

CONTENTS IN DETAIL

ACKNOWLEDGMENTS	xxv
------------------------	------------

INTRODUCTION	xxvii
---------------------	--------------

Why Use the Command Line?	xxviii
What This Book Is About.	xxix
Who Should Read This Book	xxix
What's in This Book	xxx
How to Read This Book.	xxx
Prerequisites	xxx
What's New in the Third Print Edition	xxxii
Your Feedback Is Needed!	xxxii

PART I: LEARNING THE SHELL **1**

1	
WHAT IS THE SHELL?	3

Terminal Emulators	4
Making Your First Keystrokes	4
Command History	4
Cursor Movement	5
Try Some Simple Commands	5
Ending a Terminal Session	6
Summing Up	7

2	
NAVIGATION	9

Understanding the Filesystem Tree	9
The Current Working Directory	10
Listing the Contents of a Directory	11
Changing the Current Working Directory	11
Absolute Pathnames	11
Relative Pathnames	11
Some Helpful Shortcuts	13
Summing Up	14

3	EXPLORING THE SYSTEM	15
More Fun with ls		15
Options and Arguments		16
A Longer Look at Long Format		17
Determining a File's Type with file		18
Viewing File Contents with less		19
Taking a Guided Tour		20
Symbolic Links		23
Hard Links		23
Summing Up		24
4	MANIPULATING FILES AND DIRECTORIES	25
Wildcards		26
Dot Files		28
mkdir—Create Directories		28
cp—Copy Files and Directories		29
Useful Options and Examples		29
mv—Move and Rename Files		30
Useful Options and Examples		30
rm—Remove Files and Directories		31
Useful Options and Examples		31
ln—Create Links		32
Hard Links		33
Symbolic Links		33
Let's Build a Playground		34
Creating Directories		34
Copying Files		34
Moving and Renaming Files		35
Creating Hard Links		36
Creating Symbolic Links		37
Removing Files and Directories		38
Summing Up		39
5	WORKING WITH COMMANDS	41
What Exactly Are Commands?		42
Identifying Commands		42
type—Display a Command's Type		42
which—Display an Executable's Location		43
Getting a Command's Documentation		43
help—Get Help for Shell Builtins		43
--help—Display Usage Information		44
man—Display a Program's Manual Page		45
apropos—Display Appropriate Commands		46
whatis—Display One-Line Manual Page Descriptions		46
info—Display a Program's Info Entry		47
README and Other Program Documentation Files		48

Creating Our Own Commands with alias	48
Summing Up	50
6	
REDIRECTION	51
Standard Input, Output, and Error	52
Redirecting Standard Output	52
Group Commands	54
Redirecting Standard Error	54
Redirecting Standard Output and Standard Error to One File	55
Disposing of Unwanted Output	55
Redirecting Standard Input	56
cat—Concatenate Files	56
Pipelines	58
Filters	58
uniq—Report or Omit Repeated Lines	59
wc—Print Line, Word, and Byte Counts	60
grep—Print Lines Matching a Pattern	60
head/tail—Print First/Last Part of Files	61
tee—Read from Stdin and Output to Stdout and Files.	62
Summing Up	63
7	
SEEING THE WORLD AS THE SHELL SEES IT	65
Expansion	65
Pathname Expansion	66
Tilde Expansion	68
Arithmetic Expansion	68
Brace Expansion	69
Parameter Expansion	70
Command Substitution	71
Quoting	71
Double Quotes	72
Single Quotes	74
Escaping Characters	74
Backslash Escape Sequences	74
Summing Up	75
8	
ADVANCED KEYBOARD TRICKS	77
Command Line Editing	78
Cursor Movement	78
Modifying Text	78
Cutting and Pasting (Killing and Yanking) Text.	79
Command Completion	80
Using History	81
Searching History	82
History Expansion	83
Summing Up	84

9		
PERMISSIONS		85
Users, Group Members, and Everybody Else		86
Reading, Writing, and Executing		87
chmod—Change File Mode		89
Setting File Mode with the GUI		92
umask—Set Default Permissions		93
Some Special Permissions		94
Changing Identities		95
su—Run a Shell with Substitute User and Group IDs.		95
sudo—Execute a Command as Another User		96
chown—Change File Owner and Group		98
chgrp—Change Group Ownership		98
Exercising Our Privileges.		99
Changing Your Password		100
Summing Up		101

10		
PROCESSES		103
How a Process Works.		104
Viewing Processes		104
Viewing Processes Dynamically with top		107
Controlling Processes		109
Interrupting a Process		109
Putting a Process in the Background		109
Returning a Process to the Foreground		110
Stopping (Pausing) a Process		111
Changing Process Priority		111
Signals		112
Sending Signals to Processes with kill		113
Making a Process Hang-Up Proof		115
Sending Signals to Multiple Processes with killall.		115
Shutting Down the System		116
More Process-Related Commands.		117
Summing Up		117

PART II: CONFIGURATION AND THE ENVIRONMENT **119**

11		
THE ENVIRONMENT		121
What Is Stored in the Environment?		122
Examining the Environment.		122
Some Interesting Variables		123

How Is the Environment Established?	124
What's in a Startup File?	125
Exploring How Child Processes Inherit Their Environments	126
Launching a Program with a Temporary Environment	128
Modifying the Environment	128
Which Files Should We Modify?	128
Text Editors	129
Using a Text Editor	129
Activating Our Changes	132
Summing Up	133

12

A GENTLE INTRODUCTION TO VI(M) 135

Why We Should Learn vi	136
A Little Background	136
Starting and Stopping vi	136
Editing Modes	138
Entering Insert Mode	139
Saving Our Work	139
Moving the Cursor Around	139
Basic Editing	140
Appending Text	140
Opening a Line	141
Deleting Text	142
Cutting, Copying, and Pasting Text	143
Joining Lines	144
Search-and-Replace	144
Searching Within a Line	145
Searching the Entire File	145
Global Search-and-Replace	145
Editing Multiple Files	147
Switching Between Files	147
Opening Additional Files for Editing	148
Copying Content from One File into Another	148
Inserting an Entire File into Another	149
Saving Our Work	150
bash Does vi Too	150
Summing Up	151

13

CUSTOMIZING THE PROMPT 153

Anatomy of a Prompt	153
Trying Some Alternative Prompt Designs	155
Adding Color	156
Moving the Cursor	158
Saving the Prompt	159
Summing Up	160

PART III: COMMON TASKS AND ESSENTIAL TOOLS

161

14 PACKAGE MANAGEMENT 163

Packaging Systems	164
How a Package System Works	164
Package Files	164
Repositories	165
Dependencies	165
High- and Low-Level Package Tools	166
Common Package Management Tasks	166
Finding a Package in a Repository	167
Installing a Package from a Repository	167
Installing a Package from a Package File	167
Removing a Package	168
Updating Packages from a Repository	168
Upgrading a Package from a Package File	169
Listing Installed Packages	169
Determining Whether a Package Is Installed	169
Displaying Information About an Installed Package	170
Finding Which Package Installed a File	170
Summing Up	171

15 STORAGE MEDIA 173

Mounting and Unmounting Storage Devices	174
Viewing a List of Mounted Filesystems	175
Determining Device Names	178
Creating New Filesystems	181
Manipulating Partitions with parted	182
Creating a New Filesystem with mkfs	185
Testing and Repairing Filesystems	186
Moving Data Directly to and from Devices	187
Creating CD-ROM Images	187
Creating an Image Copy of a CD-ROM	187
Creating an Image from a Collection of Files	188
Writing CD-ROM Images	188
Mounting an ISO Image Directly	189
Blanking a Rewritable CD-ROM	189
Writing an Image	189
Verifying Data	189
Summing Up	190

16 NETWORKING 191

Examining and Monitoring a Network	192
ping	192
traceroute	193
ip	194

Transporting Files Over a Network	195
ftp	195
lftp—A Better ftp	197
curl—Transfer a URL	197
wget—Non-Interactive Network Downloader	198
Secure Communication with Remote Hosts	198
ssh	198
scp and sftp	202
Summing Up	203

17

SEARCHING FOR FILES 205

locate—Find Files the Easy Way	206
find—Find Files the Hard Way	207
Tests	208
Operators	210
Predefined Actions	212
User-Defined Actions	214
Improving Efficiency	214
xargs	215
A Return to the Playground	216
Options	218
Summing Up	218

18

ARCHIVING AND BACKUP 219

Compressing Files	220
gzip	220
bzip2	222
Archiving Files	223
tar	223
zip	228
Synchronizing Files and Directories	230
Using rsync Over a Network	232
Summing Up	233

19

REGULAR EXPRESSIONS 235

What Are Regular Expressions?	236
grep	236
Metacharacters and Literals	237
The Any Character	238
Anchors	239
Bracket Expressions and Character Classes	240
Negation	240
Traditional Character Ranges	241
POSIX Character Classes	242
POSIX Basic vs. Extended Regular Expressions	245
Alternation	246

Quantifiers	247
?—Match an Element Zero or One Time	247
*—Match an Element Zero or More Times	247
+—Match an Element One or More Times	248
{ }—Match an Element a Specific Number of Times	248
Putting Regular Expressions to Work	249
Validating a Phone List with grep	249
Finding Ugly Filenames with find	250
Searching for Files with locate	251
Searching for Text with less and vim	251
Summing Up	253

20

TEXT PROCESSING

255

Applications of Text	256
Documents	256
Web Pages	256
Email	256
Printer Output	257
Program Source Code	257
Revisiting Some Old Friends	257
cat	257
sort	259
uniq	264
Slicing and Dicing	266
cut	266
paste	269
join	270
tac	272
rev	272
Comparing Text	273
comm	273
diff	274
patch	276
Editing on the Fly	277
tr	277
sed	279
aspell	286
Summing Up	289
Extra Credit	289

21

FORMATTING OUTPUT

291

Simple Formatting Tools	292
nl—Number Lines	292
fold—Wrap Each Line to a Specified Length	294
fmt—A Simple Text Formatter	295
pr—Format Text for Printing	298
printf—Format and Print Data	299

Document Formatting Systems	302
groff	302
Summing Up	307

22 PRINTING 309

A Brief History of Printing	310
Printing in the Dim Times	310
Character-Based Printers	310
Graphical Printers	311
Printing with Linux	312
Preparing Files for Printing	312
pr—Convert Text Files for Printing	313
Sending a Print Job to a Printer	314
lpr—Print Files (Berkeley Style)	314
lp—Print Files (System V Style)	315
Another Option: a2ps	315
Monitoring and Controlling Print Jobs	317
lpstat—Display Print System Status	317
lpq—Display Printer Queue Status	318
lprm/cancel—Cancel Print Jobs	319
Summing Up	319

23 COMPILING PROGRAMS 321

What Is Compiling?	322
Are All Programs Compiled?	323
Compiling a C Program	323
Obtaining the Source Code	324
Examining the Source Tree	325
Building the Program	327
Installing the Program	330
Summing Up	330

PART IV: WRITING SHELL SCRIPTS 331

24 WRITING YOUR FIRST SCRIPT 333

What Are Shell Scripts?	334
How to Write a Shell Script	334
Script File Format	334
Executable Permissions	335
Script File Location	335
Good Locations for Scripts	336
More Formatting Tricks	337
Long Option Names	337
Indentation and Line-Continuation	337
Summing Up	339

25		
STARTING A PROJECT		341
First Stage: Minimal Document		342
Second Stage: Adding a Little Data		343
Variables and Constants		344
Assigning Values to Variables and Constants		346
Here Documents		348
Summing Up		350
26		
TOP-DOWN DESIGN		351
Shell Functions		352
Local Variables		355
Shell Functions and Redirection		356
Keep Scripts Running		357
Summing Up		360
27		
FLOW CONTROL: BRANCHING WITH IF		361
if Statements		362
Exit Status		362
Using test		364
File Expressions		364
String Expressions		367
Integer Expressions		368
A More Modern Version of test		369
(())—Designed for Integers		370
Combining Expressions		371
Control Operators: Another Way to Branch		373
Summing Up		374
28		
READING KEYBOARD INPUT		377
read—Read Values from Standard Input		378
Options		380
IFS		382
Validating Input		384
Menus		385
Summing Up		387
Extra Credit		387
29		
FLOW CONTROL: LOOPING WITH WHILE/UNTIL		389
Looping		390
while		390
break and continue		392
select		393
until		396

Reading Files with Loops	397
Summing Up	397
30	
TROUBLESHOOTING	399
Syntactic Errors	399
Missing Quotes	400
Missing or Unexpected Tokens	401
Unanticipated Expansions	402
Logical Errors	403
Defensive Programming	403
set -e, set -u, and set -o pipefail	404
ShellCheck Is Your Friend	405
Watch Out for Filenames	405
Verifying Input	406
Testing	407
Test Cases	408
Debugging	408
Finding the Problem Area	409
Tracing	409
Examining Values During Execution	411
Summing Up	412
31	
FLOW CONTROL: BRANCHING WITH CASE	413
case	414
Patterns	415
Performing Multiple Actions	417
Summing Up	418
32	
POSITIONAL PARAMETERS	419
Accessing the Command Line	419
Determining the Number of Arguments	421
shift—Getting Access to Many Arguments	421
Simple Applications	422
Using Positional Parameters with Shell Functions	423
Handling Positional Parameters en Masse	424
A More Complete Application	425
The getopt options	427
Interactive Mode	429
File Output	429
Summing Up	430
33	
FLOW CONTROL: LOOPING WITH FOR	435
for—Traditional Shell Form	435
for—C Language Form	438
Summing Up	439

34

STRINGS AND NUMBERS

441

Parameter Expansion	442
Basic Parameters.	442
Expansions to Manage Empty Variables.	443
Expansions That Return Variable Names	444
String Operations	445
Case Conversion.	447
Arithmetic Evaluation and Expansion	449
Number Bases	449
Unary Operators.	450
Simple Arithmetic	450
Assignment.	451
Bit Operations	453
Logic	454
The Comma Operator	456
bc—An Arbitrary Precision Calculator Language	456
Using bc	457
An Example Script.	458
Summing Up	459
Extra Credit.	459

35

ARRAYS

461

What Are Arrays?	461
Creating an Array	462
Assigning Values to an Array.	462
Accessing Array Elements	463
Array Operations.	465
Outputting the Entire Contents of an Array	465
Determining the Number of Array Elements	465
Finding the Subscripts Used by an Array	466
Assigning Array Elements with read -a.	466
Adding Elements to the End of an Array.	467
Reading a File Into an Array.	467
Slicing an Array	469
Sorting an Array.	469
Deleting an Array	470
Associative Arrays	471
Using Associative Arrays to Simulate Multiple Dimensions	472
Summing Up	473

36

EXOTICA

475

Group Commands and Subshells 476

Process Substitution 480

Constructing Commands with eval 482

 A Wordle Helper 484

Traps 487

Asynchronous Execution 491

 wait. 491

Named Pipes. 492

 Setting Up a Named Pipe 493

 Using Named Pipes. 493

Summing Up 493

INDEX

495