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- Getting an overview of the Linux Professional Institute exams
- Looking at an overview of each exam

Chapter 1

Studying for the Linux Professional Institute Exams

Just as you can attain many levels of degrees through an educational institution (associate's, bachelor's, master's, and doctorate degrees), you can achieve multiple levels of Linux certification. The Linux Professional Institute (LPI; `www.lpi.org`) is a nonprofit organization committed to Linux certification; it provides different certifications of increasing difficulty to help employers gauge the competency level of prospective Linux administrators. This chapter discusses the different LPI certification exams, allowing you to determine which exam path is right for your Linux career goals.

Overview of LPI Certification Exams

LPI provides three separate categories of certification in common open-source tools:

- **Linux Essentials:** Demonstrating the essentials of installing and running a Linux system; oriented toward students learning the basics of Linux

- **Linux Professionals:** A series of exams intended to test increasing competency for professional Linux administrators
- **Open Technology:** Two exams intended for additional open-source topics, such as DevOps and BSD administrators

The following sections discuss the Linux Essentials exam in detail, and provide a general overview of what to expect if you decide to go on to the more advanced Linux Professional series of exams.

Overview of the Linux Essentials Exam

The Linux Essentials Certificate of Achievement was created by the Linux Professional Institute (LPI) to appeal to the academic sector. Students taking semester-based classes in Linux may not get through all the topics necessary to pass the two exams that are needed to gain the Linux Professionals certification, but LPI still wanted to recognize and authenticate their knowledge. This program was created through international collaboration with a classroom focus in mind. As of this writing, the current version is 1.6, and the exam code is 010-160.

REMEMBER

Linux Essentials is a certificate of achievement intended to be a much lower-level (subset) certification than the Linux Professionals certification (LPIC). Although Linux Essentials is recommended, it's not required for any of the LPIC professional certification or any other certifications.

The exam has five domains, called *topics.* Table 1-1 shows these topics and their weightings. It's important to note that weightings are always subject to change; it's not uncommon for them to be tweaked a bit over time.

TABLE 1-1 Domains on the Linux Essentials Exam

Topic	Weighting
The Linux Community and a Career in Open Source	7
Finding Your Way on a Linux System	9
The Power of the Command Line	9
The Linux Operating System	8
Security and File Permissions	7

The sections that follow look at each of these topics in more detail.

Getting involved in the Linux community and finding a career in open source

Table 1-2 shows the subtopics, weight, description, and key knowledge areas for this topic.

TABLE 1-2 **Breakout of Topic 1**

Subtopic	Weight	Description	Key Areas
Linux Evolution and Popular Operating Systems	2	Knowledge of Linux development and major distributions	Open-source philosophy, distributions, and embedded systems (The distributions to be cognizant of include Android, Debian, Ubuntu, CentOS, openSUSE, and Red Hat.)
Major Open Source Applications	2	Awareness of major applications and their uses and development	Desktop applications, server applications, development languages, and package management tools and repositories (Topics include OpenOffice.org, LibreOffice, Thunderbird, Firefox, GIMP, Apache HTTPD, NGINX, MySQL, NFS, Samba, C, Java, Perl, shell, Python, dpkg, apt-get, rpm, and yum.)
Understanding Open Source Software and Licensing	1	Open communities and licensing open-source software for business	Licensing, Free Software Foundation (FSF), and Open Source Initiative (OSI) (Topics include GPL, BSD, Creative Commons, Free Software, FOSS, FLOSS, and open-source business models.)
ICT Skills and Working in Linux	2	Basic Information and Communication Technology (ICT) skills and working in Linux	Desktop skills, getting to the command line, industry uses of Linux, and cloud computing and virtualization (Topics include using a browser, privacy concerns, configuration options, searching the web, and saving content.)

Here are the top ten items to know as you study for this domain:

- Linux is the best-known example of open-source software so far developed (and still in development).
- The *shell* is the command interpreter that resides between the user and the operating system. Although many shells are available, the most common today is the `bash` shell.

- A plethora of applications and tools is available for use with the various Linux distributions. Many of these tools are also open-source.
- The Apache Software Foundation distributes open-source software under the Apache license Free and Open Source Software (FOSS).
- The Free Software Foundation (FSF) supports the free (open-source) software movement and copyleft under the GNU General Public License. *Copyleft* makes it possible for modifications to be made to software while preserving the same rights in the produced derivatives.
- The Open Source Initiative (OSI) also supports the open-source software movement, as do the GNOME Foundation, the Ubuntu Foundation, and many other organizations.
- OpenOffice.org was a popular suite of open-source office-productivity software. LibreOffice is a fork of OpenOffice that has eclipsed it in popularity.
- Samba makes it possible for Linux systems to share files with Windows-based systems.
- Thunderbird is a popular mail and news client created by the Mozilla Foundation.
- Many web browsers are available for Linux, and one of the most popular is Mozilla Firefox.

Finding your way on a Linux system

Table 1-3 shows the subtopics, weights, descriptions, and key knowledge areas for this topic.

Here are the top ten items to know as you study for this domain:

- Regular expressions — often referred to as *globbing* — can be used with the shells available in Linux to match wildcard characters. Among the possible wildcards, the asterisk (*) matches any number of characters; the question mark (?) matches only one character.
- Linux is a case-sensitive operating system.
- Files can be hidden by preceding their names with a single period (.). In pathnames, however, a single period (.) specifies the active directory, and two periods (..) signifies the parent directory.
- Absolute paths give the full path to a resource, whereas relative paths give directions from where you're currently working. An example of an absolute path is `/tmp/eadulaney/file`, and an example relative link is `../file`.

- Files can be copied by using `cp` or moved by using `mv`. Files can be deleted with `rm`, and directories (which are created with `mkdir`) can be removed with `rmdir`. Recursive deletion can be done with `rm -r`.
- To change directories, use the `cd` command. When this command is used without parameters, it moves you to your home directory. To see what directory you're currently working in, use the `pwd` (present working directory) command.
- The `ls` command has a plethora of options allowing you to list files. The `-a` option lists all files (including hidden files).
- Help is available through the manual pages (accessed with the `man` command) and `info` (which shows help files stored below `/user/info`).
- The `whatis` command shows which manual pages are available for an entry, and `whereis` shows the location of the file and all related files (including any manual pages).
- Many standard utilities allow you to enter the name of the executable followed by `--help` to obtain help only on the syntax.

TABLE 1-3 **Breakout of Topic 2**

Subtopic	Weight	Description	Key Areas
Command Line Basics	3	Using the Linux command line	Basic shell, command-line syntax, variables, globbing, and quoting (Topics include bash, echo, history, PATH env variables, export, and type.)
Using the Command Line to Get Help	2	Running help commands and navigation of the various help systems, man, and info	The topics include: `man` files, `info` command, `/usr/share/doc`, and `locate`
Using Directories and Listing Files	2	Navigating home and system directories and listing files in various locations	Files, directories, hidden files and directories, home directory, and absolute and relative paths (Topics include common options for `ls`, recursive listings, `cd`, . and .., `home`, and ~.)
Creating, Moving, and Deleting Files	2	Creating, moving, and deleting files under the home directory	Files and directories, case sensitivity, and simple globbing and quoting (Topics include `mv`, `cp`, `rm`, `touch`, `mkdir`, and `rmdir`.)

The power of the command line

Table 1-4 shows the subtopics, weights, descriptions, and key knowledge areas for this topic.

TABLE 1-4 Breakout of Topic 3

Subtopic	Weight	Description	Key Areas
Archiving Files on the Command Line	2	Archiving files in the user home directory	Files, directories, archives, and compression (Topics include `tar` as well as common `tar` options, `gzip`, `bzip2`, `zip`, and `unzip`.)
Searching and Extracting Data from Files	3	Searching and extracting data from files in the home directory	Command-line pipes, I/O redirection, and basic regular expressions (Topics include `grep`, `less`, `cat`, `head`, `tail`, `sort`, `cut`, and `wc`.)
Turning Commands into a Script	4	Turning repetitive commands into simple scripts	Basic shell scripting and awareness of common text editors (Topics include `#!`, `/bin/bash`, variables, arguments, `for` loops, `echo`, and `exit` status.)

Here are the top ten items to know as you study for this domain:

- Standard input (`stdin`) is traditionally the keyboard, and standard output (`stdout`) is traditionally the monitor. Both can be redirected, as can standard error (`stderr`), by using the symbols `>`, `>>`, `<`, and `|`.
- Commands can be joined on the command line by the semicolon (`;`), and each command runs independently. You can also use the pipe (`|`) to send the output of one command as the input of another command.
- The `cut` command can pull fields from a file, and the fields can be combined by using either `paste` or `join`. The latter offers more features than the former and can be used with conditions.
- The `wc` command can count the number of lines, words, and characters in a file.
- The `grep` utility (and its counterparts `egrep` and `fgrep`) can be used to find matches for strings within files.

- The `find` command can be used to search the system for files/directories that meet any number of criteria. When these entities are found, the `xargs` command can be used to look deeper within them for other values (such as in conjunction with `grep`).
- You can use the `tar` command (which can combine multiple files into a single archive) to do backups.
- In addition to archiving, you can compress files with the `gzip` or `pack` command. To uncompress files, use `uncompress`, `unzip`, or `unpack`.
- Variables can be given at the command line and referenced as `$1`, `$2`, and so on, or entered into the executing file with the `read` command.
- Logic can be added to scripts by testing conditions with `test` or `[`. Commands can execute through `if–then–fi` deviations or looping (`while`, `until`, or `for`). You can use the `exit` command to leave a script or use `break` to leave a loop.

The Linux operating system

Table 1-5 shows the subtopics, weights, descriptions, and key knowledge areas for this topic.

Here are the top ten items to know as you study for this domain:

- When run, every command spans at least one process; processes can be viewed with `ps` or `top` (which updates the display dynamically).
- Jobs can run in the foreground or background and be moved between the two. Jobs running in the foreground can be suspended by pressing Ctrl+Z.
- IPv4 uses 32-bit addresses, each divided into four octets. The first octet identifies the class of address (A, B, or C). The address can be public or private.
- The `ifconfig` utility can be used to see the current IP configuration of the network cards.
- The `ping` utility is an all-purpose tool for testing connectivity. It sends echo messages to a specified host to see whether that host can be reached. You can use `ping` with the loopback address (127.0.0.1) to test internal configuration.
- The `route` utility displays the routing table and allows you to configure it.
- The `netstat` utility shows the current status of ports — those that are open, listening, and so on.

- The system log is `/var/log/messages`, and this log is where the majority of events are written to by the system log daemon (`syslogd`). Messages routed there can be viewed with the `dmesg` command.
- The `logrotate` command can be used to automatically archive log files and perform maintenance as configured in `/etc/syslog.conf`.
- You can manually write entries to log files by using the `logger` command.

TABLE 1-5 **Breakout of Topic 4**

Subtopic	Weight	Description	Key Areas
Choosing an Operating System	1	Knowledge of major operating systems and Linux distributions	Windows, Mac, and Linux differences; distribution lifecycle management (Topics include GUI versus command line, desktop configuration; maintenance cycles, and Beta and Stable.)
Understanding Computer Hardware	2	Familiarity with the components that go into building desktop and server computers	Hardware (Topics include motherboards, processors, power supplies, optical drives, peripherals, hard drives and partitions, /dev/sd*, and drivers.)
Where Data Is Stored	3	Where various types of information are stored on a Linux system	Programs and configuration, packages and package databases, processes, memory addresses, system messaging, and logging (Topics include `ps`, `top`, `free`, `syslog`, `dmesg`, `/etc/`, `/var/log`, `/boot/`, `/proc/`, `/dev/`, and `/sys/`.)
Your Computer on the Network	2	Querying vital networking settings and determining the basic requirements for a computer on a local area network (LAN)	Internet, network, routers, querying DNaS client configuration, and querying network configuration (Topics include `route`, `ip route show`, `ifconfig`, `ip addr show`, `netstat`, `/etc/resolv.conf`, `/etc/hosts`, IPv4, IPv6, `ping`, and `host`.)

Security and file permissions

Table 1-6 shows the subtopics, weights, descriptions, and key knowledge areas for this topic.

TABLE 1-6 **Breakout of Topic 5**

Subtopic	Weight	Description	Key Areas
Basic Security and Identifying User Types	2	Understanding various types of users on a Linux system	Root, standard, and system users (Topics include `/etc/passwd`, `/etc/group`, `id`, `who`, `w`, `sudo`, and `su`.)
Creating Users and Groups	2	Creating users and groups on a Linux system	User and group commands, and user IDs (Topics include `/etc/passwd`, `/etc/shadow`, `/etc/group`, `/etc/skel`, `id`, `last`, `useradd`, `groupadd`, and `passwd`.)
Managing File Permissions and Ownership	2	Understanding and manipulating file permissions and ownership settings	File/directory permissions and owners (Topics include `ls -l`, `ls -a`, `chmod`, and `chown`.)
Special Directories and Files	1	Understanding special directories and files on a Linux system, including special permissions	Using temporary files and directories, and symbolic links (Topics include `/tmp`, `/var/tmp`, Sticky Bit, `ls -d`, and `ln -s`.)

Here are the top ten items to know as you study for this domain:

- File and directory permissions can be changed with the `chmod` command (which accepts numeric and symbolic values).
- Adding 1000 to standard permissions turns on the sticky bit; adding 2000 turns on the `SGID` permission. Adding 4000 turns on the `SUID` permission.
- Links are created with the `ln` command. A *hard link* is nothing more than an alias to a file (sharing the same inode). The `ln -s` command creates a symbolic link that's an actual file with its own inode. The symbolic link contains a pointer to the original file and can span file systems; the hard link can't.
- User accounts can be added by manually editing the configuration files or using the `useradd` command; they can be removed with `userdel`.
- The `groupadd` utility can be used to create groups, and `groupdel` can be used to remove groups. Groups can be modified with `groupmod`, and users can be moved from one group to another with the `newgrp` command.
- Passwords are changed with the `passwd` command. Older systems stored passwords in `/etc/passwd`; now passwords are stored in `/etc/shadow`, where they're more secure.
- To see who logged on most recently and may still be on the network, you can use the `last` command.

- The `su` command allows you to become another user (returning with `exit`). If no other username is specified, the root user is implied — hence, the `su` for *superuser.*
- Use `sudo` instead of `su` when you want to run a command as another user (usually, `root`) without becoming that user.
- The `who` command shows who's logged on; the `w` command shows information combining `who` with `uptime`.

Overview of the Linux Professionals Exams

The LPI Linux Professionals series of exams is oriented toward the professional Linux administrator, working in a real-world production environment. The series has three levels of formal LPI certification to determine the competency level of Linux administrators:

- **LPIC-1:** Validates a candidate's ability to install and configure a computer running Linux, configure basic networking, and perform system maintenance tasks from the command line.
- **LPIC-2:** Validates a candidate's ability to administer small to medium-sized mixed networks.
- **LPIC-3:** A grouping of advanced certifications that validate a candidate's advanced knowledge of specific Linux topics.

The following sections describe the different Linux Professional Exams in more detail.

The LPIC-1 exams

The LPIC-1 level of certification exams is designed to validate a candidate's proficiency in basic, real-world Linux administration tasks. LPI has performed extensive surveying of Linux employers to determine the skills most often sought after for junior Linux administrators and incorporated those skills into its LPIC-1 certification. Currently, the LPIC-1 certification is at version 5.0 and consists of two exams that you must pass to gain certification:

- **101-500 exam:** Tests knowledge of system architecture, Linux installation and package management, GNU and Unix commands, devices, Linux file systems, and the Linux Filesystem Hierarchy Standard (FHS)

- **102-500 exam:** Tests knowledge of shells and shell scripting, Linux user interfaces and graphical desktops, Linux administrative tasks, essential system services, networking fundamentals, and Linux security

The LPIC-1 101-500 exam covers four topics, with each topic covering several subtopics. Here's a general overview of what's contained in each topic and subtopic, along with the individual weighting on the exams:

- Topic 101: System Architecture (weight: 8)
  - 101.1: Determine and configure hardware settings (weight: 2)
  - 101.2: Boot the system (weight: 3)
  - 101.3: Change runlevels/boot targets and shut down or reboot system (weight: 3)
- Topic 102: Linux Installation and Package Management (weight: 12)
  - 102.1: Design hard disk layout (weight: 2)
  - 102.2: Install a boot manager (weight: 2)
  - 102.3: Manage shared libraries (weight: 1)
  - 102.4: Use Debian package management (weight: 3)
  - 102.5: Use RPM and YUM package management (weight: 3)
  - 102.6: Linux as a virtualization guest (weight: 1)
- Topic 103: GNU and Unix Commands (weight: 26)
  - 103.1: Work on the command line (weight: 4)
  - 103.2: Process text streams using filters (weight: 2)
  - 103.3: Perform basic file management (weight: 4)
  - 103.4: Use streams, pipes, and redirects (weight: 4)
  - 103.5: Create, monitor, and kill processes (weight: 4)
  - 103.6: Modify process execution priorities (weight: 2)
  - 103.7: Search text files using regular expressions (weight: 3)
  - 103.8: Basic file editing (weight: 3)
- Topic 104: Devices, Linux File Systems, Filesystem Hierarchy Standard (weight: 14)
  - 104.1: Create partitions and file systems (weight: 2)
  - 104.2: Maintain the integrity of file systems (weight: 2)

- 104.3: Control mounting and unmounting of file systems (weight: 3)
- 104.4: Subtopic removed
- 104.5: Manage file permissions and ownership (weight: 3)
- 104.6: Create and change hard and symbolic links (weight: 2)
- 104.7: Find system files and place files in the correct location (weight: 2)

Whereas the 101-500 exam covers the basics of Linux administration, the 102-500 exam digs a little deeper into the Linux skills required to perform real-world Linux administrative tasks:

- Topic 105: Shells and Shell Scripting (weight: 8)
  - 105.1: Customize and use the shell environment (weight: 4)
  - 105.2: Customize or write simple scripts (weight: 4)
- Topic 106: User Interfaces and Desktops (weight: 4)
  - 106.1: Install and configure X11 (weight: 2)
  - 106.2: Graphical desktops (weight: 1)
  - 106.3: Accessibility (weight: 1)
- Topic 107: Administrative Tasks (weight: 12)
  - 107.1: Manage user and group accounts and related system files (weight: 5)
  - 107.2: Automate system administration tasks by scheduling jobs (weight: 4)
  - 107.3: Localization and internationalization (weight: 3)
- Topic 108: Essential System Services (weight: 12)
  - 108.1: Maintain system time (weight: 3)
  - 108.2: System logging (weight: 4)
  - 108.3: Mail Transfer Agent (MTA) basics (weight: 3)
  - 108.4: Manage printers and printing (weight: 2)
- Topic 109: Networking Fundamentals (weight: 14)
  - 109.1: Fundamentals of Internet protocols (weight: 4)
  - 109.2: Persistent network configuration (weight: 4)
  - 109.3: Basic network troubleshooting (weight: 4)
  - 109.4: Configure client-side DNS (weight: 2)

- Topic 110: Security (weight: 10)
  - 110.1: Perform security administration tasks (weight: 3)
  - 110.2: Set up host security (weight: 3)
  - 110.3: Securing data with encryption (weight: 4)

As you can tell from these lists, the LPIC-1 exams cover a wide range of Linux topics. However, remember that these are still oriented toward the junior Linux administrator, so they don't dig too deeply into the topics. For that, there are the LPIC-2 exams, discussed in the next section.

The LPIC-2 exams

The LPIC-2 level of certification by LPI is intended for more experienced Linux administrators, covering more detailed topics regarding running a Linux server in a production environment. Currently at version 4.5, the LPIC-2 certification also consists of two exams.

The 201-450 exam covers these topics:

- Topic 200: Capacity planning (weight: 8)
- Topic 201: Linux kernel (weight: 9)
- Topic 202: System startup (weight: 9)
- Topic 203: File system and devices (weight: 9)
- Topic 204: Advanced storage device administration (weight: 8)
- Topic 205: Network configuration (weight: 11)
- Topic 206: System maintenance (weight: 6)

The 202-450 exam covers these general topics:

- Topic 207: Domain Name System (weight: 8)
- Topic 208: Web services (weight: 11)
- Topic 209: File sharing (weight: 8)
- Topic 210: Network client management (weight: 11)
- Topic 211: Email services (weight: 8)
- Topic 212: System security (weight: 14)

As you can see from the topic listing, the LPIC-2 certification starts to get into more of the details of designing and maintaining Linux servers. Before taking this examination, it's recommended that you have several months of hands-on Linux administration experience besides just studying the topics.

The LPIC-3 exams

Finally, the highest level of Linux certification provided by LPI is the LPIC-3 certification. The LPIC-3 certification level is a bit different from the LPIC-1 and LPIC-2 levels in that there are multiple tracks you can take. Each track consists of a single exam that specializes in a specific area related to advanced Linux administration:

- **Exam 300-300 Mixed Environments:** Covers installing and managing the Samba software package in a mixed Linux and Windows environment
- **Exam 303-300 Security:** Covers common Linux security topics, including cryptography, certificates, host security, intrusion detection, access control, network security, and vulnerability assessment
- **Exam 305-300 Virtualization and Containerization:** Covers using Linux in full virtualization environments, using and maintaining containers, and virtual machine deployment and provisioning
- **Exam 306-300 High Availability and Storage Clusters:** Covers using Linux systems enterprise-wide with an emphasis on high-availability systems and storage

As you can tell from this list, the LPIC-3 level of certifications really start to get into the advanced topics facing Linux administrators today. Each of these certification exams covers a single area of Linux administration, so you can take as many as you feel necessary to prove your advanced Linux administration skills!