----------------
198
199 function xtitle ()
200 {
201     case $TERM in
202    *term | rxvt)
203        echo -n -e "\033]0;$*\007" ;;
204    *)  ;;
205     esac
206 }
207
208 alias top='xtitle Processes on $HOST && top'
209 alias make='xtitle Making $(basename $PWD) ; make'
210 alias ncftp="xtitle ncFTP ; ncftp"
211
212
213 #---------------
214 # and functions
215 #---------------
216
217 function man ()
218 {
219     xtitle The $(basename $1|tr -d .[:digit:]) manual
220     man -a "$*"
221 }
222
223
224
225 function ll(){ ls -l  $*| egrep "^d" ; ls -lh  $* 2>&-| egrep -v "^d|total "; }
226 function xemacs() { { command xemacs -private $* 2>&- & } && disown ;}
227 function te()  # wrapper around xemacs/gnuserv
228 {
229     if [ "$(gnuclient -batch -eval t 2>&-)" == "t" ]; then
230    gnuclient -q $@;
231     else
232    ( xemacs $@ & );
233     fi
234 }
235
236
237 #----------------------------------
238 # File & strings related functions:
239 #----------------------------------
240
241 function ff() { find . -name '*'$1'*' ; }
```

```
function fe() { find . -name '*'$1'*' -exec $2 {} \; ; }
function fstr() # find a string in a set of files
{
    if [ "$#" -gt 2 ]; then
        echo "Usage: fstr \"pattern\" [files] "
   return;
    fi
    SMSO=$(tput smso)
    RMSO=$(tput rmso)
    find . -type f -name "${2:-*}" -print | xargs grep -sin "$1" | \
sed "s/$1/$SMSO$1$RMSO/gI"
}
function cuttail() # cut last n lines in file, 10 by default
{
    nlines=${2:-10}
    sed -n -e :a -e "1,${nlines}!{P;N;D;};N;ba" $1
}

function lowercase()  # move filenames to lowercase
{
    for file ; do
        filename=${file##*/}
        case "$filename" in
        */*) dirname==${file%/*} ;;
        *) dirname=.;;
        esac
        nf=$(echo $filename | tr A-Z a-z)
        newname="${dirname}/${nf}"
        if [ "$nf" != "$filename" ]; then
            mv "$file" "$newname"
            echo "lowercase: $file --> $newname"
        else
            echo "lowercase: $file not changed."
        fi
    done
}

function swap()            # swap 2 filenames around
{
    local TMPFILE=tmp.$$
    mv $1 $TMPFILE
    mv $2 $1
    mv $TMPFILE $2
}



# Misc utilities:

function repeat()  # repeat n times command
{
    local i max
    max=$1; shift;
```

```
295     for ((i=1; i <= max ; i++)); do  # --> C-like syntax
296    eval "$@";
297     done
298 }
299
300
301 function ask()
302 {
303     echo -n "$@" '[y/n] ' ; read ans
304     case "$ans" in
305         y*|Y*) return 0 ;;
306         *) return 1 ;;
307     esac
308 }
309
310
311
312 #============================================================================
313 #
314 # PROGRAMMABLE COMPLETION - ONLY IN BASH-2.04
315 # (Most are taken from the bash 2.04 documentation)
316 #
317 #============================================================================
318
319 if [ "${BASH_VERSION%.*}" \< "2.04" ]; then
320     echo "No programmable completion available"
321     return
322 fi
323
324 shopt -s extglob   # necessary
325
326 complete -A hostname   rsh rcp telnet rlogin r ftp ping disk
327 complete -A command    nohup exec eval trace gdb
328 complete -A command    command type which
329 complete -A export     printenv
330 complete -A variable   export local readonly unset
331 complete -A enabled    builtin
332 complete -A alias      alias unalias
333 complete -A function   function
334 complete -A user       su mail finger
335
336 complete -A helptopic  help        # currently same as builtins
337 complete -A shopt      shopt
338 complete -A stopped -P '%' bg
339 complete -A job -P '%'     fg jobs disown
340
341 complete -A directory  mkdir rmdir
342
343 complete -f -X '*.gz'   gzip
344 complete -f -X '!*.ps'  gs ghostview gv
345 complete -f -X '!*.pdf' acroread
346 complete -f -X '!*.+(gif|jpg|jpeg|GIF|JPG|bmp)' xv gimp
```

```
347
348
349 _make_targets ()
350 {
351     local mdef makef gcmd cur prev i
352
353     COMPREPLY=()
354     cur=${COMP_WORDS[COMP_CWORD]}
355     prev=${COMP_WORDS[COMP_CWORD-1]}
356
357     # if prev argument is -f, return possible filename completions.
358     # we could be a little smarter here and return matches against
359     # `makefile Makefile *.mk', whatever exists
360     case "$prev" in
361    -*f)    COMPREPLY=( $(compgen -f $cur ) ); return 0;;
362     esac
363
364     # if we want an option, return the possible posix options
365     case "$cur" in
366    -)      COMPREPLY=(-e -f -i -k -n -p -q -r -S -s -t); return 0;;
367     esac
368
369     # make reads `makefile' before `Makefile'
370     if [ -f makefile ]; then
371    mdef=makefile
372     elif [ -f Makefile ]; then
373    mdef=Makefile
374     else
375    mdef=*.mk               # local convention
376     fi
377
378     # before we scan for targets, see if a makefile name was specified
379     # with -f
380     for (( i=0; i < ${#COMP_WORDS[@]}; i++ )); do
381    if [[ ${COMP_WORDS[i]} == -*f ]]; then
382        eval makef=${COMP_WORDS[i+1]}       # eval for tilde expansion
383        break
384    fi
385     done
386
387    [ -z "$makef" ] && makef=$mdef
388
389     # if we have a partial word to complete, restrict completions to
390     # matches of that word
391     if [ -n "$2" ]; then gcmd='grep "^$2"' ; else gcmd=cat ; fi
392
393     # if we don't want to use *.mk, we can take out the cat and use
394     # test -f $makef and input redirection
395     COMPREPLY=( $(cat $makef 2>/dev/null | awk 'BEGIN {FS=":"} /^[^.#
][^=]*:/ {print $1}' | tr -s ' ' '\012' | sort -u | eval $gcmd ) )
396 }
397
398 complete -F _make_targets -X '+($*|*.[cho])' make gmake pmake
```

```
399
400
401 _configure_func ()
402 {
403     case "$2" in
404    -*)     ;;
405    *)      return ;;
406     esac
407
408     case "$1" in
409    \~*)    eval cmd=$1 ;;
410    *)      cmd="$1" ;;
411     esac
412
413     COMPREPLY=( $("$cmd" --help | awk '{if ($1 ~ /--.*/) print $1}' | grep ^"$2"
| sort -u) )
414 }
415
416 complete -F _configure_func configure
417
418 _killall ()
419 {
420     local cur prev
421     COMPREPLY=()
422     cur=${COMP_WORDS[COMP_CWORD]}
423
424     # get a list of processes (the first sed evaluation
425     # takes care of swapped out processes, the second
426     # takes care of getting the basename of the process)
427     COMPREPLY=( $( /usr/bin/ps -u $USER -o comm  | \
428    sed -e '1,1d' -e 's#[]\[]##g' -e 's#^.*/##'| \
429    awk '{if ($0 ~ /^'$cur'/) print $0}' ))
430
431     return 0
432 }
433
434 complete -F _killall killall
435
436
437 # Local Variables:
438 # mode:shell-script
439 # sh-shell:bash
440 # End:
```

Appendix G. 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 script ones.

Table G-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 *FILENAME*	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 G-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

Note Virtually all UNIX and shell operators and commands have many more options and enhancements than their DOS and batch file equivalents. Many DOS batch files rely on auxiliary utilities, such as **ask.com**, a crippled counterpart to read.

DOS supports a very limited and incompatible subset of filename wildcard expansion, recognizing only the * and ? characters.

Converting a DOS batch file into a shell script is generally straightforward, and the result ofttimes reads better than the original.

Example G-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.

Example G-2. viewdata.sh: Shell Script Conversion of VIEWDATA.BAT

```
 1 #!/bin/bash
 2 # Conversion of VIEWDATA.BAT to shell script.
 3
 4 DATAFILE=/home/bozo/datafiles/book-collection.data
 5 ARGNO=1
 6
 7 # @ECHO OFF       Command unnecessary here.
 8
 9 if [ $# -lt "$ARGNO" ]    # IF !%1==! GOTO VIEWDATA
10 then
11   less $DATAFILE          # TYPE C:\MYDIR\BOOKLIST.TXT | MORE
12 else
13   grep "$1" $DATAFILE     # FIND "%1" C:\MYDIR\BOOKLIST.TXT
14 fi
15
16 exit 0                   # :EXIT0
17
18 # GOTOs, labels, smoke-and-mirrors, and flimflam unnecessary.
19 # The converted script is short, sweet, and clean,
20 # which is more than can be said for the original.
```

Ted Davis' Shell Scripts on the PC site has a set of comprehensive tutorials on the old-fashioned art of batch file programming. Certain of his ingenious techniques could conceivably have relevance for shell scripts.

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Appendix H. Copyright

Hyun Jin Cha has done a Korean translation of an earlier version of this document. If you wish to translate it into another language, please feel free to do so, subject to the terms stated above. The author would appreciate being notified of such efforts.

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