

# CONTENTS

---

## *PREFACE xxxi*

## CHAPTER 1: WELCOME TO LINUX AND MAC OS X 1

The History of UNIX and GNU-Linux	2
The Heritage of Linux: UNIX	2
Fade to 1983	3
Next Scene, 1991	4
The Code Is Free	5
Have Fun!	5
What Is So Good About Linux?	6
Why Linux Is Popular with Hardware Companies and Developers	9
Linux Is Portable	9
The C Programming Language	10
Overview of Linux	11
Linux Has a Kernel Programming Interface	11
Linux Can Support Many Users	12
Linux Can Run Many Tasks	12
Linux Provides a Secure Hierarchical Filesystem	12
The Shell: Command Interpreter and Programming Language	13
A Large Collection of Useful Utilities	15
Interprocess Communication	15
System Administration	16
Additional Features of Linux	16
GUIs: Graphical User Interfaces	16
(Inter)Networking Utilities	17
Software Development	17
Chapter Summary	18
Exercises	18

## PART I THE LINUX AND MAC OS X OPERATING SYSTEMS 21

### CHAPTER 2: GETTING STARTED 23

- Conventions Used in This Book 24
- Logging In from a Terminal or Terminal Emulator 26
- Working with the Shell 28
  - Which Shell Are You Running? 28
  - Correcting Mistakes 29
  - Repeating/Editing Command Lines 31
- su/sudo: Curbing Your Power (root Privileges) 31
- Where to Find Documentation 33
  - The `--help` Option 33
  - man: Displays the System Manual 33
  - apropos: Searches for a Keyword 35
  - info: Displays Information About Utilities 36
  - HOWTOs: Finding Out How Things Work 38
  - Getting Help with the System 38
- More About Logging In 40
  - Using Virtual Consoles 40
  - What to Do If You Cannot Log In 41
  - Logging Out 41
  - Changing Your Password 41
- Chapter Summary 43
- Exercises 44
- Advanced Exercises 44

### CHAPTER 3: THE UTILITIES 45

- Special Characters 46
- Basic Utilities 47
  - ls: Lists the Names of Files 47
  - cat: Displays a Text File 48
  - rm: Deletes a File 48
  - less Is more: Display a Text File One Screen at a Time 48
  - hostname: Displays the System Name 49
- Working with Files 49
  - cp: Copies a File 49
  - mv: Changes the Name of a File 50
  - lpr: Prints a File 51
  - grep: Searches for a String 52
  - head: Displays the Beginning of a File 52

tail: Displays the End of a File	53
sort: Displays a File in Order	54
uniq: Removes Duplicate Lines from a File	54
diff: Compares Two Files	54
file: Identifies the Contents of a File	56
(Pipe): Communicates Between Processes	56
Four More Utilities	57
echo: Displays Text	57
date: Displays the Time and Date	58
script: Records a Shell Session	58
todos/unix2dos: Converts Linux and Mac OS X Files to Windows Format	59
Compressing and Archiving Files	60
bzip2: Compresses a File	60
bunzip2 and bzip2: Decompress a File	61
gzip: Compresses a File	62
tar: Packs and Unpacks Archives	62
Locating Commands	65
which and whereis: Locate a Utility	65
slocate/locate: Searches for a File	66
Obtaining User and System Information	67
who: Lists Users on the System	67
finger: Lists Users on the System	68
w: Lists Users on the System	69
Communicating with Other Users	70
write: Sends a Message	70
mesg: Denies or Accepts Messages	71
Email	72
Chapter Summary	72
Exercises	75
Advanced Exercises	75

## CHAPTER 4: THE FILESYSTEM 77

The Hierarchical Filesystem	78
Directory Files and Ordinary Files	78
Filenames	79
The Working Directory	82
Your Home Directory	82
Pathnames	83
Absolute Pathnames	83
Relative Pathnames	84
Working with Directories	85
mkdir: Creates a Directory	86
cd: Changes to Another Working Directory	87

**xvi CONTENTS**

---

rmdir: Deletes a Directory	88
Using Pathnames	89
mv, cp: Move or Copy Files	90
mv: Moves a Directory	90
Important Standard Directories and Files	91
Access Permissions	93
ls -l: Displays Permissions	93
chmod: Changes Access Permissions	94
Setuid and Setgid Permissions	96
Directory Access Permissions	98
ACLs: Access Control Lists	99
Enabling ACLs	100
Working with Access Rules	100
Setting Default Rules for a Directory	103
Links	104
Hard Links	106
Symbolic Links	108
rm: Removes a Link	110
Chapter Summary	111
Exercises	112
Advanced Exercises	114
<b>CHAPTER 5: THE SHELL</b>	<b>117</b>
The Command Line	118
Syntax	118
Processing the Command Line	120
Executing the Command Line	123
Editing the Command Line	123
Standard Input and Standard Output	123
The Screen as a File	124
The Keyboard and Screen as Standard Input and Standard Output	125
Redirection	126
Pipes	131
Running a Command in the Background	134
Filename Generation/Pathname Expansion	136
The ? Special Character	137
The * Special Character	138
The [ ] Special Characters	139
Builtins	141
Chapter Summary	142
Utilities and Builtins Introduced in This Chapter	142
Exercises	143
Advanced Exercises	144

## PART II THE EDITORS 147

### CHAPTER 6: THE vim EDITOR 149

- History 150
- Tutorial: Using vim to Create and Edit a File 151
  - Starting vim 151
  - Command and Input Modes 153
  - Entering Text 154
  - Getting Help 155
  - Ending the Editing Session 158
  - The **compatible** Parameter 158
- Introduction to vim Features 158
  - Online Help 158
  - Terminology 159
  - Modes of Operation 159
  - The Display 160
  - Correcting Text as You Insert It 160
  - Work Buffer 161
  - Line Length and File Size 161
  - Windows 161
  - File Locks 161
  - Abnormal Termination of an Editing Session 162
  - Recovering Text After a Crash 163
- Command Mode: Moving the Cursor 164
  - Moving the Cursor by Characters 165
  - Moving the Cursor to a Specific Character 165
  - Moving the Cursor by Words 166
  - Moving the Cursor by Lines 166
  - Moving the Cursor by Sentences and Paragraphs 167
  - Moving the Cursor Within the Screen 167
  - Viewing Different Parts of the Work Buffer 167
- Input Mode 168
  - Inserting Text 168
  - Appending Text 168
  - Opening a Line for Text 168
  - Replacing Text 169
  - Quoting Special Characters in Input Mode 169
- Command Mode: Deleting and Changing Text 169
  - Undoing Changes 169
  - Deleting Characters 170
  - Deleting Text 170
  - Changing Text 171
  - Replacing Text 172
  - Changing Case 173

**xviii CONTENTS**

---

Searching and Substituting	173
Searching for a Character	173
Searching for a String	174
Substituting One String for Another	176
Miscellaneous Commands	180
Join	180
Status	180
. (Period)	180
Copying, Moving, and Deleting Text	180
The General-Purpose Buffer	181
Named Buffers	182
Numbered Buffers	182
Reading and Writing Files	183
Reading Files	183
Writing Files	183
Identifying the Current File	184
Setting Parameters	184
Setting Parameters from Within vim	184
Setting Parameters in a Startup File	185
The <code>.vimrc</code> Startup File	185
Parameters	185
Advanced Editing Techniques	189
Using Markers	189
Editing Other Files	190
Macros and Shortcuts	190
Executing Shell Commands from Within vim	191
Units of Measure	193
Character	193
Word	193
Blank-Delimited Word	194
Line	194
Sentence	194
Paragraph	195
Screen (Window)	196
Repeat Factor	196
Chapter Summary	196
Exercises	201
Advanced Exercises	202
<b>CHAPTER 7: THE emacs EDITOR</b>	<b>205</b>
History	206
Evolution	206
emacs Versus vim	207
Command-Line emacs Versus Graphical emacs	208

---

Tutorial: Getting Started with emacs	208
Starting emacs	208
Exiting	210
Inserting Text	210
Deleting Characters	210
Moving the Cursor	211
Editing at the Cursor Position	214
Saving and Retrieving the Buffer	214
The emacs GUI	215
Basic Editing Commands	216
Keys: Notation and Use	216
Key Sequences and Commands	217
META-x: Running a Command Without a Key Binding	217
Numeric Arguments	218
Point and the Cursor	218
Scrolling Through a Buffer	218
Erasing Text	219
Searching for Text	219
Using the Menubar from the Keyboard	221
Online Help	223
Advanced Editing	225
Undoing Changes	225
Point, Mark, and Region	226
Cut and Paste: Yanking Killed Text	228
Inserting Special Characters	230
Global Buffer Commands	230
Visiting and Saving Files	232
Buffers	235
Windows	236
Foreground Shell Commands	238
Background Shell Commands	239
Major Modes: Language-Sensitive Editing	239
Selecting a Major Mode	240
Human-Language Modes	240
C Mode	243
Customizing Indention	246
Comments	247
Special-Purpose Modes	247
Customizing emacs	249
The .emacs Startup File	250
Remapping Keys	251
A Sample .emacs File	253
More Information	254
Access to emacs	254
Chapter Summary	254
Exercises	262
Advanced Exercises	264

## PART III THE SHELLS 267

### CHAPTER 8: THE BOURNE AGAIN SHELL 269

- Background 270
- Shell Basics 271
  - Startup Files 271
  - Commands That Are Symbols 275
  - Redirecting Standard Error 275
  - Writing a Simple Shell Script 278
  - Separating and Grouping Commands 281
  - Job Control 285
  - Manipulating the Directory Stack 288
- Parameters and Variables 290
  - User-Created Variables 292
  - Variable Attributes 295
  - Keyword Variables 296
- Special Characters 304
- Processes 306
  - Process Structure 306
  - Process Identification 306
  - Executing a Command 308
- History 308
  - Variables That Control History 308
  - Reexecuting and Editing Commands 310
  - The Readline Library 318
- Aliases 324
  - Single Versus Double Quotation Marks in Aliases 325
  - Examples of Aliases 326
- Functions 327
- Controlling `bash`: Features and Options 330
  - Command-Line Options 330
  - Shell Features 330
- Processing the Command Line 334
  - History Expansion 334
  - Alias Substitution 334
  - Parsing and Scanning the Command Line 334
  - Command-Line Expansion 335
- Chapter Summary 343



Exercises 345  
Advanced Exercises 347

## CHAPTER 9: THE TC SHELL 349

Shell Scripts 350  
Entering and Leaving the TC Shell 351  
    Startup Files 352  
Features Common to the Bourne Again and TC Shells 353  
    Command-Line Expansion (Substitution) 354  
    Job Control 358  
    Filename Substitution 358  
    Manipulating the Directory Stack 359  
    Command Substitution 359  
Redirecting Standard Error 359  
Working with the Command Line 360  
    Word Completion 360  
    Editing the Command Line 363  
    Correcting Spelling 364  
Variables 365  
    Variable Substitution 366  
    String Variables 366  
    Arrays of String Variables 367  
    Numeric Variables 368  
    Braces 370  
    Special Variable Forms 371  
    Shell Variables 371  
Control Structures 378  
    **if** 378  
    **goto** 381  
    Interrupt Handling 381  
    **if...then...else** 382  
    **foreach** 383  
    **while** 385  
    **break** and **continue** 385  
    **switch** 386  
Builtins 387  
Chapter Summary 391  
Exercises 392  
Advanced Exercises 394

## PART IV PROGRAMMING TOOLS 395

### CHAPTER 10: PROGRAMMING THE BOURNE AGAIN SHELL 397

- Control Structures 398
  - if...then** 398
  - if...then...else** 402
  - if...then...elif** 405
  - for...in** 411
  - for** 412
  - while** 414
  - until** 418
  - break** and **continue** 420
  - case** 421
  - select** 427
  - Here Document 429
- File Descriptors 431
- Parameters and Variables 434
  - Array Variables 434
  - Locality of Variables 436
  - Special Parameters 438
  - Positional Parameters 440
  - Expanding Null and Unset Variables 445
- Builtin Commands 446
  - type**: Displays Information About a Command 447
  - read**: Accepts User Input 447
  - exec**: Executes a Command or Redirects File Descriptors 450
  - trap**: Catches a Signal 453
  - kill**: Aborts a Process 456
  - getopts**: Parses Options 456
  - A Partial List of Builtins 459
- Expressions 460
  - Arithmetic Evaluation 460
  - Logical Evaluation (Conditional Expressions) 461
  - String Pattern Matching 462
  - Operators 463
- Shell Programs 468
  - A Recursive Shell Script 469
  - The **quiz** Shell Script 472
- Chapter Summary 478
- Exercises 480
- Advanced Exercises 482

## CHAPTER 11: THE PERL SCRIPTING LANGUAGE 485

- Introduction to Perl 486
  - More Information 486
  - Help 487
  - perldoc** 487
  - Terminology 489
  - Running a Perl Program 490
  - Syntax 491
- Variables 493
  - Scalar Variables 495
  - Array Variables 497
  - Hash Variables 500
- Control Structures 501
  - if/unless** 501
  - if...else** 503
  - if...elsif...else** 504
  - foreach/for** 505
  - last and next** 506
  - while/until** 508
- Working with Files 510
- Sort 513
- Subroutines 515
- Regular Expressions 517
  - Syntax and the **=~** Operator 518
- CPAN Modules 523
- Examples 525
- Chapter Summary 529
- Exercises 529
- Advanced Exercises 530

## CHAPTER 12: THE AWK PATTERN PROCESSING LANGUAGE 531

- Syntax 532
- Arguments 532
- Options 533
- Notes 534
- Language Basics 534
  - Patterns 534
  - Actions 535
  - Comments 535
  - Variables 535
  - Functions 536
  - Arithmetic Operators 537

**xxiv CONTENTS**

---

Associative Arrays	538
<b>printf</b>	538
Control Structures	539
Examples	541
Advanced <b>gawk</b> Programming	558
<b>getline</b> : Controlling Input	558
Coproces: Two-Way I/O	560
Getting Input from a Network	562
Chapter Summary	563
Exercises	563
Advanced Exercises	564

**CHAPTER 13: THE sed EDITOR 565**

Syntax	566
Arguments	566
Options	566
Editor Basics	567
Addresses	567
Instructions	568
Control Structures	569
The Hold Space	570
Examples	570
Chapter Summary	581
Exercises	581

**CHAPTER 14: THE rsync SECURE COPY UTILITY 583**

Syntax	584
Arguments	584
Options	584
Notes	586
More Information	586
Examples	587
Using a Trailing Slash (/) on <i>source-file</i>	587
Removing Files	588
Copying Files to and from a Remote System	590
Mirroring a Directory	590
Making Backups	591
Chapter Summary	594
Exercises	594

## PART V COMMAND REFERENCE 597

- Standard Multiplicative Suffixes 602
- Common Options 603
- The sample Utility 604
  - sample Brief description of what the utility does 605
  - aspell Checks a file for spelling errors 607
    - at Executes commands at a specified time 611
  - bzip2 Compresses or decompresses files 615
  - cal Displays a calendar 617
  - cat Joins and displays files 618
  - cd Changes to another working directory 620
  - chgrp Changes the group associated with a file 622
  - chmod Changes the access mode (permissions) of a file 626
  - chown Changes the owner of a file and/or the group the file is associated with 631
  - cmp Compares two files 634
  - comm Compares sorted files 636
  - configure Configures source code automatically 638
    - cp Copies files 640
    - cpio Creates an archive, restores files from an archive, or copies a directory hierarchy 644
  - crontab Maintains crontab files 649
    - cut Selects characters or fields from input lines 652
  - date Displays or sets the system time and date 655
    - dd Converts and copies a file 658
    - df Displays disk space usage 661
    - diff Displays the differences between two text files 663
  - diskutil Checks, modifies, and repairs local volumes *OS X* 668
  - ditto Copies files and creates and unpacks archives *OS X* 671
  - dmesg Displays kernel messages 673
  - dscl Displays and manages Directory Service information *OS X* 674
  - du Displays information on disk usage by directory hierarchy and/or file 677
  - echo Displays a message 680
  - expr Evaluates an expression 682
    - file Displays the classification of a file 686
  - find Finds files based on criteria 688
  - finger Displays information about users 695
    - fmt Formats text very simply 697
  - fsck Checks and repairs a filesystem 699
    - ftp Transfers files over a network 704
  - gawk Searches for and processes patterns in a file 711
  - gcc Compiles C and C++ programs 712

**xxvi CONTENTS**

---

- GetFileInfo Displays file attributes **OS X** 717
- grep Searches for a pattern in files 719
- gzip Compresses or decompresses files 724
- head Displays the beginning of a file 727
- kill Terminates a process by PID 729
- killall Terminates a process by name 731
- launchctl Controls the **launchd** daemon **OS X** 733
- less Displays text files, one screen at a time 735
- ln Makes a link to a file 740
- lpr Sends files to printers 742
- ls Displays information about one or more files 745
- make Keeps a set of programs current 753
- man Displays documentation for commands 759
- mkdir Creates a directory 763
- mkfs Creates a filesystem on a device 764
- Mtools Uses DOS-style commands on files and directories 767
- mv Renames or moves a file 771
- nice Changes the priority of a command 773
- nohup Runs a command that keeps running after you log out 775
- od Dumps the contents of a file 776
- open Opens files, directories, and URLs **OS X** 780
- otool Displays object, library, and executable files **OS X** 782
- paste Joins corresponding lines from files 784
- pax Creates an archive, restores files from an archive, or copies a directory hierarchy 786
- plutil Manipulates property list files **OS X** 792
- pr Paginates files for printing 794
- ps Displays process status 796
- rcp Copies one or more files to or from a remote system 800
- renice Changes the priority of a process 802
- rlogin Logs in on a remote system 803
- rm Removes a file (deletes a link) 804
- rmdir Removes directories 806
- rsh Executes commands on a remote system 807
- rsync Copies files and directory hierarchies securely over a network 809
- scp Securely copies one or more files to or from a remote system 810
- sed Edits a file noninteractively 812
- SetFile Sets file attributes **OS X** 813
- sleep Creates a process that sleeps for a specified interval 815
- sort Sorts and/or merges files 817
- split Divides a file into sections 826
- ssh Securely executes commands on a remote system 828
- stat Displays information about files 835

strings	Displays strings of printable characters	837
stty	Displays or sets terminal parameters	838
sysctl	Displays and alters kernel variables <i>OS X</i>	842
tail	Displays the last part (tail) of a file	843
tar	Stores or retrieves files to/from an archive file	846
tee	Copies standard input to standard output and one or more files	851
telnet	Connects to a remote system over a network	852
test	Evaluates an expression	854
top	Dynamically displays process status	858
touch	Creates a file or changes a file's access and/or modification time	862
tr	Replaces specified characters	864
tty	Displays the terminal pathname	867
tune2fs	Changes parameters on an <i>ext2</i> , <i>ext3</i> , or <i>ext4</i> filesystem	868
umask	Establishes the file-creation permissions mask	870
uniq	Displays unique lines	872
w	Displays information about system users	874
wc	Displays the number of lines, words, and bytes	876
which	Shows where in <i>PATH</i> a command is located	877
who	Displays information about logged-in users	879
xargs	Converts standard input to command lines	881

## PART VI APPENDIXES 885

### APPENDIX A: REGULAR EXPRESSIONS 887

Characters	888
Delimiters	888
Simple Strings	888
Special Characters	888
Periods	889
Brackets	889
Asterisks	890
Caret and Dollar Signs	890
Quoting Special Characters	891
Rules	891
Longest Match Possible	891
Empty Regular Expressions	892
Bracketing Expressions	892
The Replacement String	892
Ampersand	893
Quoted Digit	893
Extended Regular Expressions	893
Appendix Summary	895

## APPENDIX B: HELP 897

- Solving a Problem 898
- The Apple Web Site 899
- Finding Linux and OS X–Related Information 899
  - Documentation 900
  - Useful Linux and OS X Sites 901
  - Linux and OS X Newsgroups 902
  - Mailing Lists 903
  - Words 903
  - Software 904
  - Office Suites and Word Processors 906
- Specifying a Terminal 906

## APPENDIX C: KEEPING THE SYSTEM UP-TO-DATE 909

- Using yum 910
  - Using yum to Install, Remove, and Update Packages 910
  - Other yum Commands 912
  - yum Groups 913
  - Downloading rpm Package Files with yumdownloader 914
  - Configuring yum 914
- Using apt-get 916
  - Using apt-get to Install, Remove, and Update Packages 917
  - Using apt-get to Upgrade the System 918
  - Other apt-get Commands 919
  - Repositories 919
  - `sources.list`: Specifies Repositories for apt-get to Search 920
- BitTorrent 921
  - Prerequisites 921
  - Using BitTorrent 922

## APPENDIX D: MAC OS X NOTES 925

- Open Directory 926
- Filesystems 927
  - Nondisk Filesystems 927
  - Case Sensitivity 927
  - `/Volumes` 928
  - Carbon Pathnames 928
- Extended Attributes 928
  - File Forks 929
  - File Attributes 931
  - ACLs 932
- Activating the META Key 935



Startup Files 936  
Remote Logins 936  
Many Utilities Do Not Respect Apple Human Interface Guidelines 936  
Mac OS X Implementation of Linux Features 936

*GLOSSARY 939*

*FILE TREE INDEX 989*

*UTILITY INDEX 991*

*MAIN INDEX 995*