## Contents at a Glance

**Introduction**

| CHAPTER 1 | Installing Linux | 3 |
| CHAPTER 2 | Boot Process and Runlevels | 27 |
| CHAPTER 3 | Package Install and Management | 51 |
| CHAPTER 4 | Basic Command Line Usage | 91 |
| CHAPTER 5 | File Management | 109 |
| CHAPTER 6 | Text Processing/Advanced Command Line | 151 |
| CHAPTER 7 | Process Management | 193 |
| CHAPTER 8 | Editing Text | 219 |
| CHAPTER 9 | Partitions and Filesystems | 241 |
| CHAPTER 10 | Permissions and Ownership | 289 |
| CHAPTER 11 | Customizing Shell Environments | 311 |
| CHAPTER 12 | Shell Scripting | 339 |
| CHAPTER 13 | Basic SQL Management | 365 |
| CHAPTER 14 | Configuring User Interfaces and Desktops | 397 |
| CHAPTER 15 | Managing Users and Groups | 419 |
| CHAPTER 16 | Schedule and Automate Tasks | 445 |
| CHAPTER 17 | Configuring Print and Email Services | 465 |
| CHAPTER 18 | Logging and Time Services | 497 |
| CHAPTER 19 | Networking Fundamentals | 529 |
| CHAPTER 20 | System Security | 571 |
| CHAPTER 21 | Final Preparation | 603 |

**APPENDIX A** Answers to the “Do I Know This Already?” Quizzes and Review Questions | 619 |

**GLOSSARY** | 659 |

**INDEX** | 693 |

**ON THE DVD**

**APPENDIX B** Study Planner
Contents

Chapter 1 Installing Linux 3

“Do I Know This Already?” Quiz 3
Understanding Your Hardware 6
Peripheral Compatibility 7
Enumerating Your Peripherals 7
The Proc Filesystem 8
Friends of procfs 10
Dealing with Integrated Peripherals 10
Laying Out the Hard Drive 11
Partitions and Devices 11
The Root Filesystem 12
Logical Volume Manager (LVM) 14
Commonly Used Mounts 16
Swap Files 16
Working with Boot Managers 17
GRUB Legacy 17
GRUB2 18
Installing GRUB2 18
Using the GRUB2 Command Line 19
Configuring GRUB2 20
Summary 21
Exam Preparation Tasks 22
Review All Key Topics 22
Define Key Terms 22
Review Questions 23

Chapter 2 Boot Process and Runlevels 27

“Do I Know This Already?” Quiz 27
The Linux Boot Process 30
What Is the Boot Process? 30
Boot Loaders 30
Common Commands at Boot Time 32
Boot Sequence from BIOS to Fully Running System 33
SysVinit 33
systemd 34
Units in systemd 36
systemd Targets and Runlevels 37
Wants and Requires 38
Booting with systemd 38
Upstart 39
Managing System Runlevels 40
Determining the Default Runlevel 40
Contents

What Belongs Where 112
The Root of the System 112
Classifying Data 113
Where Programs Live 114

File Management Commands 114
  Tips for Working with Linux Files 115
  Basic Navigation 115
  Advanced Navigation 116
  Listing Files and Directories 116
  Determining File Types 118
  Touching Files 120
  Copying Files and Directories 121
  Moving Objects 123
  Transforming Data Formats 126
  Creating and Removing Directories 127
  Removing Objects 128

Where Are Those Files? 128
  Locating Files with Locate 128
  Finding Files 130
  Which Command Will Run? 132
  Researching a Command 132
  Linking Files 133
  Symbolic Links 134
  Hard Links 135

Backup Commands 136
  Using tar 137
  Taking Pity on the Unarchiver 139
  Useful Creation Options 140
  Listing Archive Files 140
  Using cpio 141
  Compression Utilities 143

Summary 144
Exam Preparation Tasks 144
  Review All Key Topics 144
  Define Key Terms 145
  Review Questions 146

Chapter 6  Text Processing/Advanced Command Line 151
“Do I Know This Already?” Quiz 151
Working with Input/Output Streams 154
  Standard In 154
  Standard Out 154
  Standard Error 155
  Redirection of Streams 156
Redirecting Standard Input 157
Redirecting Standard Output 157
Redirecting Standard Error 157
Redirection Redux 158
Pipes 159
Executing Multiple Commands 161
  Multiple Command Operators 161
  Command Substitution 162
Splitting and Processing Streams 163
  Splitting Streams with the tee Command 163
  Processing Output with the xargs Command 163
Filters 165
  Sorting 165
  Numbering Lines 166
  Tabs 167
  Cutting Columns 168
  Pasting and Joining 168
  Unique Data 169
  Heads or Tails? 170
  Splitting Files 172
  When cat Goes Backward 173
  Viewing Binary Files Safely 173
Formatting Commands 174
  Translating Files 175
  He sed, She sed 176
  Getting a grep 178
  Examples of Using grep 179
  Expanding grep with egrep and fgrep 184
Using Regular Expressions and grep 185
Summary 188
Exam Preparation Tasks 188
  Review All Key Topics 188
  Define Key Terms 189
  Review Questions 189
Chapter 7  Process Management 193
  “Do I Know This Already?” Quiz 193
Managing Processes 196
  Viewing Processes 196
  What’s the Diff? 197
  The free Command 198
  Blocks and Buffers 199
  Pages, Slabs, and Caches 199
Chapter 10 Permissions and Ownership 289
“Do I Know This Already?” Quiz 289
Working with Permissions 292
  Permission Trio Bits 292
Manipulating Permissions 294
  Numeric Mode 294
  Symbolic Mode 296
Special File Permissions 297
  Special Bit Permissions 298
  Setting the SUID Bit on Files 299
  Setting the SGID Bit on Files 300
  Setting the SGID Bit on Directories 301
  Setting the Sticky Bit 302
Finding Files by Permission 302
Default Permissions 303
Changing User Ownership 305
Changing Group Ownership 306
Summary 307
Exam Preparation Tasks 307
  Review All Key Topics 307
  Define Key Terms 308
  Review Questions 308

Chapter 11 Customizing Shell Environments 311
“Do I Know This Already?” Quiz 311
Working Within the Shell 314
  Environment Variables 315
  Variable Scope 316
  Setting Variables from a Child 316
  Setting and Unsetting Variables 317
  Subshells 318
  The env Wrapper 319
Extending the Shell 320
  Global and User Settings 320
  A Login Shell Session 321
  A Non-Login Shell Session 321
  The PATH 322
  Aliases and Functions 323
  Functions 323
  PS1 324
  Adding More Dynamic Content 325
  PS2 326
  Creating New Users (skeleton) 326
Localization and Internationalization 327
  Time Zones 327
  Displaying Time 328
  Setting Time Zones 328
  Character Encoding 329
  Representing Locales 330
  Fallback Locales 331
  Contents of a Locale 331
  How Linux Uses the Locale 332
  Converting Files Between Encodings 334

Exam Preparation Tasks 334
  Review All Key Topics 334
  Define Key Terms 335
  Review Questions 335

Chapter 12 Shell Scripting 339
  “Do I Know This Already?” Quiz 339
  Basics of Scripting 342
    Running a Script 343
    Good Design 343
    Managing Your Scripts 344
  Shell Script Commands 344
    Use the Output of Another Command 344
    Do Math 345
    Conditions 346
    Testing Files 348
    An Easier Test Syntax 348
    Testing Strings 349
    Testing Integers 350
    Combining Multiple Tests 351
    Case Statements 351
    Loops 353
    For Loops 353
    Sequences 354
    While Loops 355
    Reading from stdin in a Loop 356
    Interacting with Other Programs 356
    Returning an Error Code 357
    Accepting Arguments 357
    Transferring Control to Another Program 358

Exam Preparation Tasks 359
  Review All Key Topics 359
  Define Key Terms 360
  Review Questions 360
Chapter 13  Basic SQL Management  365
        “Do I Know This Already?” Quiz  365
        Database Basics  368
            Types of Databases  368
            Key-Value Databases  368
            Relational Databases  369
            Schemaless Databases  370
        Learning SQL  371
            Using SQLite  371
            SQL Basics  372
            Keywords Versus Data  372
            Selecting Data  373
            Being Choosy  374
            Multiple Conditions  376
            Sorting  377
            Limiting Results  378
            Working with Multiple Tables  378
            Writing Queries with Joins  379
            Cleaning Up the Query  381
            Advanced Joins  381
            Left Versus Right Joins  384
            Null  384
            Subselects  385
            Grouping Data  386
            Inserting Data  387
            Updating Data  388
            Deleting Data  388
            Creating Tables  388
        Summary  390
        Exam Preparation Tasks  390
            Review All Key Topics  390
            Define Key Terms  391
            Review Questions  392

Chapter 14  Configuring User Interfaces and Desktops  397
        “Do I Know This Already?” Quiz  397
        Quick Overview of X  400
            How X Works  400
            Window Managers  401
            Linux Desktops  402
        The Xorg System  402
            The Xorg Configuration File  402
            Fonts in X  405
            Tuning X  406
Managing Interfaces 545
  Viewing IP Information 545
  Red Hat Interface Configuration 547
  Debian Interface Configuration 548
  Viewing and Configuring Gateway Addresses 550
  Viewing the Default Gateway 550
  Configuring a Default Gateway 550
  Local Name Configuration 551

Network Configuration Utilities 553
  Network Utility Examples 554
  The ifconfig Command 555
  The route Command 555
  DHCP Client Tools 556
  The host, getent, and dig Commands 557
  Hostname Utilities 559
  Using netstat 559
  The ping Command 562
  Using traceroute 563
  Using tcpdump 565

Summary 566

Exam Preparation Tasks 566
  Review All Key Topics 566
  Define Key Terms 567
  Review Questions 567

Chapter 20 System Security 571

“Do I Know This Already?” Quiz 571

Gaining Access to the root Account 574
  The su Command 574
  The sudo Command 575

Providing Services on Demand 576
  Using inetd and xinetd 576
  inetd Configuration Files 577
  xinetd Configuration Files 578

Using TCP Wrappers for Securing Services 581
  inetd and TCP Wrappers 581
  xinetd and TCP Wrappers 582
  The hosts.allow and hosts.deny Files 582
  Wrapper Read Order 583
  Format of hosts.allow and hosts.deny 583
  Sample Configurations 583
  Using Rule Options 585
Contents

Understanding Permission Problems 586
  Finding Files by Permissions 587
GnuPG Keys 587
Secure Shell 590
  SSH Components 591
  Using SSH Client Utilities 592
Additional Security Features 596
Summary 597
Exam Preparation Tasks 598
  Review All Key Topics 598
  Define Key Terms 599
  Review Questions 599

Chapter 21 Final Preparation 603
How to Prepare for the LPI Exams 604
  Caveat and Warning 604
  Exam Objectives 604
  Important Exam Facts 605
  Right Before Your Exam Starts 605
  How to Look at the Objectives 606
  Studying for the Exams—What to Do 608
  Machines or Virtual Machines? 609
  Studying for the Exams—What Not to Do 609
  Don’t Believe Everything 610
  Don’t Worry, Be Happy 610
  LPI Certifications and Distributions 610
  You Have to Install Something 611
  LPI Exam Question Types 611
  Single Answer Multiple Choice 612
  Choose Two/Choose Three 613
  Choose All That Apply 613
  Fill in the Blank 615
  Final Recommendations 616

Summary 617

Appendix A Answers to the “Do I Know This Already?” Quizzes and Review Questions 619

Glossary 659
Index 683
About the Authors

Ross Brunson has more than 20 years of experience as a Linux and Open Source trainer, training manager, and technologist and is author of the popular LPIC-1 Exam Cram (QUE Publishing).

Ross is currently senior training/certification engineer at SUSE and recently spent almost five years as the director of member services for the Linux Professional Institute, where he contributed to placing several LPI courses into the Cisco Networking Academy, conducted dozens of Train-the-Trainer sessions, and provided sales enablement support for the worldwide Master Affiliate network spanning more than 100 countries.

Ross holds a number of key IT certifications and is also author of several successful technical books and dozens of technical courses for major organizations (including the first LPI Certification Bootcamps). He is skilled at both contributing to and building community around IT products.

He lives in Paradise Valley, Montana, with his family and enjoys traveling far and wide, winter sports, and photography.

Sean Walberg has more than 20 years of experience as a Linux administrator, network engineer, and software developer. He has written extensively on Linux certification for IBM and NetDevGroup, and has contributed to other books both as an author and technical reviewer.

Sean currently works at Northfield IT and is responsible for infrastructure automation for a large professional sports league. Using tools like Ruby, shell scripts, and Chef, he automates the creation and maintenance of more than a thousand servers and the associated network infrastructure. Sean works closely with developers to scale applications to the demands of an internationally recognized series of web properties.

He lives in Northern Virginia with his wife and three sons.
About the Contributing Author

At the impressionable age of 14, William “Bo” Rothwell crossed paths with a TRS-80 Micro Computer System (affectionately known as a “Trash 80”). Soon after the adults responsible for Bo made the mistake of leaving him alone with the TRS-80. He immediately dismantled it and held his first computer class, showing his friends what made this “computer thing” work.

Since this experience, Bo’s passion for understanding how computers work and sharing this knowledge with others has resulted in a rewarding career in IT training. His experience includes Linux, Unix, and programming languages such as Perl, Python, Tcl, and BASH. He is the founder and president of One Course Source, an IT training organization.

About the Technical Reviewer

Ted Jordan has more than 25 years of programming, administration, and training experience in UNIX, IRIX, Solaris, and Linux. His career spans from General Motors, Silicon Graphics, to SUN. He holds the LPIC, Linux+, and SUSE Linux certifications. He is the founder and president of two successful startups, the latest being Funutation Tech Camps where he teaches kids to code computer games.

Ted lives with his family near Worcester, Massachusetts, and enjoys tennis, golf, and karaoke.

Dedications

Ross Brunson: To my good friends, Andres and Ken, we few, we happy few. With love and respect to my wife and daughter, for putting up with my being locked in my office writing and editing while the sun shone and breezes blew. To every student/attendee/customer I've ever taught a Linux topic to, it's really all for you.

Sean Walberg: To my amazingly beautiful and intelligent wife, Rebecca. The completion of this book happens to coincide with the start of our new adventure together, and I can think of no one else I'd like to share it with.
Acknowledgments

Ross Brunson: To the ultimate nerd-herders, Ellie Bru and Mary Beth Ray; Ellie for her ability to take the peeping and muttering of technical geeks and make it something useful, workable, and often profound, and Mary Beth for believing in authors and technologists, even when we break her heart by blowing out deadlines and not doing what we say we will on time.

To my little brother, Leighton, who will make the most awesome history professor one day.

To Sean Walberg, who I have known and respected over several book projects, years of interactions in the LPI community, and all the way back to the Cramsession days with Qcumber and the gang.

To Bo Rothwell and Ted Jordan, awesome technical editors and great guys, as well as two of the best technical trainers it is my pleasure to know.

Sean Walberg: To the crew at Pearson, most notably Geneil, Ellie, and Mary Beth: This project is better because of your patience and input.

The technical editors, Ted and Bo, also deserve special mention. Not only did you fix my technical missteps, but your years of experience as trainers pointed out where I was using some words that were going to confuse new Linux users.

Finally, my knowledge of Linux wasn’t earned alone. It came through long nights, hard work, and lots of arguing with people like Marc Caron, Hany Fahim, Patrick leMaistre, Daniel Little, Dave Rose, and of course, my co-author Ross Brunson who I’m happy to have known for more than 15 years.
We Want to Hear from You!

As the reader of this book, you are our most important critic and commentator. We value your opinion and want to know what we’re doing right, what we could do better, what areas you’d like to see us publish in, and any other words of wisdom you’re willing to pass our way.

We welcome your comments. You can email or write to let us know what you did or didn’t like about this book—as well as what we can do to make our books better.

Please note that we cannot help you with technical problems related to the topic of this book.

When you write, please be sure to include this book’s title and author as well as your name and email address. We will carefully review your comments and share them with the author and editors who worked on the book.

Email: feedback@pearsonitcertification.com
Mail: Pearson IT Certification
ATTN: Reader Feedback
800 East 96th Street
Indianapolis, IN 46240 USA

Reader Services

Register your copy of CompTIA Linux+/LPIC-1 Cert Guide at www.pearsonitcertification.com for convenient access to downloads, updates, and corrections as they become available. To start the registration process, go to informit.com/register and log in or create an account. Enter the product ISBN (9780789754554) and click Submit. Once the process is complete, you will find any available bonus content under “Registered Products.” Be sure to check the box that you would like to hear from us in order to receive exclusive discounts on future editions of this product.
Introduction

This book was written to help people learn to use Linux. Not just learning Linux by memorizing commands, but learning Linux by understanding how the parts are put together. Approaching Linux from this perspective means that you’ll know where to look when you run up against something new and are better suited to handle problems as they come up. The authors of this book are experienced writers, but more importantly, are in the trenches every day.

The CompTIA Linux+ exams LX0-103 and LX0-104 and Linux Professional Institute LPIC Level 1 exams 101-400 and 102-400 (which are identical) encompass the knowledge necessary to become an entry level Linux administrator. There are certainly other books that cover this material, but this is the one that looks beyond the exam to preparing people for the Linux workforce.

You don’t need to be taking either the Linux+ or LPIC exams to get use out of this book. Concepts such as filesystems, hardware, shell usage, and managing email systems are needed in the workforce, and we, as authors, have endeavored to produce a book that is just as helpful to all new Linux users.

Goals and Methods

The goal of this book is to provide a guided tour of the Linux operating system with an eye to achieving an entry-level certification at the completion of the book. Readers with no intention of writing an exam will still find this book helpful as the certification content, by design, closely maps to the skills required by a Linux administrator. The authors also hope that the examples and practical advice in this text prove valuable well after the reader is done with the book.

The Linux+ and LPIC Level 1 certification exams are broken into specific topics that build upon each other, and the book does its best to mirror those. Not only does this provide a natural progression to learning Linux, but for those who are taking the exam, allows them to focus on troublesome areas.

Linux commands and their output are interspersed with the text to provide concrete examples right next to the description. Examples, for the most part, are adaptations of real world usage rather than being contrived. And since no good Linux graybeard should take himself too seriously, the authors have done their best to inject some levity into the discussion.
Who Should Read This Book?

This book was written for people who want to learn Linux—people just getting into the information technical field, Windows administrators who want to branch out to Linux, or students looking to understand Linux. Even if you’re not taking the Linux+ or LPIC Level 1 exams you’ll find this book helpful.

The first half of the book focuses on concepts and basic command usage, while the second half turns the attention to applications found in a typical Linux environment. People looking to be more competent Linux users, as opposed to administrators, will find immense benefit in the first half of the book, but will still appreciate the view of what else can be done on Linux provided by the second half.

Managers looking for some Linux familiarity will also find this book helpful because of the abundant examples and real world applications that will help them to speak in the same language as their more technical reports.

This book was not meant just to be read and cast aside. Instead, it can be a reference for common command usage and some basic application administration.

How To Use This Book

The best way to learn Linux is to use Linux. There are many examples within the text, from simple one-line commands to reusable scripts. Find yourself a Linux distribution such as Fedora, Ubuntu, Debian, or openSUSE. They’re free and run on most hardware.

If you don’t have a spare computer on which to install Linux you can try a LiveCD, which is a bootable image that runs entirely in memory. Most distributions offer a LiveCD download. Alternatively, you can run Linux in a virtual machine with software like VirtualBox (http://www.virtualbox.org).

All the software shown in this book is available on the most basic of Linux distributions and does not need an extra download. However Chapter 13, “Basic SQL Management,” offers a sample database that you can use to follow the examples. To install this, download the compressed attachment from http://www.pearsonitcertification.com/title/9780789754554. Inside the compressed file are two database files. The first, called lpic_basic.sqlite3, contains the data for the first part of the chapter. The second includes the additional data for the later examples. Instructions for using the databases are found in Chapter 13.

Above all, experiment with your Linux system. Try a couple of different distributions. Run the commands in this book and see whether you can come up with your own examples. Poke around in the configuration files and explore alternative uses for the commands in this book.
How This Book Is Organized

Although you could read this book cover-to-cover, it is designed to be flexible and allow you to easily move between chapters and sections of chapters to cover only the material you need. If you do intend to read them all, the order in which they are presented is an excellent sequence.

Chapters 1 through 12 cover the following topics:

- **Chapter 1, “Installing Linux”**: This chapter teaches you the basics of how a Linux system is installed. Core topics like hard disk partitioning and dealing with hardware are the focus of this chapter.

- **Chapter 2, “Boot Process and Runlevels”**: The Linux system has a specific order in which things happen both for starting up and shutting down. This chapter discusses the way these processes work and how to make changes so that you get the services that you need on your system.

- **Chapter 3, “Package Install and Management”**: Finding, installing, and configuring software is a big part of the system administrator’s job description. This chapter walks you through the usage of both the Debian and RedHat package systems.

- **Chapter 4, “Basic Command Line Usage”**: This chapter takes you through the basics of working on the Linux command line, including running applications and some commands to orient yourself on a new system. The work here forms the basis of the next three chapters.

- **Chapter 5, “File Management”**: This chapter delves into the commands that manipulate files. You create, delete, compress, move, and look at the files on disk and gain a solid understanding of how the Linux filesystems operate.

- **Chapter 6, “Text Processing/Advanced Command Line”**: The Linux command line is a programming environment that lets you do complicated tasks with a few keystrokes. This chapter introduce you to the most powerful feature of the shell of all: chaining together individual commands into increasingly powerful command lines. Along the way you learn how to search through text using regular expressions.

- **Chapter 7, “Process Management”**: Things that run on a Linux system are called processes, and this chapter teaches you how to manipulate these processes. You learn how to start and stop processes, run them in the background, and see which ones are taking the most resources from your computer.

- **Chapter 8, “Editing Text”**: This chapter teaches you to be productive in the vim editor. Vim makes repetitive tasks a breeze and lets you perform powerful edits on text files without moving the mouse. As most configuration and
programming on Linux is through a text file, an administrator who can wield a
text editor with efficiency is one who has her work done on time.

- **Chapter 9, “Partitions and Filesystems”**: This chapter takes a deep dive
  into how a Linux system uses disks. You learn how filesystems work and how
  to add and remove capacity from a Linux workstation.

- **Chapter 10, “Permissions and Ownership”**: Linux was built as a multiuser
  system from the very beginning, so an understanding of how access to
  resources is granted and checked is important to maintain the security of your
  data and the sanity of your users. This chapter investigates the Linux permis-
  sion model along with the commands used to check and set permissions.

- **Chapter 11, “Customizing Shell Environments”**: This chapter explores
  ways that you can customize your command line, such as by making shorter
  versions of longer commands or adding your own functions to the command
  line. Here, we also look at the roles played by internationalization and local-
  ization, which are methods that let the shell adapt to different languages and
countries without needing to maintain multiple installations.

- **Chapter 12, “Shell Scripting”**: The Linux shell is actually a sophisticated
  programming environment and this chapter shows you the basics. You don’t
  have to be a programmer to write shell scripts—this chapter starts with the
  most basic script and works from there.

- **Chapter 13, “Basic SQL Management”**: The Structured Query Language
  is a way that databases query and manipulate data. This chapter, through real
  world examples, teaches you the basics of SQL so that you can more effec-
  tively help your users and answer questions about your own data.

- **Chapter 14, “Configuring User Interfaces and Desktops”**: Linux isn’t just
  a command line system—there are many graphical tools from word processors
  to video games. This chapter shows you how to use Linux in a graphical mode.

- **Chapter 15, “Managing Users and Groups”**: Users and groups are the
  other half of the Linux permissions model that was started in Chapter 10. This
  chapter teaches the administrative tasks associated with managing the users on
  your system.

- **Chapter 16, “Schedule and Automate Tasks”**: This chapter walks you
  through the various ways that Linux systems can run tasks without user inter-
  vention, such as to process statistics from logs while you’re sleeping.

- **Chapter 17, “Configuring Print and Email Services”**: This chapter looks
  at two basic services that Linux is often called to solve: printing and email.
  With printing, you learn how the Common Unix Printing System (CUPS) is
  put together and how it can be used to manage printing for a single system or
a large enterprise. In the email half of the chapter you learn how email works and what software is used on Linux to perform the various roles in an Internet email system. You also see how to do basic account management in an email system.

- **Chapter 18, “Logging and Time Services”**: Logs provide a detailed accounting of what happened when you weren’t looking. This chapter explains the Linux logging systems and how to configure and use them. Additionally you learn how time is kept on a Linux system and how different Linux systems can talk to coordinate their time.

- **Chapter 19, “Networking Fundamentals”**: A Linux system that provides network services is only as good as its network configuration. This chapter gives you the solid understanding of networking needed to determine whether Linux or the network is causing a problem. You also learn about the various services used to connect computers on a network.

- **Chapter 20, “System Security”**: Security is all about assessing the risk to your machine and keeping the bad guys out. In this chapter you learn how to assess the security of your system, lock down services to only people you want, and encrypt your data from prying eyes.

- **Chapter 21, “Final Preparation”**: In this final chapter you find exam questions that challenge your understanding of the material and provide a test that assesses your readiness to take either the LPIC 101 or Linux+ exams.

- **Glossary**: The glossary defines all terms that you were asked to define at the end of each chapter.

Each chapter follows the same format and incorporates the following tools to assist you by assessing your current knowledge and emphasizing specific areas of interest within the chapter:

- **“Do I Know This Already?” Quizzes**: Each chapter begins with a quiz to help you assess your current knowledge of the subject. The quiz is divided into specific areas of emphasis that enable you to best determine where to focus your efforts when working through the chapter.

- **Foundation Topics**: The foundation topics are the core sections of each chapter. They focus on the specific commands, concepts, or skills that you must master to successfully prepare for the examination.

- **Exam Preparation Tasks**: At the end of the foundation topics, the Exam Preparation Tasks highlight the key topics from the chapter and lists the pages where you can find them for quick review. This section also provides a list of key terms that you should be able to define in preparation for the exam. It is unlikely that you will be able to successfully complete the certification exam
by just studying the key topics and key terms, although they are a good tool for last-minute preparation just before taking the exam. For a thorough understanding of how to prepare for the exam, see Chapter 21.

- **Review Questions:** Questions at the end of each chapter measure your understanding of the topics discussed in the chapter.

- **DVD-Based Practice Exam:** This book includes a DVD containing several interactive practice exams. It is recommended that you continue to test your knowledge and test-taking skills by using these exams. You will find that your test-taking skills improve by continued exposure to the test format. Remember that the potential range of exam questions is limitless. Therefore, your goal should not be to “know” every possible answer but to have a sufficient understanding of the subject matter so that you can figure out the correct answer with the information provided.

### Pearson IT Certification Practice Test Engine and Questions on the DVD

The DVD in the back of the book includes the Pearson IT Certification Practice Test engine—software that displays and grades a set of exam-realistic multiple-choice questions. Using the Pearson IT Certification Practice Test engine, you can either study by going through the questions in Study Mode, or take a simulated exam that mimics real exam conditions. You can also serve up questions in a Flash Card Mode, which displays just the question and no answers, challenging you to state the answer in your own words before checking the actual answers to verify your work.

The installation process requires two major steps: installing the software and then activating the exam. The DVD in the back of this book has a recent copy of the Pearson IT Certification Practice Test engine. The practice exam (the database of exam questions) is not on the DVD.

**Note**  The cardboard DVD case in the back of this book includes the DVD and a piece of paper. The paper lists the activation code for the practice exam associated with this book. Do not lose the activation code. On the opposite side of the paper from the activation code is a unique, one-time-use coupon code for the purchase of the Premium Edition eBook and Practice Test.
Install the Software from the DVD

The Pearson IT Certification Practice Test is a Windows-only desktop application. Unfortunately, you cannot easily run this .exe on a Linux machine. You can run it on a Mac using a Windows virtual machine, but it was built specifically for the PC platform. The minimum system requirements are as follows:

- Windows 10, Windows 8.1, Windows 7, or Vista (SP2)
- Microsoft .NET Framework 4.0 Client
- Pentium-class 1 GHz processor (or equivalent)
- 512 MB RAM
- 650 MB disk space plus 50 MB for each downloaded practice exam
- Access to the Internet to register and download exam databases

The software installation process is routine as compared with other software installation processes. If you have already installed the Pearson IT Certification Practice Test software from another Pearson product, there is no need for you to reinstall the software. Simply launch the software on your desktop and proceed to activate the practice exam from this book by using the activation code included in the DVD sleeve.

The following steps outline the installation process:

1. Insert the DVD into your PC.
2. The media interface that automatically runs allows you to access and use all DVD-based features, including the exam engine and sample content from other Cisco self-study products. From the main menu, click the Install the Exam Engine option.
3. Respond to windows prompts as with any typical software installation process.

The installation process gives you the option to activate your exam with the activation code supplied on the paper in the DVD sleeve. This process requires that you establish a Pearson website login. You need this login to activate the exam, so please do register when prompted. If you already have a Pearson website login, there is no need to register again. Just use your existing login.

Activate and Download the Practice Exam

Once the exam engine is installed, you should then activate the exam associated with this book (if you did not do so during the installation process) as follows:
1. Start the Pearson IT Certification Practice Test software from the Windows Start menu or from your desktop shortcut icon.

2. To activate and download the exam associated with this book, from the My Products or Tools tab, click the Activate Exam button.

3. At the next screen, enter the activation key from the paper inside the cardboard DVD holder in the back of the book. Once entered, click the Activate button.

4. The activation process downloads the practice exam. Click Next and then click Finish.

When the activation process completes, the My Products tab should list your new exam. If you do not see the exam, make sure that you have selected the My Products tab on the menu. At this point, the software and practice exam are ready to use. Simply select the exam and click the Open Exam button.

To update a particular exam you have already activated and downloaded, display the Tools tab and click the Update Products button. Updating your exams ensures that you have the latest changes and updates to the exam data.

If you want to check for updates to the Pearson Cert Practice Test exam engine software, display the Tools tab and click the Update Application button. You can then ensure that you are running the latest version of the software engine.

**Activating Other Exams**

The exam software installation process and the registration process, only have to happen once. Then, for each new exam, only a few steps are required. For instance, if you buy another Pearson IT Certification Cert Guide, extract the activation code from the DVD sleeve in the back of that book; you do not even need the DVD at this point. From there, all you have to do is start the exam engine (if not still up and running) and perform steps 2 through 4 from the previous list.

**Certification Exam Topics and This Book**

The questions for each certification exam are a closely guarded secret. However, we do know which topics you must know to successfully complete this exam. CompTIA and LPI publish them as an exam blueprint.

Tables I.1 and I.2 list the exam topics for each exam.
### Exam Topics for CompTIA Linux+ (LX0-103) and LPIC-1 (101-400) Exam

<table>
<thead>
<tr>
<th>Topic</th>
<th>Exam Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>101.1</td>
<td>Determine and configure hardware settings</td>
</tr>
<tr>
<td>101.2</td>
<td>Boot the system</td>
</tr>
<tr>
<td>101.3</td>
<td>Change run levels/boot targets and shutdown or reboot system</td>
</tr>
<tr>
<td><strong>Topic 102: Linux Installation and Package Management</strong></td>
<td></td>
</tr>
<tr>
<td>102.1</td>
<td>Design hard disk layout</td>
</tr>
<tr>
<td>102.2</td>
<td>Install a boot manager</td>
</tr>
<tr>
<td>102.3</td>
<td>Manage shared libraries</td>
</tr>
<tr>
<td>102.4</td>
<td>Use Debian package management</td>
</tr>
<tr>
<td>102.5</td>
<td>Use RPM and YUM package management</td>
</tr>
<tr>
<td><strong>Topic 103: GNU and Unix Commands</strong></td>
<td></td>
</tr>
<tr>
<td>103.1</td>
<td>Work on the command line</td>
</tr>
<tr>
<td>103.2</td>
<td>Process text streams using filters</td>
</tr>
<tr>
<td>103.3</td>
<td>Perform basic file management</td>
</tr>
<tr>
<td>103.4</td>
<td>Use streams, pipes, and redirects</td>
</tr>
<tr>
<td>103.5</td>
<td>Create, monitor, and kill processes</td>
</tr>
<tr>
<td>103.6</td>
<td>Modify process execution priorities</td>
</tr>
<tr>
<td>103.7</td>
<td>Search text files using regular expressions</td>
</tr>
<tr>
<td>103.8</td>
<td>Perform basic file editing operations using vi</td>
</tr>
<tr>
<td><strong>Topic 104: Devices, Linux Filesystems, Filesystem Hierarchy Standard</strong></td>
<td></td>
</tr>
<tr>
<td>104.1</td>
<td>Create partitions and filesystems</td>
</tr>
<tr>
<td>104.2</td>
<td>Maintain the integrity of filesystems</td>
</tr>
<tr>
<td>104.3</td>
<td>Control mounting and unmounting of filesystems</td>
</tr>
<tr>
<td>104.4</td>
<td>Manage disk quotas</td>
</tr>
<tr>
<td>104.5</td>
<td>Manage file permissions and ownership</td>
</tr>
<tr>
<td>104.6</td>
<td>Create and change hard and symbolic links</td>
</tr>
<tr>
<td>104.7</td>
<td>Find system files and place files in the correct location</td>
</tr>
</tbody>
</table>
### Table I-2  CompTIA Linux+ (LX0-104) and LPIC-1 (102-400) Exam Topics for CompTIA Linux+ (LX0-104) and LPIC-1 (102-400)

<table>
<thead>
<tr>
<th>Topic 105: Shells, Scripting, and Data Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>105.1 Customize and use the shell environment</td>
</tr>
<tr>
<td>105.2 Customize or write simple scripts</td>
</tr>
<tr>
<td>105.3 SQL data management</td>
</tr>
<tr>
<td>Topic 106: User Interfaces and Desktops</td>
</tr>
<tr>
<td>106.1 Install and configure X11</td>
</tr>
<tr>
<td>106.2 Set up a display manager</td>
</tr>
<tr>
<td>106.3 Accessibility</td>
</tr>
<tr>
<td>Topic 107: Administrative Tasks</td>
</tr>
<tr>
<td>107.1 Manage user and group accounts and related system files</td>
</tr>
<tr>
<td>107.2 Automate system administration tasks by scheduling jobs</td>
</tr>
<tr>
<td>107.3 Localization and internationalization</td>
</tr>
<tr>
<td>Topic 108: Essential System Services</td>
</tr>
<tr>
<td>108.1 Maintain system time</td>
</tr>
<tr>
<td>108.2 System logging</td>
</tr>
<tr>
<td>108.3 Mail Transfer Agent (MTA) basics</td>
</tr>
<tr>
<td>108.4 Manage printers and printing</td>
</tr>
<tr>
<td>Topic 109: Networking Fundamentals</td>
</tr>
<tr>
<td>109.1 Fundamentals of Internet protocols</td>
</tr>
<tr>
<td>109.2 Basic network configuration</td>
</tr>
<tr>
<td>109.3 Basic network troubleshooting</td>
</tr>
<tr>
<td>109.4 Configure client side DNS</td>
</tr>
<tr>
<td>Topic 110: Security</td>
</tr>
<tr>
<td>110.1 Perform security administration tasks</td>
</tr>
<tr>
<td>110.2 Set up host security</td>
</tr>
<tr>
<td>110.3 Securing data with encryption</td>
</tr>
</tbody>
</table>
Assessing Exam Readiness

Exam candidates never really know whether they are adequately prepared for the exam until they have completed about 30% of the questions. At that point, if you are not prepared, it is too late. The best way to determine your readiness is to work through the “Do I Know This Already?” quizzes at the beginning of each chapter and review the foundation and key topics presented in each chapter. It is best to work your way through the entire book unless you can complete each subject without having to do any research or look up any answers.

Exam Registration

For LPI exams, start at lpi.org to get a member ID and a link to pearsonvue.com/lpi/ to schedule an exam. For the Linux+ variants, sign up directly from https://certification.comptia.org/certifications/linux.

Where Are the Companion Content Files?

Register this print version of *CompTIA Linux+ / LPIC-1 Cert Guide* to access the content from the DVD online.

This print version of this title comes with a disc of companion content. You have online access to these files by following these steps:

1. Go to www.pearsonITcertification.com/register and log in or create a new account.
2. Enter the ISBN: 9780789754554.
3. Answer the challenge question as proof of purchase.
4. Click on the Access Bonus Content link in the Registered Products section of your account page to be taken to the page where your downloadable content is available.

Please note that many of our companion content files can be very large, especially image and video files.

If you are unable to locate the files for this title by following these steps, please visit www.pearsonITcertification.com/ contact and select the Site Problems/Comments option. Our customer service representatives will assist you.
This page intentionally left blank
This chapter covers the following topics:

- Filesystem Overview
- File Management Commands
- Where Are Those Files?
- Backup Commands

This chapter covers the following objectives:

- Perform basic file management: 103.3
- Create and change hard and symbolic links: 104.6
- Find system files and place files in the correct location: 104.7
File Management

Most of what you do on a Linux machine involves manipulating files in some manner. You have to know where certain files go, such as binaries, configuration, and user data. You also need to be able to manipulate files from the command line rather than a GUI.

“Do I Know This Already?” Quiz

The “Do I Know This Already?” quiz enables you to assess whether you should read this entire chapter or simply jump to the “Exam Preparation Tasks” section for review. If you are in doubt, read the entire chapter. Table 5-1 outlines the major headings in this chapter and the corresponding “Do I Know This Already?” quiz questions. You can find the answers in Appendix A, “Answers to the ‘Do I Know This Already?’ Quizzes and Review Questions.”

<table>
<thead>
<tr>
<th>Foundation Topics Section</th>
<th>Questions Covered in This Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filesystem Overview</td>
<td>1, 3</td>
</tr>
<tr>
<td>File Management Commands</td>
<td>2, 4-6</td>
</tr>
<tr>
<td>Where Are Those Files?</td>
<td>7-8</td>
</tr>
<tr>
<td>Backup Commands</td>
<td>9-11</td>
</tr>
</tbody>
</table>

1. Files that change often should go under:
   a. /usr
   b. /proc
   c. /root
   d. /var
2. Your shell is in /usr/local. You type cd ../bin. Which directory is shown when you type pwd?
   a. /bin
   b. /usr/bin
   c. /usr/local/bin
   d. Nothing, this command returns an error.

3. Which of the following directories should be on the same partition as the root?
   a. /boot
   b. /usr
   c. /home
   d. /sbin

4. You happen across a file in a directory called foo. What is a good way to find out what the file is or does?
   a. file foo
   b. /foo
   c. cat foo
   d. which foo

5. What command would be used to update the date on a file?
   a. tar
   b. file
   c. date
   d. touch

6. You are trying to create a new series of nested directories: /a/b/c/d/. What is the fastest way to create this nested directory set?
   a. mkdir /a; mkdir /a/b; mkdir /a/b/c; mkdir /a/b/c/d
   b. mkdir /a/b/c/d
   c. mkdir -p /a/b/c/d
   d. md /a/b/c/d
7. You know that you have multiple copies of the `doit` command on your system. How do you find which one you will run if you type `doit` at the command line?
   a. `whereis doit`
   b. `locate doit`
   c. `find doit`
   d. `which doit`

8. You know that you downloaded a file called `backup.tar.gz` this morning but can’t remember where you put it. Which is the most appropriate command to find the file?
   a. `find / -name backup.tar.gz`
   b. `find backup.tar.gz`
   c. `locate backup.tar.gz`
   d. `whereis backup.tar.gz`

9. You want to package up Fred’s home directory on a USB stick to send with him as he’s leaving your company. Which command is the best? Hurry, because there’s cake!
   a. `find /home/fred | tar -czf > /media/removable/fred.tar.gz`
   b. `tar -czf /home/fred > /media/removable/fred.tar.gz`
   c. `cd /home/; tar -cjf /media/removable/fred.tar.bz2 fred`
   d. `cd /home/fred tar -cjf /media/removable/fred.tar.bz2 *`

10. What does the command `tar -tf archive.tar etc/pine.conf` do?
    a. Makes a new archive called `archive.tar` containing `/etc/pine.conf`
    b. Adds `/etc/pine.conf` to `archive.tar`
    c. Checks to see whether `/etc/pine.conf` is inside the archive
    d. Extracts `/etc/pine.conf` from `archive.tar`

11. Which compression utility offers the highest level of compression?
    a. `bzip2`
    b. `gzip`
    c. `compress`
    d. `cpio`
Foundation Topics

Filesystem Overview

The filesystem’s structure starts with the root of the filesystem, which is denoted by the forward slash character (/). Every item on the filesystem is accessible by a single unique path from the root of the system, such as /usr/local/bin/foobar, no matter which device that file is stored on.

Unix evolved its own set of traditions as to where certain files would go. The fragmentation of the commercial and academic Unixes led to differences in conventions depending on which flavor of Unix you were using.

Linux borrows practices from many different Unixes and has fragmentation of its own in the form of different distributions. The community started working on a standard for filesystem layout called the File System Hierarchy Standard (FHS) to make it easier for both people and software to know where files can be found.

The latest FHS is always found at http://www.pathname.com/fhs/.

LPI bases the exam questions about the directory structure from the FHS 2.3. The FHS isn’t really a standard but a firm set of suggestions that most, but not all, distribution vendors obey. A good number of questions on the exams reference the FHS.

What Belongs Where

The exams make somewhat of a big deal about what the proper directories and locations are for Linux files, but few things are more vexing than to be asked what should positively be in the root (/) directory, or what can be elsewhere.

The Root of the System

Starting in the root (/) directory, the Table 5-2 lists common top-level directories and includes a short explanation for each:

<table>
<thead>
<tr>
<th>Directory</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin</td>
<td>Binaries for all users</td>
</tr>
<tr>
<td>boot</td>
<td>Kernel, system map, boot files</td>
</tr>
<tr>
<td>dev</td>
<td>Device files</td>
</tr>
<tr>
<td>etc</td>
<td>Configuration files for the host</td>
</tr>
</tbody>
</table>
### Directory Management

<table>
<thead>
<tr>
<th>Directory</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>home</td>
<td>Home directories for users</td>
</tr>
<tr>
<td>lib</td>
<td>Necessary shared libraries/modules</td>
</tr>
<tr>
<td>lost+found</td>
<td>Storage directory for unlinked files (found with fsck)</td>
</tr>
<tr>
<td>media</td>
<td>Mount points for removable media</td>
</tr>
<tr>
<td>mnt</td>
<td>Temporary mount point for the sysadmin</td>
</tr>
<tr>
<td>opt</td>
<td>Third-party application software</td>
</tr>
<tr>
<td>proc</td>
<td>Kernel and process information</td>
</tr>
<tr>
<td>root</td>
<td>The root user’s home directory</td>
</tr>
<tr>
<td>sbin</td>
<td>System binaries needed for boot</td>
</tr>
<tr>
<td>tmp</td>
<td>Temporary data</td>
</tr>
<tr>
<td>usr</td>
<td>Sharable, read-only data and programs, no host-specific data</td>
</tr>
<tr>
<td>var</td>
<td>Variable data, logs, Web, FTP, and so on</td>
</tr>
</tbody>
</table>

The exam makes a big deal out of what’s optional and required in the root (/) directory. If you read the FHS 2.3 (highly recommended), you see that the word “optional” appears next to the /root and /home directories. It is possible that the computer is some kind of application server where users are not expected to log in. This is key because you’ll be asked questions about which directories are optional in the root filesystem.

The FHS documentation states, “The contents of the root filesystem must be adequate to boot, restore, recover, and/or repair the system. To boot a system, enough must be present on the root partition to mount other filesystems. This includes utilities, configuration, boot loader information, and other essential start-up data. /usr, /opt, and /var are designed such that they may be located on other partitions or filesystems.”

From this statement you can understand which of the preceding directories need to be on the root partition and which can be moved to other partitions.

### Classifying Data

FHS makes distinctions between data that changes and data that is static, and data that can be shared versus data that’s local to the computer. Data of different categories should be separated into different directories.

Because of the way the FHS is laid out, with the root filesystem being described in section 3 and /usr and /var happening later, it’s easy to misunderstand what is really
supposed to be on the root filesystem as opposed to another device that’s mounted after boot.

The relationship between /usr and /var is that, long ago in Unix times, /usr used to contain all types of data. The FHS tried to extract the data that changes and is non-sharable to /var, leaving /usr with just static, sharable data.

Where Programs Live

The FHS does not allow programs to create their individual named directories in the /usr section. The subdirectories allowed to exist directly under the /usr directory are

- **bin**—Contains user commands
- **include**—Contains header files for C programs
- **lib**—Contains libraries
- **local**—Contains local/sharable programs
- **sbin**—Contains nonessential system binaries
- **share**—Contains data/programs for multiple architectures

The /usr section has a location for programs named /usr/local. This is for the sysadmin to install software in a place that won’t conflict with the distribution files. Programs in the /usr/local path are also allowed for sharing among groups of hosts.

For example, say your developers have come up with a program to calculate loans and you want to install it on the workgroup server for other systems to remotely mount and use. Because this is a third-party or custom application, the logical place for it is in /usr/local/appname, possibly with a link to the program binary in the /usr/local/bin directory (because that’s where local binaries are expected to be found).

If given a choice between putting the software package BIGPROG in the /usr/local/ BIGPROG section and the /opt/BIGPROG section, it’s hard to choose. Read any relevant exam question closely—the main difference being that the /opt section is not considered to be sharable, whereas the /usr section is often shared and mounted by client systems.

File Management Commands

A major section of the 101 exam is dedicated to how to run commands properly with the right options and arguments. As a good sysadmin, you are expected to know how to create, delete, edit, set permissions, display, move, copy, and determine the type of files and programs.
Tips for Working with Linux Files

Because most users and sysadmins come from a Windows or other OS background, a quick set of recommendations for the less-experienced can be of help here:

- **Hidden files aren’t really hidden**—They just begin with a ., such as the .bashrc and .bash_profile files. They are normally not visible unless you explicitly ask for them to be displayed and aren’t deleted by commands such as `rm -f *.*`.

- **Filenames can contain multiple periods or no period characters**—The filenames `this.is.a.long.file` and `thisisalongfile` are perfectly reasonable and possible.

- **Spaces in filenames look nice, but are a pain to type**—Use an _ or a - instead of spaces because it’s neater and easier than prefixing all spaces with a `. (To display a space in a filename, the system shows a space prefixed with a backslash.)

- **File extensions aren’t mandatory**—But they are useful for sorting, selection, and copy/move/delete commands, as well as for quickly identifying a file’s type.

Basic Navigation

The command to change the current working directory, `cd`, is used frequently and knowing how to move around the filesystem is a main focus of the exams.

The following command simply moves you from wherever you are to the `/etc` directory. This type of move uses absolute pathnames and can be used from within any directory:

```
cd /etc
```

The path is called *absolute* because it defines a path starting at the root of the filesystem. The easy way to tell whether the path is absolute is that it starts with a slash (/).

Moving relatively from the current directory to a subdirectory is quick and easy, such as if you are in the `/etc` directory and want to change into the `/etc/samba` directory. Here’s how:

```
cd samba
```
This is referred to as a relative path because the option you pass to the `cd` command is relative to the current directory. You are in `/etc` and moving to `samba` gets you in `/etc/samba`. If you were in `/home` and ran `cd samba` it would not work unless `/home/samba` also existed.

If you get confused as to where you currently are, use the `pwd` command to print the working (current) directory:

```bash
# pwd
/etc/samba
```

By itself, the `cd` command takes you back to your home directory, wherever you happen to be. The tilde (~) also means “home directory,” so `cd ~` takes you to your home directory and `cd ~sean` takes you to Sean’s home directory.

**Advanced Navigation**

It’s good to get experience with some complex relative path situations. For example, if you were in the directory `/home1/user1` and wanted to move into the directory `/home2/user2`, which command could be used?

```bash
$ tree /
/
|-- home1
| `-- user1
`-- home2
    `-- user2
```

Remember, you aren’t using absolute pathnames, just relative pathnames.

The answer is

```bash
# cd ../../home2/user2
```

Each of the `..` pairs takes you up one level: The first takes you to `/home1` and the second puts you at the root. From there it’s relative pathnames. Practice this method, and remember that going up one level in this exercise only got you to the `/home1` directory. This is a relative path because the path does not start with a `/`. The directory in which you end up depends on where you started.

Though this example of relative and absolute pathnames was used to look at changing directories, it applies to any situation where you’re prompted for a filename.

**Listing Files and Directories**

The `ls` command is used for listing directories or files, or both.
If you use the `ls` command to see a multicolumn output of the current directory, only the file or directory names are shown, not other details about the file:

```
ls
file1  file2  file3  file4
```

Use the `-l` long listing option to see all the details of a particular file or directory, or set of files or directories in a single column, like so:

```
$ ls -l
total 0
-rw-r--r--  1 root     root            0 Jan 24 18:55 file1
-rw-r--r--  1 root     root            0 Jan 24 18:55 file2
-rw-r--r--  1 root     root            0 Jan 24 18:55 file3
-rw-r--r--  1 root     root            0 Jan 24 18:55 file4
```

The `-l` long listing style is the only way to use the `ls` command and see the permissions, ownership, and link counts for objects. The only other command that can give such information is the `stat` command, which shows a single filesystem object at a time.

Other examples of using the `ls` command include

- **`ls /home/user`**—Shows a plain listing of that directory.
- **`ls -a`**—Lists all files, including hidden `. files`.
- **`ls -d foo`**—Lists just the directory called foo, not the contents.
- **`ls -i`**—Lists the inode number for the target file or directory. Inodes are the way Linux represents a file on disk and are discussed later in the section “Copying Files and Directories.”
- **`ls -l`**—Shows permissions; links; and date, group, and owner information. Permissions dictate who can access the file and are discussed in detail in Chapter 10, “Permissions.”
- **`ls -lh`**—Shows human-readable output of file sizes, in KB, MB, and GB, along with file details.

Chaining the options together produces useful results. For example, if you needed to see all the files (including hidden ones) in the current directory, their permissions, and their inode numbers, you would use the following command:

```
# ls -lai
290305 drwxr-x--- 13 root root 4096 Jan 24 18:55 .
 2 drwxr-xr-x 20 root root 4096 Jan 24 17:56 ..
292606 -rw-r--r--  1 root root  1354 Jan 21 00:23 anaconda-ks.cfg
```
Determining File Types

With no requirement for extensions on Linux files, a tool for easily determining file types is essential. The `file` command can be used to read the file’s headers and match that data against a known set of types.

The `file` command uses several possible sources, including the `stat` system call, the magic number file (`/usr/share/magic`), and a table of character sets including ASCII and EBCDIC. Finally, if the file is text and contains recognizable strings from a given programming or other language, it is used to identify the file.

The output can be used, manipulated, and filtered to show you useful things.

For example, simply using the `file` command on a given file shows the type:

```
$ file file1
file1: ASCII text
```

Running the `file` command against a known binary shows various elements about the architecture and layout of the file, such as shown here:

```
$ file /bin/ls
/bin/ls: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV),
dynamically linked (uses shared libs), for GNU/Linux 2.6.32, stripped
```

Running the `file` command against a directory full of files is useful for viewing the possible types, but the real gold lies in filtering the output using the pipe operator (`|`) and the `grep` command, showing only the results that contain the word “empty”:

```
$ file /etc/* | grep empty
/etc/dumpdates: empty
/etc/exports: empty
/etc/fstab.REVOKE: empty
/etc/motd: empty
/etc/printconf.local: empty
```

This is one way of finding empty files that are littering your system. They are probably required in the `/etc` directory but only clutter temporary directories such as `/tmp`. 
NOTE The asterisk (*) in the previous command is known as a glob. A glob is a wildcard operator that matches some number of files based on a pattern. /etc/* matches all files in the /etc directory such as /etc/foo, /etc/bar, but not /etc/foo/bar!

One thing that’s distinct about Linux (and all Unices) is that the shell is responsible for expanding the glob to the list of files it matches. If you type `ls /tmp/thing*` and there are two files that start with thing such as `thing1` and `thing2`, it’s the same thing as if you typed `ls /tmp/thing1 /tmp/thing2`:

```
$ ls thing*
thing1  thing2
```

This globbing feature is why renaming a group of files is harder. In Windows you could type `ren *.foo *.bar` and any file with an extension of foo would then have an extension of bar. In Linux, typing `mv *.foo *.bar` would expand the globs to the list of files matched—`*.foo` would match the files you want to rename and `*.bar` would match nothing. This is different from what you might expect! The following output shows this problem.

```
$ ls *.foo *.bar
ls: *.bar: No such file or directory
file1.foo  file2.foo
$ echo mv *.foo *.bar
mv file1.foo file2.foo *.bar
$ mv *.foo *.bar
mv: target `*.bar' is not a directory
```

In the output, the first command shows there are three files with an extension of `foo` but none of `bar`. The `echo` command displays the output that follows it, such that it shows what would be executed if you ran the `mv` command by itself. The `*.bar` glob shows up because there are no files that match it. The error happens because there is no such directory called `*.bar`.

There are other glob operators. Example 5-1 shows some uses of file globs.

---

**Example 5-1** Examples Using a Glob

```
$ ls
file  file1  file10  file11  file2
$ ls file*
file  file1  file10  file11  file2
$ ls file?
file1  file2
```
Example 5-1 starts by listing all the files in the directory. The same list of files is also available with `file*`, which matches the word “file” followed by anything, or nothing at all. Note how it includes the bare name “file”. Next the `file?` glob matches anything starting with the word “file” and followed by one character. Both “file” and the files with two-digit numbers in their names are excluded.

Globs don’t have to appear at the end of a filename. `*1` matches anything ending in the number “1”. Finally, `file[123]` uses the square bracket operator that means “any one character from the set”. This matches file1 and file2.

**Touching Files**

The `touch` command seems odd at first, but it comes in handy often. You give it the name of one or more files, and it creates the files if they don’t exist or updates their timestamps if they do.

There are various reasons to use the `touch` command, such as creating a new blank log file or updating a file’s modification time to use as a reference such as to know the last time a job was run.

To create a new file, you can use the relative pathname for creating one in the current directory:

```
touch filename
```

Or, you can use absolute pathname to create the file, such as shown here:

```
touch /home/rossb/filename
```

Expect to see `touch` on the exams for log file creation, along with using a reference file to mark the last backup. In other words, if a log file is created from a successful backup, that file can be used as a date and time reference file because it occurred at a desirable time.

When you use `touch` on an existing file, the default action is to update all three of the file’s times:

- **access**—The last time a file was written/read from
- **change**—The last time the contents of the file were changed, or that the file’s metadata (owner, permission, inode number) was changed

- **modify**—The last time the file’s contents were changed

A programmer preparing a new release of a software package would use the `touch` command to ensure that all files have the exact same date and times. Therefore, the release could be referred to by the file date, given multiple revisions.

Setting a file’s date is relatively easy; the following command sets `file1`’s date to a particular date and time:

```
touch -t 201501010830 file1
```

The time format used is represented by `yyyymmddhhmm`, or a four-digit year, two-digit month, two-digit day, two-digit hour, and two-digit minutes.

Reference files are useful, particularly when you just want to have a file or set of files updated to a particular date/time, not the current one. You could use

```
touch -r reffile file2update
```

The date and time of `reffile` is applied to the `file2update` file date and time.

### Copying Files and Directories

One aspect of copying an object is that the act creates a new file with a separate inode. This means that the operating system sees the new file as separate from the old one. Contrast this to a move operation where it’s the same file with a new name.

When you create an object in a filesystem, it gets its own permissions. `cp` doesn’t always copy the permissions over to the new file. This can be done, but it requires the use of the `-p` option to preserve the permissions and ownership. The root user is the only user that can change the ownership of a file; therefore, regular users using this option always own the copied files no matter who the original owner was.

A normal copy is simple to perform. You’re essentially causing the file to be replicated to the new location:

```
cp file1 /dir1/file2
```

A few options that make life easier for copying files include

- `-d`—Doesn’t follow symbolic links; copies the link instead. Links point one file to another and are explored later in the “Linking Files” section.

- `-f`—Force overwriting existing files.

- `-i`—Interactively asks before overwriting.
■ -l—Creates a hard link to the source file.
■ -r or –R—Recursively traverses directories (copying everything).
■ -s—Creates a symlink to the source file.
■ -u—Only updates the copy when the source is newer than the target or the target doesn’t exist.
■ –x—Doesn’t traverse to filesystems mounted from other devices.

Copying an existing directory to a new one is simple:

```
# cp -r dir1 dir2
```

The -r option is necessary because the cp command doesn’t process directories by default. As long as the target directory does not exist, the previous command makes an identical copy of the source and all subordinate files and directories in the target directory.

Copying a source directory to an existing target directory doesn’t attempt an overwrite; it makes the source directory into a new subdirectory of the target.

For example, if you are in the /test directory and have the structure shown in the following, you might assume that issuing a cp -r dir1 dir2 would overwrite dir2, or at least prompt you to see whether you wanted to:

```
$ tree .
|-- dir1
 | `-- file1
| `-- subdir1
`-- dir2
```

When you issue the cp -r dir1 dir2 command, the filesystem (along with the cp command) notices the existing dir2 entry and automatically drops the source directory into dir2 as a subdirectory, like this:

```
|-- dir1
 | `-- file1
| `-- subdir1
  `-- dir2
     `-- dir1
        `-- file1
        `-- subdir1
```

The correct way to copy the contents of dir1 into dir2, thereby mirroring dir1 exactly, is to focus on the word “contents.” By suffixing the source (dir1) with a forward slash and an asterisk (dir1/*), you tell the cp command to ignore the directory entry and focus on the filenames inside the directory.
With the same initial setup, if you issue the command `cp -r dir1/* dir2`, you get the correct results:

```
$ tree .
|-- dir1
 |  |-- file1
 |  `-- subdir1
`-- dir2
     |-- file1
     `-- subdir1
```

The inability to properly copy a directory or its contents will come back to haunt you on the exam. In addition, if you see a source directory with only a trailing forward slash (dir1/) but no asterisk, it’s identical to using (dir1). In other words, to copy just the contents of a directory, you have to address them specifically with the forward slash and asterisk (dir1/*).

Two special characters used in relative directory naming are often used when copying files. The current directory is represented by a single period (.) and the parent directory by two periods (..).

For example, if you are currently in the `/home/rossb` directory and want to copy a set of files from the `/home/lukec` directory, you can avoid typing the full path of the current directory with the (.) character. Both of these commands perform the same action:

```
cp /home/lukec/*.mp3 .
cp /home/lukec/*.mp3 /home/rossb
```

**Moving Objects**

Where the `cp` command copies a file by creating a new file, inode, and data, the `mv` command simply changes which directory file contains the file or directory entry or alters the entry in the file if it stays in the same directory. By changing just the metadata that points to the file, moving a file on the same device is quick. If the file move happens across two devices, the file is copied to the new device and deleted from the old one.

Create a file named `file1`; then run the `stat` command on it to check the details, as shown in Example 5-2.
Example 5-2  Running the stat Command on file1

```
$ touch file1
$ stat file1
  File: `file1'
  Size: 0          Blocks: 0          IO Block: 4096   regular empty
file
  Device: fd00h/64768d         Inode: 2261179     Links: 1
  Access: (0664/-rw-rw-r--) Uid: (500/sean)    Gid: (500/sean)
  Modify: 2015-02-03 21:47:46.000000000 -0600
  Change: 2015-02-03 21:47:46.000000000 -0600
  Birth: -
```

Now move the file to a new name with the mv command, as shown in Example 5-3.

Example 5-3  Moving Files to a New Name

```
$ mv file1 file2
$ stat file2
  File: `file2'
  Size: 0          Blocks: 0          IO Block: 4096   regular empty
file
  Device: fd00h/64768d         Inode: 2261179     Links: 1
  Access: (0664/-rw-rw-r--) Uid: (500/sean)    Gid: (500/sean)
  Modify: 2015-02-03 21:47:46.000000000 -0600
  Change: 2015-02-03 21:47:46.000000000 -0600
  Birth: -
```

Because the device and inode stayed the same you know this is the same file as before. The change time was modified to reflect the fact that the file was renamed.

When you move a file, the mv command overwrites the destination if it exists. This command supports an option, -i, that first checks the target to see whether it exists. If it does, mv asks whether you want to overwrite the target. Some distributions make -i a default option with a shell alias. Chapter 11, “Customizing Shell Environments,” discusses shell aliases in more detail.

Another quirk of the command is the lack of an -r, or recursive, option. This is because when you move a directory or a file you’re just changing the directory entry for the file. The directory continues to point to the same files so there is no need to move the files themselves.
You can avoid the overwriting of newer target files or directories with the `-u` option, preserving the latest copy of an object.

Examples of moving files and directories include moving a single directory to another directory name, as shown here:

```bash
mv -f dir1 dir2
```

This merely changes the directory entry `dir1` to the new name `dir2`. It also removes the “are-you-sure” prompt with the `-f` option.

Just like the `cp` command, moving directory contents requires a correctly formed command; otherwise, you’ll move a directory not to the new name, but to a subdirectory of the existing directory.

For example, consider the `/test` directory again, with its structure similar to the following:

```
$ tree .
|-- dir1
   |-- file1
   `-- subdir1
`-- dir2
```

If you were a Windows administrator, it would make sense to run the following command to move `dir1` to `dir2`:

```bash
mv dir1 dir2
```

If you do this on a Linux system and then run the `tree` command, you see the following output:

```
$ tree .
`-- dir2
   `-- dir1
       |-- file1
       `-- subdir1
```

This moves `dir1` under `dir2` because `dir2` already existed. To properly move the contents of the source `dir1` to the target `dir2`, you don’t need to use the nonexistent `-r` option (exam trick). You can just use a forward slash and an asterisk to refer to the files underneath `dir1`, like this:

```bash
mv dir1/* dir2
```
NOTE The * wildcard operator won’t match hidden files because they begin with a period. Handling this case is actually quite complicated and outside the scope of the exam.

If you run the `tree` command, you see the following output:

```
$ tree .
|-- dir1
  `-- dir2
      |-- file1
      `-- subdir1
```

Finally, the directories you pass to the `mv` command don’t always have to be underneath your current directory. You can use absolute pathnames, such as `mv /dir1` to move `dir1`, which is off the root directory into the current directory. You can also run `mv /dir1 /tmp` from anywhere in the system to move that same directory into the temporary directory.

**Transforming Data Formats**

The `dd` command is useful for a variety of tasks, not the least of which is creating backup images, called ISO files, of CD or DVDs. The two main formats `dd` interacts with are the raw device file and the full path of a file or object on the system.

For example, when creating a new boot disk, the `.img` binary file is read block by block from the CD-ROM (as a file) and written to a USB disk raw device as a set of blocks:

```
dd if=/mnt/cdrom/images/boot.img of=/dev/sdb
```

Creating an image of a CD-ROM involves reading the raw USB device block by block and creating a file on the filesystem that contains all those blocks:

```
dd if=/dev/sdb of=/root/usb.img
```

To duplicate a USB device named sdb to another USB device named sdc, the command is

```
dd if=/dev/sdc of=/dev/sdc
```

The `if` keyword means input file and the `of` keyword means output file. The exact order is unimportant, but as you can imagine, mixing up the in and out files can cause you to do terrible things such as overwriting parts of your hard drive!

`dd`, unlike most other Unix utilities, does not use dashes for its options. Options are specified in the format of `option=value`. 
The `dd` command is also often used to duplicate a drive or partition of a drive to another like object.

For example, to copy the first partition from the `/dev/sda` disk to the same location on the second hard drive on the system, you would use the following command:

```
dd if=/dev/sda1 of=/dev/sdb1
```

You can also copy an entire disk device to another on the system by leaving off the partition numbers:

```
dd if=/dev/sda of=/dev/sdb
```

This works only if the second device is as large as or larger than the first; otherwise, you get truncated and worthless partitions on the second one.

Backing up the MBR is another trick that `dd` does well. Remember that the master boot record contains the indexes of all the partitions on that drive, and thus is very important. To create a disk file that contains only the first 512 bytes of the first hard drive in the system, use this command:

```
dd if=/dev/sda of=/root/MBR.img count=1 bs=512
```

The `count` keyword sets the number of reads from the input file you want to retrieve, and the `bs` keyword sets the block size.

If you don’t set the count and block size on this command to back up the MBR, you’ll be copying the entire device’s blocks to the filesystem—a snake-eating-its-own-tail operation that is guaranteed to fill up the partition quickly and crash the system.

The restoration procedure is just the opposite:

```
dd if=/root/MBR.img of=/dev/sda count=1 bs=512
```

### Creating and Removing Directories

A basic task of file management is to be able to create and remove directories, sometimes creating or removing whole trees at once. To create a directory named `dir1`, you use `mkdir dir1`. To create a directory named `subdir1` in the `dir1` directory, you use `mkdir dir1/subdir1`.

Always think of the last segment of any directory path as the object being created or removed, and think of the rest as supporting or parent objects. The `mkdir` and `rm-dir` commands are similar in features and options, including the capability of `mkdir` to create a deep subdirectory tree from scratch in a single command:

```
mkdir -p /dir1/dir2/dir3/dir4
```
One of the quirks about the `rmdir` command is that it cannot remove anything but an empty directory. For example, the last directory of the chain `/dir1/dir2/dir3/dir4` is the real target for this command, and only if that directory is empty (no regular or directory files) can it be removed.

```bash
rmdir -p /dir1/dir2/dir3/dir4
```

One option to the `rmdir` command does allow it to remove directories that have files and so on in them. It’s called `--ignore-fail-on-non-empty` and is the longest option I know of in Linux. I’d rather type `rm -rf targetdir` 20 times than this beast.

**Removing Objects**

It follows that you’ll want to remove objects after creating or copying them, and this is done with the `rm` command for most objects. `rmdir` can also be used.

Deleting files with the `rm` command is a matter of choosing the target to be removed and the options that work best.

If you want to remove a particular file and never be prompted by confirmation messages, the command is `rm -f target`.

To remove a directory and all its contents, and never get a confirmation message, the command is `rm -rf /full/path/to/target`.

**Where Are Those Files?**

Having a mechanism for finding or locating files on a Linux system is essential because the sheer amount of directories and files makes searching manually nearly impossible.

There are two methods for accomplishing this task—quick and dirty or slow and methodical. Most people try the quick `locate` command before resorting to the plodding `find` command.

**Locating Files with Locate**

The quickest way to find a file or set of files is to use the `locate` command. It’s fast, database-driven, and secure. When you run the `locate` command you are searching a database instead of the filesystem, and only files that you have access to are shown. The downside of the database is that it’s updated nightly and is therefore unaware of any changes that have happened since the last update.

`locate` has a quirky way of showing results. You would probably expect that using `locate` for a file named `readme` would locate only files named `readme`, but that’s
not quite true. It finds anything that has a filename of **readme**, including regular files and any part of the path.

For example, while attempting to locate the **readme** file, you run the following command:

`locate readme`

This finds both of the following entries, one with the string **readme** as a part of the filename and the other a directory:

```
/readme
/usr/src/linux-2.4.20-8/drivers/net/wan/8253x/readme.txt
```

Use the **locate** command to find items you know are on the disk, or that you know existed before the last **locate** database update. The database that **locate** uses is updated nightly when the system runs its maintenance routines, or on demand. If you don’t have permissions to the object, it isn’t shown in the **locate** output.

Use **locate** with the `-i` option to ignore the case (upper or lower) and return anything that matches your search string using a case-insensitive match:

`locate -i string`

The **locate** database needs to be updated regularly to ensure good results. Your distribution probably puts it in the list of nightly jobs to be run. For more details on the nightly jobs, see Chapter 16, “Schedule and Automate Tasks.” Updating the database can take a long time, and it is frustrating having to wait for the updates to finish when you need to search.

The **update** commands must be run as **root**, and either one will do the job:

`updatedb`

Sometimes you want to exclude files or directories from the **locate** database because they either are inappropriate or simply take too long to index without any apparent benefit. This is configurable in the `/etc/updatedb.conf` file. This file is read and the variables are used by the updating commands.

The two main methods of excluding objects in the configuration file are either by filesystem type or path. The following output is an example of a working `/etc/updatedb.conf` file:

```
PRUNEFS="devpts NFS nfs afs sfs proc smbfs autoiso9660"
PRUNEPATHS="/tmp /usr/tmp /var/tmp /afs /net /sfs"
export PRUNEFS
export PRUNEPATHS
```
The **PRUNEFS** keyword is for filesystem types you want excluded from the **locate** database update; as you might expect, the **PRUNEPATHS** keyword is for directory trees you want excluded. Notice that most of the paths are temporary data locations or exotic file locations.

Remember for the exam that **locate** returns results for the search string in any portion of the path or filename it finds the string in. There will be questions that **locate** is right for, and some that really want the **whereis** command.

**Finding Files**

The **find** command is the most accurate but time-consuming method for searching the system for file objects because it crawls the list of files in real time versus the **locate** indexed database. The command consists of several (sometimes confusing) sections. But, if it's learned properly, it can be a powerhouse for the busy sysadmin.

The structure of a **find** command is

```
find startpath -options arguments
```

To make sense of this jumble of sections, let's take a look at a useful **find** command and match up the sections:

```
# find /home -iname *.mp3
/home/snuffy/g3 - red house.mp3
```

The previous command sets the start path to the `/home` directory and then looks for any instance of the string `mp3` as a file extension, or after the last . in the filename. It finds a file in the user `snuffy`'s home directory and returns the full path for that file.

Options for **find** include

- **group**—Based on files belonging to the specified group
- **newer**—Based on files more recent than the specified file
- **name**—Based on files with names matching a case-sensitive string
- **iname**—Based on files with names matching a non-case-sensitive string
- **user**—Searches for files belonging to the specified user
- **mtime**—The modify time; used for finding files x days old
- **atime**—Based on the number of days since last accessed
- **ctime**—Based on the number of days since the directory entry was last changed
A useful feature of the `find` command is its capability to execute another command or script on each and every entry normally returned to standard output.

For example, to find all MP3 files in the user’s home directories and archive a copy into the root user’s home directory, you could use this command:

```bash
find /home -iname *.mp3 -exec cp -f {} .\;
```

This command uses the `-exec` option, which accepts every line returned to standard output one by one and inserts the full path and filename between the curly brackets (`{}`). When each line of output is parsed and the command is executed, it reaches the `\;` at the end of the line and goes back to standard input for the next line. The last line of output is the last one with a command executed on it; it doesn’t just keep going and error out.

Running multiple operators in a single command is possible, too. Just be sure not to get the values for one operator mixed up in the next. You could look for all MP3 files owned by a given user with the following command:

```bash
find /home -iname *.mp3 -user snuffy /home/snuffy/bls - all for you.mp3
```

The `find` command is complex, and rather than bore you with more possible options, I’ve worked out a number of examples of how to use `find`:

To find a file and execute `cat` on it, use

```bash
find /etc -iname fstab -exec cat {} \;
```

To delete all `core` files older than seven days, use the following:

```bash
find /home -mtime +7 -iname core -exec rm -f {} \;
```

To find all files on the system owned by `bob` and change the ownership to `root`, use

```bash
find / -user bob -exec chown root {} \;
```

To find all files by user `tjordan` and change his group, use this command:

```bash
find /data -user tjordan -exec chGRP users {} \;
```

For safety you can use `-ok` instead of `-exec` to be prompted for confirmation each time the command runs.

```bash
find /data -user tjordan -ok chgrp users {} \;
```

To find all inodes related to a hard link, use the command `find / -inum 123456`.

The `find` command’s operators and the capability to execute commands on the search results will be covered on the exam. Practice all the examples you see here.
and get inventive with the possibilities. Particularly watch out for the use of `-mtime`
and its cousins: `-atime` and `-ctime`.

### Which Command Will Run?

With the plethora of commands and executable scripts offered on a Linux machine, you need to know which of the possible commands will run when you type the name of it on the command line. This all depends on the contents of the `PATH` variable. This variable’s contents are used as a sequentially read set of locations to search for executable objects.

The `which` command is used to determine the full path of commands that are queried from the `PATH` variable. To determine which command is indeed executed just by typing the name, run the following command:

```
which ls
```

```
alias ls='ls --color=tty'
/bin/ls
```

As you can see, two entries were found that contain the `ls` command. The first is an alias, one that sets some color functions to the `ls` command; the other is the real command binary in `/bin/ls`.

When you execute a command, it finds the first available match, which might not be the one you wanted, as is the case with the `ls` command. To make it execute a physical binary and ignore any aliases that have been set, preface the command with a backslash (\), like so:

```
\ls
```

Try it again on a command that has two executables on the system, the `gawk` command:

```
which gawk
```

```
/bin/gawk
```

This returns a single entry, but there are multiple `gawk` commands on a Linux box. The first matching command found is returned by default, and only if you use the proper switch does it find all possibilities:

```
which -a gawk
```

```
/bin/gawk
/usr/bin/gawk
```

### Researching a Command

When you need more information about a command than just which one will execute, try `whereis`. This command shows up to three possible bits of information,
including its binary files, the man page path, and any source files that exist for it. Here’s its syntax:

```bash
$ whereis ls
ls: /bin/ls /usr/man/man1/ls.1.gz
```

Options for `whereis` include

- `-b`—Searches for binaries
- `-m`—Searches for manual entries
- `-s`—Searches for sources
- `-u`—Finds unusual or improperly documented entries

To find a file by name but not get all the entries that contain the name in the path, use the `whereis` command—not the `locate` command—because it finds the string in all elements of the path.

In Chapter 11, Customizing Shell Environments, you will learn how to extend the shell to make common tasks even easier. The `type` command will tell you if a command has been extended. To check what happens when you type `ps`:

```bash
$ type ps
ps is /bin/ps
```

The output of the `type` command above indicates that the `/bin/ps` application will be run if you type `ps`.

The `ls` command is often extended to show common options, such as to add color to the output:

```bash
$ type ls
ls is aliased to `ls --color=auto'
```

The output above shows that when you run `ls`, you actually get `ls --color=auto`. You can see all the possible variants of `ls` by using `type`’s `-a` option:

```bash
$ type -a ls
ls is aliased to `ls --color=auto'
ls is /bin/ls
```

The `-a` option shows that the shell knows about both an alias and a file on disk.

### Linking Files

Links come in two varieties: symbolic and hard. (Symbolic links are often known as soft links.) Each has its own set of advantages and disadvantages. Sysadmins use links
for a multitude of purposes; chief among them is the need to make shortcuts on the
system for users to access data without having to navigate multiple directory levels.

If you have users on your Linux systems, you need to have a single mount point ac-
cessible to multiple users. The options include having users navigate to the /mnt/

**somemount** directory to save data or putting a link to that mount point in their
home directories. You’re much better off using a link for this task.

**Symbolic Links**

Symbolic links are used primarily to make a shortcut from one object to another. A
symbolic link creates a tiny file with its own inode and a path to the linked file. Sym-
links can span across filesystems and drives, primarily because a symlink has its own
inode. Figure 5-1 shows the relationship between a symlink and the target file.

For example, you might mount an external disk on the /mnt/projdata mount point
and want each user to be able to access that remote share from her own home direc-
tory. You simply have to issue the following command in each user’s home directory
to accomplish this:

```bash
ln -s /mnt/projdata projdata
ls -l projdata
lrwxrwxrwx 1 root root 13 Jan 26 12:09 projdata -> /mnt/projdata
```

Notice that the listing for the new symlink shows exactly where the link points, and
the permissions are set to the maximum so as to not interfere with the permissions
on the target object.
Symbolic links always look like they have the same permissions, but don’t try to change them. Changing permissions on a symlink changes the permissions on the target permissions instead.

**Hard Links**

A *hard link* is normally used to make a file appear in another place. A hard link is simply an additional name in a directory that points to the exact same inode and shares every aspect of the original file except the actual name (although the filename could be identical if in a different directory). Figure 5-2 shows the relationship between a hard link and the target file.

![Figure 5-2](image)

For an example of using a hard link, consider the need to ensure that a frequently deleted file is easily restorable for a given user. The user, Jaime, travels a lot, but when he’s in the office he seems to delete things a lot or claims the system has eaten his files. When Jaime is flying, you don’t have any issues, so the problem must be the user’s actions.

To anchor or back up an important file such as the company contact list in Jaime’s home directory, you first must create a backup directory, something like `/backup`.

Then, you create a hard link from Jaime’s `contactlist.txt` file to a file in the `/backup` directory, like so:

```bash
cd ~jaime
ln contactlist.txt /backup/home_jaime_contactlist.txt
ls -l contactlist.txt
-rw-r--r-- 2 jaime users 0 Jan 26 13:08 contactlist.txt
```

Notice that the file appears normal, but the number 2 for the link count lets you know that another name entry for this file exists somewhere.
Also notice that the listing for the new hard link doesn’t show the target file or seem to refer to it in any way. Running the `stat` command on this file won’t show you the other filename or seem to be aware of it outside the higher link count.

The name and location of a file are the only things about the file not stored in the inode. This appears on the exam in questions for this set of objectives.

Hard links can’t be created if the target is on another filesystem, disk, or remote object. The need to associate multiple names to the same inode makes this impossible.

Be careful when changing the permissions and ownership on the hard-linked files because all name entries point to exactly the same inode. Thus, any changes are instantly made to what would appear to be multiple files but what, in reality, are only filenames.

To delete a file that has multiple hard links requires the removal of every hard link or the multiple names. To find all the links for a file, run the following command:

```
ls -i ccontactlist.txt
17392 ccontactlist.txt
find / -inum 17392
/home/jaime/ccontactlist.txt
/backup/home_jaime_ccontactlist.txt
```

**NOTE** On the exam, remember that a symlink is another actual file with its own inode. A large number of symlinks can therefore cause a problem for a filesystem, such as one that contains users’ home directories. Too many inodes used can restrict you from using the storage space available. Run the `df -i` command to see what the statistics are.

### Backup Commands

As an administrator you often are called upon to deal with file archives, which are one or more files that have been packaged into one file and optionally compressed.

There are several uses for archives:

- You want to send a few files to someone or copy them to another server and want to package and compress them.
- You need to back up a partition to other media in case a disk fails or the file is otherwise lost.
You want to make a temporary copy of something before you make a change so you can restore it quickly if needed.

You need to keep files around but in compressed format, such as for archiving old logs.

A number of backup options are available for Linux systems. Some are more useful than others, and some act on files, whereas others work best on partitions or disks as a unit.

Backup commands on the exams include the following:

- cpio
- tar
- gzip and gunzip
- bzip2 and bunzip2
- xz

**Using tar**

The `tar` command is the workhorse of the archival world. The name comes from the term tape archive and goes back to the time when most backup was done to a local tape drive. You can think of `tar` as a pipeline that takes in a series of files and outputs a single file that is meant to be streamed to tape, but this output could be sent to a file on disk as well.

On the way through the pipeline you can do some transformations on the files such as chop up the output onto something that fits across multiple tapes, exclude files that weren’t recently changed, or rewrite the directory names stored in the archive.

`tar` also provides the extraction options. You take a `.tar` file, also called a tarball, and run it through `tar` to get back a copy of the original files. It is possible to extract only certain files and manipulate the filenames.

The `tar` command also can use various compression commands, particularly the `gzip/gunzip` and `bzip2/bunzip2` commands by the use of special option characters. This has the effect of creating a compressed archive file, typically named `tar.gz` for `gzip`-compressed files and `tar.bz2` for `bzip2`-compressed files.

`tar` commands have an unusual syntax. The command is `tar`, followed by a dash (-), and then all the options concatenated together such as `xvf`. After this is a list of zero or more filenames; the meanings depend on the options you chose.
The **tar** command has three main methods that act on files or **tar** archives; each has a corresponding letter that must be the first letter in the list of options:

- **c**—Creates an archive
- **t**—Tells you the contents of an archive
- **x**—Extracts files from an archive

The rest of the command can be optional, but some typical options are

- **v**—Be verbose by giving a list of files as they are processed.
- **j** or **z**—Compress or decompress with **bzip2** or **gzip**, respectively.
- **f**—The next word is the name of the file to operate on.

Figure 5-3 shows your choices graphically. We look at examples of each.

![Figure 5-3 Picturing the tar options](image)

When you’re creating an archive with **tar**, you should think about what you want to archive, where you want the resulting archive to be created, and what compression if any you want to use.

To create a simple **tar** archive, the options you need are as follows:

```
tar -cf archive.tar /foo
```

In this example, the **-c** option signals **tar** to create the file specified after the **-f** option and specifies the directory you are archiving, which is the `/foo` directory. Note that you have to add the `.tar` suffix. By default the operation is recursive.

To create the same archive with **gzip** compression, you simply insert a **-z** option and use the letters `.gz` as the filename suffix:

```
tar -czf archive.tar.gz /foo
```

This creates a compressed archive file that uses the **gzip** compression algorithms. If you want slightly higher compression, use the **-j** option (instead of the **-z** option) for **bzip2** compression and create your archive with a suffix of `.bz` or `.bz2`.

You will likely see questions on the exam that test your knowledge of which compression command has the highest compression. For example, using **bzip2** generally results in a smaller archive file at the expense of more CPU cycles to compress and
uncompress. The gzip package is almost always part of the default installation of Linux while bzip2 may not be.

To create a tar archive and see the filenames as they are processed use the -v option:

```
tar -cvf archive.tar /foo
```

This produces the following output:

```
tar: Removing leading `/' from member names
foo/
foo/install.log
foo/install.log.syslog
foo/.bash_logout
```

If given an absolute directory name to archive, tar strips the leading / from the full path of the objects in the archive. It would not be good if you could overwrite files in your /usr directory by extracting a file in an unrelated directory!

You may pass more than one directory or file to tar. For example, tar –cf foo.tar bin var creates an archive called foo.tar containing both the bin and var directories.

Taking Pity on the Unarchiver

It’s considered proper and elegant to create tar archives by specifying a directory that contains the files to be archived, not just a bunch of files that are in the current directory. This means that when the files are untarred they show up in a single directory instead of in the current directory.

For example, create an archive of the /etc directory contents with the following command:

```
tar -cf etc.tar /etc
```

When you unarchive the tar file, by default it creates an etc directory in the current directory, which contains the entirety of the /etc directory you archived.

Contrast this with the nightmare that happens when you navigate to the /etc directory and create the archive from there with this command:

```
tar -cf /root/badetc.tar *
```

This archive file contains the same files as the previous one, except they aren’t contained in a top-level etc directory—everything is in the top level of the archive.

Imagine what will happen to your system when you unarchive this file in the root user’s home directory. You will have spewed approximately 2,400 files directly into the root user’s home directory!
It really does matter where you are in the filesystem and which path options you use when you create or expand an archive file. It’s best practice to use absolute pathnames.

To solve the problem of 2,400 files polluting your root user’s home directory, use the following command, where `badetc.tar` is the offending archive file:

```
tar -tf badetc.tar | xargs rm -rf
```

This command produces a list of the paths and filenames of files in the archive and uses the `xargs` command to feed each line of output as a filename specification to the `rm -rf` command, removing all the files and directories expanded from the `badetc.tar` file.

**Useful Creation Options**

A number of other options can be used for creating `tar` archives. Here is a list of the more useful and testable ones:

- `-b`—Sets the block size to fit the media to which you are archiving. This is necessary for some tape devices.
- `-M`—This specifies multiple archive targets or spreads a large archive across multiple tapes or media.
- `-g`—Creates a new format incremental backup (only those that have changed since the last full or incremental).
- `-l`—Stays on the local filesystem; it’s used to keep from backing up the entire NFS network by accident.
- `-L`—This is followed by a number that reflects 1024 bytes, so `-L 500` equals 500KB. (It’s used for setting the tape length so multiple tapes can be used for an archive.)
- `--remove-files`—This is dangerous because the specified files are removed from the filesystem after they have been added to the archive!

**Listing Archive Files**

An underrated option, listing is something that typically is used after you don’t get the results you want or realize what you’ve just done and want to confirm how hard it is going to be to clean up.

To tell you the contents of a `tar` archive, use the following command:

```
tar -tf archive.tar
```
This produces the output shown here:

```
etc/
etc/sysconfig/
etc/sysconfig/network-scripts/
etc/sysconfig/network-scripts/ifup-aliases
etc/sysconfig/network-scripts/ifcfg-lo
```

To list an archive that uses compression, simply insert the necessary letter between the `-t` and the `-f` options, such as the `bzip2` `-j` option shown here:

```
tar -tjf archive.tar.bz2
```

This produces the following output:

```
etc/
etc/sysconfig/
etc/sysconfig/network-scripts/
etc/sysconfig/network-scripts/ifup-aliases
etc/sysconfig/network-scripts/ifcfg-lo
```

To list an archive and see the file details for its contents, you add the `-v` option to the existing command to see an output of the details:

```
tar -tvjf archive.tar.bz2
```

This returns output similar to the following:

```
-rwxr-xr-x  root/root  0  2015-02-10 03:46 etc/
rw-r-xr-x  root/root  0  2015-01-31 10:09 etc/sysconfig/
rw-r-xr-x  root/root  0  2014-11-10 22:13 etc/sysconfig/network-scripts/
```

When you create an archive with the `-v` option, a list of the files being archived is shown onscreen. When you unarchive an archive with the `-v` option, it shows a similar list of the files being unarchived.

It's only when you list an archive with the `-v` option that you get the type of output that approximates an `ls -l` command being run on the archive contents. This is an exam topic, so be ready for it.

**Using cpio**

The `cpio` command appears extensively in the Level 2 LPI objectives. This level of the exam might ask you about the `cpio` command at only the simplest levels, such as knowing that it exists, how it works in general terms, and whether it can be used to back up a Linux system.
The `cpio` command actions all treat the filesystem as the home base. If you are copying out, it’s from the filesystem out to another file. The same is true with copying in—it’s from a file into the filesystem.

The `cpio` command has three options for acting on files and filesystems:

- `-o` or `--create`—This copies files to an archive using a list of files typically created by the `find` command.
- `-i` or `--extract`—This copies files into the filesystem from an archive or a list of the archive contents.
- `-p` or `--pass-through`—This copies files from one directory tree to another without the use of an archive, essentially performing the same function as the `cp -r` command.

The `cpio` command accepts a list of files in a one-file-per-line format and uses this list to send the archived files to either the standard output or an archive file you specify.

`cpio` supports a variety of archive formats, including binary, ASCII, crc, and tar, to name the most relevant.

An example of creating a cpio archive from the files in the current directory is shown here:

```bash
find . "*" | cpio -o > archive.cpio
```

This outputs the list of files found by this particular `find` command, with the `cpio` command taking the entirety of the files and sending them to the `archive.cpio` file by redirecting standard output to the file.

The `cpio` command doesn’t accept a list of files to archive on the command line like the other utilities you’ve seen so far. Instead, it reads the names of the files from the standard input or console. So be aware that using either the `find` or `ls` command is necessary to feed `cpio` a list of filenames.

For example, if you needed to archive all the files that have an extension of .txt in the current directory to a `cpio` archive named `txt.cpio`, you would use the following command:

```bash
ls *.txt | cpio -o > txt.cpio
```

Notice that you’re redirecting the output of `cpio` to a file rather than letting it write the file itself. Therefore the filename is up to you, and if you want a `cpio` file extension, you need to add it yourself.
Compression Utilities

Whereas the `tar` command is used to gather files and put them in a container, the `gzip`, and `bzip2` commands are used to compress that container. Used by themselves, they act on each file they find and replace that file with a compressed version that has an extension that indicates the file is compressed.

The `gzip` and `bzip2` compression utilities compress files and are similar in their functions and operations. The main difference is that `bzip2` offers slightly better compression than `gzip`, but `gzip` is much more widely used.

These commands replace the original file with a new file that has an additional extension, so don’t delete the `.gz` or `.bz2` files that you create. They are the original files in a compressed wrapper!

To compress all the files in the current directory with `gzip` or `bzip2`, use this command:

```
gzip *
```

This replaces all the regular files (not the directories or their contents) in the current directory with the original filenames plus a `.gz` extension. So, if you had two files named `file1` and `file2` in the directory, they would be replaced with:

```
file1.gz
file2.gz
```

To uncompress these files, just do the exact opposite of the compression:

```
gunzip *
```

This restores the original files.

Using `bzip2` produces the same sort of results. You can issue the following command in the same directory:

```
bzip2 *
```

You would then have the following two files:

```
file1.bz2
file2.bz2
```

To uncompress these files, issue this command:

```
bunzip2 *
```

This restores the files to their original states.
xz is a third option for compressing files just like bzip2 and gzip. It is newer, and in some cases has better performance than bzip2 at a cost of more memory. Files are compressed with one of xz, xz -z, or xz --compress, and decompressed with one of unxz, xz -d, xz --uncompress, or xz --decompress.

The .xz file extension indicates that a file was compressed with xz. To uncompress foo.xz you would run xz -d foo.xz, and would be left with an uncompressed file called foo.

Watch for questions that ask about why you would use either gzip or bzip2 for a particular compression task. bzip2 offers slightly better compression at the expense of increased CPU cycles. gzip2 is faster but doesn’t compress as well. gzip2 also has a recursive option (-r) that compresses all files in a directory.

Summary

In this chapter you learned about the Linux File System Hierarchy Standard (FHS) and what it means for laying out partitions. You also learned how to find files in real time with the find command, and through a database lookup with the locate command. This chapter also covered the cp, mv, and touch commands for copying, moving, and updating files, along with the proper use of file globs for matching files on the command line.

Finally you learned about the various archival and compression utilities that Linux makes available to you.

Exam Preparation Tasks

As mentioned in the section “How to Use This Book” in the Introduction, you have a couple of choices for exam preparation: the exercises here, Chapter 21, “Final Preparation,” and the practice exams on the DVD.

Review All Key Topics

Review the most important topics in this chapter, noted with the Key Topics icon in the outer margin of the page. Table 5-3 lists a reference of these key topics and the page numbers on which each is found.
Table 5-3  Key Topics for Chapter 5

<table>
<thead>
<tr>
<th>Key Topic Element</th>
<th>Description</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paragraph</td>
<td>FHS documentation about what goes on the root volume</td>
<td>113</td>
</tr>
<tr>
<td>Paragraph</td>
<td>The use of the /usr and /usr/local/ directories</td>
<td>114</td>
</tr>
<tr>
<td>Paragraph</td>
<td>Relative pathnames and . (period character)</td>
<td>116</td>
</tr>
<tr>
<td>Paragraph</td>
<td>Long listing format (-l) to see permissions</td>
<td>117</td>
</tr>
<tr>
<td>Paragraph</td>
<td>Using the <code>touch</code> command</td>
<td>120</td>
</tr>
<tr>
<td>Paragraph</td>
<td>Using a glob to avoid copying into a directory incorrectly</td>
<td>122</td>
</tr>
<tr>
<td>Paragraph</td>
<td><code>Locate</code> needs the database refreshed periodically</td>
<td>129</td>
</tr>
<tr>
<td>Paragraph</td>
<td><code>Locate</code> searches whole names</td>
<td>130</td>
</tr>
<tr>
<td>Paragraph</td>
<td>Examples of <code>find</code> usage</td>
<td>131</td>
</tr>
<tr>
<td>Paragraph</td>
<td>When to use <code>whereis</code> versus <code>locate</code></td>
<td>133</td>
</tr>
<tr>
<td>Paragraph</td>
<td>The filename is not stored in the inode</td>
<td>136</td>
</tr>
<tr>
<td>Note</td>
<td>Symlinks consume inodes</td>
<td>136</td>
</tr>
<tr>
<td>Paragraph</td>
<td>The order and function of <code>tar</code>’s options</td>
<td>138</td>
</tr>
<tr>
<td>Paragraph</td>
<td>Creating a <code>tar</code> archive</td>
<td>138</td>
</tr>
<tr>
<td>Paragraph</td>
<td><code>bzip2</code> has the highest compression rate</td>
<td>138</td>
</tr>
<tr>
<td>Paragraph</td>
<td>The <code>-v</code> option to <code>tar</code></td>
<td>141</td>
</tr>
<tr>
<td>Paragraph</td>
<td><code>cpio</code> accepts its files from the standard input</td>
<td>142</td>
</tr>
</tbody>
</table>

**Define Key Terms**

Define the following key terms from this chapter and check your answers in the glossary:

- File System Hierarchy Standard
- relative path
- absolute path
- hard link
Review Questions

The answers to these review questions are in Appendix A.

1. You are installing a customized server and need to strip the root filesystem down to the essentials only. According to the FHS 2.3, which of the following are considered optional on the root (/) filesystem? (Choose two.)
   a. /root
   b. /usr
   c. /tmp
   d. /home

2. One of your programmers has produced an order entry system that will be shared among your users from a central file server. What is the appropriate directory to place this program and its associated files in?
   a. /usr/local/bin
   b. /usr/local
   c. /usr/share
   d. /opt

3. Which of the following is a true statement about files on a default Linux system? (Choose all that apply.)
   a. Filenames can start with a number.
   b. Filenames can contain multiple periods.
   c. Filenames can contain spaces.
   d. Filenames can contain ampersands.
   e. Filenames can contain backslashes.

4. You find a string in a shell script that contains the following command:
   `cp /data/*.doc ~tarfoo`
   What is the meaning of the characters ~tarfoo?
   a. A special function named tarfoo
   b. A directory named tarfoo in your home directory
   c. The tarfoo user’s home directory
   d. The /data/tarfoo directory
5. You are currently in the directory /home1/user1/subdir1 and need to navigate to the directory /home12/user3. Which of the following commands will accomplish this?
   a. cd home12/user3
   b. cd ~/user3
   c. cd ../../home12/user3
   d. cd ../../../home12/user3

6. You have a directory named /dir1 that contains subdirectories and regular files. You want to replicate this directory structure exactly into an existing directory named /dir2. Which of the following commands accomplish this? (Choose all that apply.)
   a. cp --contents dir1/ /dir2
   b. cp -r /dir1/* /dir2
   c. xcopy /dir1 /dir2
   d. cp -r /dir1 /dir2

7. You are currently in the /bbb directory and want to move the contents from the /ccc directory to this one. What is the shortest command that will accomplish this?
   a. mv /ccc/*.* .
   b. mv ../.ccc/*.* .
   c. mv /ccc/*. *
   d. mv /ccc/ /bbb

8. Which option to the mkdir and rmdir commands allows you to create a nested subdirectory tree?
   Example:
   
   /dir1/dir2/dir3/dir4

   a. -c
   b. -n
   c. -d
   d. -p
9. You are the sysadmin of a busy server and need to save space on your /home partition. You need to remove all files named `core` that are older than seven days in the users’ home directories, without receiving any prompts.
   a. `find /home -mtime +7 -name core -exec rm -f {} \;`
   b. `find ~ -mtime +7 -name core -exec rm -f {} \;`
   c. `find /home -mtime -7 -name core -exec rm -f {} \;`
   d. `find /home -older 7d -name core -exec rm -f {} \;`

10. Which of the following situations would prevent you from creating a hard link?
   a. The link spans filesystems.
   b. The source of the link is a hidden file.
   c. The source of the link is a device file.
   d. The source of the link is a directory.
   e. The destination contains special characters.

11. How would you back up Rebecca’s home directory using the best compression available?
   a. `cd /home; tar -czf rebecca.tgz rebecca`
   b. `find ~rebecca | tar -cjf - > rebecca.tar.bz2`
   c. `tar -cjf rebecca.tar.bz2 ~rebecca`
   d. `tar -xjf rebecca.tar.bz2 ~rebecca`
Index

Numbers
1 boot option, 32
2 boot option, 32
3 boot option, 32
4 boot option, 32
5 boot option, 32
100 entry, /etc/passwd file, 424
500 entry, /etc/passwd file, 424

A
access times setting (xinetd command), 580
accounts, 422
group, 425-427
   /etc/group file entries, 427
   adding, 431
   GIDs, 422-423, 426
   modifying, 432-433
   passwords, 427-428
   primary, 425
   removing, 434-435
   secondary, 426
   UPG (User Private Group), 426-427
limiting, 440
passwords, changing, 437-440
root, access, 574-576
security, Shadow Suite, 435-437

user
   adding, 428-430
   entries in /etc/passwd file, 423-424
   modifying, 431-432
   removing, 433-434
   special login files, 424-425
   UIDs (User IDs), 422-423, 424

actual commands, 97
adding
   group accounts, 431
   user accounts, 428-430
ADDITIONAL section (dig query), 558
address class ranges, networks, 534-535
address classes, networking, 535
address schema, IP (Internet Protocol), 544-545
ad-hoc jobs, running, 456
   batch command, 458-459
   at command, 456-458
aging passwords, 438-439
aliases, 97
   creating, MTAs (Mail Transfer Agents), 489
   MTAs (Mail Transfer Agents), 490
   shells, 93, 323
always on services, 576
anacron system, 447, 455-456
ANSWER section (dig query), 558
apm boot option, 32
apt-cache command, 66
apt-get command, 67
aquota.group file, 277
aquota.user file, 277
archives, tar, creating, 137-141
arguments, accepting, 357-358
ash shell, 314
at command, 447, 456-458
atq command, 457
atrm command, 457
AUTHORITY section (dig query), 558
autoconfigure, IPv6, 545
automatically mounting filesystems, 273
automount units (systemd), 36
awk command, 168

B
backup commands, 136-137
bash shell, 93
    history feature, 103-104
    setting options, 104-105
batch command, 458-459
bin directory (FHS), 112
bin subdirectory (/usr directory), 114
    /bin/bash entry, /etc/passwd file, 424
    /bin/false file, 424
binaries, software, 54
binary files, viewing, 173-174
binary shell, 93
blkid command, 270
blocks, processes, 199
boot directory (FHS), 112
boot events, logging, 45-46
boot loaders, 17-21, 30-31
GRUB (Grand Unified Boot Loader), 17-18, 31
GRUB2, 18
    command line, 19-20
    configuring, 20-21
    installing, 18-19
LILO, 31
Loadlin, 31
SYSLINUX, 31
boot process, 30
    command prompts, 32
    common commands, 32-33
    phases, 30
systemd, 34-36, 38-42
    changing runlevels, 41-42
    determining default runlevels, 40-41
    managing system runlevels, 40
    runlevels, 37
    setting default runlevels, 41
    targets, 37-38
    units, 36
    Upstart system initialization scheme, 39-40
    wants and requires, 38
daemons, 35
    SysVinit, 33-34
Bounce Keys, X Window System, 411
 Bourne Again shell, 314
Braille Display, X Window System, 413
breaking long command line, 98-99
broadcast addresses, 538
btrfs filesystem, 256
buffers
    processes, 199
    vim text editor, 229-230
built-in commands, 97
buses, peripheral/CPU communication, 7
bzip2 command, 143-144

caches, 199
remote package repositories, 65-66
case statements, 351
cat command, 164
cd command, 115-116
certifications, 610-611
chage command, 438-439, 596
character encoding, 329-330
checking filesystems, 263-266
chgrp command, 306-307
child environment, setting variables from, 316-317
chmod command, 295-297, 303
chown command, 305-306
classes.conf file, 482
classifying data, FHS (Filesystem Hierarchy Standard), 113-114
clauses, WHERE, SQL (Structured Query Language), 374-376
cleaning up SQL queries, 381
client utilities, SSH (Secure Shell), 592-596
clocks, 500
hardware, 500
synchronizing, 504-505
system, 500
columns, cutting, 168
command line, 90-91, 97
commands
breaking long, 98-99
completion, 99
controlling execution, 100-101
executing multiple, 161-163
structuring, 98
types, 97
CUPS (Common Unix Printing System), 477
environment variables, 101-104
GRUB2, 19-20
input/output streams, 154-158
pipes, 159-161
printing from, 478
rebooting from, SysVinit, 43
shutting down from, SysVinit, 42
Command mode, vim text editor, 223
command prompts, boot process, 32
commands
actual, 97
aliases, 97
apt-cache, 66
apt-get, 67
at, 456-458
atq, 457
atrm, 457
awk, 168
backup, 136-137
batch, 458-459
blkid, 270
built-in, 97
bzip2, 143-144
cat, 164
cd, 115-116
chage, 438-439, 596
chgrp, 306-307
chmod, 295-297, 303
chown, 305-306
controlling execution, 100-101
cp, 121-123, 125
cpio, 141-142
crontab, 447-448
cupsaccept, 480-481
cupsdisable, 481
cupsenable, 481
cupsreject, 480-481
cut, 168
date, 328, 500-503
dd, 126-127
debugfs, 257, 268-269
df, 275-276
dhclient, 554, 556-557
dhcpcd, 554, 556-557
dig, 554, 557-559
dmesg, 45-46
dpkg, 59-60
du, 274-275
dumpe2fs, 262-263
dech, 119
edquota, 277
egrep, 184-185
ev, 319-320
executing multiple, 161-163
expand, 167-168
export, 316
fdisk, 246-250
features, 269
fgrep, 184-185
file, 118-120
filters, 165-174
find, 130-132, 586-587, 596
fmt, 174-175
formatting, 174-175
grep command, 178-184
sed (stream editor) command, 175-176
translating files, 175-176
free, 198-201
fsck, 263-266, 269
fstab, 270
functions, 97
fuser, 596
gdisk, 250-254
getent, 557-559
gpasswd, 428
gpg -gen-key, 587-589
grep, 178-187
groupadd, 431
groupmod, 432-433
grpquota, 277
grub-mkconfig, 21
gzip, 143-144
halt, 42
head, 170-171
history, 103-104
host, 554, 557-559
hostname, 350, 554, 559
hwclock, 503-504
ifconfig, 554-555
ifdown, 554
ifup, 554
inetd, 576-578, 581
install, 64-65
ip, 554
ip addr show, 547
ipconfig, 545-546
join, 168-169
journaletl, 515-516
kill, 44-45
killall, 44-45, 204
last, 596
less, 159
locale, 330-334
locate, 128-130
logdump, 269
logger, 512
lp, 478
lpq, 479
lpr, 478
lprm, 479-480
lpstat, 478-479
ls, 116-118, 132, 269
lsblk, 9
lscpu, 9
lsdev, 9
lsmod, 8
lsf, 596
lspci, 9
lsraid, 9
lsscsi, 9
lsusb, 9
mkdir, 127-128
mkfs, 260-262
mount, 270, 273
mv, 124-126
n, 252-253
netstat, 554, 559-562
newgrp, 428
nice, 207
nl, 166-167
nslookup, 554
ntpd, 507-508
od, 173-174
open, 269
parted, 254-255
paste, 168-169
passwd, 439, 596
ping, 554, 562-563
pkill, 204-205
poweroff, 42
pr, 174-175
ps, 196-198
pstree, 197-198
pump, 554, 556-557
pwd, 269
quit, 269
quota, 277, 280-282
quotacheck, 277
quotaon, 277
quotoff, 277
renice, 207-208
route, 554-555
rpm, 70-71
scp, 591, 593
screen, 210-213
scripts, 97
sed, 176-178
seq, 354-355
set, 317-318
shell script, 344
combining multiple tests, 351
performing math, 345-346
testing files, 348-349
testing integers, 349-350
testing strings, 349-350
use output of another command, 344-345
shutdown, 42
sort, 165-166
split, 172-173
SQL (Structured Query Language), 372-373
ssh, 591-592
ssh-add, 591
ssh-agent, 591
sshd, 591
stat, 124
stats, 269
structuring, 98
su, 574-575
substitution, 162-163
sudo, 575-576
swap, 245
tac, 173
tail, 171-172
tar, 137-141
tcpdump, 554, 565
tee, 163
test, 348
top, 208-209
touch, 120-121
tr, 175-176
tcpdump, 554, 563-564
tune2fs, 266-267
ulimit, 440, 596
undelete, 269
uniq, 169-170
unset, 317-318
uptime, 201-202
useradd, 428-430
userdel, 433-434
usermod, 431-432, 596
usrquota, 277
vi text editor, running external, 234
vim text editor, cut/copy/paste, 228-229
w, 596
whereis, 132-133
which, 132
who, 596
xargs, 163-164
xfs, 267-268
xinetd, 576-583
xwininfo, 407-408
comments, SQL (Structured Query Language), 372
Common Unix Printing System (CUPS). See CUPS (Common Unix Printing System)
communication, peripherals, 7
compatibility, peripherals, 7
completion shell, 93
component groups, systemd, 35
compression utilities, 143-144
conditions
scripts, 346-347
SQL (Structured Query Language), multiple, 376-377
conffiles section (.deb file), 59
configuration
cron system, crontabs, 447-448
CUPS (Common Unix Printing System), 470-474
default gateways, 550-551
disk quotas, 278-280
GRUB2, 20-21
interfaces
Debian, 548-549
Red Hat, 547-548
network utilities, 553-554
dbcient command, 556-557
dbcped command, 556-557
dig command, 557-559
getent command, 557-559
host command, 557-559
hostname command, 558-559
ifconfig command, 555
netstat command, 559-562
ping command, 562-563
pump command, 556-557
route command, 555
tcpdump command, 565
traceroute command, 563-564
ntpd daemon, 506-507
systemd, 512-514
TCP wrappers, 583-585
YUM packages, 84-86
configuration files
inetd, 577-578
RPM packages, querying, 79
xinetd, 578-581
Xorg, 402-405
console, 210-211
locking, 213
multiple sessions, 210-211
consoled daemon (systemd), 35
control section (.deb file), 59
convenience crontabs, 454
copy command, vim text editor, 228-229
copying files and directories, 121-123
cp command, 121-123, 125
cpio command, 141-142
CPUs, peripherals, addressing, 7-8
cron system, 447
configuring crontabs, 447-448
convenience crontabs, 454
crontab command, 447-448
files, 452-453
finishing crontab, 450
making multiple matches, 449
matching time, 448-449
nicknames extension, 452
output, 451-452
PATH, 450-451
restricting access, 454-455
spelling out month and day names, 449
step values, 450
system crontabs, 453
crontab command, 447-448
C-shell, 314
CUPS (Common Unix Printing System), 468
Administration menu, 476
command-line tools, 477
configuration files, 482
configuring, 470-474
daemon, 468
daemons, configuring, 481
Jobs List, 477
legacy printing tools, 477-480
maintenance, 474-475
maintenance and administration pull-downs, 476
pipeline, 468-470
print jobs, rejecting, 480-481
printer state, 475
printers, enabling/disabling, 481
troubleshooting printing, 482-483
cupsaccept command, 480-481
cupsd.conf file, 482
cupsd.conf.default file, 482
cupsdisable command, 481
cupsenable command, 481
cupsreject command, 480-481
custom network masks, 538-541
cut command, 168
time, 451-452
vim text editor, 228-229
cutting columns, 168
D

daemons
CUPS (Common Unix Printing System), 468
ntpd, configuring, 506-507
systemd, 35
data formats, transforming, 126-127
databases, 368
key-value, 368-369
relational, 369-370
RPM, 68-69
schemaless, 370-371
SQL (Structured Query Language), 371
  advanced joins, 381-384
  cleaning up queries, 381
  commands, 372-373
  comments, 372
  creating tables, 388-389
  deleting data, 388
  grouping data, 386-387
  inserting data, 387
  keywords, 372-373
  left versus right joins, 384
  limiting results, 378
  multiple conditions, 376-377
  multiple tables, 378-379
  NULL, 384-385
  selecting data, 373-374
  semicolons, 372
  sorting results, 377-378
  SQLite, 371-372
  subselects, 385-386
  updating data, 388
  WHERE clause, 374-376
  writing queries with joins, 379-380
date command, 328, 500-503
date specifier (at command), 457
dd command, 126-127
.deb files. See local packages
Debian, 50
  interface configuration, 548-549
  package management, 58-59
    caches, 65-66
    dependency issues, 60-61
    graphical managers, 67
    installing packages, 59-60
    installing remote packages, 64-65
    querying packages, 61-63
    reconfiguring packages, 61-63
    removing packages, 60
    removing remote packages, 67
    system upgrade, 66-67
debgfs command, 257, 268-269
debugging filesystems, 268-269
default gateways
  configuring, 550-551
  viewing, 550
default network mask, 536-537
default permissions, files, 303-305
defaults, useradd command, 429
Delete Printer command
  (Administration menu), 476
deleting
  data, SQL (Structured Query Language), 388
Debian packages, dpkg command, 60
  group accounts, 434-435
  objects, 128
remote Debian packages, apt-get command, 67
RPM packages, 75-76
  text, 227-228
user accounts, 433-434
dependencies, RPM packages, querying, 80
dependency issues, Debian packages, 60-61
descriptors, files, 154
stderr, 155-156
stdin, 154
stdout, 154-155
design, scripts, 343
desktops, X Window System, 402
detaching processes, 212-213
dev directory (FHS), 112
device units (systemd), 36
devices, 6
compatibility, 7 enumerating, 7-8 integrated, 10-11
procs, 8-10
df command, 275-276
dhclient command, 554, 556-557
dhcpcd command, 554, 556-557
dig command, 554, 557-559
direct memory access (DMA),
CPU/peripheral addressing, 8
directories
copying, 121-123 creating and removing, 127-128
FHS (Filesystem Hierarchy Standard), 112
/usr directory, 114
inodes, 258-259
permissions, setting SGID bit, 301-302
disable setting (xinetd command), 580
disabled services, 576
disk partitioning tools, 245
fdisk, 246-250
gdisk, 250-254
parted, 254-255
disks
/dev/sda, 21
disk quotas, 277-282
filesystem mounts, 16
laying out, 11-17
PIBS (Performance, Integrity, Backup, Security), 14
LVM (Logical Volume Manager), 14-16
partitions, 11-12
swap, 16-17
tools, 243-255
quotas, 277-282
commands, 277
configuring, 278-280
grace period, 278, 281
hard limit, 277, 280-281
obtaining information, 281-282
soft limit, 277, 280-281
root filesystem, 12-14
space, inodes, 259-260
display managers, X Window System, 408-409
distributions, 610-611
DMA (direct memory access),
CPU/peripheral addressing, 8
dmesg command, 45-46
DNS (domain name system), MTAs
(Mail Transfer Agents), 487
documents
replacing, 231
searching, 231
dpkg command
installing packages, 59-60
removing packages, 60
viewing packages, 58-59
du command, 274-275
dumpe2fs command, 262-263
error code, returning, 357
/etc directory (FHS), 112
/etc/group file, 427
/etc/init.d directory, 596
/etc/locktab file, 596
/etc/login.defs file, 425
/etc/motd file, 425
/etc/nonlogins file, 424
/etc/passwd file, 596
/etc/security file, 425
/etc/shadow file, 596
/etc/usertty file, 425
error checking, filesystems, 263-266

E

echo command, 119
editing shell, 93
EDTOr environment variables, 448
edquota command, 277
egrep command, 184-185
emacs option (bash), 105
e-mail
flow, 484
language, 485-486
MTAs (Mail Transfer Agents), 484-485
aliases, 490
committed changes, 489-490
creating aliases, 489
DNS (domain name system), 487
forwarding, 489
Linux, 486-487
mail server, 488-489
managing queues, 491-492
MDAs (Mail Delivery Agents), 488
user-defined forwarding, 491
encodings, converting files between, 334
encryption
GnuPG keys, 587-590
passwords, Shadow Suite, 435-437
enumerating, peripherals, 7-8
env command, 319-320
environment variables, 315
EDITOR, 448
error checking, filesystems, 263-266
examples
/etc/adtime (18-3), 504
Actual Hierarchy of the Boot Process (2-2), 39
Contents of an /etc/xinetd.conf File (20-1), 579
Contents of an /etc/xinetd.d Service File (20-2), 580
Create a Partition with the Label “MyData” Going from the Beginning of the Drive to 7GB (9-8), 254-255
Create Partition for Primary Partition Number 2 (9-2), 248
debfs Command (9-9), 257
Default Sources List File (3-3), 65
Default yum.conf Configuration for Fedora (3-10), 84-85
Demonstration of Changing GID (15-2), 433
Demonstration of /etc/skel (15-1), 430
Demonstration of SUID (10-1), 300
dumpe2fs (9-11), 262-263
Example journald.conf (18-11), 519
Example ntp.conf (18-4), 506
Example of a Variable (11-1), 315
Example of an ifconfig Command’s Output (19-2), 546
Example of Contents of the /etc/network/interfaces File (19-4), 549
Example of dig Command Output (19-5), 558-559
Example of ip addr show Command Output (19-3), 547
Example of the /etc/services File (19-1), 542-543
Example of traceroute Command Output (19-7), 563-564
Example of xwininfo Output (14-22), 407
Example Xorg Configuration File (14-1), 403-404
Examples Using a Glob (5-1), 119-120
-f Forces a Check (9-13), 266
Finding a Package’s Configuration Files (3-5), 79
Finding Out What’s Inside a .deb File (3-1), 58-59
Individual Repository’s Configuration from Fedora (3-11), 85
Installing a Package from a Remote Repository (3-7), 81-82
Installing a Remote Package (3-2), 64
Installing GRUB2 to an Alternate Location (1-2), 18-19
List the Partitions (9-5), 252
Listing Packages That Match a Wildcard (3-8), 83-84
logrotate Configuration (18-12), 521
Looking at the Logs Verbosely (18-10), 517-519
lsdev Command (1-1), 9
Mail Queue (17-8), 491
Making the Filesystem with xfs (9-14), 267-268
mkfs and Options (9-10), 261-262
Moving Files to a New Name (5-3), 124
Output of the gpg --gen-key Command (20-3), 588
Output of the gpg --gen-key Command (20-4), 588-589
Output of the gpg --gen-key Command (20-5), 589
Partition Verification (9-7), 253-254
Printing from the Command Line (17-1), 478
Querying a Package for Information (3-4), 77-78
Querying All the Service’s Logs (18-9), 517
Querying an NTP Server’s Peers (18-5), 507
Querying the Dependencies of a Package File (3-6), 80
Querying the Journal for sshd Logs (18-8), 516-517
Querying the Printer for Status (17-3), 479
Rejecting Jobs (17-5), 480-481
Removing a Print Job (17-4), 480
Running Commands and Functions in Your Prompt (11-6), 325
Running the stat Command on file1 (5-2), 124
Sample Check on a Filesystem (9-12), 265
Sample /etc/syslog.conf (18-6), 512-513
Script to Demonstrate BASH_SUBSHELL Levels (11-5), 319
Searching YUM Repositories for Packages That Match a Concept (3-9), 84
Setting the Time in Various Formats (18-1), 501
Shell Script to Demonstrate Subshells (11-4), 319
Showing the Status of All Printers (17-2), 478
SMTP Conversation Between Two MTAs (17-6), 485
String Matched as if It Were a File Glob (12-2), 352
Theoretical Hierarchy of the Boot Process (2-1), 38
Updating aquota.* with quotacheck -avuc (9-15), 279
Using case Instead of if/elif/else (12-1), 351
Using date in a Shell Script (18-2), 502
Using /etc/skel (11-7), 326-327
Using gdisk -l to View Partition Information (9-3), 251
Using gdisk to Convert an Existing MBR Partition Table to GPT (9-4), 252
Using locale (11-10), 333
Using locale-gen (11-9), 332
Using n to Create a Partition (9-6), 253
Using noclobber (11-3), 318
Using the locale -a Command to See the Locales Installed on Your System (11-8), 331
Using the shift Keyword (12-3), 357-358
Using unset to Destroy a Variable (11.2), 317
Verify the Partition Was Created (9-1), 247
Viewing the Unfiltered Log with journalctl (18.7), 515-516

exams (LPI)
certifications and distributions, 610-611

executing multiple commands, 161-162
evaluation, commands, controlling, 100-101
expand command, 167-168
export command, 316
expressions, grep command, 185-187
ext2 filesystem, 255
ext3 filesystem, 255
ext4 filesystem, 255
extending shells, 320
adding dynamic content, 325-326
aliases, 323
creating new users, 326-327
functions, 323-324
global and user settings, 320
login session, 321
non-login session, 321
PATH variable, 322-323
PS1 variable, 324-325
PS2 variable, 326

extensions, files, 115
external commands, vi text editor, running, 234
fallback locales, 331
fdisk command, 246-250
features command, 269
fgrep command, 184-185
FHS (Filesystem Hierarchy Standard), 54, 112-115
classifying data, 113-114
commands
  backup, 136-137
cpio, 141-142
researching, 132-133
common directories, 112
data formats, transforming, 126-127
directories
  /usr, 114
copying, 121-123
creating and removing, 127-128
listing, 116-118
files
  compression utilities, 143-144
copying, 121-123
determining type, 118-120
finding, 130-132
linking, 133-134
listing, 116-118
locating, 128-130
touching, 120-121
navigation commands, navigation, 115-116
objects
  moving, 123-126
  removing, 128
which command, 132
file command, 118-120
file permissions, Shadow Suite, 437
files
  aquota.group, 277
  aquota.user, 277
  binary, viewing, 173-174
  compression utilities, 143-144
  converting encodings, 334
copying, 121-123
.deb, managing, 58-64
descriptors, 154
  stderr, 155-156
  stdin, 154
  stdout, 154-155
determining types, 118-120
/etc/group file, 427
/etc/passwd, entries, 423-424
extensions, 115
finding, 130-132
group ownership, changing, 306-307
hidden, 115
inodes, 256-258
linking, 133-134
locating, 128-130
names
  characters, 115
  spaces, 115
navigating within, vim text editor, 224-225
opening, vim text editor, 223-224
permissions, 292, 297-298
default, 303-305
finding by, 302-303, 587
setting SGID bit, 300-301
setting sticky bit, 302
special bit, 298-299, 586-587

RPM packages, 69
saving, vim text editor, 226
splitting, 172-173
tar archives, creating, 137-141
testing, 348-349
touching, 120-121
user ownership, changing, 305-306

Filesystem Hierarchy Standard (FHS).
See FHS (Filesystem Hierarchy Standard)

filesystems, 240-241, 255
creating, mkfs command, 260-262
debugging, 268-269
directories, inodes, 258-259
disk space, inodes, 259-260
derror checking, 263-266
FHS (Filesystem Hierarchy Standard), 54, 112-113
/usr directory, 114
classifying data, 113-114
commands, 114-136
files, inodes, 256-258
mounting, 269-272
automatically, 273
manually, 272-273
mounts, 16
procfs, 8-10
root, 12-14
space utilization, 274
df command, 275-276
disk quotas, 277-282
du command, 274-275
superblocks, 256
tables, 270-272
tuning, 266-267
types, 255-256
unmounting, 273-274
xfs commands, 267-268

filters, 165-174
cut command, 168
expand command, 167-168
head command, 170-171
join command, 168-169
nl command, 166-167
od command, 173-174
paste command, 168-169
sort command, 165-166
tac command, 173
tail command, 171-172
uniq command, 169-170
find command, 130-132, 586-587, 596
finding files by permissions, 302-303
flags setting (xinetd command), 580
flow, email, 484
fmt command, 174-175
fonts, X Window System, 405-406
Foreign Address column (netstat output), 561
format strings, data command, 502
formats, data, transforming, 126-127
formatting commands, 174-175
grep command, 178-184
sed (stream editor) command, 175-176
translating files, 175-176
forwarding email, MTAs (Mail Transfer Agents), 489
free command, 198-201
freezes, X Window System, 409-410
freshening, RPM packages, 74-75
fsck command, 263-266, 269
fstab command, 270
functions, 97
  shells, 93, 323-324
fuser command, 596

G

gateway addresses, 537-538
  configuring, 550-551
  viewing, 550
gdisk command, 250-254
GDM display manager, 408
GECOS field, /etc/passwd file, 424
gentent command, 557-559
GIDs (Group IDs), 422-423, 426
  entry, /etc/group file, 427
  modifying, 433
glob operators, 119
global settings, 94-96
  shells, 320
GnuPG keys, 587-590
gpasswd command, 428
GPG, RPM package validation, 71
gpg -gen-key command, 587-589
grace period, disk quotas, 278, 281
graphical package managers, Debian
  packages, 67
grep command, 178-184
  options, 178-179
  regular expressions, 185-187
group accounts, 422, 425-427
  /etc/group file entries, 427
  adding, 431
  GIDs, 422-423, 426
  limiting, 440
  modifying, 432-433
  passwords, 427-428
  changing, 437-440
primary, 425
removing, 434-435
secondary, 426
security, Shadow Suite, 435-437
UPG (User Private Group), 426-427
GROUP BY clause (SQL), 386-387
group ownership, changing, 306-307
groupadd command, 431
grouping data
  SQL (Structured Query Language), 386-387
  SQL results, 386-387
groupmod command, 432-433
grpquota command, 277
GRUB (Grand Unified Boot Loader), 17-18, 31
GRUB2, 18
  command line, 19-20
  configuring, 20-21
  installing, 18-19
grub.cfg file, 20
grub-mkconfig command, 21
GUI (graphical user interface), X
  Window System, 400-402
  Braille Display, 413
  display managers, 408-409
  freezes, 409-410
  High Contrast/Large Desktop themes, 412
  Mouse Keys, 411
  onscreen keyboard, 413
  remote clients, 413-414
  screen reader, 412
  Slow/Bounce/Toggle Keys, 411
  Sticky/Repeat Keys, 410
  Xorg, 402-408
gzip command, 143-144
halt command, 42
hanging up processes, 45
hard drives
/dev/sda, 21
disk quotas, 277-282
filesystem mounts, 16
laying out, 11-17

PIBS (Performance, Integrity, Backup, Security), 14
LVM (Logical Volume Manager), 14-16
partitions, 11-12
swap, 16-17
tools, 245-255
quotas, 277-282
commands, 277
configuring, 278-280
grace period, 278, 281
hard limit, 277, 280-281
obtaining information, 281-282
soft limit, 277, 280-281
root filesystem, 12-14
space, inodes, 259-260
hard limit, disk quotas, 277, 280-281
hard links, 134-135
hardware
dev/sda, 21
disk quotas, 277-282
filesystem mounts, 16
laying out, 11-17, 14
LVM (Logical Volume Manager), 14-16
partitions, 11-12, 16-17, 245-255
quotas, 277-282
root filesystem, 12-14
space, inodes, 259-260
peripherals, 6
compatibility, 7
enumerating, 7-8
integrated, 10-11
profs, 8-10
viewing list, 8
hardware clock, 500, 503
hwclock command, 503-504
system clock, synchronizing, 504-505
hashall option (bash), 105
.hushlogin file, 425
head command, 170-171
HEADER section (dig query), 558
headers, IPv6, 545
hidden files, 115
High Contrast theme, X Window System, 412
history command, 103-104
history option (bash), 105
history shell, 93
history variables, 104
home directory (FHS), 112
HOME variable, 102-103
/home/ross entry, /etc/passwd file, 424
host command, 554, 557-559
hostname command, 350, 554, 559
hosts, 532
networks, 534
viewing IPs, 555
hwclock command, 503-504
ICMP (Internet Control Message Protocol), 542
idle state, printers, 475
ifconfig command, 554-555
ifdown command, 554
ifup command, 554
IMAP (Internet Message Access Protocol), 488
include subdirectory (/usr directory), 114
inetd command, 576-578
TCP wrappers, 581
init boot option, 32
inodes
  directories, 258-259
disk space, 259-260
files, 256-258
input streams
  numbering lines, 166-167
  splitting, 163
  stderr file descriptor, 155-156
  stdin file descriptor, 154
INSERT command (SQL), 387
Insert mode, vim text editor, 223
inserting data, SQL (Structured Query Language), 387
install command, 64-65
installation
  Debian packages, dpkg command, 59-60
  GRUB2, 18-19
  Linux, 3-6
    boot managers, 17-21
    laying out hard drive, 11-17
    peripherals, 6-8
remote Debian packages, 64-65
RPM packages, 72-73
YUM packages, 80-83
integers, testing, 349-350
integrated peripherals, 10-11
interfaces
  managing, 545
    configuring default gateway, 550-551
    Debian configuration, 548-549
    log name configuration, 551-553
    Red Hat configuration, 547-548
    viewing default gateway, 550
    viewing IP information, 545-547
X Window System, 400-402
  Braille Display, 413
  display managers, 408-409
  freezes, 409-410
  High Contrast/Large Desktop themes, 412
  Mouse Keys, 411
  onscreen keyboard, 413
  remote clients, 413-414
  screen reader, 412
  Slow/Bounce/Toggle Keys, 411
  Sticky/Repeat Keys, 410
  Xorg, 402-408
internationalization, 327
  character encoding, 329-330
displaying time, 328
time zones, 327-328
setting, 328-329
Internet Control Message Protocol (ICMP), 542
Internet Message Access Protocol (IMAP), 488
Internet Printing Protocol (IPP), 468
Internet Protocol (IP), 532
interrupt requests (IRQs), CPU/peripheral addressing, 7
IO port, CPU/peripheral addressing, 7
IP (Internet Protocol), 532, 541
addresses, 533-534
viewing information, 545-547
ip addr show command, 547
ip command, 554
ipconfig command, 545-546
IPP (Internet Printing Protocol), 468
IPv6, 544-545
versus IPv4, 544-545
IRqs (interrupt requests), CPU/peripheral addressing, 7
iso9660 filesystem, 255

jobs
print
  list, 477
  rejecting, 480-481
running ad-hoc, 456-458
  batch command, 458-459
Jobs List (CUPS), 477
join command, 168-169
joins, SQL queries
  advanced, 381-384
  left versus right, 384
  subselects, 385-386
  writing with, 379-380
journalctl command, 515-516
journald logging system (systemd), 35
  configuring, 519-520

K

KDE desktop, 43
KDM display manager, 408
key-value databases, 368-369
keywords, SQL (Structured Query Language), 372-373
kill command, 44-45
killall command, 44-45, 204
killing processes
  killall command, 204
  PID (process ID), 203
  pkill command, 204-205
Korn shell, 314
KVM, 609

L

language, email, 485-486
Large Print Desktop theme, X Window System, 412
last command, 596
laying out hard drive, 11-17
   PIBS (Performance, Integrity, Backup, Security), 14
legacy printing tools, CUPS (Common Unix Printing System), 477-480
less command, 159
lib directory (FHS), 112
lib subdirectory (/usr directory), 114
libraries
   required, 56-57
   searches, 57
   shared, 54-56
LILO boot loader, 31
line printer daemon protocol, 467
line printer remote (LPR), 467
lines
   joining, vi text editor, 234
   numbering, 166-167
linking files, 133-134
Linux
   boot process, 30
      boot loaders, 30-31
      common commands, 32-33
      phases, 30
      systemd, 34-42
      SysVinit, 33-34
installing, 3-6
   boot managers, 17-21
   laying out hard drive, 11-17
   peripherals, 6-8
Live DVDs, 7
open source, 6
rebooting from command line,
   SysVinit, 43
shutting down from command line,
   SysVinit, 42-43
listing
   files, archive, 140-141
   partitions, 252
Live DVDs, Linux, 7
Loadlin boot loader, 31
Local Address column (netstat output), 561
local subdirectory (/usr directory), 114
locale command, 330-334
localization, 327
   converting files between encodings, 334
   fallback locales, 331
   locale command, 332-333
   locale contents, 331-332
   representing locales, 330-331
   time zones, 327-328
locate command, 128-130
locking console, 213
log name configuration, 551-553
log_on_failure setting (xinetd command), 580
logdump command, 269
logger command, 512
logging, system
   boot events, 45-46
   journald logging system, configuring, 519-520
   querying logs, 515-519
   rotating logs, 520-522
   syslog, 508-511
      alternate implementations, 514
   systemd, 35, 508-509, 514-515
      configuring, 512-514
      logger command, 512
Logical Volume Manager (LVM), 14-16
login files, user accounts, 424-425
login shell sessions, 95-96, 321
logind daemon (systemd), 35
logout, leaving programs running after, 209-213
logs, rotating, 520-522
loops, 353
reading from stdin, 356
sequences, 354-355
while, 355-356
lost+found directory (FHS), 112
lp command, 478
LPI exams
certifications and distributions, 610-611
objectives, 604, 606-608
preparation, 603-605, 610
software installation, 611
studying, 608
studying don’ts, 609-610
VMs (virtual machines), 609
question amount and time, 605
question types, 611-612, 616
choose all that apply, 613-614
choose two/choose three, 613
fill in the blank, 615-616
single answer multiple choice, 612
lpq command, 479
LPR (line printer remote), 467
lpr command, 478
lprn command, 479-480
LPRng (Next generation of LPR), 467
lpstat command, 478-479
ls command, 116-118, 132, 269
lsblk command, 9
lscpu command, 9
lsdev command, 9-10
lsmod command, 8
lsol command, 596
lspci command, 9
lsraid command, 9
lsscsi command, 9
lsusb command, 9
LVM (Logical Volume Manager), 14-16

M

mail servers, 488-489
Mail Transfer Agents (MTAs). See
MTAs (Mail Transfer Agents)
Mail User Agent (MUA), 484-485
maintenance, CUPS (Common Unix
Printing System), 474-475
manually mounting filesystems,
272-273
matching time, cron system, 448-449
math, performing, shell script
commands, 345-346
MD5, RPM package validation, 71
md5sums section (.deb file), 59
MDAs (Mail Delivery Agents), 488
media directory (FHS), 112
mem=xxxxM boot option, 33
message line, vim text editor, 222
midnight specifier (at command), 457
mkdir command, 127-128
mkdev command, 260-262
mnt directory (FHS), 112
Modify Printer command
(Administration menu), 476
monitor option (bash), 105
mount command, 270, 273
mount units (systemd), 36
networking 713

mounting filesystems, 16, 269-272
automatically, 273
manually, 272-273

Mouse Keys, X Window System, 411

moving objects, 123-126

MTAs (Mail Transfer Agents), 484-485
aliases, 490
committing changes, 489-490
creating aliases, 489
dNS (domain name system), 487
forwarding email, 489
Linux, 486-487
mail server, 488-489
managing queues, 491-492
MDAs (Mail Delivery Agents), 488
SMTP (Simple Mail Transfer Protocol)
conversation, 485-486
user-defined forwarding, 491

MUA (Mail User Agent), 484-485

multiple commands, executing, 161-162

multiple console sessions, 210-211

mv command, 124-126

navigation commands, FHS
(Filesystem Hierarchy Standard), 115-116

netstat command, 554, 559-562

network mask, 533, 536
custom, 538-541
default, 536-537

network printing protocols, 467-468

CUPS (Common Unix Printing System), 468
Administration menu, 476
command line tools, 477
configuration files, 482
configuring, 470-474
configuring of CUPS daemon, 481
daemons, 468
enabling/disabling printers, 480-481
Jobs List, 477
legacy printing tools, 477-480
maintenance, 474-475
maintenance and administration
pull-downs, 476
pipeline, 468-470
printer state, 475
rejecting jobs, 480-481
troubleshooting printing, 482-483

Network Time Protocol (NTP). See
NTP (Network Time Protocol)

networkd daemon (systemd), 35

networking
address class ranges, 534-535
address classes, 535
broadcast addresses, 538
common ports, 542-544
configuration utilities, 553-554
dclient command, 556-557
dbcpcd command, 556-557

n command, 252-253

name conventions, RPM packages, 69-70

named buffers, vim text editor, 229-230

names, files
characters, 115
spaces, 115

navigating files, vim text editor, 224-225
dig command, 557-559
getent command, 557-559
host command, 557-559
hostname command, 559
ifconfig command, 555
netstat command, 559-562
ping command, 562-563
pump command, 556-557
route command, 555
tcpdump command, 565
traceroute command, 563-564
gateway addresses, 533, 537-538
hosts, 534
ICMP (Internet Control Message Protocol), 542
interface management, 545
     configuring default gateway, 550-551
     Debian configuration, 548-549
     log name configuration, 551-553
     Red Hat configuration, 547-548
     viewing default gateway, 550
     viewing IP information, 545-547
IP (Internet Protocol), 532, 541
     addresses, 533-534
IPv6, 544-545
network mask, 533, 536
     custom, 538-541
     default, 536-537
NPP (Network Printing Protocols), 467-468
     CUPS (Common Unix Printing System), 468-482
NTP (Network Time Protocol), 504-505
     configuring ntpd daemon, 506-507
     monitoring ntpd daemon, 507-508
     pool.ntp.org servers, 505-506
TCP (Transmission Control Protocol), 542
UDP (User Datagram Protocol), 542
newgrp command, 428
Next generation of LPR (LPRng), 467
nfs filesystem, 256
nice command, 207
nl command, 166-167
noclobber option, 105, 317-318
noexec option (bash), 105
non-login shell sessions, 96, 321
noon specifier (at command), 457
notify option (bash), 105
now + time specifier (at command), 457
nslookup command, 554
NTP (Network Time Protocol), 504-505
     configuring ntpd daemon, 506-507
     monitoring ntpd daemon, 507-508
     pool.ntp.org servers, 505-506
ntpd command, 507-508
ntpd daemon
     configuring, 506-507
     monitoring, 507-508
NULL, SQL queries, 384-385
numeric mode, permissions, 294-295

O

objectives, LPI exams, 604, 606-608
objects
     group ownership, changing, 306-307
     moving, 123-126
     permissions, 292
     default, 303-305
     finding files by, 302-303
     manipulating, 294-297
numeric mode, 294-295
special file, 297-302
symbolic mode, 296-297
trio bits, 292-294
removing, 128
user ownership, changing, 305-306

od command, 173-174
on demand services, 576
inetd command, 576-578
xinetd command, 576-581
only_from setting (xinetd command), 580
onscreen keyboard, X Window System, 413
open command, 269
open source, Linux, 6
opening files, vim text editor, 223-224
operators
glob, 119
multiple command, 161-162
opt directory (FHS), 112
output, commands, using from another, 344-345
output streams
processing, 163-164
splitting, 163
stderr file descriptor, 155-156
stdout file descriptor, 154-155
tabs, 167-168
ownership
group, changing, 306-307
user, changing, 305-306

P
package management, Debian, 58-59
package managers, 54
packages, 86
Debian, 61-63
dependency issues, 60-61
installing, 59-60
reconfiguring, 61-63
remote repositories, 64
removing, 60
remote Debian
caches, 65-66
graphical managers, 67
installing, 64-65
removing, 67
updating, 66-67
RPM
files, 69
freshening, 74-75
installing, 72-73
name conventions, 69-70
querying, 77-80
removing, 75-76
rpm command, 70-71
upgrading, 74-75
validation, 71
verification, 73-74
YUM
configuring, 84-86
finding, 83-84
installing, 80-84
updates, 83

pages, 199
panic=#seconds boot option, 32
Parallels Workstation, 609
parted command, 254-255
partitions, 11-12, 240-241, 244
disk partitioning tools, 245
fdisk, 246-250
gdisk, 250-254
parted, 254-255
listing, 252
swap, 16-17
swap command, 245
verifying, 253-254
passwd command, 439, 596
passwords
aging, 438-439
changing, 437-440
encryption, Shadow Suite, 435-437
group accounts, 427-428
paste command, 168-169
vim text editor, 228-229
path units (systemd), 36
PATH variable, 322-323
cron system, 450-451
paused state, printers, 475
Performance, Integrity, Backup, Security (PIBS), 14
peripherals, 6
compatibility, 7
enumerating, 7-8
integrated, 10-11
procsfs, 8-10
permissions, 292, 586-587
directories, setting SGID bit, 301-302
files, 297-298
  default, 303-305
  finding by, 302-303, 587
  setting SGID bit, 300-301
  setting sticky bit, 302
  special bit, 298-299, 586-587
manipulating, 294-297
numeric mode, 294-295
symbolic mode, 296-297
trio bits, 292-294
phases, boot process, 30
PIBS (Performance, Integrity, Backup, Security), hard drives, 14
PID (process ID), killing processes, 203
ping command, 554, 562-563
pipeline, CUPS (Common Unix Printing System), 468-470
pipes, 159-161
pkill command, 204-205
pool.ntp.org servers, 505-506
POP (Post Office Protocol), 488
ports, common, 542-544
Post Office Protocol (POP), 488
postinst section (.deb file), 59
postrm section (.deb file), 59
PostScript Printer Description (PPD) file, 473
poweroff command, 42
PPD (PostScript Printer Description) file, 473
PPD files, 482
pr command, 174-175
prerm section (.deb file), 59
primary group accounts, 425
print jobs, removing, 479-480
print spoolers, 467
printers, 467
CUPS (Common Unix Printing System), 468
  Administration menu, 476
  command line tools, 477
  configuration files, 482
  configuring, 470-474
  configuring of CUPS daemon, 481
daemon, 468
  enabling/disabling printers, 481
  Jobs List, 477
  legacy printing tools, 477-480
maintenance, 470-474
maintenance and administration pull-downs, 476
pipeline, 468-470
printer state, 475
rejecting jobs, 480-481
troubleshooting printing, 482-483
print spooler, 467
querying status, 479
showing status, 478-479
state, CUPS (Common Unix Printing System), 475
states, 475
printers.conf file, 482
printing, 467
command line, 478
troubleshooting, 482-483
proc directory (FHS), 112
proc filesystem, 8-10
processes, 196
blocks, 199
buffers, 199
caches, 199
detaching, 212-213
interpreting displayed information, 200-201
job control, 205-206
killing
killall command, 204
PID (process ID), 203
pkill command, 204-205
leaving programs running after logout, 209-213
pages, 199
properly terminating, 44-45
reattaching, 212-213
reloading, 45
sending signals to, 202-205
slabs, 199
system uptime, 201-202
viewing, 196-198
processing, output streams, 163-164
processing state, printers, 475
programs, leaving running after logout, 209-213
Proto column (netstat output), 561
protocols
ICMP (Internet Control Message Protocol), 542
IP (Internet Protocol), 532, 541
IPv6, 544-545
NTP (Network Time Protocol), 504-508
TCP (Transmission Control Protocol), 542
UDP (User Datagram Protocol), 542
ps command, 196-198
PS1 variable, shells, 324-325
PS2 variable, 326
pstree command, 197-198
pump command, 554, 556-557
pwd command, 269
Q
queries
dig, 558-559
SQL
advanced joins, 381-384
cleaning up, 381
left versus right joins, 384
NULL, 384-385
subselects, 385-386
writing with joins, 379-380
querying
    logs, 515-519
    packages, 61-63
    printer status, 479
    RPM packages, 77-80
    
    configuration files, 79
    dependencies, 80

QUESTION section (dig query), 558
queues, mail, managing, 491-492
quit command, 269
quitting vi text editor, 226-227
quota command, 277, 280-282
quotacheck command, 277
quotaon command, 277

quotas (disk)
    commands, 277
    configuring, 278-280
    grace period, 278, 281
    hard limit, 277, 280-281
    obtaining information, 281-282
    soft limit, 277, 280-281
quotoff command, 277

Red Hat, 50
    interface configuration, 547-548
redirection shell, 93
Redundant Array of Independent Disks (RAID), 11
regular expressions
    grep command, 185-187
    searches, vim text editor, 231-232
ReiserFS, 256
reloading processes, 45
remote clients, X Window System, 413-414
remote Debian packages
    caches, 65-66
    graphical managers, 67
    installing, 64-65
    remote repositories, 64
    removing, 67
    updating, 66-67
renice command, 207-208
Repeat Keys, X Window System, 410
replacing documents, 231
repositories
    remote Debian, 64
    YUM (Yellowdog Updater Modified), 84
Request For Comment (RFC), 534-535
required libraries, 56-57
requires, systemd, 38
results, SQL queries
    limiting, 378
    sorting, 377-378
RFC (Request For Comment), 534-535
ro boot option, 32

RAID (Redundant Array of Independent Disks), 11
rational databases, 369-370
read-only TCP wrappers, 583
real-time clock (RTC). See RTC (real-time clock)
reattaching processes, 212-213
rebooting from command line, SysVinit, 43
reconfiguring Debian packages, 61-63
Recv-Q column (netstat output), 561

R
root account, access, 574
  su command, 574-575
  sudo command, 575-576
root directory (FHS), 112
root filesystem, hard drives, 12-14
ross,snuffy entry, /etc/group file, 427
Ross Brunson field, /etc/passwd file, 424
ross entry, /etc/passwd file, 424
rotating logs, 520-522
route command, 554-555
routing, IPv6, 545
RPM (Red Hat Package Manager)
database, 68-69
packages
  files, 69
  freshening, 74-75
  installing, 72-73
  managing, 68
  name conventions, 69-70
  querying, 77-80
  removing, 75-76
  rpm command, 70-71
  upgrading, 74-75
  validation, 71
  verification, 73-74
rpm command, 70-71
RTC (real-time clock), 503
hwclock command, 503-504
runlevels, systemd, 37
  changing, 41-42
  determining default, 40-41
  managing, 40
  setting default, 41
running scripts, 343
rw boot option, 32

S

saving files, vim text editor, 226
sbin directory (FHS), 112
sbin subdirectory (/usr directory), 114
scheduling jobs
  anacron system, 455-456
  cron system, 447
    configuring crontabs, 447-448
    convenience crontabs, 454
    crontab command, 447-448
    files, 452-453
    finishing crontab, 450
    making multiple matches, 449
    matching time, 448-449
    nicknames extension, 452
    output, 451-452
    PATH, 450-451
    restricting access, 454-455
    spelling out month and day names, 449
    step values, 450
    system crontabs, 453
schemaless databases, 370-371
scope, variables, 316
scope units (systemd), 36
scp command, 591, 593
screen command, 210-213
screen reader, X Window System, 412
screens, creating windows in, 211-212
scripts, 97
  see also listings
  accepting arguments, 357-358
  case statements, 351
  commands, 344
    combining multiple tests, 351
    performing math, 345-346
testing files, 348-349
testing integers, 349-350
testing strings, 349-350
use output of another command, 344-345
conditions, 346-347
design, 343
executing, 94
interacting with other programs, 356
loops, 353
    reading from stdin, 356
    sequences, 354-355
    while, 355-356
returning error code, 357
running, 343
sourcing, 94-95
transferring control to another program, 358
searches, YUM packages, 83-84
searching documents, 231
secondary group accounts, 426
security
    chage command, 596
    /etc/init.d directory, 596
    /etc/inittab file, 596
    /etc/passwd file, 596
    /etc/shadow file, 596
    find command, 596
    fuser command, 596
    GnuPG keys, 587-590
    IPv6, 545
    last command, 596
    ls -f command, 596
    passwd command, 596
    permissions, 586-587
    providing services on demand, 576
        inetd command, 576-577
root account access, 574
    su command, 574-575
    sudo command, 575-576
services, securing using TCP wrappers, 581-586
    Shadow Suite, 435-437
    SSH (Secure Shell), 590-591
dient utilities, 592-596
    components, 591-592
    enabling without passwords, 594-596
TCP wrappers
    configuration, 583-585
    hosts.allow/hosts.deny format, 583
    read-only, 583
    rule options, 585-586
ulimit command, 596
usermod command, 596
w command, 596
who command, 596
sed command, 176-178
    SELECT statement, SQL (Structured Query Language), 373-374
semicolons, SQL (Structured Query Language), 372
sending signals to processes, 202-205
Send-Q column (netstat output), 561
seq command, 354-355
sequences, loops, 354-355
server setting (xinetd command), 580
service units (systemd), 36
services
    on demand, 576
        inetd command, 576-578
        xinetd command, 576-581
    securing, TCP wrappers, 581-586
Set Allowed Users command
    (Administration menu), 476
Set as Server Default command  
(Administration menu), 476  
set command, 317-318  
Set Default Options command  
(Administration menu), 476  
severities, syslog, 509  
SGID bits  
  directories, setting, 301-302  
  files, setting, 300-301  
Shadow Suite, 435-437  
share subdirectory (/usr directory), 114  
shared libraries, 54-56  
shell scripting, 338, 342  
  accepting arguments, 357-358  
  case statements, 351  
  conditions, 346-347  
  interacting with other programs, 356  
  loops, 353  
    reading from stdin, 356  
    sequences, 354-355  
    while, 355-356  
returning error code, 357  
script commands, 344  
  combining multiple tests, 351  
  performing math, 345-346  
  testing files, 348-349  
  testing integers, 349-350  
  testing strings, 349-350  
  use output of another command, 344-345  
scripts  
  design, 343  
  running, 343  
transferring control to another program, 358  
shells, 93, 314  
  bash  
    history feature, 103-104  
    setting options, 104-105  
env wrapper, 319-320  
environment variables, 315  
extending, 320  
  adding dynamic content, 325-326  
  aliases, 323  
  creating new users, 326-327  
  functions, 323-324  
  global and user settings, 320  
  login session, 321  
  non-login session, 321  
  PATH variable, 322-323  
  PS1 variable, 324-325  
  PS2 variable, 326  
internationalization, 327  
  character encoding, 329-330  
  displaying time, 328  
  setting time zones, 328-329  
  time zones, 327-328  
localization, 327  
  converting files between encodings, 334  
  fallback locales, 331  
  locale command, 332-333  
  locale contents, 331-332  
  representing locales, 330-331  
  time zones, 327-328  
login shell sessions, 95-96  
non-login shell sessions, 96  
special characters, 99  
SSH (Secure Shell), 590-591  
  client utilities, 592-596  
  components, 591-592  
  enabling without passwords, 594-596
subshells, 318-319
T C-shell, 314
variables
  scope, 316
  setting and unsetting, 317-318
  setting from child, 316-317
working within, 314-320
Show All Jobs button (Jobs List), 477
shutdown command, 42
shutting down from command line,
  SysVinit, 42
SIGHUP signal, 202
SIGINIT signal, 202
SIGKILL signal, 202
signals
  common, 202
  processes, sending to, 202-205
SIGSTOP signal, 202
SIGTERM signal, 202
SIGTSTP signal, 202
Simple Mail Transfer Protocol
  (SMTP), 485-486
single boot option, 32
skel templates, 429-430
slabs, 199
slice units (systemd), 36
Slow Keys, X Window System, 411
smb filesystem, 256
SMTP (Simple Mail Transfer
  Protocol), 485-486
snapshot units (systemd), 36
socket type setting (xinetd
  command), 580
socket units (systemd), 36
soft limit, disk quotas, 277, 280-281
software, 54
  binaries, 54
  pieces, 54
  shared libraries, 54-56
sort command, 165-166
sourcing scripts, 94-95
spaces, filenames, 115
special characters, shells, 99
special login files, user accounts,
  424-425
special permissions
  directories, setting SGID bit, 301-302
  files, 297-298
    bit, 298-299, 586-587
    setting SGID bit, 300-301
    setting sticky bit, 302
split command, 172-173
split windows, vi text editor, 234-235
splitting
  files, 172-173
  streams, 163
spoolers, print, 467
SQL (Structured Query Language), 371
  commands, 372-373
  comments, 372
  conditions, multiple, 376-377
  deleting data, 388
  grouping data, 386-387
  inserting data, 387
  keywords, 372-373
  queries
    advanced joins, 381-384
    cleaning up, 381
    left versus right joins, 384
    NULL, 384-385
    subselects, 385-386
    writing with joins, 379-380
results

limiting, 378
sorting, 377-378
selecting data, 373-374
semicolons, 372
SQLite, 371-372
tables
creating, 388-389
multiple, 378-379
updating data, 388
WHERE clause, 374-376
SQLite, 371-372
SSH (Secure Shell), 590-591
client utilities, 592-596
components, 591-592
enabling without passwords, 594-596
ssh command, 591-592
ssh-add command, 591
ssh-agent command, 591
sshd command, 591
sshd logs, querying, 516
stat command, 124
State column (netstat output), 561
statements
case, 351
SELECT, SQL (Structured Query Language), 373-374
states, printers, 475
STATISTICS section (dig query), 558
stats command, 269
status, printers
querying, 479
showing, 478-479
stderr file descriptor, 155-156
stdin file descriptor, 154
reading loops from, 356
stdout file descriptor, 154-155
steams, numbering lines, 166-167
step values, cron system, 450
sticky bits, files, setting, 302
Sticky keys, X Window System, 410
stopped state, printers, 475
streams
output, processing, 163-164
processing output, 163-164
sed (stream editor) command, 176-178
splitting, 163
stderr file descriptor, 155-156
stdin file descriptor, 154
stdout file descriptor, 154-155
tabs, 167-168
strings, testing, 349-350
structuring commands, 98
studying for LPI exams, 608
su command, 574-575
subselects, SQL queries, 385-386
subshells, 318-319
substitution, commands, 162-163
sudo command, 575-576
SUID permission set, 300
superblocks, filesystems, 256
swap command, 245
swap partitions, 16-17
swap units (systemd), 36
symbolic links, 134-135
symbolic mode, permissions, 296-297
synchronization, clocks, 504-505
syntax, test command, 348-349
SYSLINUX boot loader, 31
syslog
alternate implementations, 514
system logging, 508-511
system clock, 500-503
  hardware clock, synchronizing, 504-505
system crontabs, 453
system logging
  journald logging system, configuring, 519-520
  querying logs, 515-519
  rotating logs, 520-522
  syslog, 508-511
  alternate implementations, 514
systemd, 508-509, 514-515
  configuring, 512-514
  logger command, 512
system resource allocation, systemd, 36
system time
  clocks, 500
    hardware, 500, 503-504
    synchronizing, 504-505
    system, 500-503
NTP (Network Time Protocol), 504-505
  configuring ntpd daemon, 506-507
  monitoring ntpd daemon, 507-508
  pool.ntp.org servers, 505-506
  setting time from command line, 505
system uptime, 201-202
systemctl utility (systemd), 35
TCP (Transmission Control Protocol), 542
  wrappers
    configuration, 583-585
    hosts.allow/hosts.deny format, 583
    read-only, 583
T
T C-shell, 314
tables
  filesystems, 270-272
SQL (Structured Query Language)
  creating, 388-389
    multiple, 378-379
tabs, data fields, 167-168
tac command, 173
tail command, 171-172
tar archives, creating, 137-141
tar command, 137-141
target units (systemd), 36
targets, systemd, 37-38
task scheduling, PUT Everything Under Job Scheduling, 451
tasks, PUT Everything Under Jobs, 451
T
rule options, 585-586
securing services, 581-586
tcpdump command, 554, 565
teatime specifier (at command), 457
tee command, 163
terminating processes, 44-45
test command, 348
combining multiple tests, 351
syntax, 348-349
testing integers, 350
testing strings, 349-350
testing
time specifiers, at command, 457
files, 348-349
integers, 349-350
strings, 349-350
tests, combining multiple, 349-350
text
changing, 227
deleting, 227-228
replacing, 227
searching in vi, 230
time
clocks, 500
hardware, 500, 503-504
synchronizing, 504-505
system, 500-503
displaying, 328
matching, cron system, 448-449
NTP (Network Time Protocol), 504-505
configuring ntpd daemon, 506-507
monitoring ntpd daemon, 507-508
pool.ntp.org servers, 505-506
setting time from command line, 505
time zones, 327-328
setting, 328-329
time specifiers, at command, 457
time zones, 327-328
setting, 328-329
time-of-day specifier (at command), 457
timer units (systemd), 36
tmp directory (FHS), 112
Toggle Keys, X Window System, 411
top command, 208-209
touch command, 120-121
touching files, 120-121
tr command, 175-176
traceroute command, 554, 563-564
Transmission Control Protocol (TCP), 542
trio bits, permissions, 292-294
troubleshooting, printing, 482-483
tune2fs command, 266-267
tuning
filesystems, 266-267
X Window System, 406-408
U
udf filesystem, 255
UDP (User Datagram Protocol), 542
UIDs (User IDs), 422-424
ulimit command, 440, 596
undelete command, 269
undo operators, vim text editor, 225-226
uniq command, 169-170
units, systemd, 36
Unix epoch, 501
unmounting, filesystems, 269-274
unnamed buffers, vim text editor, 229-230
unset command, 317-318
UPDATE command (SQL), 388
updates, YUM packages, 83
upgrading RPM packages, 74-75
Upstart system initialization scheme, 39-40
uptime command, 201-202
user accounts, 422
adding, 428-430
defaults, 429
entries in /etc/passwd file, 423-424
history, 104
limiting, 440
modifying, 431-432
paths, 322-323
modifying, 431-432
passwords, changing, 437-440
removing, 433-434
security, Shadow Suite, 435-437
special login files, 424-425
UIDs (User IDs), 422-424
configuring default gateway, 550-551
Debian configuration, 548-549
log name configuration, 551-553
Red Hat configuration, 547-548
viewing default gateway, 550
user ownership, changing, 305-306
user setting (xinetd command), 580
user settings, 94-96
shells, 320
useradd command, 428-430
defaults, 429
options, 429
skel templates, 429-430
user-defined forwarding, MTAs (Mail Transfer Agents), 491
userdel command, 433-434
usermod command, 431-432, 596
users entry, /etc/group file, 427
usr directory (FHS), 112
/usr directory, FHS (Filesystem Hierarchy Standard), 114
usrquota command, 277
validation, RPM packages, 71
var directory (FHS), 112
variables
environment, 101-104, 315
EDITOR, 448
history, 104
PATH, 322-323
PS1, 324-325
PS2, 326

V
User Datagram Protocol (UDP), 542
user interfaces
managing, 545
X Window System, 400-402
Braille Display, 413
display managers, 408-409
freezes, 409-410
High Contrast/Large Desktop themes, 412
Mouse Keys, 411
onscreen keyboard, 413
remote clients, 413-414
screen reader, 412
Slow/Bounce/Toggle Keys, 411
Sticky/Repeat Keys, 410
Xorg, 402-408

UPG (User Private Group), 426-427
scope, 316
setting and unsetting, 317-318
setting from child, 316-317
**verbose option (bash), 105**

**verification**
partitions, 253-254
RPM packages, 73-74
**vfat filesystem, 255**
**vga boot option, 32**
**vi option (bash), 105**
**vi text editor, 219-218**
joining lines, 234
options, 232-233
quitting, 226-227
running external commands, 234
split windows, 234-235
**viewing**
default gateways, 550
hardware list, 8
processes, 196-198
**vim text editor, 219-222**
buffers, 229-230
Command mode, 223
copy command, 228-229
cut command, 228-229
editing in vi, 222-223
force multipliers, 225
Insert mode, 223
message line, 222
navigating within file, 224-225
opening files, 223-224
options in vi, 232-233
paste command, 228-229
regular expression searches, 231-232
replacing documents, 231
saving files, 226
searching documents, 231
searching in vi, 231
text
changing, 227
deleting, 227-228
replacing, 227
undo operators, 225-226
**VirtualBox, 609**
**VMs (virtual machines), studying for LPI exams, 609**
**VM Ware, 609**

W

**w command, 596**
wait setting (xinetd command), 580
wants, systemd, 38
**WHERE clause, SQL (Structured Query Language), 374-376**
**whereis command, 132-133**
**which command, 132**
while loops, 355-356
who command, 596
**window managers, X Window System, 401-402**
windows, creating in screens, 211-212
wrappers (TCP)
configuration, 583-585
hosts.allow/hosts.deny format, 583
read-only, 583
rule options, 585-586
securing services, 581-586
X entry
/etc/group file, 427
/etc/passwd file, 424

X Window System, 400-402
Braille Display, 413
desktops, 402
display managers, 408-409
fonts, 405-406
freezes, 409-410
High Contrast/Large Desktop themes, 412
Mouse Keys, 411
onscreen keyboard, 413
remote clients, 413-414
screen reader, 412
Slow/Bounce/Toggle Keys, 411
Sticky/Repeat Keys, 410
tuning, 406-408
window managers, 401-402
Xorg, 402-408

xargs command, 163-164
XDM display manager, 408

XEN, 609

xfs commands, 267-268
xfs filesystem, 256

xinetd command, 576-581
TCP wrappers, 582-583

Xorg, 402-408
xwininfo command, 407-408

Y

YUM (Yellowdog Updater Modified), 80
packages
  configuring, 84-86
  finding, 83-84
  installing, 80-83
  updates, 83

zsh shell, 314
# Appendix B

## Study Planner

<table>
<thead>
<tr>
<th>Element</th>
<th>Task</th>
<th>Goal Date</th>
<th>First Date Completed</th>
<th>Second Date Completed (Optional)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Read Introduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 1. Installing Linux      | Read Foundation Topics                    |           |                      |                                  |       |
| 1. Installing Linux      | Review Key Topics                         |           |                      |                                  |       |
| 1. Installing Linux      | Define Key Terms                           |           |                      |                                  |       |
| 1. Installing Linux      | Answer Review Questions                    |           |                      |                                  |       |
| Practice Test            | Take practice test in study mode using Exam Bank 1 questions for Chapter 1 in practice test software |           |                      |                                  |       |

| 2. Boot Process and Runlevels | Read Foundation Topics |           |                      |                                  |       |
| 2. Boot Process and Runlevels | Review Key Topics                          |           |                      |                                  |       |
| 2. Boot Process and Runlevels | Define Key Terms                           |           |                      |                                  |       |
| 2. Boot Process and Runlevels | Answer Review Questions                    |           |                      |                                  |       |
| Practice Test            | Take practice test in study mode using Exam Bank 1 questions for Chapter 2 in practice test software |           |                      |                                  |       |

| 3. Package Install and Management | Read Foundation Topics |           |                      |                                  |       |
| 3. Package Install and Management | Review Key Topics                          |           |                      |                                  |       |
| 3. Package Install and Management | Define Key Terms                           |           |                      |                                  |       |
| 3. Package Install and Management | Answer Review Questions                    |           |                      |                                  |       |
| Practice Test            | Take practice test in study mode using Exam Bank 1 questions for Chapter 3 in practice test software |           |                      |                                  |       |

<p>| 4. Basic Command Line Usage | Read Foundation Topics |           |                      |                                  |       |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Basic Command Line Usage</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td></td>
<td>Define Key Terms</td>
</tr>
<tr>
<td></td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 4 in practice test software</td>
</tr>
<tr>
<td>5. File Management</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td></td>
<td>Review Key Topics</td>
</tr>
<tr>
<td></td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td></td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 5 in practice test software</td>
</tr>
<tr>
<td>6. Text Processing/Advanced Command Line</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td></td>
<td>Review Key Topics</td>
</tr>
<tr>
<td></td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td></td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 6 in practice test software</td>
</tr>
<tr>
<td>7. Process Management</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td></td>
<td>Review Key Topics</td>
</tr>
<tr>
<td></td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td></td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 7 in practice test software</td>
</tr>
<tr>
<td>8. Editing Text</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td></td>
<td>Review Key Topics</td>
</tr>
<tr>
<td></td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 8 in practice test software</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>9. Partitions and Filesystems</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>9. Partitions and Filesystems</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>9. Partitions and Filesystems</td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>9. Partitions and Filesystems</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 9 in practice test software</td>
</tr>
<tr>
<td>10. Permissions</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>10. Permissions</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>10. Permissions</td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>10. Permissions</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 10 in practice test software</td>
</tr>
<tr>
<td>11. Customizing Shell Environments</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>11. Customizing Shell Environments</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>11. Customizing Shell Environments</td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>11. Customizing Shell Environments</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 11 in practice test software</td>
</tr>
<tr>
<td>12. Shell Scripting</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>12. Shell Scripting</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>12. Shell Scripting</td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>12. Shell Scripting</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 12 in practice test software</td>
</tr>
<tr>
<td>13. Basic SQL Management</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>13. Basic SQL Management</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>Chapter</td>
<td>Section</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>13.</td>
<td>Basic SQL Management</td>
</tr>
<tr>
<td>13.</td>
<td>Basic SQL Management</td>
</tr>
<tr>
<td>Practice Test</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Configuring User Interfaces and Desktops</td>
</tr>
<tr>
<td>14.</td>
<td>Configuring User Interfaces and Desktops</td>
</tr>
<tr>
<td>14.</td>
<td>Configuring User Interfaces and Desktops</td>
</tr>
<tr>
<td>Practice Test</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Managing Users and Groups</td>
</tr>
<tr>
<td>15.</td>
<td>Managing Users and Groups</td>
</tr>
<tr>
<td>15.</td>
<td>Managing Users and Groups</td>
</tr>
<tr>
<td>Practice Test</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Schedule and Automate Tasks</td>
</tr>
<tr>
<td>16.</td>
<td>Schedule and Automate Tasks</td>
</tr>
<tr>
<td>16.</td>
<td>Schedule and Automate Tasks</td>
</tr>
<tr>
<td>Practice Test</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Configuring Print and Email Services</td>
</tr>
<tr>
<td>17.</td>
<td>Configuring Print and Email Services</td>
</tr>
<tr>
<td>17.</td>
<td>Configuring Print and Email Services</td>
</tr>
<tr>
<td>Practice Test</td>
<td></td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 17 in practice test software</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18. Logging and Time Services</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>18. Logging and Time Services</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>18. Logging and Time Services</td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>18. Logging and Time Services</td>
<td>Answer Review Questions</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 18 in practice test software</td>
</tr>
<tr>
<td>19. Networking Fundamentals</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>19. Networking Fundamentals</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>19. Networking Fundamentals</td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 19 in practice test software</td>
</tr>
<tr>
<td>20. Topic 110: Security</td>
<td>Read Foundation Topics</td>
</tr>
<tr>
<td>20. Topic 110: Security</td>
<td>Review Key Topics</td>
</tr>
<tr>
<td>20. Topic 110: Security</td>
<td>Define Key Terms</td>
</tr>
<tr>
<td>Practice Test</td>
<td>Take practice test in study mode using Exam Bank 1 questions for Chapter 20 in practice test software</td>
</tr>
<tr>
<td>21. Final Preparation</td>
<td>Review Exam Essentials for each chapter on the PDF from the DVD</td>
</tr>
<tr>
<td>21. Final Preparation</td>
<td>Review all Key Topics in all chapters</td>
</tr>
<tr>
<td>21. Final Preparation</td>
<td>Take practice test in practice exam mode using Exam Bank #1 questions for all chapters</td>
</tr>
<tr>
<td>21. Final Preparation</td>
<td>Take practice test in practice exam mode using Exam Bank #2 questions for all chapters</td>
</tr>
</tbody>
</table>
Visit pearsonITcertification.com today to find:

- **IT CERTIFICATION EXAM** information and guidance for
  
  - Cisco
  - CompTIA
  - Microsoft
  - VMware

  Pearson is the official publisher of Cisco Press, IBM Press, VMware Press and is a Platinum CompTIA Publishing Partner—CompTIA’s highest partnership accreditation

- **EXAM TIPS AND TRICKS** from Pearson IT Certification’s expert authors and industry experts, such as
  
  - *Mark Edward Soper* – CompTIA
  - *David Prowse* – CompTIA
  - *Wendell Odom* – Cisco
  - *Kevin Wallace* – Cisco and CompTIA
  - *Shon Harris* – Security
  - *Thomas Erl* – SOACP

- **SPECIAL OFFERS** – pearsonITcertification.com/promotions

- **REGISTER** your Pearson IT Certification products to access additional online material and receive a coupon to be used on your next purchase

CONNECT WITH PEARSON IT CERTIFICATION

Be sure to create an account on pearsonITcertification.com and receive members-only offers and benefits
These unique video products provide a solid understanding of all topics that candidates need to master to pass the CompTIA Linux+ / LPIC-1 certifications.

- These unique video products provide a solid understanding of all topics that candidates need to master to pass the CompTIA Linux+ / LPIC-1 certifications.
- CompTIA Linux+ / LPIC-1 Complete Video Course offers 28 lessons that cover every objective in the CompTIA Linux+ LX0-103 and LX0-104 and the LPIC-1 101 and 102 exams. You also receive practice exam questions, interactive exercises, and CLI simulations so you can practice your skills and knowledge before taking the exams.
- Each course doesn’t just offer a preparation for the exams; they also serve as an introduction for people who want to learn basic Linux administration skills.
- Each video provides thorough coverage of command-line skills that work on multiple distributions and prepares anyone who wants to acquire more in-depth knowledge of common Linux administration tasks.
- The course can be used to study for the newest CompTIA Linux+ LX0-103 and LX0-104 exams, the LPIC-1 (Exam 101) and LPIC-1 (Exam 102) certifications, and the SUSE CLA exams.

PearsonITcertification.com
To receive your 10% off Exam Voucher, register your product at:

www.pearsonitcertification.com/register

and follow the instructions.