

LPIC-1 Exam Workbook

A Chapter-by-Chapter Syllabus with Practice Questions

Version 1.0

Author: Mehdi JAFARIZADEH

Date: January 1, 2025

Contents

1	Topic 101: System Architecture	3
101.1	Determine and Configure Hardware Settings	3
101.2	Boot the System	11
101.3	Change Runlevels / Boot Targets and Shutdown or Reboot System	18
2	Topic 102: Linux Installation and Package Management	27
102.1	Design Hard Disk Layout	28
102.2	Install a Boot Manager	35
102.3	Manage Shared Libraries	43
102.4	Use Debian Package Management	50
102.5	Use RPM and YUM Package Management	59
102.6	Linux as a virtualization guest	69
3	Topic 103: GNU and Unix Commands	78
103.1	Work on the command line	79
103.2	Process text streams using filters	87
103.3	Perform basic file management	95
103.4	Use streams, pipes and redirects	105
103.5	Create, monitor and kill processes	114
103.6	Modify process execution priorities	124
103.7	Search text files using regular expressions	131
103.8	Basic file editing	140
4	Topic 104: Devices, Linux Filesystems, Filesystem Hierarchy Standard	148
104.1	Create partitions and filesystems	149
104.2	Maintain the integrity of filesystems	156
104.3	Control mounting and unmounting of filesystems	163
104.5	Manage file permissions and ownership	170
104.6	Create and change hard and symbolic links	177
104.7	Find system files and place files in the correct location	184
5	Topic 105: Shells and Shell Scripting	191
105.1	Customize and use the shell environment	192
105.2	Customize or write simple scripts	195
6	Topic 106: User Interfaces and Desktops	198
106.1	Install and configure X11	199
106.2	Graphical Desktops	202
106.3	Accessibility	205

7	Topic 107: Administrative Tasks	208
	107.1 Manage user and group accounts and related system files	209
	107.2 Automate system administration tasks by scheduling jobs	212
	107.3 Localisation and internationalisation	215
8	Topic 108: Essential System Services	218
	108.1 Maintain system time	219
	108.2 System logging	222
	108.3 Mail Transfer Agent (MTA) basics	225
	108.4 Manage printers and printing	228
9	Topic 109: Networking Fundamentals	231
	109.1 Fundamentals of internet protocols	232
	109.2 Persistent network configuration	235
	109.3 Basic network troubleshooting	238
	109.4 Configure client side DNS	241
10	Topic 110: Security	244
	110.1 Perform security administration tasks	245
	110.2 Setup host security	248
	110.3 Securing data with encryption	251
	Answers	254
	Topic 101: System Architecture	254
	Topic 102: Linux Installation and Package Management	257
	Topic 103: GNU and Unix Commands	263
	Topic 104: Devices, Linux Filesystems, Filesystem Hierarchy Standard	271
	Topic 105: Shells and Shell Scripting	278
	Topic 106: User Interfaces and Desktops	278
	Topic 107: Administrative Tasks	278
	Topic 108: Essential System Services	278
	Topic 109: Networking Fundamentals	278
	Topic 110: Security	278

Chapter 1

Topic 101: System Architecture

101.1 Determine and Configure Hardware Settings

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 101.1
- Weight: 2

Key Knowledge Areas

- Enabling/disabling integrated peripherals (BIOS/UEFI).
- Identifying different types of mass storage devices.
- Determining hardware resources for devices (IRQ, DMA, etc.).
- Using tools (`lsusb`, `lspci`, `lsmod`) for hardware inspection.
- Manipulating USB devices.
- Understanding `sysfs`, `udev`, and `dbus` concepts.

Important Files, Terms, and Utilities

- `/sys/`
- `/proc/`
- `/dev/`
- `modprobe`
- `lsmod`
- `lspci`
- `lsusb`

Lesson Overview

Modern computers rely on standards for firmware and hardware interaction. On x86 platforms, the firmware could be traditional **BIOS** or newer **UEFI**. Both allow for configuring hardware resources (e.g., integrated peripherals, IRQs, DMA settings) even before the operating system loads.

Once Linux is running, device detection and configuration rely on the kernel and support from user-space utilities such as `lspci`, `lsusb`, `lsmod`, and various pseudo-filesystems in `/proc` and `/sys`.

1. BIOS and UEFI Configuration

- **Accessing Firmware:** Typically press Del, F2, or F12 at startup.
- **Common Configurations:**
 - Enable/disable integrated peripherals (USB ports, onboard audio, etc.).
 - Set boot order and define the primary device for the bootloader.
 - Adjust CPU features or RAM parameters if needed.
- **Impact:** Misconfiguration (e.g., wrong boot device) can prevent the OS from loading.

2. Device Detection in Linux

- **Goal:** Match hardware parts to the correct driver (**kernel module**).
- **Basic Workflow:**
 1. **Check if hardware is detected** (e.g., lspci, lsusb).
 2. **Verify if a driver is loaded** (e.g., lsmod, lspci -k).
 3. **Confirm functionality** via logs, testing, or additional tools.

3. Commands for Hardware Inspection

1. lspci

- Lists PCI devices (graphics cards, network interfaces, etc.).
- Use -v for more detail and -k to see which kernel modules are in use.
- Example:

```
lspci -s 04:02.0 -v
lspci -s 01:00.0 -k
```

2. lsusb

- Lists USB devices (keyboards, mice, USB hubs, etc.).
- Use -v for verbose output and -d <vendor:product> to focus on a specific device.
- Example:

```
lsusb -v -d 1781:0c9f
lsusb -t # Show devices in a tree structure
```

3. lsmod

- Shows loaded kernel modules.
- Columns: **Module**, **Size**, **Used by** (dependency information).
- Example:

```
lsmod | grep snd_hda_intel
```

4. modprobe

- Loads or unloads modules (with dependencies).
- modprobe -r <module> removes a module if not in use.
- modinfo <module> shows module details (author, license, parameters, etc.).
- Configuration files in /etc/modprobe.d/ can blacklist or set module parameters.

4. Hardware Information Files

- **/proc** (pseudo-filesystem for processes and hardware info)
 - `/proc/cpuinfo`, `/proc/interrupts`, `/proc/ioports`, `/proc/dma`
- **/sys** (`sysfs` for device and kernel data)
- **/dev** (device files)
 - Each entry represents a device (e.g., `/dev/sda1`, `/dev/fd0`).
 - `udev` dynamically creates/removes these files as devices connect or disconnect.

5. Storage Devices

- **Block Devices:** Accessed in fixed-size blocks (hard disks, SSDs, etc.).
- **Naming Conventions:**
 - Newer kernels use `sd` prefix for most disks; partitions are numbered (`/dev/sda1`).
 - **IDE** devices also appear as `sd` on modern kernels
 - **NVMe** devices get names like `/dev/nvme0n1p1`.
 - **SD Cards** often appear as `/dev/mmcblk0p1`.
- **Hotplug and Coldplug:**
 - **Hotplug:** device recognized after boot (e.g., USB).
 - **Coldplug:** device recognized during boot (built-in or already connected).

Workbook Exercises

1. Accessing BIOS/UEFI

- Reboot a test machine and enter BIOS/UEFI.
- Locate the sections that let you enable/disable integrated peripherals.
- Identify the menu where boot order is set.

2. Listing Hardware

- On a Linux system, run `lspci -k`.
 - Identify which driver is used by the video card.
- Run `lsusb -t`.
 - Check which USB driver modules are in use (e.g., `btusb`, `usbhid`).

3. Exploring `/proc` and `/sys`

- View CPU details with `cat /proc/cpuinfo`.
- Inspect interrupts with `cat /proc/interrupts`.
- Explore `/sys/class` and `/sys/block` to see how devices are represented.

4. Managing Kernel Modules

- Use `lsmod` to list all loaded modules.
- Pick a module (e.g., a sound driver) and unload it with `sudo modprobe -r <module>`.

- Check if removal is allowed (the module should not be in use).
- Use `modinfo -p <module>` to see possible parameters, and note how you might apply them in `/etc/modprobe.d/`.

5. Blacklisting a Module

- Create a test file in `/etc/modprobe.d/` to blacklist an unwanted module (e.g., `nouveau`).
- Reboot and confirm it is not loaded by checking `lsmod`.

Summary

- Modern systems rely on firmware (BIOS/UEFI) for initial hardware configuration.
- Linux identifies devices via kernel modules; tools like `lspci`, `lsusb`, `lsmod`, and `modprobe` allow you to inspect and manage hardware.
- `/proc` and `/sys` provide detailed, real-time system information, while `udev` dynamically manages device nodes in `/dev`.
- Storage device naming conventions follow standard patterns such as `sd`, `nvme`, `mmcblk`, and partition numbers like `/dev/sda1`.
- Understanding how to enable/disable devices, load/unload modules, and explore hardware information files is crucial for effective system administration and LPIC-1 success.

Multiple-Choice Questions for 101.1

1. When trying to enable or disable motherboard-integrated peripherals, which component of the system is typically used?
 - A) The BIOS or UEFI configuration utility
 - B) The Linux kernel's initrd
 - C) The `/boot` partition
 - D) The `lsusb` command
2. Which command lists devices currently connected to the PCI bus?
 - A) `modprobe`
 - B) `lsmod`
 - C) `lspci`
 - D) `lshw`
3. Which of the following commands helps you list USB devices in a tree-like hierarchy?
 - A) `lsusb -a`
 - B) `lsusb -s`
 - C) `lsusb -f`
 - D) `lsusb -t`
4. To remove a kernel module (along with its dependencies) while the system is running, which command should be used?
 - A) `modinfo -r`
 - B) `modprobe -r`
 - C) `rmmod -all`
 - D) `lsmod -r`
5. On modern Linux systems, SATA disks are generally identified as which kind of device name?
 - A) `/dev/sdX`
 - B) `/dev/hdX`
 - C) `/dev/nvmeXnY`
 - D) `/dev/fdX`
6. Which file below would you edit to permanently blacklist a problematic kernel module such that it doesn't load automatically?
 - A) `/etc/rc.local`
 - B) `/etc/modprobe.d/blacklist.conf`
 - C) `/boot/grub/grub.cfg`
 - D) `/proc/blacklist/modules`
7. Which pseudo-filesystem is most specifically devoted to storing device and kernel data related to hardware?
 - A) `/dev`
 - B) `/proc`

- C) `/sys`
 - D) `/home`
8. Which command line will show a specific USB device's verbose information using its vendor:product ID (e.g., 1781:0c9f)?
- A) `lsusb -d 1781:0c9f -v`
 - B) `lsusb -p 1781:0c9f -v`
 - C) `lsusb -i 1781:0c9f`
 - D) `lsusb -v -s 01:02`
9. In the output of `lsmod`, the "Used by" column indicates:
- A) the file size of the module on disk
 - B) the user-level applications that installed the module
 - C) the modules or processes depending on that module
 - D) kernel version compatibility for that module
10. If you need to confirm which kernel driver is in use by a particular PCI device, which `lspci` option combination is most helpful on recent distributions?
- A) `lspci -m`
 - B) `lspci -k`
 - C) `lspci -D`
 - D) `lspci -driver`
11. What does the output of `lsusb -t` specifically highlight that differs from plain `lsusb`?
- A) The exact partition layout of attached USB drives
 - B) A hierarchical (tree-like) representation of USB devices and drivers
 - C) The SCSI ID mappings of USB-attached devices
 - D) A summary of device's kernel modules only
12. Which best describes the function of the `modinfo` command?
- A) It removes the specified module from the kernel
 - B) It displays all processes currently using a kernel module
 - C) It lists detailed information about a specified module, including parameters
 - D) It inserts the specified module and resolves dependencies
13. What is the role of `udev` on a modern Linux system?
- A) It is a pseudo-filesystem used to track hardware devices in `/sys`
 - B) It permanently stores device drivers in `/boot`
 - C) It manages device nodes in `/dev`, handling hotplug/coldplug events
 - D) It only configures CPU frequency scaling
14. Which file inside `/proc` would you inspect to see how many interrupts have occurred for each device?
- A) `/proc/ioports`
 - B) `/proc/dma`

- C) `/proc/cpuinfo`
 - D) `/proc/interrupts`
15. If a device is recognized by the kernel but not functioning correctly, which of the following is the most likely underlying cause?
- A) The BIOS is not set to read the device's firmware
 - B) The associated kernel module (driver) is not loaded or is misconfigured
 - C) The CPU lacks the required SSE instruction set
 - D) The device was not assigned a correct IRQ in the `/etc/fstab`
16. Which file is typically used to pass persistent module load options like `options nouveau modeset=0`?
- A) `/etc/udev/rules.d/99-custom.rules`
 - B) `/proc/meminfo`
 - C) `/etc/modprobe.d/<module>.conf`
 - D) `/etc/modules-load.d/module.options`
17. What is the main purpose of SysFS (`/sys`) in a Linux system?
- A) Stores process information like CPU usage
 - B) Holds user configuration data for `/home`
 - C) Exports device and driver information from the kernel to user space
 - D) Contains scripts to mount all system filesystems
18. Which command is most appropriate for listing all currently loaded kernel modules?
- A) `ls -la /lib/modules/$(uname -r)`
 - B) `depmod -a`
 - C) `lsmod`
 - D) `insmod`
19. To selectively unload the `snd-hda-intel` module along with related dependent modules, which command would you use?
- A) `modinfo snd-hda-intel -remove`
 - B) `lsmod -unload snd-hda-intel`
 - C) `depmod -r snd-hda-intel`
 - D) `modprobe -r snd-hda-intel`
20. If you see a disk labeled as `/dev/mmcblk0p1`, which type of physical device is this likely referring to?
- A) A SATA SSD
 - B) An older IDE HDD
 - C) An SD card or MMC device
 - D) A USB DVD drive

Fill-in-the-Blank Questions for 101.1

1. The older firmware commonly used before the UEFI standard is called _____.
2. The _____ command lists all kernel modules currently loaded into the system.
3. A kernel module responsible for controlling hardware in Linux is often referred to as a _____.
4. The Linux subsystem that manages device node creation in `/dev` and handles hotplug/coldplug events is called _____.
5. The special, memory-based filesystem used for storing process and hardware information is the _____ directory.
6. To configure boot device priority and enable or disable onboard peripherals, a user must typically access the _____ or UEFI setup utility.
7. In Linux, disks commonly appear under `/dev` as _____ devices (e.g., `/dev/sda`, `/dev/sdb`) on modern systems.
8. The _____ command is used to insert or remove kernel modules and their dependencies.
9. When blacklisting a kernel module to prevent it from loading automatically, the configuration file is often placed in _____.
10. To see a hierarchical (tree-like) view of USB devices and the drivers handling them, you can run _____ with the `-t` option.

101.2 Boot the System

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 101.2
- Weight: 3

Key Knowledge Areas

- Providing common bootloader commands and kernel options at boot.
- Understanding the boot sequence (BIOS/UEFI through OS startup).
- Familiarity with SysVinit, systemd, and Upstart.
- Checking boot events and logs (`dmesg`, `journalctl`).

Important Files, Terms, and Utilities

- `dmesg`
- `journalctl`
- BIOS / UEFI
- bootloader (GRUB)
- kernel
- `initramfs`
- `init` (SysVinit, systemd, Upstart)
- `/proc/cmdline`
- `/var/log/`

Lesson Overview

Booting a Linux system involves multiple stages:

1. **Firmware Load:** BIOS or UEFI initializes basic hardware.
2. **Bootloader:** Typically **GRUB**, which locates and loads the kernel.
3. **Kernel & initramfs:** Kernel initializes hardware and reads modules from the `initramfs`.
4. **System Initialization:** `init` (SysVinit, systemd, Upstart) starts services and completes the boot process.

1. BIOS vs. UEFI

- BIOS
 - Uses MBR (first 512 bytes) to load boot code (GRUB stage 1).
 - Relies on a DOS partition scheme and the Master Boot Record.
 - Boots the second stage of the bootloader, which in turn loads the kernel.
- UEFI

- Looks at entries in **NVRAM** to find an **EFI application** (usually GRUB).
- Loads the EFI application from a dedicated **EFI System Partition (ESP)**.
- Supports **Secure Boot** to allow only signed EFI applications.

2. Bootloader (GRUB)

- Presents a menu of installed kernels or operating systems.
- Enables passing **kernel parameters** (e.g., `quiet`, `acpi=off`, `root=/dev/sdaX`, etc.).
- Kernel parameters can be made persistent in `/etc/default/grub` and then updated with:

```
grub-mkconfig -o /boot/grub/grub.cfg
```

- Current kernel parameters are visible in `/proc/cmdline`.

3. System Initialization

1. initramfs

- Temporary root filesystem with essential drivers/modules.
- Lets the kernel mount the actual root filesystem.

2. init

- The “first process” in user space.
- **SysVinit**: uses **runlevels** (0–6).
- **systemd**: uses **targets**, concurrency, D-Bus, cgroups. Most common in modern distros.
- **Upstart**: parallel boot focusing on faster startup. Largely replaced by systemd.

4. Boot Logging and Inspection

- **dmesg**
 - Displays the **kernel ring buffer** (including boot messages).
 - Clears with `dmesg -clear`.
- **journalctl**
 - Systemd-based logging tool.
 - `journalctl -b` shows current boot messages.
 - `journalctl -list-boots` lists previous boots.
- Traditional log files also found in `/var/log/`, e.g., `/var/log/messages` or `/var/log/syslog`.

Workbook Exercises

1. Firmware Awareness

- Reboot a test machine.
- Determine whether it uses **BIOS** or **UEFI**.
- In BIOS: Find where the boot order is set.

- In UEFI: Locate the ESP partition and explore contents if possible.

2. GRUB Menu and Kernel Parameters

- Boot into the GRUB menu by pressing **Shift** (BIOS) or **Esc** (UEFI).
- Edit a menu entry to add or change a kernel parameter (e.g., `init=/bin/bash`, `acpi=off`).
- After boot, check `/proc/cmdline` to confirm your changes.

3. System Initialization Tools

- Identify which init system your distribution uses (`ps -p 1 -o comm=`).
- If it's systemd, compare output of these commands:

```
systemctl list-units --type=service
journalctl -b
```

- If SysVinit is present, inspect runlevel scripts in `/etc/rc.d/` or `/etc/init.d/`.

4. Inspecting Boot Logs

- Run `dmesg | less` to page through the kernel ring buffer.
- If using systemd, run `journalctl -list-boots` to see previous boots.
- View the logs for the current boot with `journalctl -b 0`.

5. initramfs Exploration

- Locate your initramfs file (commonly in `/boot`, e.g., `initramfs-<version>.img`).
- List contents using `lsinitrd` or `unmkinitramfs` (may require additional packages).
- Identify which modules are included for the root filesystem.

Summary

- The boot process starts with **BIOS/UEFI** firmware, which calls **GRUB** to load the **kernel**.
- The **initramfs** contains essential modules and mounts the real root filesystem.
- An **init** system (SysVinit, systemd, Upstart) then starts daemons and services.
- **dmesg** and **journalctl** provide essential logs for troubleshooting.
- Understanding these steps ensures you can troubleshoot common startup issues and manage kernel parameters effectively.

Multiple-Choice Questions for 101.2

1. Which of the following best describes the role of the **kernel ring buffer** during the boot process?
 - A) It stores a copy of the MBR after BIOS initialization.
 - B) It holds user processes' initialization scripts during startup.
 - C) It temporarily stores kernel messages, including boot messages.
 - D) It provides secure boot verification for the EFI System Partition.
2. On a typical Linux system with GRUB, which file should be edited to **persistently** add kernel boot parameters?
 - A) `/etc/default/grub`
 - B) `/etc/systemd/system.conf`
 - C) `/boot/vmlinuz`
 - D) `/proc/cmdline`
3. Which bootloader is most commonly associated with modern x86-based Linux systems?
 - A) LILO
 - B) SYSLINUX
 - C) BURG
 - D) GRUB
4. Which of the following statements about **Secure Boot** is **true**?
 - A) It forces the user to boot only from a local disk rather than USB devices.
 - B) It requires EFI applications to be signed/authorized by the hardware vendor or a trusted party.
 - C) It loads the SysVinit scripts in parallel to reduce the boot time of the OS.
 - D) It uses MBR partition tables exclusively and disables GPT.
5. The BIOS in a legacy (non-UEFI) x86 system typically reads and executes boot code from what specific location?
 - A) The first 440 bytes of the MBR on the primary boot device
 - B) The second stage of GRUB in `/boot/grub`
 - C) The NVRAM partition labeled `/efi/boot`
 - D) `/boot` partition
6. What is the **primary purpose** of `initramfs` during the boot process?
 - A) To store the kernel ring buffer.
 - B) To provide early user accounts for system security.
 - C) To load required kernel modules so the real root filesystem can be mounted.
 - D) To replace the BIOS firmware in older systems.
7. You want to limit a Linux guest system to a maximum of 1 GB of RAM at boot time. Which kernel parameter should be used?
 - A) `nosmp=1G`
 - B) `mem=1G`

- C) `ram=1G`
 - D) `maxcpus=1G`
8. Which of the following is a feature of **systemd**?
- A) Entirely depends on runlevels 0–6 and SysV scripts.
 - B) Uses sockets and D-Bus for on-demand service activation.
 - C) Must be installed as a kernel module.
 - D) It can only run one service at a time to avoid concurrency issues.
9. While troubleshooting a boot issue, you want to see **previous** system boots' log messages. Which systemd-related command enables you to do this?
- A) `dmesg -previous`
 - B) `journalctl -list-boots`
 - C) `systemctl -history`
 - D) `logrotate -b`
10. After you edit `/etc/default/grub` to add a new kernel parameter, which command is typically used to **update** the GRUB configuration on many distributions?
- A) `cp /etc/default/grub /boot/grub/grub.conf`
 - B) `touch /boot/grub/grub.cfg`
 - C) `grub-install /boot`
 - D) `grub-mkconfig -o /boot/grub/grub.cfg`
11. What does the kernel parameter `acpi=off` do?
- A) Disables multi-processor support, similar to `nosmp`.
 - B) Disables BIOS POST checks and loads the kernel directly.
 - C) Disables ACPI functions to troubleshoot power management or ACPI-related issues.
 - D) Forces the root filesystem to be mounted as read-only.
12. In a SysVinit-based system, which file primarily determines which **runlevel** the system will go to when it finishes booting?
- A) `/etc/fstab`
 - B) `/boot/initramfs-<version>.img`
 - C) `/etc/inittab`
 - D) `/var/log/boot.log`
13. When using UEFI, which partition **must** contain the bootloader or EFI applications?
- A) The root (`/`) filesystem partition
 - B) A dedicated GPT partition labeled "MBR"
 - C) An NVRAM-based partition called `/var/lib/EFI`
 - D) The EFI System Partition (ESP)
14. Which kernel parameter instructs the system to **start** a different **initial process** instead of the default `/sbin/init` or `systemd`?
- A) `init=/bin/bash`

- B) `systemd.unit=multi-user.target`
 - C) `noapic`
 - D) `ro`
15. The term **daemon** is typically used to describe which kind of program in a Linux system?
- A) A program that only runs once at boot and then terminates.
 - B) A service that remains **running** in the background.
 - C) Any script that an administrator invokes manually from the command line.
 - D) A background service process (e.g. system or network) that runs indefinitely.
16. Which of the following is **not** a valid kernel parameter for controlling the amount of displayed boot information?
- A) `verbose=0`
 - B) `quiet`
 - C) `vga=ask`
 - D) `maxcpus=1`
17. If a critical system service fails to start during boot and the system uses **systemd**, where would you most likely check **first** for the relevant error messages?
- A) `/proc/cmdline`
 - B) `/etc/default/grub`
 - C) `systemctl list-jobs`
 - D) `journalctl -b` or `journalctl -boot`
18. In a system that uses SysVinit, which runlevel is **commonly** used for **single-user mode** (maintenance mode)?
- A) 2
 - B) 5
 - C) 1
 - D) 3
19. Which of the following statements about **Upstart** is correct?
- A) It can parallelize the initialization of services but has largely been replaced by `systemd`.
 - B) It replaces the BIOS in older systems.
 - C) It is strictly a tool for reading the kernel ring buffer.
 - D) It is used to sign EFI applications for Secure Boot.
20. The BIOS POST (Power-On Self-Test) primarily checks for:
- A) Valid ext4 partitions on the system's boot drive.
 - B) Basic hardware components and any major hardware failures.
 - C) Corrupted kernel parameters in `/proc/cmdline`.
 - D) Upstart jobs that should be started first.

Fill-in-the-Blank Questions for 101.2

1. The firmware on modern x86 systems can be either traditional _____ or the more advanced _____.
2. On legacy BIOS-based systems, the first stage of the bootloader is typically located in the first _____ bytes of the _____.
3. When using UEFI, the bootloader or EFI applications are stored in a dedicated partition called the _____, often formatted with a FAT filesystem.
4. The kernel parameter _____=`/bin/bash` causes the system to start a Bash shell as the first user-space process instead of the standard init system.
5. The file `/etc/default/grub` contains the directive `GRUB_CMDLINE_LINUX`, which is used to specify _____ passed to the kernel at boot time.
6. The command `grub-mkconfig -o /boot/grub/grub.cfg` is needed after modifying `/etc/default/grub` to _____ the bootloader configuration.
7. The memory area that stores kernel messages, including boot information, is called the _____, which can be viewed with the `dmesg` command.
8. The _____ process runs basic hardware checks (like checking memory) as soon as the machine is powered on, before loading the bootloader.
9. In a SysVinit-based system, the file `/etc/_____` typically defines which runlevel the system will enter when it finishes booting.
10. A(n) _____ is a background service or process that remains running to provide system or network functionality.

101.3 Change Runlevels / Boot Targets and Shutdown or Reboot System

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 101.3
- Weight: 3

Key Knowledge Areas

- Setting the default runlevel/boot target.
- Changing between runlevels/targets, including single-user mode.
- Shutting down and rebooting from the command line.
- Alerting users before switching runlevels/boot targets or major system events.
- Properly terminating processes.
- Awareness of **acpid** (power management).

Important Files, Terms, and Utilities

- **/etc/inittab** (SysVinit)
- **shutdown**
- **init, telinit** (SysVinit)
- **/etc/init.d/** (SysVinit scripts)
- **systemd, systemctl**
- **/etc/systemd/, /usr/lib/systemd/**
- **wall** (send messages to all logged-in users)

Lesson Overview

Linux can operate in different “states” or “modes” called **runlevels** in SysVinit or **targets** in systemd. Being able to switch between them and perform system shutdowns or reboots is essential for system administration.

1. SysVinit Runlevels

1. Runlevels

- **0** – Shutdown
- **1 (single), s** – Single-user (maintenance) mode
- **2, 3, 4** – Multi-user modes (3 is typical, 2/4 vary by distro)
- **5** – Multi-user plus graphical mode
- **6** – Reboot

2. Configuration

- `/etc/inittab` defines default runlevel (`id:x:initdefault:`)
- Each runlevel has a dedicated directory: `/etc/rc0.d/`, `/etc/rc1.d/`, etc.
- Scripts in `/etc/init.d/` are symlinked to these runlevel directories.
 - Names starting with **S** start services.
 - Names starting with **K** kill services.

3. Switching Runlevels

- `init` or `telinit` commands set the current runlevel.
- `telinit 1`: move to runlevel 1 (maintenance mode).
- `runlevel`: shows current and previous runlevel (e.g., `N 3` means currently 3 and no prior change).

4. Reloading `/etc/inittab`

- After editing `/etc/inittab`, run `telinit q` to re-read the config.

2. systemd Targets

1. systemd Concepts

- **Units** represent services, sockets, devices, mounts, automounts, targets, and snapshots.
- `systemctl` is the primary command to manage these units (start, stop, enable, etc.).

2. Targets

- systemd uses **targets** to group units. Examples:
 - **multi-user.target** – analogous to runlevel 3 (no GUI).
 - **graphical.target** – analogous to runlevel 5 (GUI mode).
- You can isolate a target:

```
systemctl isolate multi-user.target
```

3. Default Target

- Change default target:

```
systemctl set-default multi-user.target
```

- View current default:

```
systemctl get-default
```

- Avoid pointing to **shutdown.target** or **reboot.target**.

4. Service Management

- `systemctl start/stop/restart <service>.service`
- `systemctl enable/disable <service>.service` (at boot)
- `systemctl status <service>.service`
- `systemctl list-unit-files -type=service` – list available services
- `systemctl list-units -type=service` – list loaded/running services

5. Power Management

- `systemctl suspend`, `systemctl hibernate`
- For finer power-event control (e.g., lid close), **acpid** can be used instead of systemd's built-in power management.

3. Upstart (Historical)

1. **Upstart** was used in older Ubuntu-based systems before switching to systemd.
2. **Commands:**
 - `initctl list` – list services and states
 - `start / stop / status <service>` – control services
 - Initialization scripts: `/etc/init/`
3. `runlevel` and `telinit` still work for basic runlevel tasks.

4. Shutting Down and Rebooting

1. shutdown

- Syntax:

```
shutdown [option] time [message]
```

- **time** can be `now`, `+m` (minutes from now), or `hh:mm` (absolute time).
- Common options:
 - **-h** – halt/power off
 - **-r** – reboot
- Notifies logged-in users and prevents new logins (unless overridden).

2. systemctl (systemd)

- `systemctl reboot` – reboot system
- `systemctl poweroff` – power off system
- Sometimes distros alias `poweroff` and `reboot` to systemd commands.

3. wall

- Sends a message to all logged-in users' terminals (similar to `shutdown`'s broadcast).
- Useful for manual warnings before switching to single-user mode or shutting down.

Workbook Exercises

1. Identify Your Init System

- Run `ps -p 1 -o comm=` to see if your system uses **systemd**, **init**, or **Upstart**.

2. Practice Switching Runlevels (SysV)

- On a SysVinit system, edit `/etc/inittab` to set default runlevel to **3**.
- Run `telinit q` and verify with `runlevel`.
- Switch to single-user mode: `telinit 1`.

3. Practice Managing systemd Targets

- Show the current default target: `systemctl get-default`.
- Switch from **graphical.target** to **multi-user.target** using:

```
systemctl isolate multi-user.target
```

- Confirm the change: `systemctl status multi-user.target`.

4. Service Control with systemd

- Start a service (e.g., `ssh.service`):

```
sudo systemctl start ssh
```

- Check service status: `systemctl status ssh`.
- Enable service at boot: `systemctl enable ssh`.

5. Shutdown Commands

- Schedule a reboot in 10 minutes, sending a warning message:

```
sudo shutdown -r +10 "System will reboot in 10 minutes."
```

- Cancel a scheduled shutdown with:

```
sudo shutdown -c
```

- Use **systemctl** to reboot immediately: `systemctl reboot`.

6. Sending Warnings

- Open a second terminal and log in as a test user.
- From the admin terminal, run:

```
wall "Warning! System moving to single-user mode in 1 minute."
```

- Confirm the message appears in the other terminal.

Summary

- **SysVinit** uses numbered runlevels (0–6), configured via **/etc/inittab**, and manages services in **/etc/init.d/**.
- **systemd** uses **targets** and **units**, with **systemctl** providing service control and target isolation.
- **Upstart** (historical) uses **initctl** and scripts in **/etc/init/**.
- Shutting down, rebooting, or switching modes should alert current users (via **wall** or **shutdown**'s broadcast).
- Proper runlevel/target configuration ensures the correct set of services starts at boot, maximizing system stability and user support.

Multiple-Choice Questions for 101.3

1. Which file traditionally defines the default runlevel in a SysVinit system?
 - A) `/etc/inittab`
 - B) `/etc/rc.conf`
 - C) `/etc/systemd/system.conf`
 - D) `/etc/default/runlevel`
2. In SysVinit, which runlevel usually corresponds to **system restart**?
 - A) Runlevel 1
 - B) Runlevel 3
 - C) Runlevel 5
 - D) Runlevel 6
3. Which command is used on a SysVinit system to **check the current runlevel**?
 - A) `who -r`
 - B) `runlevel`
 - C) `init`
 - D) `sysvcheck`
4. On a SysVinit system, which **runlevel** is typically reserved for **multi-user mode without a graphical environment**?
 - A) Runlevel 0
 - B) Runlevel 1
 - C) Runlevel 3
 - D) Runlevel 6
5. Which command **reloads** the `/etc/inittab` file after changes are made (on a SysVinit system)?
 - A) `telinit q`
 - B) `init reload`
 - C) `systemctl daemon-reload`
 - D) `reload runlevel`
6. Which **systemd unit type** is used for grouping other units so they can be controlled as a single entity?
 - A) `service`
 - B) `automount`
 - C) `target`
 - D) `socket`
7. On a **systemd** system, which command would you use to **switch** the system to `multi-user.target` immediately?
 - A) `systemctl default multi-user.target`
 - B) `systemctl multi-user.target`

- C) `systemctl reload multi-user.target`
 - D) `systemctl isolate multi-user.target`
8. Which command is commonly used on SysVinit systems to **change** the current runlevel **without** rebooting?
- A) `systemctl isolate`
 - B) `telinit`
 - C) `initctrl`
 - D) `switchrun`
9. In a SysVinit layout, scripts in directories like `/etc/rc3.d/` typically **start** with what letter if they are launched upon entering that runlevel?
- A) R
 - B) G
 - C) S
 - D) T
10. Which **runlevel** or mode is typically used for **maintenance** when the system is only available to the administrator (no network services)?
- A) Single-user (Runlevel 1)
 - B) Graphical mode (Runlevel 5)
 - C) Multi-user mode (Runlevel 3)
 - D) Runlevel 2
11. Which **SysVinit** command can be used to **halt** the system, after modifying the `/etc/inittab` entry for Ctrl+Alt+Del with the `-a` option?
- A) `halt -a`
 - B) `shutdown`
 - C) `poweroff`
 - D) `stop system`
12. Which **systemctl** command would you use to **turn off** the system immediately on a **systemd** host?
- A) `systemctl shutdown`
 - B) `systemctl down`
 - C) `systemctl isolate runlevel0.target`
 - D) `systemctl poweroff`
13. Which **systemd** unit type is used for hardware devices identified by the kernel?
- A) target
 - B) service
 - C) device
 - D) mount
14. Which file is **not** used by **systemd** to set the default system target?
- A) `/etc/systemd/system/default.target`

- B) `/lib/systemd/system/multi-user.target`
 - C) `/lib/systemd/system/graphical.target`
 - D) `/etc/inittab`
15. If you see the output `tty5 start/running, process 1764` on an Ubuntu system, which **init system** is likely in use?
- A) SysVinit
 - B) Upstart
 - C) systemd
 - D) OpenRC
16. On a **systemd** system, which command **reboots** the machine?
- A) `systemctl shutdown -r`
 - B) `systemctl kill`
 - C) `systemctl isolate reboot.target`
 - D) `systemctl reboot`
17. Which **systemd** unit type is used to define an on-demand mount point?
- A) device
 - B) service
 - C) socket
 - D) automount
18. Which **Upstart** command is used to **stop** a currently running job or service?
- A) `upstartctl kill`
 - B) `stop`
 - C) `service halt`
 - D) `haltjob`
19. Which command is typically used to **send a message** to all logged-in users' terminals?
- A) `wall`
 - B) `announce`
 - C) `globalmsg`
 - D) `bcast`
20. In the **SysVinit** scheme, which directory contains startup scripts (symbolic links) specifically for **runlevel 2**?
- A) `/etc/init.d2/`
 - B) `/etc/rc.d/2/`
 - C) `/etc/rc2.d/`
 - D) `/etc/sysvinit/2/`

Fill-in-the-Blank Questions for 101.3

1. In a **SysVinit** system, the default runlevel is configured in the file _____.
2. To switch the system to **single-user mode** (runlevel 1) on a SysVinit system, you can type _____
1 or _____ **s**.
3. The command _____ **q** is used to make **init** re-read the `/etc/inittab` file after changes are made.
4. In **System V** style initialization, scripts controlling services are located in _____, while each runlevel (e.g., runlevel 3, 5) has its own subdirectory like `/etc/rc3.d/` or `/etc/rc5.d/`.
5. Under **systemd**, each background process or subsystem is referred to as a _____ (e.g., **httpd.service**).
6. To change the **default target** in **systemd** without editing kernel parameters directly, you can use the command `systemctl set-default _____`.**target**.
7. In **systemd**, if you want to switch to **multi-user mode** without rebooting, you can execute `systemctl _____` **multi-user.target**.
8. When switching from **Upstart**, Ubuntu replaced its init system with _____.
9. The _____ command sends a message to the terminal sessions of all logged-in users and is useful before shutting down or switching runlevels.
10. In a **SysVinit** system, **Runlevel 0** corresponds to _____, while **Runlevel 6** corresponds to a **restart** of the system.

Chapter 2

Topic 102: Linux Installation and Package Management

102.1 Design Hard Disk Layout

Reference to LPI Objectives:

- LPIC-1 v5, Exam 102, Objective 102.1
- Weight: 2

Key Knowledge Areas

- Allocating filesystems and swap space to separate partitions or disks.
- Tailoring the partitioning scheme to system usage.
- Understanding `/boot` or EFI System Partition requirements for booting.
- Basic familiarity with LVM (Logical Volume Manager).

Important Terms and Utilities

- `/` (root), `/boot`, `/home`, `/var`
- **EFI System Partition (ESP)**
- **swap**
- **mount points** (e.g., `/mnt`, `/media/USER/LABEL`)
- **partitions** and **logical volumes**
- **LVM** (Physical Volumes, Volume Groups, Logical Volumes)

Lesson Overview

Designing an effective disk layout is critical for system stability, performance, and ease of administration. You must understand partitions, filesystems, mount points, swap, and how LVM can simplify storage allocation.

1. Partitions, Filesystems, and Mount Points

1. Partitions

- Logical “fences” on a disk; each partition has its own filesystem.
- Partition information is stored in the **partition table**.
- Partitions **cannot** span multiple disks (unless using LVM or RAID).

2. Filesystems

- Define how data is organized in directories, files, and metadata.
- Must be **mounted** on a mount point (e.g., `/mnt/mydata`).

3. Mount Points

- Directory where a filesystem is attached.
- Common directories:
 - `/mnt/` – traditional manual mount point.
 - `/media/` – automatic mounting of removable media.
- Existing contents of a mount point become hidden while another filesystem is mounted.

2. Recommended Partitions and Their Uses

1. Root Partition (/)

- Base of the Linux directory structure.
- Typically holds OS binaries and system config if not separated elsewhere.

2. /boot or EFI System Partition (ESP)

- /boot stores bootloader files (kernel images, initramfs, GRUB).
- ESP is used on UEFI systems (formatted as FAT).
- Usually 200–300 MB in size is sufficient for either.
- Keeping boot files separate can help ensure the system can still boot if root is damaged.

3. /home

- Houses users' personal files and preferences.
- Separating /home allows OS reinstallation without erasing user data.
- Size depends on user data and expected usage.

4. /var

- Contains variable data: logs (/var/log), caches (/var/cache), temp data (/var/tmp), etc.
- On servers, /var can grow significantly (e.g., web or database data).
- Putting /var on a separate partition (or disk) improves stability and prevents root from filling up.

5. Swap

- Extension of RAM to disk; cannot be mounted as a normal directory.
- Often sized according to usage (e.g., old rule was 2×RAM; modern guidelines vary).
- Consider **hibernation** requirements (swap ≥ RAM if hibernation is used).

3. LVM (Logical Volume Manager)

1. Overview

- Provides flexible “virtual” partitions called **Logical Volumes (LVs)**.
- **Physical Volumes (PVs)** → grouped into **Volume Groups (VGs)** → split into **Logical Volumes (LVs)**.
- LVM allows resizing or adding storage more easily than traditional partitions.

2. Advantages

- **Ease of extension:** add space without reformatting or migrating data.
- **Abstracts** underlying physical disks.
- Logical volumes appear in /dev/VG_NAME/LV_NAME.

3. Basic Workflow (High-level)

- (a) Create or identify a **partition** (or entire disk) as a PV (`pvcreate /dev/sdaX`).
- (b) Combine PVs into a **Volume Group** (`vgcreate MYVG /dev/sdaX`).
- (c) Create a **Logical Volume** (`lvcreate -L 20G -n MYSERVICELV MYVG`).
- (d) Format LV with a filesystem (`mkfs.ext4 /dev/MYVG/MYSERVICELV`).
- (e) Mount where desired (/etc/fstab entry or `mount` command).

Workbook Exercises

1. Plan a Basic Partition Scheme

- Imagine you have a 500 GB disk for a personal workstation.
- Sketch out your proposed partition table: `/boot` (300 MB), root (`/`), `/home`, `/var`, and swap.
- Consider sizes for each partition and justify your choices.

2. Identify ESP/BIOS Partitions

- On a UEFI-based system, locate and identify the **EFI System Partition** (`/boot/efi`).
- Check partition type using `gdisk -l /dev/sda` or `fdisk -l /dev/sda`.
- Verify its filesystem (FAT-based) with `lsblk -f` or `blkid`.

3. Decide on Swap Size

- If your system has 8 GB of RAM, use Red Hat's guidelines to propose a recommended swap size.
- If planning hibernation, recalculate.

4. Mount Points

- Create a directory `/mnt/testmount`.
- Using an existing spare partition (or loopback device), manually mount it on `/mnt/testmount`.
- Verify it is mounted with `mount | grep /mnt/testmount`.

5. LVM Planning

- Using a virtual environment with two disks, plan an LVM layout:
 - (a) Convert one partition from each disk into PVs.
 - (b) Create a Volume Group that spans both.
 - (c) Create one or more Logical Volumes for `/data`.
- Write down how you will format and mount `/data`.

6. Storage Scenarios

- You run out of disk space on `/home`. What steps can you take with LVM to add more space?
- If `/var` was not separated and you frequently run out of space due to logs, how might you redesign?

Summary

- **Partitions** define logical divisions of a disk, while **filesystems** define how data is stored.
- Strategic partitioning improves **stability, security, and maintenance** (e.g., `/boot`, `/home`, `/var` separate).
- **UEFI** systems require an **EFI System Partition (ESP)**; BIOS systems may benefit from a separate `/boot`.
- Adequate **swap** is essential; guidelines depend on RAM, system usage, and whether hibernation is used.
- **LVM** adds flexibility for resizing and pooling storage among multiple physical disks.

Multiple-Choice Questions for 102.1

1. Which statement best describes the purpose of a **partition table** on a disk?
 - A) It is the directory on the filesystem that contains user data
 - B) It is the bootloader used to start the operating system
 - C) It contains information about the sectors and types of partitions on the disk
 - D) It is the tool used to create logical volumes
2. On most Linux distributions, **removable media** (e.g., USB drives, memory cards) are:
 - A) Automatically mounted under `/media/USER/LABEL`
 - B) Expected to be manually mounted under `/opt`
 - C) Required to be unmounted only after a reboot
 - D) Limited to read-only access by default
3. What is one **benefit** of creating a dedicated `/boot` partition?
 - A) It automatically encrypts the disk to improve security
 - B) It merges multiple storage devices into a single volume
 - C) It allows `/home` to remain untouched during upgrades
 - D) It ensures the system can still boot if the root filesystem is corrupted
4. Which of the following is a **directory** that frequently benefits from being put on a separate partition, due to potential growth of log files and database data?
 - A) `/bin`
 - B) `/var`
 - C) `/root`
 - D) `/tmp`
5. The **EFI System Partition (ESP)** on a UEFI-based system is typically:
 - A) Formatted with an ext4 filesystem
 - B) Formatted with a FAT-based filesystem
 - C) Placed at the end of the disk to maximize disk space
 - D) Labeled as `/swap` in the `/etc/fstab` file
6. What is the primary **purpose** of the **swap partition**?
 - A) To store user home directories
 - B) To store kernel bootloader files for GRUB
 - C) To hold system logs and database files
 - D) To provide virtual memory (swap out pages from RAM)
7. Which of the following is **NOT** a reason to create a separate `/home` partition?
 - A) To prevent boot issues on legacy BIOS systems
 - B) To simplify system reinstallation while keeping user data
 - C) To allow for different filesystem choices for user data
 - D) To avoid overwriting user data during an OS upgrade

8. A **mount point** is best described as:
- A) A command used to set the filesystem read-only
 - B) A method to copy data from one partition to another
 - C) A directory where a filesystem is attached to the directory tree
 - D) A device driver for SATA disks
9. Which directory commonly holds the **Apache Web Server** data by default?
- A) `/home/apache`
 - B) `/var/www/html`
 - C) `/srv/httpd`
 - D) `/apache/www`
10. Under **Logical Volume Management (LVM)**, which statement is correct about **Volume Groups (VGs)**?
- A) VGs cannot be reduced in size after creation
 - B) VGs are used only for encrypting partitions
 - C) VGs aggregate multiple physical volumes into one large pool of storage
 - D) VGs must reside on a separate `/vg` partition
11. Which of the following directories is typically **not** located under `/home` on a Linux system?
- A) `/root` (the home directory for the root user)
 - B) `/john` (a normal user's home directory)
 - C) `/jack` (a normal user's home directory)
 - D) `/carol` (a normal user's home directory)
12. Which **bootloader** is most commonly used on modern Linux systems for loading the operating system?
- A) `syslinux`
 - B) `LILO`
 - C) `rEFIt`
 - D) `GRUB2`
13. The EFI System Partition (ESP) is generally **mounted** under which directory on a Linux system?
- A) `/boot`
 - B) `/ESP`
 - C) `/boot/efi`
 - D) `/usr/local/esp`
14. Which directory contains “variable data” and is known to grow due to logs and other services?
- A) `/etc`
 - B) `/var`
 - C) `/mnt`
 - D) `/bin`

15. Which of the following statements correctly describes **Physical Volumes (PVs)** in LVM?
- A) They are the mount points for the swap partition
 - B) They are user directories that can be encrypted
 - C) They are used only for backing up the master boot record
 - D) They are block devices (partitions, disks) that become part of a volume group
16. Why might a system administrator place `/home` and `/var` on **separate physical disks**?
- A) To reduce the impact of one disk's failure on another
 - B) To comply with GPT partition ID requirements
 - C) To ensure that `/boot` remains fully accessible
 - D) To use a unique journaling filesystem only on `/home`
17. **Logical Volumes (LVs)** in an LVM setup appear to the operating system as:
- A) Symbolic links pointing to `/boot`
 - B) BIOS-level CHS addresses
 - C) A directory tree with unlimited capacity
 - D) Normal block devices (e.g., `/dev/VGNAME/LVNAME`)
18. If you need to **manually** mount an additional filesystem that is **not** removable media, the best practice is typically to mount it under which directory?
- A) `/var`
 - B) `/home`
 - C) `/mnt`
 - D) `/opt/extra`
19. According to common recommendations, placing system logs and database files under a dedicated `/var` partition helps:
- A) Prevent swap space from being used
 - B) Protect the root filesystem if `/var` fills up
 - C) Force all logs to be read-only
 - D) Make the system boot faster
20. Which of the following describes a **swap file**?
- A) A regular file residing on an existing filesystem, configured to provide additional swap space
 - B) A partition created at the beginning of the disk and labeled as `0xEF`
 - C) A mount point used only for kernel boot files
 - D) A special utility run by the BIOS to load the operating system

Fill-in-the-Blank Questions for 102.1

1. The folder where user data files and preferences are typically stored is _____.
2. The BIOS limitation of 1024 cylinders initially required a dedicated _____ partition to be placed at the beginning of the disk for bootloader files.
3. A _____ is the logical subdivision of a physical disk, storing data separately from other subdivisions on the same disk.
4. On systems with UEFI firmware, the _____ partition stores boot loader and kernel files in a FAT-based filesystem.
5. The command that prepares a partition for use as swap space is _____.
6. The directory _____ is used for “variable data” such as logs, database files, caches, and spool directories.
7. A filesystem must be “attached” to the system via a process called _____ before you can access its contents.
8. In LVM, multiple Physical Volumes can be combined to form a larger _____.
9. A _____ is a file that can serve as additional swap space without requiring a dedicated swap partition.
10. Traditional partitioning can be inflexible when allocating disk space. One way to overcome this limitation is by using _____.

102.2 Install a Boot Manager

Reference to LPI Objectives:

- **LPIC-1 v5, Exam 102, Objective 102.2**
- **Weight:** 2

Key Knowledge Areas

- Providing alternate or backup boot options.
- Installing and configuring boot loaders (GRUB Legacy, GRUB 2).
- Performing basic GRUB 2 configuration changes.
- Interacting with the boot loader at startup.

Important Files, Terms, and Utilities

- **MBR** (Master Boot Record)
- `/boot` directory or partition (often containing GRUB files, kernels, `initrd`)
- `menu.lst`, `grub.cfg`, and `grub.conf`
- `grub-install`, `grub-mkconfig` (or `update-grub`)
- **chainloading** (for non-Linux OS, e.g., Windows)

Lesson Overview

A system's boot loader is the first software executed when a machine powers on. On Linux, this is typically **GRUB** (either Legacy or GRUB 2). GRUB loads the kernel and passes control to it. Having a working knowledge of installing and configuring GRUB is essential for system recovery and customizing boot behavior.

1. GRUB Legacy vs. GRUB 2

1. GRUB Legacy

- Older, no longer actively developed (last release 0.97 from 2005).
- Configuration file: `/boot/grub/menu.lst` (sometimes `grub.conf`).
- Simpler configuration, fewer features.

2. GRUB 2

- Complete rewrite, default on most modern distributions.
- Configuration files:
 - `/etc/default/grub` (main user-editable file)
 - `/boot/grub/grub.cfg` (auto-generated, do not edit manually)
- More modular, supports more filesystems, better scripting, theming, etc.

2. Bootloader Locations and Partitions

1. MBR Partition Scheme

- Legacy layout where the first 512 bytes of the disk contain the MBR (boot code + partition table).
- Boot loader code often placed in MBR + post-MBR gap (32 KB) before the first partition.

2. GPT (GUID Partition Table)

- Modern layout for large disks (>2 TB).
- Requires a **BIOS boot partition** (for BIOS systems) or uses **EFI System Partition (ESP)** on UEFI systems.

3. /boot Partition

- Often first partition on the disk, historically to avoid BIOS cylinder limits.
- Typically ~300 MB in size, containing kernel images (vmlinuz), initrd, GRUB files, etc.
- Helps ensure boot files remain accessible (especially if / uses encryption or an unsupported filesystem).

3. Installing GRUB 2

1. grub-install

- Installs GRUB 2 boot code onto a disk (e.g., /dev/sda) or EFI partition.
- Syntax examples:

```
grub-install --boot-directory=/boot /dev/sda
# or for a dedicated /boot partition mounted at /mnt/tmp:
grub-install --boot-directory=/mnt/tmp /dev/sda
```

- Must point to the **disk** (e.g., /dev/sda), not a specific partition (unless UEFI requires otherwise).

2. Configuration

- /etc/default/grub – main file for user edits. Common parameters:
 - GRUB_DEFAULT: default menu entry (0-based index, or saved).
 - GRUB_SAVEDEFAULT: if set to true with GRUB_DEFAULT=saved, boots the last-chosen entry.
 - GRUB_TIMEOUT: seconds before auto-booting the default. -1 waits indefinitely.
 - GRUB_CMDLINE_LINUX: universal kernel parameters (e.g., quiet, splash).
- grub-mkconfig (or update-grub) generates /boot/grub/grub.cfg from the above file and scripts in /etc/grub.d/:

```
grub-mkconfig -o /boot/grub/grub.cfg
# or:
update-grub
```

3. Menu Entries

- Auto-discovered for Linux, other OS, or kernels.
- Custom entries often added to /etc/grub.d/40_custom, then re-run update-grub.

4. Interacting with GRUB 2

- **Boot Menu:** highlight an entry with arrow keys, press **e** to edit before booting.
- **Shell Mode:** press **c** to access **grub>** shell.
- **Rescue Shell** (**grub rescue>**): minimal commands, must **insmod** needed modules (e.g., **normal**, **linux**) if GRUB config is broken.

4. GRUB Legacy (for Reference)

1. Installing

- Via **grub-install /dev/sda** (must specify the disk, not a partition).
- From GRUB Legacy shell:

```
grub> root (hd0,0)
grub> setup (hd0)
```

- **root (hd0,0)** means the first disk (**hd0**), first partition (**0**), if **/boot** is there.

2. Configuration: /boot/grub/menu.lst

- Example menu entry:

```
title My Linux
root (hd0,0)
kernel /vmlinuz root=/dev/hda1
initrd /initrd.img
```

- **chainloader +1** used to boot Windows or other OS by loading their own bootloader code.

5. Booting from the GRUB Shell

1. Identify Partitions:

```
grub> ls
(hd0) (hd0,msdos1)
```

2. Set root (example):

```
grub> set root=(hd0,msdos1)
```

3. Load Kernel & Initrd (GRUB 2 example):

```
grub> linux /vmlinuz root=/dev/sda1
grub> initrd /initrd.img
grub> boot
```

- #### 4. Rescue Mode:
- need to **set prefix=(hd0,msdos1)/boot/grub** and **insmod normal**, **insmod linux** before proceeding.

Workbook Exercises

1. Identify Boot Device

- Run `fdisk -l /dev/sda` or `lsblk -f` and find your **boot partition**.
- Note which partition is marked as bootable.

2. Install GRUB 2

- Mount your `/boot` (or boot partition) if needed at `/mnt/tmp`.
- Run:

```
grub-install --boot-directory=/mnt/tmp /dev/sda
```

- Verify GRUB files are placed in `/mnt/tmp/boot/grub`.

3. Customize GRUB Timeout

- Edit `/etc/default/grub` and set `GRUB_TIMEOUT=5`.
- Run `update-grub` (or `grub-mkconfig -o /boot/grub/grub.cfg`).
- Reboot and confirm you see the menu for 5 seconds.

4. Add a Kernel Parameter

- In `/etc/default/grub`, add an option to `GRUB_CMDLINE_LINUX="quiet splash"`.
- Update GRUB and reboot. Check `/proc/cmdline` to confirm the new parameter.

5. Practice Chainloading

- If you have a Windows install at `(hd0,2)`, add a custom entry in `/etc/grub.d/40_custom` (or in GRUB Legacy's `menu.lst`):

```
menuentry "Windows" {  
    set root=(hd0,2)  
    chainloader +1  
}
```

- Update GRUB and verify you can boot into Windows.

6. GRUB Rescue Simulation

- Temporarily rename `/boot/grub/grub.cfg` to break GRUB.
- Reboot to force the `grub rescue>` prompt.
- Use `ls`, `set prefix=`, `insmod normal`, etc., to recover manually.
- Restore `grub.cfg` after testing.

Summary

- **GRUB 2** is the modern bootloader on most Linux systems, replacing **GRUB Legacy**.
- `grub-install` places boot code on the MBR (BIOS) or ESP (UEFI).
- `/etc/default/grub` and scripts in `/etc/grub.d/` define the GRUB 2 menu.
- Use `update-grub` (or `grub-mkconfig`) to regenerate `/boot/grub/grub.cfg`.
- In emergencies, the **GRUB shell** (normal or rescue) can manually load kernel and `initrd` to boot.

Multiple-Choice Questions for 102.2

1. Which of the following statements correctly describes the purpose of the Master Boot Record (MBR)?
 - A) It is a legacy BIOS setting used to store GPU firmware information.
 - B) It is a reserved partition for the `/boot` directory on GPT disks.
 - C) It contains a high-level overview of the Linux file system hierarchy.
 - D) It contains a partition table and minimal bootstrap code used to start the boot process.
2. Which command is commonly used to generate a new GRUB 2 configuration file?
 - A) `grub-init /dev/sda`
 - B) `update-grub` (or `grub-mkconfig -o /boot/grub/grub.cfg`)
 - C) `mkconfig -g`
 - D) `grub-legacy -o /boot/grub/menu.lst`
3. In GRUB 2, which file is recommended for manual editing to permanently change bootloader settings?
 - A) `/boot/grub/menu.lst`
 - B) `/etc/grub.d/custom.cfg`
 - C) `/etc/default/grub`
 - D) `/boot/grub/grub.cfg`
4. Which directive in `/etc/default/grub` allows the last chosen boot option to become the default on the next reboot?
 - A) `GRUB_SAVEDEFAULT=`
 - B) `GRUB_ENABLE_CRYPTODISK=`
 - C) `GRUB_TIMEOUT=`
 - D) `GRUB_CMDLINE_LINUX=`
5. What is the main purpose of an initial RAM disk (initrd)?
 - A) It is another name for the GRUB 2 configuration file.
 - B) It is a dedicated swap partition to store kernel crash dumps.
 - C) It compresses the kernel to reduce its size in `/boot`.
 - D) It provides a minimal root filesystem so the kernel can mount the real root filesystem.
6. Which GRUB 2 command is used in a manual (interactive) session to load the Linux kernel?
 - A) `linux`
 - B) `initrd`
 - C) `chainloader`
 - D) `set root=`
7. Which of the following is **not** true regarding GPT?
 - A) It is part of the UEFI specification.
 - B) It is incompatible with BIOS-based systems.
 - C) It supports disks larger than 2 TB.
 - D) It uses GUIDs to identify partitions.

8. When chainloading Windows from GRUB Legacy or GRUB 2, which command loads the Windows bootloader from the first sector of its partition?
- A) `initrd /windows.img`
 - B) `search -set=root -fs-uuid <uuid>`
 - C) `chainloader +1`
 - D) `module /boot/grub/i386-pc/chain.mod`
9. In GRUB Legacy, which file typically stores the boot menu configuration?
- A) `/boot/grub/menu.lst`
 - B) `/boot/grub/grub.cfg`
 - C) `/etc/default/grub`
 - D) `/etc/grub.d/menu.cfg`
10. You are using a Live CD to rescue a system. You have mounted the dedicated boot partition at `/mnt/bootpartition`. Which command correctly installs GRUB 2 to the MBR on `/dev/sda`?
- A) `grub-install -root-directory=/mnt/bootpartition /dev/sda`
 - B) `update-grub -d /dev/sda /mnt/bootpartition`
 - C) `grub-mkconfig -o /dev/sda`
 - D) `grub-install -boot-directory=/mnt/bootpartition /dev/sda`
11. In the context of GRUB 2, which file is **not** recommended for direct editing?
- A) `/etc/grub.d/40_custom`
 - B) `/boot/grub/grub.cfg`
 - C) `/boot/grub/fonts/unicode.pf2`
 - D) `/etc/default/grub`
12. Which of the following describes a scenario where a separate `/boot` partition is particularly useful?
- A) When you want to mount `/boot` as a swap partition.
 - B) When you plan to store the entire root filesystem on MBR with no separate partitions.
 - C) When you want all boot files in `/bin/boot` for convenience.
 - D) When you use encryption or compression methods not supported by the bootloader.
13. Which GRUB 2 command can help you identify partitions and disks from the GRUB shell?
- A) `ls`
 - B) `disklist`
 - C) `list-devices`
 - D) `find /boot/grub/stage1`
14. What is the typical name of the Linux kernel file found in `/boot`?
- A) `System.map-VERSION`
 - B) `initrd.img-VERSION`
 - C) `vmlinuz-VERSION`
 - D) `config-VERSION`

15. Which of the following lines in a GRUB 2 `menuentry` block is responsible for loading the initial RAM disk?
- A) `chainloader +1`
 - B) `initrd /initrd.img`
 - C) `set root=(hd0,1)`
 - D) `linux /vmlinuz root=/dev/sda1 ro`
16. When using GRUB Legacy from a bootable rescue image, which command installs GRUB to the MBR **after** setting the correct root device?
- A) `update-grub (hd0)`
 - B) `mkconfig -o (hd0)`
 - C) `install (hd0,msdos1)`
 - D) `setup (hd0)`
17. Which line in `/etc/default/grub` disables the boot menu countdown and waits indefinitely for user input?
- A) `GRUB_DEFAULT=saved`
 - B) `GRUB_ENABLE_CRYPTODISK=y`
 - C) `GRUB_TIMEOUT=-1`
 - D) `GRUB_CMDLINE_LINUX_DEFAULT=""`
18. Which component of the Linux filesystem organizes kernel symbols (variables, functions) with their memory addresses for debugging?
- A) `vmlinuz-VERSION`
 - B) `config-VERSION`
 - C) `initrd-VERSION`
 - D) `System.map-VERSION`
19. Which GRUB 2 command would you use within the shell to specify the disk or partition containing the root filesystem?
- A) `chainloader +1`
 - B) `set root=(hd0,1)`
 - C) `root (hd0,0)`
 - D) `initrd /initrd.img`
20. If a misconfiguration causes GRUB 2 to drop into a rescue shell (`grub rescue>`), which modules often need to be loaded manually to regain the normal GRUB shell functionality?
- A) `normal` and `linux`
 - B) `fs_uuid` and `configfile`
 - C) `chainloader` and `search`
 - D) `ls` and `initrd`

Fill-in-the-Blank Questions for 102.2

1. When a computer is powered on, the first software component to run is the _____.
2. On a BIOS system using MBR partitioning, the very first 512-byte sector of the disk is called the _____.
3. The Linux kernel is typically stored in a compressed file named _____-VERSION in the '/boot' directory.
4. The minimal root filesystem required to load the real root filesystem is contained in the _____ file.
5. The file _____-VERSION contains a look-up table used for debugging kernel panics.
6. In GRUB 2, manual edits to the bootloader settings should be done in _____, rather than directly editing '/boot/grub/grub.cfg'.
7. The _____ command scans available disks and partitions to build a list of operating systems for GRUB 2.
8. A dedicated _____ partition is often used to store all files needed for the boot process separately from the root filesystem.
9. GRUB Legacy stores its main configuration in the file _____.
10. A technique known as _____ is used by GRUB to load other operating systems' bootloaders (e.g., Windows) from their first sector.

102.3 Manage Shared Libraries

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 102.3
- Weight: 1

Key Knowledge Areas

- Identifying shared libraries.
- Understanding typical locations of system libraries.
- Loading and configuring shared libraries at runtime.

Important Commands and Files

- `ldd` – shows shared library dependencies.
- `ldconfig` – updates library cache and symbolic links.
- `/etc/ld.so.conf` and `/etc/ld.so.conf.d/` – configuration for library paths.
- `LD_LIBRARY_PATH` – environment variable to temporarily add library paths.

Lesson Overview

Shared libraries (`.so` files) allow multiple executables to reuse common code, reducing memory usage and disk size. Administrators must know how to locate libraries, configure library paths, and troubleshoot missing dependencies.

1. Concept of Shared Libraries

1. Static Libraries (`.a`)

- Code is **copied** into an executable at compile/link time.
- Larger file size; no external dependencies at runtime.

2. Dynamic (Shared) Libraries (`.so`)

- Code is **not** copied into the executable.
- Must be present at runtime.
- More efficient memory usage (shared among processes).

2. Typical Library Naming and Locations

1. Shared Library Naming

- Usually `libXYZ.so.major.minor`.
- Example: `libc.so.6` → `libc-2.24.so`.
- Symbolic links often point from a generic name to a versioned file.

2. Locations

- `/lib`, `/lib64`, `/usr/lib`, `/usr/local/lib`, and architecture-specific directories like `/lib/x86_64-linux-gnu`.

3. Dynamic Linker

- `ld.so` or `ld-linux.so` handles runtime loading of `.so` files.

3. Configuring Library Paths

1. `/etc/ld.so.conf` and `/etc/ld.so.conf.d/*.conf`

- Lists directories to be searched by the dynamic linker.
- Usually references sub-files in `/etc/ld.so.conf.d/`.

2. `ldconfig`

- Reads config files, creates symbolic links, updates `/etc/ld.so.cache`.
- Run after installing new libraries or editing config.
- Common options:
 - `-v`: verbose mode.
 - `-p`: print current cache contents.

3. `LD_LIBRARY_PATH`

- Environment variable to **temporarily** add library directories.
- Example:

```
export LD_LIBRARY_PATH=/usr/local/mylib
```

- Similar to `PATH`, but for shared libraries.

4. Checking Dependencies with `ldd`

1. `ldd /path/to/executable`

- Shows which `.so` files an executable needs and where they're loaded from.
- Example:

```
ldd /usr/bin/git
```

2. `ldd /path/to/library.so`

- Also works on `.so` files themselves.

3. `-u` (unused)

- Shows libraries listed as dependencies but not actually used.

Workbook Exercises

1. List All Shared Libraries

- Inspect `/lib`, `/usr/lib`, and `/usr/local/lib`.
- Observe versioned vs. unversioned symbolic links (e.g., `libm.so.6` → `libm-2.31.so`).

2. Update Library Cache

- Create a directory `/opt/customlib` and put a dummy `.so` file (or symbolic link) there.
- Add `/opt/customlib` to `/etc/ld.so.conf.d/custom.conf`.
- Run `sudo ldconfig -v` and verify the new library is recognized (`ldconfig -p | grep customlib`).

3. Use LD_LIBRARY_PATH

- Temporarily set `LD_LIBRARY_PATH=/opt/customlib`.
- Run an executable depending on the custom library.
- Confirm it finds the library without editing `/etc/ld.so.conf`.

4. Check Dependencies

- Use `ldd /bin/ls` to see the libraries it requires.
- Use `ldd` on a custom binary if available.
- (Optional) Try the `-u` option to see if any direct dependencies are unused.

5. Investigate a Broken App

- Intentionally remove or rename a `.so` file that an application needs (e.g., `mv libXYZ.so.1 libXYZ.so.1.bak`).
- Attempt to run the application and note the error.
- Restore the file or fix the library path to resolve the error.

Summary

- Linux uses **shared libraries** (`.so`) to avoid embedding common code in each executable, saving resources.
- The **dynamic linker** finds libraries via paths defined in `/etc/ld.so.conf` (and sub-files in `ld.so.conf.d`) and updates a cache with `ldconfig`.
- `LD_LIBRARY_PATH` can override these directories temporarily for testing or specialized setups.
- Tools like `ldd` help identify which libraries an executable (or another library) needs, aiding in troubleshooting.

Multiple-Choice Questions for 102.3

1. What is the purpose of having a **dynamic** library as opposed to a **static** one?
 - A) It embeds all external library code into the final executable.
 - B) It decreases the chance of version conflicts between libraries.
 - C) It simplifies the debugging process by combining all symbols in one file.
 - D) It allows multiple programs to share the same library file in memory at runtime.
2. Which directory is **commonly** used by Linux systems to store 64-bit libraries?
 - A) `/etc/x86_64-linux-gnu`
 - B) `/lib64`
 - C) `/bin64`
 - D) `/usr/local/opt/lib64`
3. When you install a new library in a custom location, which **environment variable** can you set to let the system know about the additional library path?
 - A) `LIB_EXTRA_PATH`
 - B) `LD_DEBUG_PATH`
 - C) `LD_LIBRARY_PATH`
 - D) `PATHLIB`
4. After adding a new `.conf` file under `/etc/ld.so.conf.d/`, which **command** should you usually run to ensure the changes take effect?
 - A) `sudo ldconfig`
 - B) `echo $LD_LIBRARY_PATH`
 - C) `ldd -u /etc/ld.so.conf`
 - D) `touch /etc/ld.so.cache`
5. A **static library** is characterized by:
 - A) Having no effect on program size.
 - B) Being dynamically loaded at runtime.
 - C) Residing exclusively under `/usr/local/lib`.
 - D) Being fully integrated into the binary during link time.
6. Which file typically holds **symbolic links** to the actual versioned shared library files and speeds up library lookups?
 - A) `/etc/bash.bashrc`
 - B) `/etc/ld.so.conf.d/`
 - C) `/etc/ld.so.cache`
 - D) `/etc/profile`
7. What is the **main** function of the command `ldd /usr/bin/git`?
 - A) It loads any missing libraries into memory for the executable.
 - B) It displays which shared libraries and memory addresses the program will use.

- C) It modifies `/etc/ld.so.conf` to remove outdated references.
 - D) It compiles the binary from source code.
8. Which statement is **true** regarding the file `/etc/ld.so.conf` on many modern Linux distributions?
- A) It directly lists all directories containing library files without any inclusion mechanisms.
 - B) It typically has an `include` line that references additional `.conf` files in `/etc/ld.so.conf.d/`.
 - C) It is unrelated to dynamic library configuration.
 - D) It must only contain symbolic links, not absolute paths.
9. Which command option would show **unused** direct library dependencies for an executable?
- A) `ldconfig -v`
 - B) `ldconfig -p`
 - C) `ldd -verbose`
 - D) `ldd -u`
10. The **logical name** given to a shared library (like `libm.so.6`) is called the:
- A) Full path reference.
 - B) Statically linked file name.
 - C) Base library handle.
 - D) Soname.
11. Which directory is **not** typically part of the default library search path?
- A) `/opt/libraries/`
 - B) `/lib/`
 - C) `/usr/lib/`
 - D) `/usr/local/lib/`
12. In a typical modern Linux system, if you run `ldconfig -p`, what does the `-p` option do?
- A) It permanently deletes old cache entries from `/etc/ld.so.cache`.
 - B) It lists the directories and candidate libraries in the **current** cache.
 - C) It prints out any undefined symbols in the loaded libraries.
 - D) It prompts the user for additional library paths.
13. During the build process, an executable may mark certain libraries as **NEEDED** even if they aren't used at runtime. This often happens because of:
- A) Accidental corruption in the library file.
 - B) Missing environment variables in the developer's system.
 - C) Linker flags that reference multiple libraries.
 - D) Repeated calls to `ldconfig`.
14. Which of the following **best** describes what `ld-linux.so` (or `ld.so`) does?
- A) It locates, loads, and links the needed shared libraries at runtime.
 - B) It compiles source code into object files for linking.
 - C) It performs static linking of libraries during application build time.

- D) It generates symbolic links in `/etc/ld.so.conf.d/` automatically.
15. What is a **key advantage** of using shared libraries on a system with many processes?
- A) Each application runs in its own memory space without any shared code.
 - B) You never need to update libraries since they are compiled into each executable.
 - C) They can be loaded in user space without root privileges.
 - D) Only one copy of the library is loaded into memory and used by multiple processes.
16. If a program is **statically** linked against a library, then:
- A) You do **not** need the library on the system at runtime for the program to function.
 - B) You must always place a copy of the library in `/lib/x86_64-linux-gnu`.
 - C) The linker will load the library into memory each time it's called.
 - D) There must be an exact match between library version and kernel version.
17. What does the command `ldconfig -v` do **in addition** to updating the library cache?
- A) It permanently locks the library version in place.
 - B) It displays verbose details about the libraries found, links created, and directories scanned.
 - C) It only updates symbolic links, but not the cache.
 - D) It filters out symbolic links that are unused or broken.
18. Which of these files would you **most likely** edit or create to specify a custom library directory (e.g., `/opt/mylib`)?
- A) `/etc/ld.so.conf.d/custom.conf`
 - B) `/usr/local/lib/custom.ld.so.conf`
 - C) `/var/run/ldconfig/ld.so.conf`
 - D) `/etc/bash.bashrc`
19. `LD_LIBRARY_PATH` is similar to `PATH` in the sense that:
- A) Both are used solely for system administrators to track dependencies.
 - B) Both contain hashed references to libraries that get pre-loaded.
 - C) Both are environment variables that list directories to search, but for different purposes (executables vs. libraries).
 - D) Neither can be exported in a user shell.
20. Which statement accurately **describes** the role of symbolic links like `libpthread.so.0 -> libpthread-2.31.so`?
- A) They are stored in `/etc/ld.so.cache` for quick loading of kernel modules.
 - B) They connect older kernel releases to new libraries.
 - C) They enable the system to reference a library by its **soname** while pointing to the actual versioned file.
 - D) They are used exclusively for statically linking code.

Fill-in-the-Blank Questions for 102.3

1. The utility used to check the **shared libraries** required by a specific program is _____.
2. The **environment variable** that can be set to add or override library paths at runtime is _____.
3. On many Linux systems, the file ‘/etc/ld.so.conf’ includes a line pointing to configuration files in the _____ directory.
4. When building an application, if the library code is **copied** into the executable at link time, we say the program is using _____ linking.
5. If we install a new library in ‘/usr/local/mylib’ and do **not** want to modify system-wide configurations, we can temporarily set _____=/usr/local/mylib.
6. A library name like ‘libfuse.so.2’ is often a symbolic link pointing to a **versioned** file such as ‘libfuse.so.2.9.7’; this more general filename is often called the _____.
7. The command _____ -p lists the directories and candidate libraries stored in the current library cache.
8. We typically run _____ after modifying or adding a new ‘.conf’ file under ‘/etc/ld.so.conf.d/’ to update the library cache.
9. The file ‘/etc/ld.so.cache’ is used to **speed up** the lookup of _____.
10. A static library file typically ends in the extension _____.

102.4 Use Debian Package Management

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 102.4
- Weight: 3

Key Knowledge Areas

- Installing, upgrading, and uninstalling Debian binary packages.
- Finding packages containing specific files or libraries (installed or not).
- Obtaining package information (version, contents, dependencies, integrity, status).
- Awareness of `apt` and related commands.

Important Files, Terms, and Utilities

- `/etc/apt/sources.list` (and `/etc/apt/sources.list.d/`) – repository lists
- `dpkg` – the low-level Debian package tool
- `dpkg-reconfigure` – re-run configuration scripts for installed packages
- `apt-get` (or `apt`) – higher-level tool for package handling
- `apt-cache` (or `apt search/show`) – searching in and displaying details about packages

Lesson Overview

In Debian-based Linux distributions (including Ubuntu and others), packages come in `.deb` format. The `dpkg` utility can install and remove `.deb` files, but does not automatically handle dependencies. For that, tools like `apt-get` (or the more modern `apt`) help resolve dependencies, perform upgrades, and search repositories.

1. Using dpkg (Debian Package Tool)

1. Install a .deb Package

```
sudo dpkg -i PACKAGE_FILE.deb
```

- Installs or upgrades the package if an older version is detected.
- Fails if dependencies are missing.

2. Remove a Package

```
sudo dpkg -r PACKAGE_NAME
```

- Leaves config files behind.
- `-P` (purge) removes config files as well.

3. Listing Installed Packages

```
dpkg --get-selections
```

- Outputs every installed package.

4. Package Contents

```
dpkg -L PACKAGE_NAME
```

- Lists all files installed by that package.

5. Which Package Owns a File?

```
dpkg-query -S /path/to/file
```

- Shows the package name that installed the file.

6. Inspect a .deb File

```
dpkg -I PACKAGE_FILE.deb
```

- Prints metadata (dependencies, maintainer, version, etc.).

7. Reconfigure Installed Packages

```
sudo dpkg-reconfigure PACKAGE_NAME
```

- Reruns post-install scripts, can fix or reset configuration.

Note. *Using -force overrides safety checks but risks breaking the system.*

2. apt-get or apt for Dependency Handling

1. Updating Package Index

```
sudo apt-get update
```

- Fetches latest package info from repositories.

2. Installing Packages

```
sudo apt-get install PACKAGE_NAME
```

- Resolves and installs dependencies automatically.

3. Removing Packages

```
sudo apt-get remove PACKAGE_NAME
```

- Leaves config files; use **-purge** to remove them.

4. Fixing Broken Dependencies

```
sudo apt-get install -f
```

- Attempts to fix unmet dependencies.

5. Upgrading Packages

```
sudo apt-get upgrade
```

- Upgrades all installed packages to latest versions in the repositories.
- Run `apt-get update` beforehand to refresh index.

6. Cleaning Cache

```
sudo apt-get clean
```

- Clears `.deb` files in `/var/cache/apt/archives` to free space.

3. Searching for Packages

1. `apt-cache search` (or `apt search`)

```
apt-cache search KEYWORD
```

- Lists packages whose name/description match `KEYWORD`.

2. `apt-cache show` (or `apt show`)

```
apt-cache show PACKAGE_NAME
```

- Provides detailed info (dependencies, version, maintainers, etc.).

3. `apt-file`

- May need `sudo apt-get install apt-file` first.
- Then `sudo apt-file update` to sync its own index.

- **Listing contents of a package:**

```
apt-file list PACKAGE_NAME
```

- **Finding which package provides a file:**

```
apt-file search FILENAME
```

- Unlike `dpkg-query -S`, works for **uninstalled** packages as well.

4. Configuring Repositories (`sources.list`)

- `/etc/apt/sources.list` or `/etc/apt/sources.list.d/*.list`
- Lines typically look like:

```
deb http://deb.debian.org/debian buster main contrib non-free
deb-src http://deb.debian.org/debian buster main contrib non-free
```

- **Archive types:** `deb` (binary packages) or `deb-src` (source).
- **Distributions:** e.g., `buster`, `stable`, `testing`, or codenames for Ubuntu.
- **Components:** `main`, `contrib`, `non-free`, `universe`, `multiverse`, etc.

After editing `sources`, run:

```
sudo apt-get update
```

Workbook Exercises

1. Install a .deb File with dpkg

- Download a .deb (e.g., from a website).
- Try to install:

```
sudo dpkg -i package.deb
```

- If dependencies fail, note the error message. Then fix them using either `dpkg` again or `apt-get install -f`.

2. Purge an Installed Package

- Select a small package to remove:

```
sudo apt-get remove --purge PACKAGE_NAME
```

- Confirm config files are removed by checking `dpkg -L PACKAGE_NAME` (should say not installed).

3. Reconfigure a Package

- Example:

```
sudo dpkg-reconfigure tzdata
```

- Verify you can reset or change the time zone.

4. Search and Install with apt

- Run:

```
apt-cache search KEYWORD
```

- Pick a package from the results and install it with `apt-get install`.
- Check the installed files with:

```
dpkg -L PACKAGE_NAME
```

5. Repository Configuration

- Inspect `/etc/apt/sources.list` and `/etc/apt/sources.list.d/`.
- Optionally add a new repository line (e.g., a backports line).
- Run `sudo apt-get update` and check if new packages are available.

6. List a Package's Contents

- Install `apt-file` if needed:

```
sudo apt-get install apt-file  
sudo apt-file update
```

- List contents for a known package:

```
apt-file list PACKAGE_NAME
```

- Search for a file across all packages:

```
apt-file search /bin/somefile
```

Summary

- `dpkg` handles `.deb` packages at a low level but does **not** resolve dependencies automatically.
- `apt-get`, `apt`, and `apt-cache` provide higher-level features like dependency resolution, searching repositories, and automated upgrades.
- `apt-file` allows searching within packages (even those not installed).
- The `sources.list` (and `.list` files in `/etc/apt/sources.list.d`) specify where `apt` should look for packages.
- Knowing these tools is critical for effectively installing, upgrading, or removing software in Debian-based systems, aligning with the LPIC-1 **102.4** objective.

Multiple-Choice Questions for 102.4

1. Which parameter in `dpkg` is used to remove both a package and its configuration files?
 - A) `-r`
 - B) `-I`
 - C) `-S`
 - D) `-P`
2. Which of the following commands updates the local package index using APT?
 - A) `apt-get remove`
 - B) `apt-get install -f`
 - C) `apt-get update`
 - D) `apt-get purge`
3. Which `dpkg` command option allows you to list all files that a package has installed on the system?
 - A) `dpkg -get-selections`
 - B) `dpkg -I`
 - C) `dpkg-reconfigure`
 - D) `dpkg -L`
4. Which command is used to remove a package but keep its configuration files?
 - A) `dpkg -P`
 - B) `apt-get remove`
 - C) `apt-get install -f`
 - D) `apt-get purge`
5. What is the correct `Archive` type that indicates a repository contains ready-to-run packages?
 - A) `deb-src`
 - B) `main`
 - C) `deb`
 - D) `contrib`
6. What is the default location of the local cache where `.deb` files are downloaded before installation?
 - A) `/etc/apt/sources.list`
 - B) `/var/cache/apt/archives`
 - C) `/usr/local/cache/dpkg`
 - D) `/var/dpkg/archives/partial`
7. Which command helps you restore or re-run the initial configuration process of a package?
 - A) `dpkg -get-selections`
 - B) `dpkg -L`
 - C) `dpkg-reconfigure`
 - D) `dpkg -S`

8. Which `dpkg` option can show you which package owns a specific file on the filesystem (e.g., `/usr/bin/example`)?
- A) `dpkg -I`
 - B) `dpkg -L`
 - C) `dpkg -P`
 - D) `dpkg -S`
9. Which of the following statements is true about `apt-get install -f`?
- A) It attempts to fix broken dependencies by installing missing packages.
 - B) It removes all configuration files of broken packages.
 - C) It removes all broken packages from the system.
 - D) It upgrades all packages to the latest version.
10. Which command can be used to search for a package by a keyword in the APT package index?
- A) `apt-get show`
 - B) `apt-cache search`
 - C) `dpkg -L`
 - D) `dpkg-query -S`
11. Which parameter of `dpkg` lists the basic metadata (like version, architecture, dependencies) of a `.deb` package file?
- A) `-I`
 - B) `-r`
 - C) `-P`
 - D) `-L`
12. Which of these lines in `/etc/apt/sources.list` indicates a repository of source packages rather than binary packages?
- A) `deb-src`
 - B) `deb http://repo.example.com stable main`
 - C) `deb /var/cache/apt/archives stable main`
 - D) `deb http://repo.example.com sources main`
13. Which command is used to remove unnecessary `.deb` files in the local cache under `/var/cache/apt/archives`?
- A) `apt-get remove`
 - B) `apt-get purge`
 - C) `apt-get update`
 - D) `apt-get clean`
14. Which `dpkg` parameter performs the same function as `dpkg -r` but leaves configuration files behind?
- A) `-r`
 - B) `-P`
 - C) `-S`
 - D) `-I`

15. Which APT command will remove a package along with its configuration files?
- A) `apt-get remove`
 - B) `apt-get update`
 - C) `apt-get install -f`
 - D) `apt-get purge`
16. When a Debian-based system warns that certain packages are “kept back,” which command would you generally use to upgrade them?
- A) `apt-get dist-upgrade`
 - B) `apt-file search`
 - C) `dpkg -P`
 - D) `dpkg -i`
17. Which Debian repository component includes software that is DFSG-compliant but depends on non-free components?
- A) `main`
 - B) `contrib`
 - C) `multiverse`
 - D) `restricted`
18. Which APT utility focuses on searching for package information and displaying metadata about packages?
- A) `dpkg`
 - B) `apt-file`
 - C) `apt-cache`
 - D) `dpkg-query`
19. Which of the following `apt-get` commands will remove a package but leave the configuration files on the system?
- A) `apt-get purge`
 - B) `apt-get remove`
 - C) `apt-get install -f`
 - D) `apt-get upgrade`
20. Which main Debian repository contains packages that are compliant with the Debian Free Software Guidelines (DFSG)?
- A) `restricted`
 - B) `non-free`
 - C) `main`
 - D) `multiverse`

Fill-in-the-Blank Questions for 102.4

1. To list all **installed packages** on a Debian-based system using `dpkg`, you can run:
`dpkg -get-_____`.
2. The **Advanced Package Tool**, also known as APT, uses repository information from the file:
`/etc/apt/_____.list`.
3. If you have missing dependencies after a failed install, you can attempt to fix them with:
`apt-get install _____`.
4. You can use `dpkg` with the `-I` parameter to get _____ about a `.deb` package file.
5. The package list that APT uses is also known as the APT _____.
6. The parameter `dpkg -L` lets you list the _____ installed by a particular package.
7. Lines beginning with a _____ character in `/etc/apt/sources.list` are ignored because they are comments.
8. The command:
`apt-_____ search p7zip`
is used to search for a package containing the term “p7zip.”
9. To remove all downloaded package files and reclaim disk space, you run:
`apt-get _____`.
10. The configuration files are only completely removed when you use the `dpkg` parameter `-P`, which stands for:
`dpkg -P _____`.

102.5 Use RPM and YUM Package Management

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 102.5
- Weight: 3

Key Knowledge Areas

- Installing, re-installing, upgrading, and removing packages with **rpm**, **YUM**, and **Zypper**
- Obtaining information on RPM packages (version, dependencies, signatures, etc.)
- Determining the files a package provides, and finding which package a specific file comes from
- Awareness of **dnf** (successor to YUM in Fedora-based systems)

Important Files, Terms, and Utilities

- **rpm**, **rpm2cpio**
- `/etc/yum.conf`, `/etc/yum.repos.d/`
- **yum**, **zypper**, **dnf**
- Various `.repo` configuration files

Lesson Overview

Linux distributions derived from Red Hat (RHEL, Fedora, CentOS, openSUSE) typically use RPM (`.rpm` files) for package distribution. The **rpm** utility handles low-level package operations but does **not** resolve dependencies automatically. Higher-level tools like **yum**, **dnf**, and **zypper** manage dependencies, perform system upgrades, and handle repository configurations.

1. Managing Packages with rpm

1. Installing a Package

```
rpm -ivh PACKAGE_FILE.rpm
```

- **-i**: install
- **-v**: verbose
- **-h**: show progress with hash marks

2. Upgrading a Package

```
rpm -Uvh PACKAGE_FILE.rpm
```

- Installs if not already present; upgrades if older version is detected.
- **-F**: freshen (upgrade only if installed; skip if not).

3. Removing (Erasing) a Package

```
rpm -e PACKAGE_NAME
```

- Fails if other packages depend on it.
- Remove those dependents first or specify them all at once.

4. Querying Installed Packages

- **List all packages:**

```
rpm -qa
```

- **Query a package's info:**

```
rpm -qi PACKAGE_NAME
```

- **List files in a package:**

```
rpm -ql PACKAGE_NAME
```

- **Find which package owns a file:**

```
rpm -qf /path/to/file
```

5. Inspecting an Uninstalled Package

- **Metadata (info):**

```
rpm -qip PACKAGE_FILE.rpm
```

- **Contents (file list):**

```
rpm -qlp PACKAGE_FILE.rpm
```

6. Dependencies

- **rpm** will list missing dependencies but cannot automatically resolve them.
- Use **yum**, **dnf**, or **zypper** to handle dependencies more effectively.

2. YUM (YellowDog Updater Modified)

1. Searching for Packages

```
yum search KEYWORD
```

- Searches names and summaries for **KEYWORD**.

2. Installing a Package

```
yum install PACKAGE_NAME
```

- Resolves and installs dependencies automatically.

3. Removing a Package

```
yum remove PACKAGE_NAME
```

- Also removes packages that depend on it.

4. Upgrading Packages

```
yum update PACKAGE_NAME
```

- Without a package name, updates the entire system.

5. Checking for Updates

```
yum check-update [PACKAGE_NAME]
```

- Lists available updates; omit package name to check all installed packages.

6. Which Package Provides a File

```
yum whatprovides FILENAME
```

- Helps identify the package that contains a needed file or library.

7. Getting Package Info

```
yum info PACKAGE_NAME
```

- Shows version, architecture, summary, repo source, etc.

8. Repositories (/etc/yum.repos.d/*.repo)

- **Add/Remove Repos:** `yum-config-manager -add-repo URL / yum-config-manager -remove-repo REPO_ID`
- **Enable/Disable Repos:** `yum-config-manager -enable REPO_ID / yum-config-manager -disable REPO_ID`
- **List Repos:** `yum repolist all`

9. Cleaning Cache

```
yum clean [packages|metadata|all]
```

- Frees disk space by removing cached `.rpm` files or metadata.

3. DNF (Dandified YUM)

1. Overview

- Used by Fedora and newer Red Hat-based systems.
- Similar commands to **yum**.

2. Basic Commands

- **Search:** `dnf search KEYWORD`
- **Install:** `dnf install PACKAGE_NAME`
- **Remove:** `dnf remove PACKAGE_NAME`
- **Upgrade:** `dnf upgrade [PACKAGE_NAME]` (upgrade entire system if no package specified)
- **Which Package Provides a File:** `dnf provides /path/to/file`
- **List Installed Packages:** `dnf list -installed`

3. Repositories

- **List all:** `dnf repolist [-enabled|-disabled]`
- **Add:** `dnf config-manager -add-repo URL`
- **Enable/Disable:** `dnf config-manager -set-enabled REPO_ID / dnf config-manager -set-disabled REPO_ID`

4. Cleaning Cache

```
dnf clean all
```

- Removes cache data (packages, metadata).

4. Zypper (openSUSE / SUSE)

1. Refreshing Repositories

```
zypper refresh
```

- Updates repository metadata.

2. Searching for Packages

```
zypper search [--installed-only|--not-installed|--provides /file]
```

- `zypper se KEYWORD`
- `zypper se -i KEYWORD` (installed only)
- `zypper se -provides /path/to/file` (find package providing a file)

3. Installing Packages

```
zypper install PACKAGE_NAME
```

- Or `zypper in PACKAGE_NAME`.

4. Upgrading Packages

```
zypper update [PACKAGE_NAME]
```

- Without specifying a package, updates all.

5. Removing Packages

```
zypper remove PACKAGE_NAME
```

- Or `zypper rm PACKAGE_NAME`.

6. Package Info

```
zypper info PACKAGE_NAME
```

- Shows version, repository, summary, etc.

7. Listing Package Contents

```
zypper search --provides /path/to/file
```

- Or `zypper info -requires PACKAGE_NAME` for dependencies.

8. Repositories

- **List:** `zypper repos`
- **Add:** `zypper addrepo URL ALIAS`
- **Remove:** `zypper removerepo ALIAS`
- **Enable/Disable:**

```
zypper modifyrepo -e ALIAS # enable
zypper modifyrepo -d ALIAS # disable
```

- **Auto-Refresh:**

```
zypper modifyrepo -f ALIAS # enable auto-refresh
zypper modifyrepo -F ALIAS # disable auto-refresh
```

Workbook Exercises

1. Basic rpm Operations

- Download an .rpm package (e.g., `wget http://example.com/somepackage.rpm`).
- Install it via:

```
sudo rpm -ivh somepackage.rpm
```

- Query what files it installed (`rpm -ql PACKAGE_NAME`).
- Remove it (`rpm -e PACKAGE_NAME`).

2. Resolve Dependencies with YUM

- Try installing a package that requires another package.
- Notice that `yum` automatically pulls needed dependencies.
- Remove the newly installed package and dependencies if desired:

```
sudo yum remove PACKAGE_NAME
```

3. Which Package Owns a File?

- Use `yum whatprovides /usr/bin/zipinfo` (or a similar file) to see who owns it.
- Confirm with `rpm -qf /usr/bin/zipinfo`.

4. Update the Entire System

- On a CentOS or RHEL system, run:

```
sudo yum update
```

- Reboot if a new kernel is installed.

5. Add/Enable a New Repository

- For CentOS, add a repo:

```
yum-config-manager --add-repo https://example.com/custom.repo
```

- Use `yum repolist all` to confirm it appears, then enable if needed.

6. Zypper Install

- On an openSUSE system, run:

```
sudo zypper refresh
sudo zypper search unzip
sudo zypper install unzip
```

- Check the installed files via `rpm -ql unzip` or `zypper info unzip`.

7. dnf Operations

- On a Fedora system, search for `gimp`:

```
dnf search gimp
```

- Install it:

```
dnf install gimp
```

- Remove it:

```
dnf remove gimp
```

Summary

- **rpm** is the low-level tool for installing `.rpm` packages, but it does **not** handle dependencies automatically.
- **yum**, **dnf**, and **zypper** provide higher-level package management with automatic dependency resolution, repository management, and system-wide updates.
- Each tool has commands for searching packages, installing, upgrading, removing, and listing package contents.
- Understanding these utilities is critical for effectively managing software on RPM-based Linux distributions—an important skill for LPIC-1 certification and real-world administration.

Multiple-Choice Questions for 102.5

1. Which `rpm` parameter is used to remove (erase) an installed package?
 - A) `-U`
 - B) `-e`
 - C) `-F`
 - D) `-qa`
2. Which `rpm` command allows you to query an *uninstalled* package file for information (name, version, etc.)?
 - A) `rpm -qi`
 - B) `rpm -ql`
 - C) `rpm -qa`
 - D) `rpm -qip`
3. Which `yum` command installs a package named `vim` from the configured repositories?
 - A) `yum install vim`
 - B) `yum remove vim`
 - C) `yum info vim`
 - D) `yum repolist vim`
4. Which `yum` subcommand removes an installed package from your system?
 - A) `yum whatprovides`
 - B) `yum info`
 - C) `yum remove`
 - D) `yum repolist`
5. Using `yum`, which command do you run to find the package that provides `/usr/bin/unzip`?
 - A) `yum search /usr/bin/unzip`
 - B) `yum repolist /usr/bin/unzip`
 - C) `yum list installed /usr/bin/unzip`
 - D) `yum whatprovides /usr/bin/unzip`
6. Which of the following `rpm` parameters lists *all* installed packages on the system?
 - A) `-e`
 - B) `-qa`
 - C) `-U`
 - D) `-ql`
7. What is the main purpose of the `rpm2cpio` utility?
 - A) It converts an RPM file into a `.cpio` archive
 - B) It lists installed `.cpio` packages
 - C) It creates a `.tar.gz` archive from an RPM
 - D) It checks package signatures in `cpio` format

8. Which `rpm` command could forcibly install (ignoring dependencies) a package named `mypkg.rpm`?
- A) `rpm -Uvh -nodeps mypkg.rpm`
 - B) `rpm -e mypkg.rpm`
 - C) `rpm -ql mypkg.rpm`
 - D) `rpm -qa -nodeps mypkg.rpm`
9. Which `dnf` command updates *all* installed packages on the system to their latest versions?
- A) `dnf info`
 - B) `dnf remove`
 - C) `dnf upgrade`
 - D) `dnf list -installed`
10. When using `dnf`, how do you find which package provides `/usr/bin/unzip`?
- A) `dnf list /usr/bin/unzip`
 - B) `dnf provides /usr/bin/unzip`
 - C) `dnf repoquery -installed /usr/bin/unzip`
 - D) `dnf info /usr/bin/unzip`
11. Which `zypper` command lets you install an RPM file on disk (e.g., `/home/user/newpkg.rpm`) while also resolving dependencies from repositories?
- A) `zypper update /home/user/newpkg.rpm`
 - B) `zypper refresh /home/user/newpkg.rpm`
 - C) `zypper query /home/user/newpkg.rpm`
 - D) `zypper in /home/user/newpkg.rpm`
12. Which `zypper` operator should you use to remove a package named `unzip` from your system?
- A) `zypper refresh unzip`
 - B) `zypper rm unzip`
 - C) `zypper se -i unzip`
 - D) `zypper up unzip`
13. Which `zypper` command syntax is used to see which packages provide a specific file, e.g., `/usr/lib64/libgimpui-2.0.so.0`?
- A) `zypper se -provides /usr/lib64/libgimpui-2.0.so.0`
 - B) `zypper addrepo -provides /usr/lib64/libgimpui-2.0.so.0`
 - C) `zypper info -provides /usr/lib64/libgimpui-2.0.so.0`
 - D) `zypper up -provides /usr/lib64/libgimpui-2.0.so.0`
14. Which `zypper` operator refreshes all enabled repositories to get the latest metadata?
- A) `zypper se`
 - B) `zypper info`
 - C) `zypper rm`
 - D) `zypper refresh`
15. If you only want to *list* available updates (without installing them) using `zypper`, which command would you use?

- A) `zypper up -list`
 - B) `zypper se updates`
 - C) `zypper list-updates`
 - D) `zypper in -updates-only`
16. How do you disable an existing repository named `repo-non-oss` using `zypper`?
- A) `zypper addrepo -d repo-non-oss`
 - B) `zypper rm repo-non-oss`
 - C) `zypper se -d repo-non-oss`
 - D) `zypper modifyrepo -d repo-non-oss`
17. What does the `yum-config-manager -add-repo <URL>` command do?
- A) It removes a repository from `/etc/yum.conf`
 - B) It adds a new `.repo` file in `/etc/yum.repos.d/` based on the specified URL
 - C) It automatically upgrades `yum` to the latest version
 - D) It disables all repositories except the one specified
18. Which `dnf` command removes an installed package from your system?
- A) `dnf remove PACKAGENAME`
 - B) `dnf fetch PACKAGENAME`
 - C) `dnf localinstall PACKAGENAME`
 - D) `dnf whatprovides PACKAGENAME`
19. Which `yum` command checks if a new version of a package (e.g., `wget`) is available, *without* installing it?
- A) `yum whatprovides wget`
 - B) `yum info wget`
 - C) `yum check-update wget`
 - D) `yum clean metadata wget`
20. Which file stores the primary configuration for `yum` by default?
- A) `/etc/rpm.conf`
 - B) `/var/log/yum.conf`
 - C) `/etc/yum.conf`
 - D) `/etc/dnf.conf`

Fill-in-the-Blank Questions for 102.5

1. To remove a package using 'rpm', we use:
`rpm _____ PACKAGENAME.`
2. On Debian-based systems, the tool analogous to 'yum' (mentioned in the lesson) is:
_____.
3. To search for a package with 'zypper', you can use either:
`zypper _____` or `zypper _____`.
4. When using 'dnf', the command to uninstall a package named 'curl' is:
`dnf _____ curl.`
5. The main configuration file for yum is located at: _____.
6. On RPM-based systems, the command 'rpm -qa' means "query _____."
7. If you want to list all available updates using 'yum' without installing them, you can run:
`yum _____`.
8. To view the metadata of the 'gimp' package using 'zypper', type:
`zypper _____ gimp.`
9. The tool that is considered a "fork" or newer version of YUM (primarily used in Fedora) is called:
_____.
10. To list the files installed by a package named 'wget' using 'rpm', you would use:
`rpm -_____ wget.`

102.6 Linux as a virtualization guest

Reference to LPI Objectives:

- **LPIC-1 v5, Exam 101, Objective 102.6**
- **Weight: 1**

Key Knowledge Areas

- General concept of virtual machines (VMs) and containers
- Key elements of Infrastructure as a Service (IaaS), such as compute instances, block storage, networking
- Changing Linux-specific system properties when cloning or templating a VM (e.g., host keys, D-Bus machine ID)
- Using system images to deploy VMs, cloud instances, and containers
- Guest drivers and integration features for Linux VMs
- Awareness of **cloud-init** for automated provisioning

Important Files, Terms, and Utilities

- **Virtual machine, Linux container, application container**
- **Guest drivers** (e.g., Virtio, VirtualBox Guest Additions)
- **SSH host keys, D-Bus machine ID**
- **cloud-init**

1. Virtualization Overview

1. Hypervisor

- Software layer allowing multiple **guest** operating systems to run on a single host.
- Manages physical resources (CPU, memory, storage).

2. Types of Hypervisors

- **Type-1 (Bare-metal):** Runs directly on hardware (e.g., **Xen**, some KVM implementations).
- **Type-2 (Hosted):** Runs on top of a host OS (e.g., **VirtualBox**).

3. Common Hypervisors

- **Xen** (Type-1, open source).
- **KVM** (kernel module in Linux; used with **libvirt**, **QEMU**).
- **VirtualBox** (cross-platform, Type-2).

4. Migration

- **Cold migration:** Move VM when powered off.
- **Live migration:** Move a running VM to another hypervisor. Useful for maintenance/resiliency.

2. Types of Virtual Machines

1. Fully Virtualized (Hardware VM)

- Guest OS is unmodified and unaware it's virtualized.
- CPU extensions (Intel VT-x, AMD-V) often required.

2. Paravirtualized (PVM)

- Guest OS is aware it's running in a VM.
- Uses special drivers for improved performance (e.g., **Virtio** in KVM, Xen drivers).

3. Hybrid

- Fully virtualized OS that uses paravirtualized drivers for I/O performance boosts (disk, network).

3. Guest Drivers and Tools

- **KVM** → **Virtio** drivers for network/storage.
- **VirtualBox** → **Guest Additions** (mounted via ISO).
- Provide near-native performance for I/O operations.

4. Virtual Machine Definition Example (libvirt + KVM)

- `/etc/libvirt/qemu/` contains XML config files describing VMs:
 - Memory, CPUs, disk images, network interfaces, etc.
- Example snippet:

```
<domain type='kvm'>
  <name>rhel8.0</name>
  <memory unit='KiB'>4194304</memory>
  <vcpu>2</vcpu>
  <devices>
    <disk type='file' device='disk'>
      <source file='/var/lib/libvirt/images/rhel8'>
      <target dev='vda' bus='virtio'>
    </disk>
    <interface type='network'>
      <source network='default'>
      <model type='virtio'>
    </interface>
    ...
  </devices>
</domain>
```

- **Networking** can be NAT-based via `virbr0` or bridged to the host network.

5. VM Disk Storage Formats

1. QCOW2 (Copy-on-write)

- Thin-provisioned (sparse), only consumes physical space for actual data.
- Can expand up to a max size.

2. RAW

- Pre-allocated, full-size image.
- Slight performance advantage.

3. Other Storage Setups

- Physical LVM volumes, SAN, NAS, or advanced solutions (oVirt, Red Hat Virtualization).

6. Cloning and Templates

1. Templates

- Pre-built VM images with baseline OS/configuration.
- Speeds deployment, reduces repetitive setup steps.

2. Unique System IDs

- Must regenerate **SSH host keys**, **D-Bus machine ID** to avoid duplicates.
- Example to regenerate machine ID:

```
sudo rm -f /etc/machine-id
sudo dbus-uuidgen --ensure=/etc/machine-id
```

7. Cloud Infrastructure (IaaS)

1. Compute Instances

- Providers bill by CPU/memory usage or by instance count/time.

2. Block Storage

- Persistent storage volumes attached to VMs; performance tiers vary by cost.

3. Networking

- Cloud providers offer subnets, routing, firewalls, DNS, or hybrid on-prem/cloud networking (VPN).

4. Access via SSH

- Typically uses key-based authentication.
- Some providers auto-generate keys or let you upload your own.

8. cloud-init for Automated Provisioning

1. cloud-init

- Tool that runs at boot to configure system settings (network, packages, SSH keys, etc.).
- Uses YAML-based **cloud-config** files.
- Example:

```
#cloud-config
timezone: Africa/Dar_es_Salaam
hostname: test-system
apt_update: true
apt_upgrade: true
packages:
  - nginx
```

- Reduces manual setup for new VMs or containers.

9. Containers

1. Container Concepts

- Isolated environment for an application.
- Shares host OS kernel, thus lighter than full VMs.
- Faster deployment and scaling, easy migration.

2. cgroups (Control Groups)

- Linux kernel feature limiting resource usage (CPU, memory, IO).
- Container engines (Docker, LXC, Kubernetes) use cgroups under the hood.

3. Use Cases

- Microservices, ephemeral workloads, dev/test environments.

Workbook Exercises

1. Compare VM Types

- Write down 3 differences between **fully virtualized** and **paravirtualized** VMs.
- List examples of **Type-1** vs. **Type-2** hypervisors.

2. Inspect a VM Definition (libvirt)

- On a KVM host, look at `/etc/libvirt/qemu/VM_NAME.xml`.
- Identify the disk image file, CPU count, and memory assignment.

3. Check Machine ID

- On a Linux VM, run:

```
dbus-uuidgen --get
```

- If cloned, try regenerating the machine ID.
- Discuss why identical IDs can cause conflicts.

4. `cloud-init` Basics

- Create a small `cloud-config` file to set a hostname and install a package.
- Discuss how it might be used in a real deployment scenario.

5. Container vs. VM

- Compare resource usage for a container vs. a full VM (e.g., Docker container vs. KVM instance).
- List potential advantages of containers in your environment.

Summary

- **Linux** supports various virtualization technologies (KVM, Xen, VirtualBox), each with different performance and integration trade-offs.
- Paravirtualization leverages special drivers for higher performance than fully virtualized guests.
- **D-Bus machine ID** and **SSH keys** must be unique for each cloned VM or template-based deployment.
- `cloud-init` automates initial OS configuration in cloud or container environments.
- **Containers** share the host kernel, providing lighter, faster deployment compared to full VMs, and rely on `cgroups` for resource isolation.

Multiple-Choice Questions for 102.6

1. Which hypervisor is described as a Type-1 (bare-metal) hypervisor that does **not** rely on an underlying operating system?
 - A) VirtualBox
 - B) VMware Workstation
 - C) KVM
 - D) Xen
2. What is the main purpose of a **guest driver** in a paravirtualized environment?
 - A) They hamper performance by adding extra overhead
 - B) They replace the hypervisor entirely
 - C) They help the guest OS interact with the hypervisor hardware more efficiently
 - D) They prevent kernel modules from loading
3. Which of the following statements about disk images is **correct**?
 - A) The raw image format is always smaller in physical size
 - B) A 10 GB raw image file only uses 5 GB by default
 - C) Copy-on-write images cannot support snapshots
 - D) `qcow2` is a copy-on-write disk image format used by QEMU
4. Which statement accurately describes **containers**?
 - A) Containers require a fully emulated BIOS and disk controllers
 - B) Containers cannot be migrated from one host to another
 - C) Containers are identical to fully virtualized machines
 - D) Containers isolate applications while sharing the host's operating system kernel
5. Which of the following is an example of a **Type-2** hypervisor mentioned in the text?
 - A) VirtualBox
 - B) Xen
 - C) KVM
 - D) Docker
6. Which command can be used to ensure a system has a D-Bus machine ID or to generate one if missing?
 - A) `systemctl machine-id`
 - B) `uuidgen`
 - C) `cloud-init -machine-id`
 - D) `dbus-uuidgen -ensure`
7. Which best describes **cloud-init** as mentioned in the text?
 - A) A virtualization environment used to create containers
 - B) A network configuration tool for bridging
 - C) A proprietary cloud computing platform
 - D) A vendor-neutral utility for automatically configuring new cloud-based systems at first boot

8. What is the recommended procedure when cloning a Linux VM that needs a **unique** D-Bus machine ID?
- A) Reboot the system, and it will generate a new ID automatically
 - B) No action is needed; the hypervisor handles ID generation
 - C) Remove `/etc/machine-id` and generate a new one with `dbus-uuidgen`
 - D) Request a new license from LPI
9. Which is **true** regarding copying SSH public keys with the `ssh-copy-id` command?
- A) `ssh-copy-id` can only be used on local machines, not remote servers
 - B) `ssh-copy-id` places the public key into the `authorized_keys` file on the remote server
 - C) The private key is automatically transferred to the remote server
 - D) `ssh-copy-id` sets the public key file permission to 700
10. In a libvirt network configuration, which statement is correct regarding **bridging**?
- A) Bridging is never used by VMs
 - B) The `default.xml` might define a bridge interface named `virbr0`
 - C) NAT is never used with bridging
 - D) The bridging device must have the same name as the hypervisor
11. Which of the following statements is **true** about NAT in the libvirt **default** network definition?
- A) NAT is never used in libvirt
 - B) The default network uses NAT to forward packets to other networks
 - C) NAT requires advanced bridging configuration
 - D) NAT can only be used with a single VM
12. Which file typically stores a **symbolic link** to `/etc/machine-id`?
- A) `/usr/lib/dbus/machine-id`
 - B) `/run/machine-id`
 - C) `/var/lib/dbus/machine-id`
 - D) `/etc/dbus/machine-id`
13. Which virtualization disk provisioning approach **only** grows in size as new data is written to the disk image?
- A) RAW
 - B) Copy-on-write (COW)
 - C) Partition-based allocation
 - D) LVM-based thick provisioning
14. Which hypervisor is described in the text as both Type-1 **and** Type-2 because it integrates with the Linux kernel but also runs on a host OS?
- A) KVM
 - B) VirtualBox
 - C) Xen
 - D) VMware ESXi

15. Which of the following are considered **IaaS computing elements** for cloud-based virtualization?
- A) Computing instances, block storage, and virtual networking
 - B) Word processors, spreadsheets, and messaging apps
 - C) Email, databases, and printers
 - D) Standard Operating Procedures (SOPs)
16. When using **ssh-keygen** to generate an SSH key pair, which file extension typically indicates the **public** key file?
- A) `.priv`
 - B) `.pub`
 - C) `.asc`
 - D) `.id`
17. What is the main advantage of paravirtualized drivers (guest drivers) over fully virtualized drivers?
- A) They are less secure
 - B) They require specialized hardware that is not widely supported
 - C) They typically offer better performance by allowing the guest OS to interact directly with the hypervisor
 - D) They reduce memory usage by 70%
18. Which of the following statements about **container technology** is correct?
- A) It always requires a separate OS kernel per container
 - B) It is always slower than a fully virtualized solution
 - C) It allows applications to run in isolated environments while sharing the host kernel
 - D) Containers cannot be migrated between hosts
19. Which command is used to **add** a public SSH key to the remote server's `authorized_keys` file automatically?
- A) `ssh-copy-id`
 - B) `scp`
 - C) `scp-pub`
 - D) `sftp`
20. Which statement accurately describes **live migration** in virtualization?
- A) Live migration is the process of moving a running VM from one hypervisor to another without downtime
 - B) Live migration means the guest OS must be halted first
 - C) Live migration is only possible with container technology
 - D) Live migration requires external storage with no snapshots

Fill-in-the-Blank Questions for 102.6

1. The software platform responsible for managing hardware resources for virtual machines is called the _____.
2. When a virtual machine is aware that it is a VM and uses specialized drivers, it is referred to as a _____ guest.
3. The _____ file format (used by QEMU) supports copy-on-write functionality.
4. In a KVM setup, the XML configuration files for virtual machines are often located under _____.
5. The _____ command can generate a new D-Bus machine ID if one does not already exist.
6. A symbolic link for the machine ID is typically found at `‘/var/lib/dbus/machine-id‘`, pointing back to _____.
7. When a virtual machine is copied to act as a _____, certain unique properties (like SSH keys or machine IDs) must be changed.
8. _____ is a vendor-neutral utility used to automatically configure new cloud-based virtual machines at first boot.
9. An example of a **Type-2** hypervisor, mentioned in the text, that runs on top of an existing OS is _____.
10. _____ is a method that allows a virtual machine to be moved from one hypervisor to another with minimal or no downtime.

Chapter 3

Topic 103: GNU and Unix Commands

103.1 Work on the command line

Reference to LPI Objectives

- LPIC-1 version 5.0, Exam 101, Objective 103.1
- Weight: 4

Key Knowledge Areas

- Using single shell commands and one-line command sequences.
- Managing the shell environment: defining, referencing, and exporting variables.
- Using and editing command history.
- Invoking commands inside and outside of the PATH.

Important Commands, Files, and Concepts

- **bash** (shell)
- **echo**, **env**, **export**
- **pwd**, **set**, **unset**
- **type**, **which**
- **man**, **uname**
- **history**, **.bash_history**
- **Quoting** (single quotes, double quotes, backslash)

Lesson Overview

Mastering the command line is foundational for Linux administration. You'll frequently need to view or modify your environment, recall and repeat past commands, and handle special characters. Below are the essentials of working efficiently from the shell.

1. Basic System and Command Information

1. Where Am I?: **pwd**

- Prints your current directory, e.g., `/home/user`.
- Example:

```
pwd
# /home/frank
```

2. System Information: **uname -a**

- Displays kernel name, version, architecture, and more.
- Example:


```
uname -a
# Linux base 4.18.0-18-generic ...
```

3. Manual Pages: `man` COMMAND

- Displays documentation for a specified command.
- If unsure of the exact command name, use `apropos` KEYWORD.

4. Command Identification:

- `type` COMMAND
 - Tells whether it's a shell builtin, a hashed command, or an external binary.
- `which` COMMAND
 - Shows the absolute path (e.g., `/usr/bin/ls`).

2. Using Command History

1. Listing Past Commands

- `history`
 - Shows a list of your previously executed commands.
- Piping to `grep` KEYWORD can search through it:

```
history | grep apt
```

2. `.bash_history`

- Hidden file in your home directory storing commands.
- Only updates when you exit a session, so the most recent commands may not appear until logout.

3. Re-executing Commands

- **Up/Down Arrow** keys cycle through your history.
- Press **Enter** to execute.
- Saves time re-typing complex commands.

3. Environment Variables

1. Listing Environment Variables

- `env` shows exported variables (visible to child processes).
- `set` shows all variables and shell functions.

2. Viewing Variable Values

- `echo $VARIABLE_NAME`
- Example:

```
echo $PATH
```

3. Creating and Exporting Variables

- `VARIABLE=value` (local to the current shell).
- `export VARIABLE` makes it inherited by child shells.
- Example:

```
myvar=hello  
export myvar
```

4. Removing Variables

- `unset VARIABLE` deletes it from the current environment.

4. Quoting and Special Characters

1. Why Quote?

- Spaces and certain symbols are interpreted by the shell.
- Quoting ensures the literal interpretation of special characters/spaces.

2. Methods

- **Double quotes** (" "): preserves most characters except `$`, ```, `\`, and `!` in some cases.
- **Single quotes** (' '): preserves all characters literally.
- **Backslash** (\): escapes just the next character.

3. Examples

- Creating a file with spaces:

```
touch "my big file"
```

- Removing it:

```
rm 'my big file'
```

- Escaping spaces:

```
touch my\ big\ file
```

Workbook Exercises

1. Check Your Current Directory

- Run `pwd` and verify the exact path to your home directory.
- Create a file there using `touch <filename>`.

2. Find Your Kernel Version

- Use `uname -a` and note the kernel version.
- Check `man uname` to see other possible options.

3. Explore Man Pages

- Run `man ls` and look for the `-l` option description.

- Use `apropos kernel` to see commands/man pages referencing “kernel.”

4. Practice Command History

- Execute 5–10 random commands (like `pwd`, `ls`, `echo test`).
- Run `history` and filter with `grep ls`.
- Press the **Up** arrow key to retrieve a previous command and re-run it.

5. Experiment with Environment Variables

- Create a variable: `myvar="test123"`.
- Echo it: `echo $myvar`.
- Start a new shell with `bash`, check if `myvar` is available.
- Go back, export `myvar`, start another shell, and see if it’s now available.
- Remove it with `unset myvar`.

6. Creating Files with Special Characters

- Try `touch my big file` (observe the result).
- Now properly create the file: `touch "my big file"`.
- Remove it in three different ways (double quotes, single quotes, backslash-escaped).

Summary

- The `pwd` and `uname` commands help locate you and your system’s details.
- `man`, `apropos`, `type`, and `which` help you find and understand commands.
- `history` and the `.bash_history` file let you recall and reuse previous commands.
- Environment variables (`PATH`, etc.) are easy to manage with `export`, `unset`, and `echo`.
- Quoting (single quotes, double quotes, or backslashes) is crucial when dealing with spaces or special characters.

Multiple-Choice Questions for 103.1

1. Which of the following commands quickly displays only the absolute pathname of an executable (without additional information)?
 - A) `type`
 - B) `file`
 - C) `whereis`
 - D) `which`
2. When using `bash`, which key sequence allows you to recall and edit previously typed commands?
 - A) `Ctrl+H` and `Ctrl+G`
 - B) The Up/Down arrow keys
 - C) Left-clicking on the command line
 - D) The Tab key
3. Which of the following commands can be used to remove an environment variable from the current shell session?
 - A) `unsetenv`
 - B) `erase`
 - C) `export -remove`
 - D) `unset`
4. Which `uname` option prints all available system information?
 - A) `-r`
 - B) `-o`
 - C) `-a`
 - D) `-v`
5. Which command will remove the file `my big file` if the file name has embedded spaces and you do NOT use quotes or backslashes correctly?
 - A) `rm my_big_file`
 - B) `rm my big file` (interpreted as removing three separate files)
 - C) `rm 'my big file'`
 - D) `rm "my big file"`
6. Which command outputs the environment variables that are exported and accessible to child processes?
 - A) `env`
 - B) `set`
 - C) `grep`
 - D) `apropos`
7. Which of the following statements is **true** regarding `type` `uname` showing “`uname` is hashed (/bin/uname)”?
 - A) It means `uname` was used previously and is cached for faster lookups

- B) It means the command is a shell builtin
 - C) It means the command no longer exists on disk
 - D) It means there is a conflict with the `uname` command location
8. By default, new local variables set in the Bash shell are only available:
- A) In the current shell session
 - B) To all newly created shells and user sessions
 - C) After a reboot only
 - D) To all users on the system
9. When you type `set | grep myvar` and see a result, but `env | grep myvar` returns nothing, what does that tell you about `myvar`?
- A) `myvar` is stored in `.bashrc`
 - B) `myvar` is a local shell variable (not exported)
 - C) `myvar` is inherited from a parent environment
 - D) `myvar` is actually a path variable
10. Which command is used to list all recent commands executed in the current user's shell session?
- A) `man`
 - B) `history`
 - C) `ls -a`
 - D) `more`
11. The file `~/.bash_history` typically contains:
- A) A script that runs every time you open your shell
 - B) A record of previously executed commands in Bash
 - C) User-defined functions
 - D) Environment variables that persist after logout
12. Which command is the quickest way to verify whether the directory `/usr/local/bin` is in your `$PATH`?
- A) `echo $PATH`
 - B) `man path`
 - C) `apropos local`
 - D) `ls /usr/local/bin`
13. Which command is most suitable for searching through the names and descriptions of all installed man pages when you do **not** remember the exact command name you need?
- A) `more`
 - B) `info`
 - C) `apropos`
 - D) `tail`
14. Which of these statements regarding `man` is **true**?
- A) `man` files are stored in `/etc/bash_completion.d/`

- B) `man` pages are often organized into separate sections
 - C) `man` only lists synonyms for commands; it does not provide usage
 - D) `man` must be run as `root` to view system documentation
15. If you type `myvar=hello` (with no spaces), what happens?
- A) This sets an environment variable globally for all shells
 - B) A local shell variable `myvar` is created with value `hello`
 - C) The variable is appended to the path
 - D) You must run `env` to permanently store that variable
16. Which of the following methods will **not** preserve special characters in a filename?
- A) Using double quotes
 - B) Using single quotes
 - C) Escaping them with a backslash (\)
 - D) Typing them as is, without quotes or escapes
17. If you run `exit` within a child shell, what happens?
- A) You return to the parent shell
 - B) The system reboots
 - C) It logs you out completely
 - D) The variable `$PATH` is cleared
18. Which command's output is typically the largest and includes all variables and functions (both local and exported)?
- A) `env`
 - B) `type`
 - C) `apropos`
 - D) `set`
19. Which of these commands is a **shell builtin** by default on most Linux systems using Bash?
- A) `uname`
 - B) `cp`
 - C) `which`
 - D) `kill`
20. What does pressing the **Up Arrow** key multiple times in Bash do?
- A) Automatically corrects the last typed command
 - B) Displays man pages for previously run commands
 - C) Logs the user out if pressed 3 times in succession
 - D) Cycles through the recent command history

Fill-in-the-Blank Questions for 103.1

1. The command _____ is used to display the system's manual pages for a given command.
2. To search through the descriptions of available man pages by keyword, you would use the _____ command.
3. By default, the _____ command displays a list of all previously executed commands in the current shell session.
4. The environment variable that contains a list of directories where executables can be found without specifying a full path is _____.
5. The command _____ prints your current working directory.
6. When you type 'bash' inside an existing Bash shell, you start a new (child) shell; typing _____ exits that child shell.
7. The _____ command will display the value of a variable if you put a '\$' in front of the variable name.
8. When you run 'type' on a command like 'uname', and it says "uname is hashed," it means the command is stored in the shell's _____.
9. The file name _____ in your home directory contains a record of recent Bash commands when you exit the shell.
10. The command _____ can be used to remove or unset an existing environment variable from the current session.

103.2 Process text streams using filters

Reference to LPI Objectives

- LPIC-1 v5, Exam 101, Objective 103.2
- Weight: 2

Key Knowledge Areas

- Sending text files and output streams through standard text utility filters.
- Familiarity with GNU textutils (now part of GNU coreutils) and related commands (**sed**, **grep**, **head**, **tail**, etc.).

Important Commands and Utilities

- **bzcat**, **cat**, **cut**, **head**, **less**, **md5sum**
- **nl**, **od**, **paste**, **sed**, **sha256sum**, **sha512sum**
- **sort**, **split**, **tail**, **tr**, **uniq**, **wc**
- **xzcat**, **zcat**
- Redirection operators (**>**, **>>**) and **pipes** (**|**).

1. Quick Review: Redirections and Pipes

1. Standard Streams

- **stdin** (standard input): file descriptor 0 (keyboard by default).
- **stdout** (standard output): file descriptor 1 (screen by default).
- **stderr** (standard error): file descriptor 2 (screen by default).

2. Redirections

- **>** → redirect stdout to a file (overwrite).
- **>>** → redirect stdout to a file (append).
- **<** → redirect a file into stdin.

3. Pipes (**|**)

- Direct output of one command as input to another.
- Example:

```
cat file.txt | grep "pattern"
```

2. Basic Usage of **cat**

1. Concatenate Files: **cat file1 file2** → writes both files to stdout in sequence.
2. Standard Input: Just **cat** (with no arguments) reads from stdin (keyboard).
3. Copying Files: **cat source > destination**.
4. Appending: **echo "new line" >> file.txt**.

3. Viewing Compressed Files

- `bzcat` → for `.bz2` compressed files.
- `xzcat` → for `.xz` compressed files.
- `zcat` → for `.gz` compressed files.
- Example:

```
gzip file.txt # produces file.txt.gz
zcat file.txt.gz
```

4. Searching Text

- `grep`:
 - Search for lines matching a pattern: `grep pattern file`.
 - Common options:
 - * `-i` → ignore case.
 - * `-v` → invert match (show lines *not* matching).
 - * `-n` → show line numbers.
- Example:

```
grep -i "this" mytextfile
# matches "This" or "this"
```

5. Paging Through Large Output

1. `less`:

- Interactive pager: scroll with arrow keys, search with `/pattern`.
- Example:

```
less /var/log/syslog
```

2. `head` and `tail`:

- `head file` → first 10 lines.
- `tail file` → last 10 lines.
- `-n <count>` → changes how many lines are shown (e.g., `head -n 5`).

3. `nl` and `wc`:

- `nl` → numbers each line of input.
- `wc` → word count, line count, etc.
- `wc -l` → line count only.

6. Editing Text Streams with sed

1. Pattern Matching

- Print only lines matching a regex: `sed -n '/regex/p' file`.
- Delete lines matching: `sed '/regex/d' file`.

2. Find and Replace

- `sed 's/old/new/' file`.
- In-place edit: `sed -i.backup 's/old/new/' file`.

3. Example:

```
sed -n /cat/p < ftu.txt # prints lines containing "cat"
sed /cat/d < ftu.txt # prints everything except lines containing "cat"
```

7. Ensuring Data Integrity with Checksums

1. Checksum Tools: md5sum, sha256sum, sha512sum.

2. Generating a Hash:

```
sha256sum ftu.txt > sha256.txt
```

3. Verifying a Hash:

```
sha256sum -c sha256.txt
# ftu.txt: OK
```

8. Looking Deeper with od (Octal Dump)

1. Default

- `od file` → displays file contents in octal.
- Often for debugging binary or unusual text files.

2. Common Options

- `-x` → display as hexadecimal.
- `-c` → display as characters (escaped for non-printable).
- `-An` → suppress addresses/offset.

3. Example

```
od -c file
# shows hidden characters like \n
```

Workbook Exercises

1. Basic Redirection

- Create `test.txt`, then run `cat > test.txt` and type some lines, press `Ctrl+C` to end.
- Use `diff` or `cat` to confirm contents.

2. Pipes

- `ls -l /etc | grep conf`
- `cat /etc/passwd | wc -l` (count lines in `/etc/passwd`).

3. Compressed File Viewing

- Create a large text file (`ls -R /usr > big.txt`).
- Compress it with `gzip big.txt`.
- Use `zcat big.txt.gz | head`.

4. Searching & Paginating

- `grep "root" /etc/passwd`
- `less /var/log/syslog` (scroll, search for "error" with `/error`).

5. sed Basics

- `sed -n '/root/p' /etc/passwd` → lines containing "root."
- `sed 's/bash/sh/' /etc/passwd | head` → replace "bash" with "sh," show first 10 lines.

6. Checksum

- Run `sha256sum ftu.txt > check.txt`.
- Modify `ftu.txt` and verify using `sha256sum -c check.txt` to observe the mismatch.

7. Examining File Contents

- `od -c ftu.txt` → see hidden newline chars.
- `od -x ftu.txt` → observe hex representation.

Summary

- Redirection and pipes let you chain commands and outputs.
- Powerful text filters include `grep`, `head`, `tail`, `less`, `nl`, `wc`, and `sed`.
- Checksum commands (`md5sum`, `sha256sum`, `sha512sum`) ensure data integrity.
- Use `od` to reveal hidden or binary data in files.
- Mastering these techniques streamlines text processing, a crucial skill for Linux administration.

Multiple-Choice Questions for 103.2

1. Which command reads from standard input if no file is specified and echoes the input to standard output?
 - A) grep
 - B) tail
 - C) sed
 - D) cat
2. Which redirection operator **creates** or **overwrites** a file with the output of a command?
 - A) >
 - B) »
 - C) |
 - D) &>
3. Which command can be used to display specific lines that match a pattern in a text file, **ignoring** case differences when the **-i** option is used?
 - A) sort
 - B) head
 - C) grep
 - D) md5sum
4. Which command is commonly used to paginate output, allowing you to scroll through text using the arrow keys?
 - A) less
 - B) cat
 - C) nl
 - D) tail
5. Which command shows only the last ten lines of a file by default?
 - A) head
 - B) tail
 - C) cut
 - D) split
6. Which command can be used to generate or check the cryptographic integrity of a file using **MD5** hashing?
 - A) md5sum
 - B) sha256sum
 - C) sha512sum
 - D) od
7. Which command is considered a **stream editor** that can filter and transform text, including find-and-replace operations?
 - A) nl

- B) wc
 - C) uniq
 - D) sed
8. Which command can be used to **display** a file in **octal** or **hexadecimal** representation (helpful for debugging)?
- A) less
 - B) paste
 - C) od
 - D) zcat
9. If you want to **append** the output of a command to an existing file (without overwriting), which redirection operator should you use?
- A) >
 - B) &>
 - C) 2>
 - D) »
10. Which command, by default, displays the **first 10 lines** of a file?
- A) tail
 - B) wc
 - C) head
 - D) cut
11. Which command is used to **decompress and display** the content of a **.gz** file without explicitly creating an uncompressed file?
- A) gzip
 - B) bzip
 - C) xzcat
 - D) zcat
12. Which option with **gzip** activates **verbose** mode to show what is happening during compression?
- A) -v
 - B) -n
 - C) -c
 - D) -q
13. Which command can **enumerate** lines of output (by placing a line number at the beginning of each line)?
- A) wc
 - B) nl
 - C) sed
 - D) sha512sum
14. Which command can **merge lines** from multiple files side-by-side into columns?

- A) sort
 - B) uniq
 - C) paste
 - D) split
15. Which command is commonly used to **sort** lines of text in **alphabetical** or **numerical** order?
- A) split
 - B) sort
 - C) tr
 - D) nl
16. Which command is used to **transform** or **translate** characters from standard input (for example, converting uppercase to lowercase)?
- A) od
 - B) cat
 - C) tr
 - D) head
17. Which tool can be used to verify file integrity using an **SHA-256** hash?
- A) sha256sum
 - B) zcat
 - C) md5sum
 - D) tail
18. Which of these commands **decompresses** a file using the **bzip2** algorithm and sends its content to standard output?
- A) zcat
 - B) bzip2
 - C) sha512sum
 - D) nl
19. Which of the following commands will **remove duplicate lines** from a sorted list?
- A) paste
 - B) uniq
 - C) od
 - D) grep
20. Which command is used to **split** large files into smaller parts?
- A) tr
 - B) md5sum
 - C) nl
 - D) split

Fill-in-the-Blank Questions for 103.2

1. When you use the command _____ `ftu.txt.gz`, it will decompress and display the file's contents on the screen without creating an uncompressed file.
2. The command _____ can be used to extract lines from a file that match a given pattern, and it supports the `-i` option for case-insensitive searches.
3. By default, _____ shows the first ten lines of a file, whereas `tail` shows the last ten lines.
4. The command _____ can perform in-place edits on a file when combined with the `-i` option, and it is known as a stream editor.
5. Using `> myfile` redirects the standard output of a command to a file, whereas _____ `myfile` appends it without overwriting.
6. The command _____ computes a 128-bit cryptographic hash value of a file, often displayed as a 32-character hexadecimal number.
7. Typing `cat ftu.txt | _____ 'this'` will output lines containing "this" in the file, ignoring character-case differences if the `-i` switch is used.
8. The command _____ can be used to paginate output one screen at a time, allowing you to scroll using arrow keys or vi-like shortcuts.
9. To display the contents of a compressed file created by `bzip2` without decompressing it to disk, you should use the _____ command.
10. When you run _____ `-c sha256.txt`, it compares the saved SHA256 sum with the current file's hash value to verify data integrity.

103.3 Perform basic file management

Reference to LPI Objectives

- LPIC-1 v5, Exam 101, Objective 103.3
- Weight: 4

Key Knowledge Areas

- Copying, moving, and removing files/directories (individually and recursively).
- Using wildcards (file globbing) for matching patterns.
- Locating files using `find` (by type, size, time).
- Using `tar`, `cpio`, `dd` for archiving, copying, and backup tasks.

Important Commands and Utilities

- `cp`, `mv`, `ls`, `rm`, `rmdir`, `mkdir`, `touch`
- `find`
- `tar`, `cpio`, `dd`
- `gzip`, `gunzip`, `bzip2`, `bunzip2`
- `file` (to identify file type)
- Wildcards: `*`, `?`, `[]`

1. File Listing and Basic Navigation

1. `ls`

- `ls` lists contents of a directory.
- Common options:
 - `-l` -- long listing (permissions, owner, size, date/time).
 - `-a` -- include hidden files (dotfiles).
 - `-h` -- human-readable sizes.
 - `-R` -- list contents recursively.
- Example:

```
ls -lh /var/log
```

2. `touch`

- Creates empty files or updates file timestamps.
- Example:

```
touch myfile.txt
# creates an empty file if it doesn't exist
```


2. Creating and Removing Directories

1. mkdir

- Make new directories.
- `mkdir dir1` -- creates `dir1`.
- `mkdir -p parents/children` -- creates a nested directory path if it doesn't already exist.

2. rmdir

- Remove empty directories.
- Fails if directory is not empty.
- `rmdir -p parents/children` -- removes nested directories if all are empty.

3. Copying, Moving, and Deleting Files

1. cp (Copy)

- `cp file1 dir2` -- copy `file1` into `dir2`.
- `cp -r dir1 dir2` -- copy directory `dir1` recursively into `dir2`.
- Useful options:
 - `-i` -- prompt before overwrite.
 - `-f` -- force overwrite.

2. mv (Move / Rename)

- `mv file1 dir2` -- move `file1` into `dir2`.
- `mv oldname newname` -- rename a file.
- Options:
 - `-i` -- prompt before overwrite.
 - `-f` -- force.

3. rm (Remove)

- `rm file1 file2` -- remove multiple files.
- `rm -r dir1` -- remove `dir1` and its contents recursively.
- `rm -i file1` -- prompt before removal.
- `rm -f file1` -- force removal (no prompt).
- **WARNING:** `rm -rf /` is very dangerous.

4. Wildcards (File Globbing)

- `*` (asterisk): matches zero or more characters.
 - Example: `ls *.txt` -- lists all `.txt` files.
- `?` (question mark): matches exactly one character.
 - Example: `ls l?st.txt` -- matches `last.txt`, `lest.txt`, `list.txt`.
- `[]` (brackets): matches any one character from the group/range inside.
 - Example: `ls file[1-3].txt` -- matches `file1.txt`, `file2.txt`, `file3.txt`.

Wildcards can be combined:

```
ls [plf]?st*
# e.g., matches last.txt, lest.txt, list.txt, past.txt
```

5. Finding Files: find

```
find STARTING_PATH [OPTIONS] [EXPRESSION]
```

1. Search by Name

- `find . -name "myfile.txt"` -- find `myfile.txt` in current directory.
- `find /home -iname "*.png"` -- case-insensitive, all `.png` under `/home`.

2. Search by Type

- `-type f` (regular file), `-type d` (directory), `-type l` (symlink).
- Example: `find /var -type d -name "log"`.

3. Search by Size

- `-size +2G` (bigger than 2GB).
- `-size -20M` (smaller than 20MB).
- Suffixes: `b` (bytes), `k` (KB), `M` (MB), `G` (GB).

4. Search by Modification Time

- `-mtime N` → changed exactly `N` days ago.
- `-mtime +N` → changed more than `N` days ago.
- `-mtime -N` → changed less than `N` days ago.
- Example:

```
find /etc -name "*.conf" -mtime -3
# conf files changed less than 3 days ago
```

5. Act on Results (-exec)

- `-exec COMMAND {} --` run a command on each match.
- Example:

```
find . -name "*.bak" -exec rm {} \;
```

- Or use `-delete` to remove matches automatically:

```
find . -name "*.bak" -delete
```

6. Archiving and Compression

6.1 tar

1. Creating an Archive

```
tar -cvf archive.tar dir1 dir2  
# -c: create, -v: verbose, -f: specify file
```

2. Extracting

```
tar -xvf archive.tar  
# -x: extract
```

3. Compression

- `-z` for gzip → `.tar.gz` or `.tgz`:

```
tar -czvf archive.tar.gz dir1  
tar -xzvf archive.tar.gz
```

- `-j` for bzip2 → `.tar.bz2`:

```
tar -cjvf archive.tar.bz2 dir1  
tar -xjvf archive.tar.bz2
```

6.2 gzip / bzip2

- `gzip file` → creates `file.gz`.
- `gunzip file.gz` → uncompress.
- `bzip2 file` → creates `file.bz2`.
- `bunzip2 file.bz2` → uncompress.

6.3 cpio

- Create:

```
ls | cpio -o > archive.cpio
```

- Extract:

```
cpio -id < archive.cpio
```

6.4 dd

- General form: `dd if=INFILE of=OUTFILE [options]`.
- Example: copy a file:

```
dd if=oldfile of=newfile status=progress
```

- Convert text to uppercase:

```
dd if=oldfile of=newfile conv=ucase
```

- Disk backup (be cautious):

```
dd if=/dev/sda of=backup.dd bs=4096
```

Workbook Exercises

1. Basic Operations

- Create a directory `testdir` with `mkdir testdir`.
- Inside `testdir`, create files (`touch file1 file2`).
- List them (`ls -l`), then copy them into a new directory `copydir`.
- Rename one file in `copydir` to `file3`.
- Remove `copydir` recursively.

2. Globbing

- Create files: `fileA`, `fileB`, `fileX`, `file12`, `f_test`, etc.
- Use wildcards to list or remove subsets (`ls f*`, `rm file?`, etc.).

3. Finding Files

- Run:

```
find . -name "*.sh"
```

- Search by size (`+1M`, etc.).
- Use `-exec echo {}` to print each match.

4. Archiving & Compressing

- Create a tar archive of a test directory:

```
tar -cvf myarchive.tar testdir
```

- Compress it (`gzip myarchive.tar`) or do it in one step (`-z`):

```
tar -czvf myarchive.tgz testdir
```

- Extract into a new location:

```
tar -xzvf myarchive.tgz -C /tmp
```

5. Using dd

- Copy a file using `dd`, e.g.:

```
dd if=testfile of=testfile_copy bs=1K status=progress
```

- Verify both files with `diff` or `cmp`.

Summary

- `ls` shows file details; `mkdir`, `rmdir` create/remove directories.
- `cp`, `mv`, `rm` handle copying, moving, renaming, and deleting files/directories.
- Use `-r` for recursive operations on directories.
- File globbing (`*`, `?`, `[]`) simplifies specifying multiple files in commands.
- `find` locates files by name, type, time, or size, and can act on them using `-exec` or `-delete`.
- `tar`, `cpio`, `dd` provide archiving, backup, and data copying capabilities, optionally with compression (`gzip`, `bzip2`).

Multiple-Choice Questions for 103.3

1. Which command is used to list files in the current directory in a **human-readable** format (showing sizes like 4.0K, 2.1M, etc.)?
 - A) `ls -lh`
 - B) `ls -lr`
 - C) `ls -a`
 - D) `ls -sd`
2. Which option with the `rm` command **prompts** the user before removing the file?
 - A) `-r`
 - B) `-f`
 - C) `-i`
 - D) `-d`
3. In the context of wildcard usage, what does the `*` (asterisk) match?
 - A) Zero or more occurrences of **any** character
 - B) Exactly one character
 - C) Only hidden files
 - D) Only directories
4. Which command **removes** an **empty directory**?
 - A) `rm -r`
 - B) `rmdir`
 - C) `rm -rf`
 - D) `cpio`
5. Which option for the `cp` command is used to copy directories **recursively**?
 - A) `-v`
 - B) `-l`
 - C) `-u`
 - D) `-r`
6. In the output of `ls -l`, which character (in the first column) indicates a **directory**?
 - A) `-`
 - B) `s`
 - C) `c`
 - D) `d`
7. Which command can be used to **create an empty file**?
 - A) `touch`
 - B) `newfile`
 - C) `cp -0`
 - D) `mv -n`

8. What is the effect of running `mv oldname newname`?
- A) Copies `oldname` to `newname`
 - B) Renames `oldname` to `newname`
 - C) Asks for confirmation before removing `oldname`
 - D) None of the above
9. Which command displays the **type** of a file (e.g., text, directory, etc.)?
- A) `file`
 - B) `type`
 - C) `grep`
 - D) `dd`
10. Which command is used to **remove** a file **permanently** without prompts, ignoring nonexistent files?
- A) `rm -f`
 - B) `rm -i`
 - C) `rm -r`
 - D) `rm -rf`
11. Which command will **list hidden files** in the current directory?
- A) `ls -l`
 - B) `ls -h`
 - C) `ls -a`
 - D) `ls -R`
12. Which of the following wildcards matches **exactly one character**?
- A) `*`
 - B) `!`
 - C) `?`
13. Which command can **create** a directory named `parents/children` along with the necessary **parent** directory if it doesn't exist?
- A) `mkdir -r parents/children`
 - B) `mkdir -create parents/children`
 - C) `mkdir -p parents/children`
 - D) `mkdir -m parents/children`
14. What does the following command do?
- ```
cp -r myfiles/ backups/
```
- A) Copies the entire `myfiles` directory, including its contents, to `backups`
  - B) Moves all content from `backups` to `myfiles`
  - C) Copies only hidden files from `myfiles` to `backups`
  - D) Backs up the entire filesystem

15. Which command is used to **move or rename** files in Linux?
- A) cp
  - B) rename
  - C) mv
  - D) rm
16. When using the **mv** command, which option **prompts** you before overwriting an existing file?
- A) -f
  - B) -n
  - C) -r
  - D) -i
17. In the context of the **find** command, what does **-type f** represent?
- A) Search for directories
  - B) Search for regular files
  - C) Search for symbolic links
  - D) Search for special files
18. Which command **recursively removes** a directory and all its contents?
- A) rmdir -r
  - B) rm -r
  - C) rm
  - D) rmdir
19. Which command can be used to **list** the content of a directory **together with its subdirectories**?
- A) ls -R
  - B) ls -a
  - C) ls -l
  - D) ls -m
20. Which wildcard expression would match filenames that start with **l**, followed by any **single** character, and end with **st.txt**?
- A) l\*[st].txt
  - B) l?st.txt
  - C) l??st?.txt
  - D) l?st.[txt]



## Fill-in-the-Blank Questions for 103.3

1. The \_\_\_\_\_ command can be used to **rename** a file or move it to a new location.
2. The command \_\_\_\_\_ **-r mydir newdir copies** a directory recursively.
3. The wildcard character \_\_\_\_\_ matches **exactly one character**.
4. To find files **larger than 2G**, you can use \_\_\_\_\_ **/var -size +2G**.
5. The command **tar** \_\_\_\_\_ **archive.tar data** is used to **create** an archive.
6. To **extract** a **.tar.gz** file with **tar**, you replace the **-c** option with \_\_\_\_\_.
7. The \_\_\_\_\_ command is used to **remove empty directories**.
8. A \_\_\_\_\_ is basically a container of multiple files bundled together by the **tar** command.
9. In the context of the **find** command with **-exec**, the placeholder \_\_\_\_\_ refers to the **currently found file**.
10. The \_\_\_\_\_ command is used to **uncompress .gz** files (and removes the original **.gz** file by default).

## 103.4 Use streams, pipes and redirects

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 103.4
- Weight: 4

### Key Knowledge Areas

- Redirecting standard input (stdin), standard output (stdout), and standard error (stderr).
- Piping output of one command into another command's input.
- Using output of one command as arguments to another command.
- Sending output to both stdout and a file.

### Important Commands, Files, and Utilities

- tee, xargs
- Redirection operators (>, >>, <, <<, <<<, 2>, &>, etc.)
- Pipes (|)
- Command substitution ('command' or \$(command))

## 1. Standard File Descriptors

1. **stdin**: file descriptor **0** (normally keyboard input).
2. **stdout**: file descriptor **1** (normally terminal display).
3. **stderr**: file descriptor **2** (normally terminal display for errors).

## 2. Redirection

### 1. Output Redirection

- > : redirect stdout (file descriptor 1) to a file (overwrite).
- >>: append stdout to a file.
- 2>: redirect stderr (file descriptor 2).
- &> or >&: redirect **both** stdout and stderr to a file.
- Example:

```
command > file.txt # overwrites file.txt
command >> file.txt # appends to file.txt
command 2> errors.txt # only stderr to errors.txt
command &> all_output.txt # stdout and stderr
```

## 2. Input Redirection

- `<` : read file content into stdin.
- Example:

```
command < file.txt
```

- Usually, commands can also specify a file directly (e.g., `cat file.txt`), but `<` can be used if needed.

## 3. Here Documents and Here Strings

### 1. Here Document (`<<`)

- Multi-line string as stdin to a command.
- Terminates on a line containing a marker (like EOF).

```
cat << EOF
line 1
line 2
EOF
```

- Everything up to the terminating word is fed to the command's stdin.

### 2. Here String (`<<<`)

- Single-line string to a command's stdin.
- Example:

```
wc -c <<< "hello world"
```

- If the string contains spaces, put it in quotes.

## 4. Pipes

### 1. Definition

- `|` connects stdout of one command to stdin of another.
- Multiple pipes can chain many commands.

### 2. Basic Example

- `cat file.txt | grep "pattern"`
- The `cat` output goes to `grep`'s input.

### 3. Combining with Redirection

- `command1 2>&1 | command2` merges stderr into stdout first, so second command can read both.

## 4. tee

- Splits output so you can see on screen **and** write to a file.
- `command | tee file.txt`
  - Output goes to screen and also saved into `file.txt`.
- `-a` appends instead of overwriting.

## 5. Command Substitution

### 1. Syntax

- ``command`` (backticks) or `$(command)`
- Example (using `$( )` recommended):

```
TODAY=$(date +%Y-%m-%d)
echo "Today's date is $TODAY"
```

- Used to store command output in variables or pass as arguments to other commands:

```
mkdir dir-$(date +%Y%m%d)
```

## 6. Using xargs

### 1. Purpose

- Takes a list (from stdin) and builds arguments for another command.
- Commonly used with `find` output or other multi-line data.

### 2. Basic Example

```
find . -name "*.txt" | xargs rm
```

- This removes all `.txt` files found.
- If filenames have spaces, use `-print0` in `find` and `-0` in `xargs`:

```
find . -name "*.txt" -print0 | xargs -0 rm
```

### 3. Options

- `-n 1`: run the specified command once per line.
- `-I {}`: placeholder to control where the arguments go in the command line.
- Example:

```
find . -name "*.jpg" | xargs -I {} mv {} /tmp
```

- Moves each `.jpg` to `/tmp`.

## Workbook Exercises

### 1. Redirecting Output

- Run `ls -l /nonexistentdir 2> error.txt`.
- Inspect `error.txt` to see `stderr` captured.

### 2. Piping

- Display line count of `/etc/passwd`:

```
cat /etc/passwd | wc -l
```

- Or shorter: `wc -l < /etc/passwd`.

### 3. Here Document

- Create a test file with multiple lines:

```
cat << EOF > mytest.txt
line1
line2
line3
EOF
```

- Check contents with `cat mytest.txt`.

### 4. tee

- Pipe a command's output to a file and terminal:

```
ls -l | tee listing.txt
```

### 5. Command Substitution

- Store today's date in a variable:

```
TODAY=$(date +%Y-%m-%d)
echo $TODAY
```

- Use it to create a directory, e.g. `mkdir backup-$TODAY`.

### 6. xargs

- Create some test files, e.g. `touch file1 file2 "file space.txt"`.
- Use `find` and `xargs` with `-print0/-0` to remove them:

```
find . -name "file*" -print0 | xargs -0 rm
```

## Summary

- **stdin** (0), **stdout** (1), and **stderr** (2) are standard I/O channels.
- **Redirects** (>, >>, 2>, <, <<, etc.) move data between commands and files.
- **Pipes** (|) send one command's output to another command's input.
- **tee** duplicates data to both stdout and a file.
- **Command substitution** (``cmd`` / `$(cmd)`) captures a command's output for variables or arguments.
- **xargs** transforms stdin lines into command arguments, often used with **find**.

## Multiple-Choice Questions for 103.4

1. What character is used to create a pipeline in Linux?
  - A) <
  - B) »
  - C) |
  - D) &
2. In a pipeline, data flows from \_\_\_ to \_\_\_\_\_.
  - A) Filesystem to memory
  - B) Left to right
  - C) Right to left
  - D) Memory to filesystem
3. What command allows the output of a pipeline to be displayed on the screen and written to a file simultaneously?
  - A) tee
  - B) uniq
  - C) grep
  - D) wc
4. Which of the following is a valid method to redirect standard error to standard output in Bash?
  - A) |
  - B) 2>&1
  - C) <&
  - D) »
5. In Bash, the `$(...)` syntax is used for \_\_\_\_\_.
  - A) Redirection
  - B) Command substitution
  - C) Background execution
  - D) Piping
6. Which command is used to pass the output of one program as arguments to another program?
  - A) uniq
  - B) xargs
  - C) grep
  - D) wc
7. When using `find` with `xargs`, which option ensures correct handling of paths with spaces?
  - A) -L
  - B) -n 1
  - C) -print0 and -0
  - D) -exec

8. Which command is used to sort output numerically?
- A) tee
  - B) uniq
  - C) sort -n
  - D) wc
9. The **xargs** option `---` specifies how many arguments to use per command execution.
- A) -L
  - B) -I
  - C) -n
  - D) -0
10. In a pipeline, which program skips duplicate lines?
- A) wc
  - B) tee
  - C) uniq
  - D) grep
11. Which of the following can capture only the standard output of a process in a pipeline?
- A) pipe (|)
  - B) Redirect (>)
  - C) uniq
  - D) grep
12. Which **xargs** option allows substituting input values anywhere in the target command?
- A) -n
  - B) -L
  - C) -I
  - D) -0
13. Command substitution in Bash allows you to `---`.
- A) Send stderr to stdout
  - B) Use command output as an argument
  - C) Redirect stdin to a file
  - D) Save stdout in a file
14. The **-exec** option in **find** `---`.
- A) Runs a command for each search result
  - B) Sorts the output of find
  - C) Moves files to a directory
  - D) Saves search results to a file
15. When using **xargs**, what option limits the number of lines used as arguments per execution?
- A) -print0



- B) -L
  - C) -n
  - D) -exec
16. How can you ensure the **xargs** command processes paths with special characters?
- A) Use -n 1
  - B) Use -print0 and -0
  - C) Use tee
  - D) Use uniq
17. Which of the following combines input redirection and piping?
- A) `cat /proc/cpuinfo | wc`
  - B) `grep 'model name' </proc/cpuinfo | uniq`
  - C) `uniq | wc`
  - D) `tee`
18. What does the **-a** option in the **tee** command do?
- A) Appends output to a file
  - B) Prevents overwriting a file
  - C) Redirects output to stderr
  - D) Filters duplicate lines
19. The **find** option **-mindepth 2** instructs the command to \_\_\_\_.
- A) Process files only at a specified depth
  - B) Include hidden files in the results
  - C) Skip symbolic links in the search
  - D) Sort results by size
20. What is the purpose of using **xargs** with **-I** in a pipeline?
- A) Handle special characters
  - B) Use the input value at a specific position
  - C) Limit arguments per command
  - D) Run a command for each result

## Fill-in-the-Blank Questions for 103.4

1. The \_\_\_\_\_ character is used to create a pipeline that connects the output of one command to the input of another.
2. In Bash, the \_\_\_\_\_ syntax or backticks can be used for command substitution to use the output of a command as an argument.
3. The \_\_\_\_\_ command can display the output of a pipeline on the screen and save it to a file simultaneously.
4. To correctly handle filenames with spaces, the `find` command should use the \_\_\_\_\_ option along with the `-0` option in `xargs`.
5. The \_\_\_\_\_ option in `xargs` specifies a substitution placeholder for input values to be placed in specific locations in a command.
6. In the pipeline `cat /proc/cpuinfo | grep 'model name' | uniq`, the \_\_\_\_\_ command filters out repeated lines.
7. To append data to a file instead of overwriting it, the \_\_\_\_\_ option should be used with the `tee` command.
8. When redirecting both `stdout` and `stderr` to a file, the \_\_\_\_\_ operator should be used before the pipe.
9. The \_\_\_\_\_ command is used to sort numerical output in ascending order in a pipeline.
10. The \_\_\_\_\_ command can be used instead of `xargs` to execute a command for each result produced by `find`.

## 103.5 Create, monitor and kill processes

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 103.5
- Weight: 4

### Key Knowledge Areas

- Running jobs in foreground and background
- Keeping processes running after logout (e.g., `nohup`)
- Monitoring active processes (e.g., `ps`, `top`, `free`, `uptime`, `watch`)
- Selecting/sorting processes (e.g., `ps` options, `top` interactions)
- Sending signals to processes (e.g., `kill`, `pkill`, `killall`)
- Using terminal multiplexers (`screen`, `tmux`)

### Important Commands, Files, and Utilities

- `bg`, `fg`, `jobs`
- `kill`, `nohup`
- `ps`, `top`
- `free`, `uptime`, `watch`
- `pgrep`, `pkill`, `killall`
- `screen`, `tmux`

## 1. Foreground and Background Jobs

### 1. Foreground Execution

- By default, commands run in foreground and occupy the terminal until complete.
- Example: `sleep 60` (blocks the terminal for 60 seconds).

### 2. Suspending a Foreground Job

- Press **Ctrl + Z** to suspend (stop) a running job.

### 3. Background Execution

- Append `&` to run a process in the background immediately:

```
sleep 60 &
```

- Or after suspending, use `bg` to continue a stopped job in the background.

## 4. jobs

- Lists active jobs associated with the current shell.
- Each job has a **job ID** (e.g., [1]).

## 5. fg

- Brings a background (or stopped) job to the foreground.
- Example: `fg %1` → bring job #1 forward.

## 6. Terminating a Job

- Use `kill %1` to send a signal (default `SIGTERM`) to job #1.
- If a job does not respond, try `kill -9 %job_number` (`SIGKILL`).

# 2. Detaching Jobs: nohup

## 1. nohup

- Runs a command immune to **SIGHUP** (hangup signal).
- The process continues after you log out.
- Example:

```
nohup ping localhost > ping.log 2>&1 &
```

- Output by default goes to `nohup.out` if not redirected.

## 2. Killing a nohup Process

- Identify the PID (e.g., `ps aux | grep ping` or `pgrep ping`) and then `kill <PID>`.

# 3. Monitoring Processes

## 1. watch

- Periodically runs a command (default every 2 seconds).
- Example:

```
watch uptime
watch -n 5 free
```

- Press **Ctrl + C** to exit.

## 2. free

- Displays memory usage (RAM, swap).
- Use `-m` or `-h` for human-readable format.

## 3. uptime

- Shows system up time, number of users, load averages.

## 4. ps

- Snapshots current processes.
- Common options:
  - `ps aux` (show all processes in BSD style)
  - `ps -ef` (show all processes in UNIX style)
  - `ps -U <user>` or `ps -user <user>` (filter by user)
- Fields: **PID**, **USER**, **%CPU**, **%MEM**, **VSZ** (virtual size), **RSS** (resident set size), **TTY**, **STAT**, **TIME**, **COMMAND**.

## 5. top

- Dynamic, real-time view of processes.
- Interactive keys (some important ones):
  - **M** (sort by memory usage)
  - **P** (sort by CPU usage)
  - **k** (kill a process by PID)
  - **r** (renice a process by PID)
  - **q** (quit)

# 4. Sending Signals to Processes

## 1. kill

- Sends a signal to a process by PID or job spec.
- Default is `-TERM` (`SIGTERM`, `signal #15`).
- `-9` (`SIGKILL`) forcibly kills.
- Example:

```
kill -TERM 1234
kill -9 1234
kill %1 # kills job #1
```

## 2. killall

- Kills all processes by command name.
- Example: `killall firefox`.

## 3. pkill

- Kills processes by name or matching pattern (use `pgrep` first to see matches).
- Example: `pkill -9 sleep`.

## 4. Signal Reference

- `kill -l` → list all signals.
- Common signals:
  - `SIGHUP` (1), `SIGINT` (2), `SIGQUIT` (3), `SIGTERM` (15), `SIGKILL` (9), `SIGSTOP` (19), `SIGCONT` (18).

## 5. Terminal Multiplexers: `screen` and `tmux`

### 5.1 `screen`

#### 1. Basic Usage

- Start: `screen` (creates a new session).
- Detach a session: **Ctrl** + **A** then **D**.
- Reattach: `screen -r [session_id]` (or `screen -ls` to list sessions).
- Kill a session: `screen -S <session_id> -X quit`.

#### 2. Windows

- Each window is like a separate terminal.
- Create new window: **Ctrl** + **A** then **C**.
- Move between windows: **Ctrl** + **A** then **N** (next) or **P** (previous).
- Rename a window: **Ctrl** + **A** then **Shift** + **A** (enter new name).

#### 3. Regions (Split Screen)

- Horizontal split: **Ctrl** + **A** then **S**.
- Vertical split: **Ctrl** + **A** then **|**.
- Move between splits: **Ctrl** + **A** then **Tab**.

#### 4. Copy Mode

- Enter copy mode: **Ctrl** + **A** then **[**.
- Use arrow keys to navigate, press **Space** to start selection, move, and **Space** again to end selection.
- Paste in a window: **Ctrl** + **A** then **]**.

### 5.2 `tmux`

#### 1. Basic Usage

- Start: `tmux` (creates a new session).
- Detach: **Ctrl** + **B** then **D**.
- List sessions: `tmux ls`.
- Attach: `tmux attach -t <session_name>`.
- Kill session: `tmux kill-session -t <name>`.

## 2. Windows

- New window: **Ctrl + B, C**.
- Switch windows: **Ctrl + B, N** (next) or **P** (previous).
- Rename: **Ctrl + B, ,**.

## 3. Panes (Splits)

- Horizontal split: **Ctrl + B, "**.
- Vertical split: **Ctrl + B, %**.
- Switch panes: **Ctrl + B, Arrow keys**.
- Kill pane: **Ctrl + B, x**.

## 4. Copy Mode

- Enter: **Ctrl + B, [**.
- Move around, press **Space** to start selection, arrow, press **Space** again to finish.
- Paste: **Ctrl + B, ]**.

# Workbook Exercises

## 1. Foreground/Background Jobs

- Run `sleep 60` in the foreground, suspend with **Ctrl + Z**.
- Check jobs.
- Send it to background with `bg`.
- Bring it back to foreground with `fg`.
- Kill it with `kill %1`.

## 2. nohup

- Run `nohup ping localhost > ping.log 2>&1 &`.
- Log out and back in.
- Check the process with `ps` or `pgrep`.
- Kill it with `kill <PID>`.

## 3. Monitoring System Load

- Run `watch uptime` or `watch -n 5 free`.
- Exit with **Ctrl + C**.
- Compare to `top` output.

## 4. Killing Processes

- Start a dummy process like `sleep 9999 &`.
- Find the PID via `ps`, `pgrep sleep`.
- Kill it with `kill <PID>`.
- Confirm it's gone (`ps` or `jobs`).

## 5. Using `top`

- Invoke `top`.
- Press **k** to kill a process (e.g., search a small CPU process).
- Sort by memory usage with **M**, or CPU usage with **P**.
- Quit with **q**.

## 6. `screen`

- Start a session (`screen`).
- Create multiple windows (**Ctrl** + **A**, **C**).
- Detach (**Ctrl** + **A**, **D**) and reattach (`screen -r`).
- Kill a session (`screen -S <session_id> -X quit`).

## 7. `tmux`

- Start a session (`tmux`).
- Create new windows (**Ctrl** + **B**, **C**).
- Split horizontally (**Ctrl** + **B**, **⌘**) or vertically (**Ctrl** + **B**, **%**).
- Detach (**Ctrl** + **B**, **D**) and reattach (`tmux a`).
- Kill with `tmux kill-session -t <name>`.

# Summary

- Background jobs (**bg**) and foreground (**fg**) are managed via **jobs**.
- `nohup` allows processes to keep running after logout.
- Process monitoring uses commands like `ps`, `top`, `free`, `uptime`, `watch`.
- Signals are sent with `kill` (by PID/job), `killall`, `pkill`, each defaulting to **SIGTERM** if unspecified.
- Terminal multiplexers `screen` and `tmux` provide multi-window, multi-pane sessions that can detach and persist in the background, invaluable for system administration over remote connections.



## Multiple-Choice Questions for 103.5

1. What command is used to run a process in the background directly while starting it?
  - A) `fg`
  - B) `&`
  - C) `nohup`
  - D) `jobs`
2. Which command is used to send a job to the foreground?
  - A) `fg`
  - B) `bg`
  - C) `kill`
  - D) `nohup`
3. Which signal is sent by default if no specific signal is mentioned while using the `kill` command?
  - A) `SIGSTOP`
  - B) `SIGHUP`
  - C) `SIGTERM`
  - D) `SIGKILL`
4. What does the `-n` option in the `watch` command do?
  - A) Changes the update interval
  - B) Displays the process ID
  - C) Lists only running jobs
  - D) Lists only stopped jobs
5. What key is pressed in `top` to sort the output by memory usage?
  - A) T
  - B) N
  - C) R
  - D) M
6. What is the purpose of the `nohup` command?
  - A) To bring a job to the foreground
  - B) To monitor active processes
  - C) To detach a job so it continues running after logout
  - D) To kill a specific process by PID
7. Which command is used to kill all instances of a specific process by name?
  - A) `killall`
  - B) `pkill`
  - C) `kill`
  - D) `nohup`

8. What is the role of the `jobs` command in Linux?
- A) To display all running processes
  - B) To list active jobs started by the current shell
  - C) To terminate jobs
  - D) To monitor memory usage
9. What does the `free` command display?
- A) Load averages
  - B) Memory usage statistics
  - C) Running jobs
  - D) Network statistics
10. Which option in the `ps` command shows all processes regardless of terminal attachment?
- A) `-u`
  - B) `x`
  - C) `a`
  - D) `aux`
11. What is a key feature of terminal multiplexers like GNU Screen and `tmux`?
- A) They replace terminal emulators entirely.
  - B) They are used exclusively for SSH connections.
  - C) They allow multiple terminal sessions within a single terminal window.
  - D) They are required to run graphical applications.
12. Which command in `tmux` splits the current window into vertical panes?
- A) `Ctrl + b - "`
  - B) `Ctrl + b - q`
  - C) `Ctrl + b - %`
  - D) `Ctrl + b - |`
13. What is the default command prefix for GNU Screen?
- A) `Ctrl + a`
  - B) `Ctrl + b`
  - C) `Ctrl + c`
  - D) `Ctrl + d`
14. In `tmux`, which command creates a new session with a specific name?
- A) `tmux new -n NAME`
  - B) `tmux create NAME`
  - C) `tmux new -s NAME`
  - D) `tmux start -n NAME`
15. Which of the following commands terminates the current pane in `tmux`?
- A) `Ctrl + b - &`

- B) Ctrl + b - X
  - C) Ctrl + b - q
  - D) Ctrl + b - x
16. How do you reattach to a detached session in tmux?
- A) tmux attach-session
  - B) tmux attach
  - C) tmux -r
  - D) tmux reconnect
17. What is the main difference between screen "regions" and tmux "panes"?
- A) Panes are more customizable than regions.
  - B) Panes are independent pseudo-terminals, while regions are not.
  - C) Panes are temporary, but regions persist between sessions.
  - D) Panes require a session to be detached to function.
18. In GNU Screen, which command prefix is used to rename a window?
- A) Ctrl + a - r
  - B) Ctrl + a - A
  - C) Ctrl + a - n
  - D) Ctrl + a - "
19. Which tmux key combination detaches a session?
- A) Ctrl + b - a
  - B) Ctrl + b - d
  - C) Ctrl + b - t
  - D) Ctrl + b - m
20. Which configuration file can be used to customize tmux on a per-user basis?
- A) /etc/tmux.conf
  - B) /.tmux.conf
  - C) /usr/share/tmux/tmux.conf
  - D) /.tmux.config

## Fill-in-the-Blank Questions for 103.5

1. The \_\_\_\_\_ command is used to run processes in the background by appending it to the end of the command.
2. The command **nohup** is used to detach jobs from the current terminal session and save the output to a default file named \_\_\_\_\_.
3. The \_\_\_\_\_ command is used to terminate a process by sending it a signal such as **SIGTERM**.
4. To bring a background process to the foreground, the command \_\_\_\_\_ followed by the job ID is used.
5. The \_\_\_\_\_ command is used to periodically execute a program and display its output, with the default interval being 2 seconds.
6. In **tmux**, the default command prefix is \_\_\_\_\_, which is used before entering other commands.
7. To create a new session in **screen**, the command \_\_\_\_\_ is used, followed by a session name.
8. In **screen**, the combination **Ctrl + a -** \_\_\_\_\_ is used to detach the current session.
9. The configuration file for customizing **tmux** is typically located at \_\_\_\_\_ for user-level settings.
10. To split a **tmux** window into vertical panes, the key combination **Ctrl + b -** \_\_\_\_\_ is used.

## 103.6 Modify process execution priorities

Reference to LPI Objectives:

- **LPIC-1 v5, Exam 101, Objective 103.6**
- **Weight:** 2

### Key Knowledge Areas

- Knowing the default priority (niceness) of newly created processes.
- Running a program with a higher or lower priority than default.
- Changing the priority of running processes.

### Important Terms and Utilities

- **nice**
- **ps**
- **renice**
- **top**

## 1. Understanding Linux Process Scheduling

- **Multi-tasking (multi-processing) Systems:** Multiple processes “share” CPU time.
- **Preemptive Scheduling:** The kernel can forcibly switch the CPU from one process to another (even if the current process never calls an I/O or system call).
- **Normal vs. Real-Time Scheduling:** Real-time processes have higher priority than normal processes. We generally only adjust normal processes using “nice” values.

### Static Priorities & Niceness

- **Static Priorities:**
  - Range 0-99 for real-time processes.
  - Range 100-139 for normal processes (kernel internal representation).
- **Nice Values:**
  - Range -20 (highest priority, "least nice") to 19 (lowest priority, "most nice").
  - Default nice value is 0 for normal processes.
  - Only **root** can set negative niceness.

## 2. Viewing Process Priorities

### 1. **ps**

- Example: **ps -el** or **ps -Al**
  - **PRI:** process priority (internal to kernel, typically 80 = normal + offset).
  - **NI:** nice value (-20 to 19).

## 2. top

- Interactive system monitor, displays **PR** (priority) and **NI** (nice).
- Priority shown in **top** for normal processes is **PR** - 100, typically ranging 0-39.
- Press **r** in **top** to renice a process.

## 3. Running a Program with Custom Priority

### nice

- Syntax:

```
nice -n <nice_value> command
```

- Example:

```
nice -n 10 tar czf backup.tar.gz /home
```

– If **-n** is omitted, default niceness becomes 10.

- A negative nice value (e.g., -5) raises priority (requires root privileges).

## 4. Changing Priority of Running Processes

### renice

- Syntax:

```
renice <new_nice_value> [options] <target>
```

- Common options:

- **-p <PID>**: target by process ID.
- **-u <username>**: target all processes by user.
- **-g <groupname>**: target all processes by group.

- Example (by PID):

```
renice +5 -p 1234
```

- Example (by user):

```
renice +10 -u alice
```

- Alternatively in **top**, press **r** to renice a running process.

## Exercises

### 1. Check Default Niceness

- Open a terminal and run:

```
sleep 300 &
ps -el | grep sleep
```

- Note **NI** value (should be 0).

### 2. Start a Process with Custom Niceness

- Example:

```
nice -n 5 gzip largefile
ps -el | grep gzip
```

- Observe **NI** column in **ps**.

### 3. Renice a Running Process

- Find a CPU-bound process (e.g., `md5sum /dev/zero`), get PID via `pgrep md5sum`.
- Increase niceness:

```
renice +10 -p <PID>
```

- Check new niceness in **top** or **ps**.

### 4. Interactive with **top**

- Run **top**.
- Press **r**, enter the PID, then a new nice value.
- Verify changes in the **NI** column.

## Summary

- **nice** sets a process's niceness at launch, default is 0, range -20 to 19.
- **renice** changes niceness of an already running process.
- **top** and **ps** display priorities; niceness is shown in **NI** columns.
- Higher priority → lower niceness (negative). Lower priority → higher niceness (positive).
- Mastering process priorities optimizes CPU usage for critical or resource-intensive tasks.

## Multiple-Choice Questions for 103.6

1. What is the default nice value assigned to a process in Linux?
  - A) -20
  - B) 0
  - C) 10
  - D) 19
2. How are real-time processes prioritized compared to normal processes in Linux?
  - A) They are ignored.
  - B) They have the same priority as normal processes.
  - C) They have higher priority than normal processes.
  - D) They have lower priority than normal processes.
3. What command is used to check the static priority of a process?
  - A) top
  - B) renice
  - C) ps
  - D) grep
4. In the ps command output, what column represents the priority?
  - A) ADDR
  - B) CMD
  - C) PRI
  - D) NI
5. Which of the following is a valid nice value range?
  - A) -30 to 30
  - B) -20 to 20
  - C) 0 to 100
  - D) -20 to 19
6. What is the default nice value assigned by the nice command if no option is specified?
  - A) -20
  - B) 0
  - C) 19
  - D) 10
7. How can the nice value of an already running process be changed?
  - A) By using the nice command.
  - B) By restarting the process.
  - C) By using the kill command.
  - D) By using the renice command.



8. What happens when a process with a lower nice value is introduced?
- A) It runs with a higher priority.
  - B) It waits for other processes to complete.
  - C) It gets executed last.
  - D) Its priority remains unchanged.
9. Which scheduling priority range is assigned to normal processes?
- A) 0 to 99
  - B) 0 to 120
  - C) 100 to 139
  - D) -20 to 19
10. What command can display dynamic priority changes continuously?
- A) ps
  - B) top
  - C) grep
  - D) nice
11. Which key is used in the top command to modify a process's priority?
- A) r
  - B) n
  - C) p
  - D) q
12. What does a nice value of -10 imply?
- A) Higher priority than default.
  - B) Default priority.
  - C) Lower priority than default.
  - D) The process cannot run.
13. What is the function of the -p option in the renice command?
- A) Modify priority of all processes.
  - B) Modify priority of all processes by a user.
  - C) Specify a PID for priority modification.
  - D) View current priorities.
14. What priority level corresponds to a real-time process with a static priority of 5?
- A) 135
  - B) 5
  - C) 40
  - D) -5
15. Which process attribute dictates execution priority in a normal scheduling policy?
- A) Static priority

- B) Nice value
  - C) System calls
  - D) File descriptors
16. What command shows the static priority of the systemd process?
- A) `ps -e`
  - B) `top`
  - C) `grep -p /proc/1/sched`
  - D) `nice -n 0`
17. In the `ps` command, which column displays the nice value?
- A) CMD
  - B) PRI
  - C) NI
  - D) SZ
18. How does `renice` modify priorities for a user's processes?
- A) `-n`
  - B) `-p`
  - C) `-u`
  - D) `-g`
19. What term describes Linux's ability to switch processes without waiting for system calls?
- A) Nice value
  - B) Priority inversion
  - C) Preemption
  - D) Static scheduling
20. What does a nice value of 19 imply?
- A) High priority.
  - B) Default priority.
  - C) Low priority.
  - D) Real-time scheduling.

## Fill-in-the-Blank Questions for 103.6

1. In Linux, the priority of a process under normal scheduling policies is determined by its \_\_\_\_\_ value.
2. The \_\_\_\_\_ command is used to change the priority of a running process.
3. The priority values for normal processes in Linux range from \_\_\_\_\_ to \_\_\_\_\_.
4. A real-time process has a static priority range of \_\_\_\_\_ to \_\_\_\_\_.
5. The default nice value for a process in Linux is \_\_\_\_\_.
6. In the `ps` command output, the \_\_\_\_\_ column represents the nice value of a process.
7. To start a process with a modified nice value, the \_\_\_\_\_ command is used with the `-n` option.
8. In the `top` command, pressing the \_\_\_\_\_ key allows you to modify the niceness of a process.
9. Lower nice values correspond to \_\_\_\_\_ priorities for a process.
10. Only the \_\_\_\_\_ user can decrease the nice value of a process below zero.

## 103.7 Search text files using regular expressions

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 103.7
- Weight: 3

### Key Knowledge Areas

- Creating simple regular expressions with various notational elements.
- Understanding differences between basic (BRE) and extended (ERE) regular expressions.
- Recognizing special characters, character classes, quantifiers, and anchors.
- Using regular expressions to search file systems or file content.
- Deleting, changing, and substituting text with regex tools.

### Important Commands and Utilities

- **grep**, **egrep** (or **grep -E**), **fgrep** (or **grep -F**)
- **sed**
- **regex(7)** (man page)
- **find** with **-regex**, **-iregex**

## 1. Regular Expression Basics

### 1. Atoms

- **Ordinary characters** match themselves (e.g., **b** matches “b” literally).
- **.** (**dot**) matches any single character.
- **^** anchors to the start of a line.
- **\$** anchors to the end of a line.
- **Brackets [ ]** define a *bracket expression* (single atom that matches any character inside).
  - Example: **[0-9]** matches any digit from 0 to 9.
  - A caret **^** inside the bracket means negation: **[^ a-z]** matches non-lowercase letters.

### 2. Character Classes (in bracket expressions)

- **[[:digit:]]** for digits, **[[:alpha:]]** for letters, **[[:alnum:]]** for alphanumeric, etc.
- Only valid **inside** bracket expressions like **[[:digit:]]**.

### 3. Anchors

- **^** (start of line), **\$** (end of line).
- Example: **^ abc\$** matches lines that are *exactly* **abc**.

## 4. Basic (BRE) vs. Extended (ERE)

- **BRE:** +, ?, and {} usually need backslashes (\+, \?, \{i,j}) for special meaning.
- **ERE:** +, ?, {} directly recognized as quantifiers without backslashes.
- Tools:
  - `grep` uses BRE by default.
  - `egrep` (or `grep -E`) uses ERE.

## 5. Quantifiers

- \*: zero or more occurrences of preceding atom.
- +: one or more occurrences (ERE or \+ in BRE).
- ?: zero or one occurrence (ERE or \? in BRE).
- {i}, {i,}, {i,j}: exact or range bounds (with backslash in BRE).

## 6. Branches and Backreferences

- **Branching:** | (ERE) or \| (BRE) for “OR” logic.
- **Backreferences:** ( ) group subexpressions (ERE) or \( \) (BRE), use \1, \2 to refer to matched groups.

# 2. Searching with `grep` / `egrep` / `fgrep`

## 1. `grep`

- Default uses basic RE.
- Common options:
  - `-i` ignore case
  - `-v` invert match
  - `-n` show line numbers
  - `-r` recursive
  - `-w` match whole words
  - `-c` count matches
  - `-H` show filename

- Example:

```
grep "^error" /var/log/syslog
```

## 2. `egrep` (or `grep -E`)

- Uses extended RE.
- Example:

```
egrep "colou?r|color" file.txt
```

- Matches `colour` or `color`.

### 3. fgrep (or grep -F)

- Interprets pattern literally (no special chars).
- Example:

```
fgrep "[a-z]*" file.txt
```

- Finds lines containing `[a-z]*` literally.

### 4. Examples

- `grep -i "warning" /var/log/messages` → case-insensitive match “warning.”
- `grep -c "root" /etc/passwd` → count lines starting with “root.”
- `grep -H -r "error" /var/log/` → recursively find “error” in `/var/log/`, show filenames.

## 3. Substitutions and Text Editing with sed

### 1. Basics

- Non-interactive stream editor, applies commands to each line.
- Syntax:

```
sed [options] -e COMMAND file
or sed [options] -f SCRIPT file
```

### 2. Common Sed Commands

- `d`: delete the matching line(s).
- `c <text>`: replace the line with `<text>`.
- `s/FIND/REPLACE/[flags]`: substitute `FIND` with `REPLACE`.
  - `g` flag: replace all occurrences in that line (global).
  - Example:

```
sed 's/foo/bar/g' file.txt
```

- `p`: print the matching line.
- `a <text>`: append text after the matching line.
- `r <file>`: read content of `<file>` after matching line.
- Lines or ranges can be specified by line number or regex.
  - Example: `1d` deletes line 1, `2,5d` deletes lines 2 to 5, `/regex/d` deletes lines matching `regex`.

### 3. Combining

- Multiple commands can be separated by `;`:

```
sed -e '1d; /test/d' file.txt
```

- Deletes line 1, then any line containing “test.”

## 4. Examples Using find + regex

### 1. find -regex

- Basic RE by default.
- `-regextype posix-extended` or `-regextype egrep` for extended RE.
- Example:

```
find /usr/share/fonts -regextype egrep -regex ".*\.(ttf|otf|woff)$"
```

### 2. find -iregex (case-insensitive)

- Example:

```
find /home/user -iregex ".*\.pdf"
```

## 5. Combining Tools for Advanced Searches

- **Chaining:**
  - Pipe outputs through `grep`, `sed`, `uniq`, etc.
- **Example: Searching logs, removing duplicates**

```
lastb -n 10 -d -a --time-format notime \
| grep -v '[0-9]$\ ' \
| sed 's/.* //' \
| sort | uniq
```

- Explanation:
  - `lastb` shows bad login attempts, `-a` puts host at the end of the line, `-n 10` shows last 10.
  - `grep -v '[0-9]$\ '` filters out lines ending in digits (assuming those are raw IPs).
  - `sed 's/.* //'` keeps only the substring after the last space (the hostname).
  - Then `sort | uniq` eliminates duplicates.

## Exercises

### 1. Basic vs. Extended

- Create a text file with lines containing special chars (+, ?, (), etc.).
- Try matching them with `grep "..."` (basic RE) and `egrep "..."` (extended).

### 2. Anchors and Dot

- Use `grep "Hello" file.txt` to find lines starting with “Hello.”
- `grep "world$" file.txt` to find lines ending with “world.”
- `grep "w.rld" file.txt` (dot matches any char).

### 3. Bracket Expressions

- `grep "[[:digit:]]" file.txt` → lines with digits.
- `grep "[A-Z]" file.txt` → uppercase letters.

### 4. sed Substitution

- `sed 's/foo/bar/g' file.txt` → replace “foo” with “bar.”
- `sed '2,4d' file.txt` → delete lines 2 to 4.
- `/old/d` → delete lines containing “old.”

## 5. Combining

- `grep -i "error" /var/log/syslog | sed -n '/warning/p'`  
– Finds lines matching “error” and then prints only lines also having “warning.”

## 6. find with -regex

- `find / -regextype posix-extended -regex ".*\.conf"` → all .conf files.

# Summary

- **Regular expressions** define a flexible method for searching (and sometimes replacing) text patterns.
- Basic RE often requires backslashes for special operators like +, ?, {}, while extended RE does not.
- Core features include **atoms**, **character classes**, **anchors**, **quantifiers**.
- **Tools:**
  - `grep/egrep/fgrep` → quick searches in lines.
  - `sed` → stream editing and substitution.
  - `find` with `-regex` → RE-based filtering of file paths.
- Combining these tools (piping, advanced regex) enables powerful text processing and filtering workflows.



## Multiple-Choice Questions for 103.7

1. Which of the following atoms matches any character in a regular expression?
  - A) `.`
  - B) `^`
  - C) `$`
  - D) `*`
2. What does the `^` atom signify in a regular expression?
  - A) End of a line
  - B) Beginning of a line
  - C) Matches any character
  - D) Literal caret character
3. Which bracket expression matches any uppercase letter?
  - A) `[A-Z]`
  - B) `[:upper:]`
  - C) `[[:upper:]]`
  - D) `[a-z]`
4. What is the effect of the `*` quantifier in both basic and extended regular expressions?
  - A) Matches exactly one occurrence
  - B) Matches zero or more occurrences
  - C) Matches one or more occurrences
  - D) Matches no occurrences
5. What is the function of the `?` quantifier in extended regular expressions?
  - A) Matches one or more occurrences
  - B) Matches zero or one occurrence
  - C) Matches zero or more occurrences
  - D) Matches exactly one occurrence
6. How do you specify a quantifier in basic regular expressions?
  - A) Directly using `{}`
  - B) Preceded by a slash `/`
  - C) Preceded by a backslash `\`
  - D) Using parentheses `()`
7. Which of the following commands enables extended regular expressions in the `find` command?
  - A) `-regex`
  - B) `-iregex`
  - C) `-regex posix-extended`
  - D) `-regextype posix-extended`

8. What is the function of a back reference in extended regular expressions?
- A) Matches any previous pattern
  - B) Denotes the start of a line
  - C) Indicates case sensitivity
  - D) Refers to a parenthesized subexpression
9. Which regular expression matches a sequence of exactly two blank characters?
- A) `[[::blank:]]{2}`
  - B) `[[::space:]]*`
  - C) `[[::blank:]]{2,}`
  - D) `[[::space:]]{1,2}`
10. What is the default regular expression type used by the `find` command?
- A) POSIX-extended
  - B) `findutils`-default
  - C) `egrep` style
  - D) None of the above
11. Which command is used to display lines matching a specific pattern within a file?
- A) `grep`
  - B) `sed`
  - C) `awk`
  - D) `find`
12. What does the `-c` option do when used with the `grep` command?
- A) Counts the number of matching files
  - B) Displays line numbers of matches
  - C) Counts the number of matching lines
  - D) Displays matching lines with filenames
13. Which option in `grep` is used to perform a case-insensitive search?
- A) `-c`
  - B) `-n`
  - C) `-i`
  - D) `-H`
14. Which program is designed to modify text in a non-interactive manner?
- A) `sed`
  - B) `grep`
  - C) `awk`
  - D) `cut`
15. What does the `-H` option in `grep` do?
- A) Suppresses output filenames

- B) Displays the search pattern used
  - C) Outputs the number of matched patterns
  - D) Displays filenames with matched lines
16. Which command in `sed` replaces the first match of `hda` with `sda`?
- A) `sda/hda`
  - B) `hda/sda/g`
  - C) `s/hda/sda/`
  - D) `g/sda/hda/`
17. What does the `-E` option enable in the `grep` command?
- A) Basic regular expressions
  - B) Extended regular expressions
  - C) File searching
  - D) Null-separated data handling
18. In `sed`, what instruction is used to delete a line that matches a specific pattern?
- A) `c`
  - B) `r`
  - C) `g`
  - D) `d`
19. Which command chain identifies failed login attempts and removes lines without hostnames?
- A) `lastb | sed 'd'`
  - B) `grep -c failed`
  - C) `lastb | grep -E hostname`
  - D) `lastb -d -a | grep -v '[0-9]$'`
20. Which program ignores regular expressions and matches only literal strings?
- A) `egrep`
  - B) `sed`
  - C) `grep`
  - D) `fgrep`

## Fill-in-the-Blank Questions for 103.7

1. A regular expression atom that matches with the beginning of a line is represented by the symbol \_\_\_\_\_.
2. The character class \_\_\_\_\_ is used to represent any printable character, including spaces.
3. In extended regular expressions, branches are separated by the \_\_\_\_\_ symbol.
4. To match a sequence of one or more occurrences of an atom in an extended regular expression, the quantifier \_\_\_\_\_ is used.
5. In the **find** command, the option \_\_\_\_\_ enables extended regular expressions.
6. The command \_\_\_\_\_ is used to modify text in a non-interactive way, often in pipelines.
7. In the **grep** command, the \_\_\_\_\_ option enables case-insensitive searches.
8. The \_\_\_\_\_ program is equivalent to **grep -E**, enabling extended regular expressions.
9. To count the number of lines that match a pattern using **grep**, the \_\_\_\_\_ option is used.
10. In **sed**, the \_\_\_\_\_ command deletes lines that match a specified pattern or address.

## 103.8 Basic file editing

### Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 103.8
- Weight: 3

### Key Knowledge Areas

- Navigating a document using **vi** (or **vim**)
- Understanding **vi modes** and using them effectively
- Inserting, editing, deleting, copying, and finding text in **vi**
- Awareness of alternative editors (Emacs, nano, etc.)
- Setting or changing the **standard editor** (**EDITOR** or **VISUAL** environment variable)

### Important Terms and Utilities

- **vi** (or **vim**)
- Search commands (**/**, **?**)
- Navigation keys (**h**, **j**, **k**, **l**)
- Insert modes (**i**, **o**, **a**)
- Deletion/copying (**d**, **p**, **y**, **dd**, **yy**)
- Exiting and saving (**ZZ**, **:w!**, **:q!**)
- **EDITOR** environment variable

## 1. Introducing vi

**vi** is a modal text editor commonly pre-installed on Unix-like systems. Two key modes to remember:

### 1. Normal (Command) Mode

- **vi** **starts** in this mode.
- Keystrokes perform navigation or editing commands.
- Press **i** (insert) or **a** (append) to switch to Insert mode.

### 2. Insert Mode

- Text typed appears in the document.
- Press **Esc** to return to Normal mode.

### Starting vi

```
vi <filename>
```

- **vi** **+<line>** **<file>** → jump to a line on opening.
- **vim** is a more feature-rich version, fully backward-compatible with **vi**.

## 2. Basic vi Navigation and Commands

In **Normal mode**:

| Key        | Action                                                          |
|------------|-----------------------------------------------------------------|
| h, j, k, l | Left, down, up, right (move cursor)                             |
| 0, \$      | Move to start/end of current line                               |
| G          | Go to end of file (use #G to go to line #)                      |
| /pattern   | Forward search for <b>pattern</b> (press <b>n</b> to find next) |
| ?pattern   | Backward search (press <b>N</b> for next backward match)        |
| u          | Undo last action                                                |
| Ctrl+R     | Redo                                                            |
| :          | Enter <b>Colon Command mode</b> (e.g., :w, :q!)                 |

### Basic Insert Commands

| Key | Action                                           |
|-----|--------------------------------------------------|
| i   | Insert at cursor                                 |
| a   | Append after cursor                              |
| o   | Open new line below cursor and enter insert mode |
| O   | Open new line above cursor                       |
| Esc | Leave insert mode, back to normal mode           |

## 3. Editing Text in vi

### Deleting and Changing

| Key | Action                                             |
|-----|----------------------------------------------------|
| x   | Delete character under cursor                      |
| dw  | Delete word (from cursor to next word boundary)    |
| dd  | Delete (cut) entire current line                   |
| d\$ | Delete from cursor to end of line                  |
| cc  | Change entire line (delete and start insert mode)  |
| c3w | Change next 3 words (example of “count + command”) |

### Copying and Pasting

| Key | Action                            |
|-----|-----------------------------------|
| yy  | Yank (copy) current line          |
| y\$ | Yank from cursor to end of line   |
| p   | Paste after cursor or below line  |
| P   | Paste before cursor or above line |

## Saving and Exiting

| Key(s)                              | Action                                            |
|-------------------------------------|---------------------------------------------------|
| <code>:w</code>                     | Write (save) changes                              |
| <code>:q</code>                     | Quit if no unsaved changes                        |
| <code>:wq</code> or <code>:x</code> | Save and quit                                     |
| <code>:q!</code>                    | Quit <b>without</b> saving                        |
| <code>ZZ</code>                     | Save changes (if any) and quit (another shortcut) |

## 4. Searching and Substituting in vi

- **Search:** Press `/` in normal mode, type a pattern, press **Enter**.
- **Backward search:** Press `?`, type a pattern, press **Enter**.
- **Substitute** (similar to `sed`):

```
:s/old/new/g
```

- Replaces all occurrences of "old" with "new" in current line.
- `:%s/old/new/g` → entire file.

## 5. Alternative Editors

### 1. vim

- “vi improved,” features syntax highlighting, multiple undo levels, plugins, etc.

### 2. nano

- Simple, user-friendly. Insert mode by default, commands are **Ctrl** + key combos.
- Common shortcuts:
  - **Ctrl** + **O** to save, **Ctrl** + **X** to exit, **Ctrl** + **K** to cut line, **Ctrl** + **U** to paste.

### 3. Emacs

- Very powerful, integrates IDE features.
- Commands use **Ctrl** + key or **Alt** + key combos.

## 6. Setting the Default Editor

- The shell checks `EDITOR` or `VISUAL` environment variables to decide which editor to use for tasks like `crontab -e` or `git commit`.
- Example:

```
export EDITOR=nano
```

- Add to `~/.bash_profile` or similar to make persistent.

## Exercises

### 1. Basic vi

- Create a test file: `vi test.txt`.
- Press `i`, enter some text. Press `Esc`.
- Move around with `h`, `j`, `k`, `l`.
- Delete a line with `dd`.
- Save and exit: `:wq`.

### 2. Navigation and Searching

- Use `:set number` inside vi to see line numbers.
- Jump to line 5 with `5G`.
- Search for "test" using `/test`.
- Press `n` to find the next match.

### 3. Substitutions

- In normal mode, type `:s/abc/xyz/g` to replace "abc" with "xyz" on the current line.
- Apply to the entire file: `:%s/abc/xyz/g`.

### 4. nano

- Run `nano test.txt`.
- Type some lines, press `Ctrl + K` to cut a line, `Ctrl + U` to paste.
- Save with `Ctrl + O`, exit with `Ctrl + X`.

### 5. Default Editor

- `export EDITOR=vim`
- Then `crontab -e` should open in vim.
- Make it permanent in `~/.bashrc` or `~/.bash_profile`.

## Summary

- **vi** (or **vim**) is a modal text editor: Normal mode (commands) and Insert mode.
- Basic movement: `h`, `j`, `k`, `l`; insertion: `i`, `a`, `o`; deleting: `d`, `x`; copying: `y`; pasting: `p`.
- Searching with `/pattern`; substituting with `:s/old/new/g`.
- Alternative editors: **nano**, **Emacs**, **vim** with advanced features.
- Shell environment variable `EDITOR` (or `VISUAL`) sets the default text editor for tasks like `crontab -e`.



## Multiple-Choice Questions for 103.8

1. Which command opens a file in `vi` and places the cursor at the 10th line?
  - A) `vi -l 10 filename`
  - B) `vi 10 filename`
  - C) `vi +10 filename`
  - D) `vi :10 filename`
2. What is the function of the `Esc` key in `vi`?
  - A) Saves the file
  - B) Closes `vi`
  - C) Exits insert mode
  - D) Deletes the current line
3. Which `vi` mode allows direct text input?
  - A) Insert mode
  - B) Normal mode
  - C) Command mode
  - D) Visual mode
4. How do you save and exit a file in `vi`?
  - A) `:x!`
  - B) `:exit`
  - C) `:wq`
  - D) `ZZ`
5. What does the `dd` command do in `vi`?
  - A) Deletes a character
  - B) Copies a word
  - C) Deletes a line
  - D) Pastes text
6. Which command navigates to the beginning of a line in `vi`?
  - A) `$`
  - B) `o`
  - C) `G`
  - D) `^`
7. What is the command to undo the last action in `vi`?
  - A) `Ctrl-R`
  - B) `u`
  - C) `z`
  - D) `U`

8. How would you search for the word "example" forward in a vi document?
- A) `?example`
  - B) `/example`
  - C) `search example`
  - D) `find example`
9. Which of the following runs a shell command from vi?
- A) `:sh`
  - B) `:bash`
  - C) `:exec`
  - D) `:!`
10. How can you paste text before the current position in vi?
- A) `P`
  - B) `p`
  - C) `d`
  - D) `y`
11. What does the `:q!` command do?
- A) Saves and exits
  - B) Exits without saving
  - C) Restarts vi
  - D) Opens a new file
12. How do you delete the current word and the next four words in vi?
- A) `dw4`
  - B) `d5w`
  - C) `d4w`
  - D) `ddw4`
13. What is the purpose of the command `vimtutor`?
- A) To teach vim commands interactively
  - B) To start vim in tutorial mode
  - C) To open a vim help document
  - D) To list all available vim commands
14. How do you yank (copy) an entire line in vi?
- A) `v`
  - B) `c`
  - C) `d`
  - D) `yy`
15. Which editor supports syntax highlighting and multilevel undo?
- A) vi

- B) `nano`
  - C) `vim`
  - D) `emacs`
16. How do you navigate to the last line of a file in `vi`?
- A) `:G`
  - B) `G`
  - C) `:end`
  - D) `$`
17. How do you start a selection in `vi`?
- A) `:select`
  - B) `s`
  - C) `v`
  - D) `Ctrl-S`
18. What is the default file for persistent `vim` configurations?
- A) `~/.bashrc`
  - B) `~/.vimrc`
  - C) `~/.vimconfig`
  - D) `~/.config/vim`
19. What is the effect of `3yy` in `vi`?
- A) Deletes the current line and two more
  - B) Yanks (copies) three lines
  - C) Pastes the last yanked content three times
  - D) Repeats the last command three times
20. Which of the following commands in `nano` starts a new selection?
- A) `Meta-A`
  - B) `Ctrl-S`
  - C) `Shift-S`
  - D) `Ctrl-K`

## Fill-in-the-Blank Questions for 103.8

1. The `vi` command to jump directly to the 15th line of a file is \_\_\_\_\_ /path/to/file.
2. To save changes and exit `vi`, the command \_\_\_\_\_ or `ZZ` is used.
3. The `vi` mode where you can directly insert text into the document is called \_\_\_\_\_.
4. To delete the current line in `vi`, the command \_\_\_\_\_ is used.
5. The \_\_\_\_\_ command in `vi` allows you to undo the last action.
6. In `vi`, to search backward in a document, you use the command \_\_\_\_\_.
7. To replace the character under the cursor in `vi`, the \_\_\_\_\_ command is used.
8. A persistent `vim` macro can be stored in the configuration file \_\_\_\_\_.
9. In `nano`, the key combination \_\_\_\_\_ is used to undo an action.
10. The default environment variable that defines the text editor for shell commands is \_\_\_\_\_.

## Chapter 4

# Topic 104: Devices, Linux Filesystems, Filesystem Hierarchy Standard

## 104.1 Create partitions and filesystems

### Reference to LPI Objectives

- LPIC-1 v5, Exam 101, Objective 104.1
- Weight: 2

### Key Knowledge Areas

- Manage MBR and GPT partition tables.
- Use **mkfs** commands to create filesystems (e.g., ext2/ext3/ext4, XFS, VFAT, exFAT).
- Basic features of Btrfs (multi-device filesystems, compression, subvolumes).

### Important Commands and Files

- **fdisk**, **gdisk**, **parted** – manage partitions.
- **mkfs**, **mkswap** – create filesystems and swap.
- **btrfs** – manage Btrfs filesystems and features.

### Lesson Overview

Disks must be partitioned and formatted with a filesystem before use. This lesson covers partitioning with tools like **fdisk**, **gdisk**, and **parted**, creating various filesystems, and setting up swap partitions or files.

## 1. Understanding MBR and GPT Partition Tables

### 1. MBR (Master Boot Record)

- Legacy partitioning scheme (4 primary partitions, max 2TB).
- Stores the partition table and boot loader in the first sector.

### 2. GPT (GUID Partition Table)

- Modern alternative to MBR, supports large disks and partitions.
- Up to 128 partitions, unique disk GUIDs for mounting.

## 2. Partition Management Tools

### 1. fdisk (MBR)

- Command-line utility for MBR disks.
- Key commands:
  - **p**: print partition table.
  - **n**: create partition.
  - **d**: delete partition.

### 2. gdisk (GPT)

- Similar interface to `fdisk` but for GPT disks.

### 3. parted

- Works with both MBR and GPT.
- Immediate changes (no "write" command needed).
- Key commands:
  - `mklabel`: create partition table.
  - `mkpart`: create a partition.
  - `resizepart`: resize partitions.

## 3. Creating Filesystems

### 1. ext2/ext3/ext4 Filesystems

- Command: `mkfs.ext4 /dev/sdX`.
- Options:
  - `-L`: set volume label.
  - `-c`: check for bad blocks.

### 2. XFS Filesystem

- High-performance journaling filesystem.
- Command: `mkfs.xfs /dev/sdX`.

### 3. VFAT and exFAT

- For compatibility with non-Linux systems.
- Commands: `mkfs.vfat /dev/sdX`, `mkfs.exfat /dev/sdX`.

### 4. Btrfs Filesystem

- Features: compression, subvolumes, snapshots.
- Command: `mkfs.btrfs /dev/sdX`.

## 4. Swap Setup

### 1. Create Swap Partition

- Partition type: Linux swap (82 for `fdisk`, 8200 for `gdisk`).
- Command: `mkswap /dev/sdX`.
- Enable: `swapon /dev/sdX`.

### 2. Create Swap File Example commands:

```
dd if=/dev/zero of=swapfile bs=1M count=1024
mkswap swapfile
swapon swapfile
```

## Workbook Exercises

### 1. List Disk Partitions

- Use `fdisk -l` or `parted /dev/sdX print`.

### 2. Create and Format Partitions

- Use `fdisk` or `parted` to create partitions.
- Format with `mkfs.ext4`, `mkfs.xfs`, or other appropriate tools.

### 3. Resize a Partition

- Use `resizepart` in `parted` and adjust the filesystem with `resize2fs`.

### 4. Set Up Swap

- Create a swap partition and enable it.

### 5. Work with Btrfs Features

- Create subvolumes and snapshots.

## Summary

- Understand and manage partition tables (MBR, GPT).
- Create and configure various filesystems (ext4, XFS, VFAT, Btrfs).
- Set up and manage swap partitions and files.
- Use tools like `fdisk`, `gdisk`, `parted`, and `mkfs` effectively.



## Multiple-Choice Questions for 104.1

1. What command is used to manage MBR partitions on Linux?
  - A) `gdisk`
  - B) `parted`
  - C) `mkfs`
  - D) `fdisk`
2. Which of the following is a limitation of MBR partitioning?
  - A) Cannot create swap partitions
  - B) Limited to 2 primary partitions
  - C) Cannot address disks over 2 TB
  - D) Does not support Linux file systems
3. What is the maximum number of primary partitions allowed on an MBR disk?
  - A) 2
  - B) 4
  - C) 6
  - D) Unlimited
4. Which command in `fdisk` is used to display the current partition table?
  - A) `p`
  - B) `w`
  - C) `d`
  - D) `n`
5. What does the `'t'` command in `fdisk` do?
  - A) Deletes a partition
  - B) Creates a new partition
  - C) Changes the partition type
  - D) Prints the partition table
6. What is the partition type code for Linux swap in `fdisk`?
  - A) 80
  - B) 82
  - C) 83
  - D) 85
7. How is the GUID Partition Table (GPT) different from MBR?
  - A) It supports more than 4 partitions
  - B) It cannot be used with UEFI
  - C) It stores the partition table in the last sector only
  - D) It has a limit of 2 TB disk size

8. Which command in `gdisk` is used to print the current partition table?
- A) `p`
  - B) `d`
  - C) `r`
  - D) `w`
9. What utility is used to create a Btrfs filesystem?
- A) `mkfs.ext4`
  - B) `mkfs.fat`
  - C) `mkfs.xfs`
  - D) `mkfs.btrfs`
10. Which flag is required to create a read-only snapshot in Btrfs?
- A) `-o`
  - B) `-f`
  - C) `-r`
  - D) `-n`
11. What is the primary tool for managing partitions with GPT?
- A) `parted`
  - B) `fdisk`
  - C) `gdisk`
  - D) `mkfs`
12. Which option in the `mkfs.ext4` command simulates filesystem creation?
- A) `-n`
  - B) `-q`
  - C) `-c`
  - D) `-L`
13. Which filesystem is the default for most Linux distributions?
- A) XFS
  - B) ext4
  - C) VFAT
  - D) NTFS
14. What does the `resize2fs` command do?
- A) Resizes partitions
  - B) Resizes ext2/3/4 filesystems
  - C) Checks for filesystem errors
  - D) Formats partitions
15. Which filesystem is designed to support multiple devices and transparent compression?
- A) ext4

- B) NTFS
  - C) XFS
  - D) Btrfs
16. What command is used to create a swap partition in Linux?
- A) `mkfs`
  - B) `mkswap`
  - C) `swapon`
  - D) `parted`
17. Which command in `parted` creates a partition table?
- A) `mkpart`
  - B) `mklabel`
  - C) `resizepart`
  - D) `print`
18. Which of these is a feature of the Btrfs filesystem?
- A) Supports only a single device
  - B) Copy-on-write functionality
  - C) Limited to 4 TB disk size
  - D) Requires manual journaling
19. What is the primary use of the `mkfs.fat` command?
- A) Creating NTFS filesystems
  - B) Creating FAT/VFAT filesystems
  - C) Creating ext4 filesystems
  - D) Creating swap partitions
20. Which Linux command enables a swap partition after it is created?
- A) `mkfs`
  - B) `mkswap`
  - C) `swapon`
  - D) `swapoff`

## Fill-in-the-Blank Questions for 104.1

1. The Master Boot Record (MBR) can only support up to \_\_\_\_\_ primary partitions per disk.
2. To create a new partition using `fdisk`, the command \_\_\_\_\_ is used.
3. A partition labeled as type \_\_\_\_\_ in `fdisk` is designated for Linux swap space.
4. The GUID Partition Table (GPT) can support up to \_\_\_\_\_ partitions, limited only by the operating system.
5. The command to simulate the creation of a filesystem with `mkfs.ext4` is \_\_\_\_\_.
6. The utility used to create a Btrfs filesystem is \_\_\_\_\_.
7. In `parted`, the command \_\_\_\_\_ is used to create a new partition table.
8. Btrfs supports a feature called \_\_\_\_\_, which allows creating a writable directory-like structure inside the filesystem.
9. To create a FAT or VFAT filesystem, the utility \_\_\_\_\_ is used.
10. After creating a swap partition, the command \_\_\_\_\_ is used to enable it for use.

## 104.2 Maintain the integrity of filesystems

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 104.2
- Weight: 2

### Key Knowledge Areas

- Verify filesystem integrity.
- Monitor free space and inodes.
- Repair simple filesystem issues.

### Important Commands and Files

- **du**, **df** -- check disk usage and free space.
- **fsck**, **e2fsck** -- verify and repair ext filesystems.
- **tune2fs** -- optimize ext filesystems.
- **xfs\_repair**, **xfs\_fsr**, **xfs\_db** -- maintain XFS filesystems.

## Lesson Overview

Modern Linux filesystems are journaled, reducing corruption risks. Administrators must monitor filesystem usage and repair issues as needed using tools like **fsck** and **xfs\_repair**.

## 1. Checking Disk Usage

### 1. Disk Usage Command (**du**)

- Recursive: shows directory and file sizes.
- Common options:
  - **-h**: human-readable sizes.
  - **-a**: show individual file sizes.
  - **-- exclude="PATTERN"**: exclude files matching a pattern.

### 2. Filesystem Usage Command (**df**)

- Displays filesystem-level information.
- Common options:
  - **-h**: human-readable sizes.
  - **-i**: show inode usage.
  - **-T**: display filesystem type.

## 2. Maintaining ext2/ext3/ext4 Filesystems

### 1. Filesystem Check (fsck)

- Checks for errors; calls appropriate tools like **e2fsck** for ext filesystems.
- Common options:
  - **-A**: check all filesystems in **/etc/fstab**.
  - **-N**: simulate actions without making changes.
  - **-y**: automatically answer "yes" to prompts.

### 2. Filesystem Tuning (tune2fs)

- Adjusts ext filesystem parameters.
- Common options:
  - **-l**: list filesystem parameters.
  - **-L**: set a label.
  - **-i 10d**: set time interval for checks (e.g., every 10 days).
  - **-j**: add journaling to an ext2 filesystem.

## 3. Maintaining XFS Filesystems

### 1. Filesystem Repair (xfs\_repair)

- Scans and repairs XFS filesystems.
- Common options:
  - **-n**: no modifications (scan only).
  - **-L**: zero out a corrupt log (last resort).
  - **-m N**: limit memory usage.

### 2. Filesystem Debugging (xfs\_db)

- Inspect XFS filesystem parameters interactively.

### 3. Filesystem Defragmentation (xfs\_fsr)

- Defragments mounted XFS filesystems.

## Workbook Exercises

### 1. Check Disk Usage

- Use **du** to analyze a directory.
- Exclude specific file types (e.g., **du -exclude="\*.log"**).

### 2. Monitor Filesystem Space

- Use **df -h** to review available space on mounted filesystems.
- Check inode usage with **df -i**.

### 3. Repair Filesystems

- Simulate repairs on `/dev/sdX1` with `fsck -N /dev/sdX1`.
- Repair an ext4 filesystem interactively using `e2fsck /dev/sdX1`.

### 4. Tune Filesystem Parameters

- Set a maximum mount count of 20: `tune2fs -c 20 /dev/sdX1`.
- Assign a label: `tune2fs -L MyDisk /dev/sdX1`.

### 5. Maintain XFS Filesystems

- Scan for issues using `xfs_repair -n /dev/sdX1`.
- Defragment using `xfs_fsr /dev/sdX1`.

## Summary

- Use `du` and `df` to monitor disk usage and free space.
- Repair ext filesystems with `fsck` and tune parameters with `tune2fs`.
- For XFS filesystems, rely on `xfs_repair` and `xfs_fsr` for maintenance.

## Multiple-Choice Questions for 104.2

1. Which command displays disk usage in a human-readable format?
  - A) `df`
  - B) `fsck`
  - C) `tune2fs`
  - D) `du -h`
2. What parameter is used with the `du` command to include a total summary in the output?
  - A) `-t`
  - B) `-a`
  - C) `-d`
  - D) `-c`
3. Which command is used to check free space at the filesystem level?
  - A) `du`
  - B) `tune2fs`
  - C) `df`
  - D) `xfs_repair`
4. What does the `-T` option in the `df` command display?
  - A) Disk usage per user
  - B) File system inode details
  - C) Total disk space used
  - D) File system type
5. What is the recommended utility for repairing XFS file systems?
  - A) `tune2fs`
  - B) `fsck`
  - C) `df`
  - D) `xfs_repair`
6. What is the `fsck` utility primarily used for?
  - A) Monitoring free space
  - B) Listing mounted filesystems
  - C) Checking and repairing filesystems
  - D) Defragmenting filesystems
7. What does the `-y` option do in `e2fsck`?
  - A) Automatically answers "no" to all prompts
  - B) Displays verbose output
  - C) Runs checks on mounted filesystems
  - D) Automatically answers "yes" to all prompts



8. Which command adjusts parameters of ext2, ext3, and ext4 filesystems?
- A) `df`
  - B) `du`
  - C) `tune2fs`
  - D) `xfs_db`
9. What does the `-j` option in `tune2fs` do?
- A) Enables verbose logging
  - B) Displays filesystem parameters
  - C) Creates a journal for the filesystem
  - D) Converts ext4 to ext2
10. What should you avoid when using `fsck`?
- A) Running it on mounted filesystems
  - B) Using it with ext4 filesystems
  - C) Specifying filesystem types
  - D) Viewing verbose output
11. Which command can be used to exclude tmpfs filesystems in `df` output?
- A) `df -x tmpfs`
  - B) `df -T tmpfs`
  - C) `df -h tmpfs`
  - D) `df -t tmpfs`
12. What parameter forces `e2fsck` to check a clean filesystem?
- A) `-f`
  - B) `-p`
  - C) `-y`
  - D) `-n`
13. Which `tune2fs` option defines the maximum number of mounts before a filesystem check is forced?
- A) `-c`
  - B) `-C`
  - C) `-f`
  - D) `-L`
14. What is the output of `xfs_repair -n`?
- A) Displays file contents
  - B) Checks for errors without modifying the filesystem
  - C) Repairs the filesystem
  - D) Lists all filesystems
15. Which option in `xfs_repair` zeroes out a corrupt log?
- A) `-m`

- B) -L
  - C) -v
  - D) -d
16. What does the **-R** option in **fsck** do?
- A) Checks all mounted filesystems
  - B) Ignores user prompts
  - C) Skips the root filesystem when used with **-A**
  - D) Verbose mode
17. Which command is used to debug XFS filesystems?
- A) **xfs\_repair**
  - B) **xfs\_db**
  - C) **xfs\_fsr**
  - D) **xfs\_check**
18. What does the **-h** option in **du** and **df** commands provide?
- A) File counts
  - B) Human-readable sizes
  - C) Usage in blocks
  - D) Help information
19. What is the **-p** option in **e2fsck** used for?
- A) Interactive mode
  - B) Previews filesystem changes
  - C) Automatically fixes errors
  - D) Displays inode information
20. Which command reorganizes an XFS filesystem to reduce fragmentation?
- A) **xfs\_repair**
  - B) **xfs\_db**
  - C) **fsck**
  - D) **xfs\_fsr**

## Fill-in-the-Blank Questions for 104.2

1. The \_\_\_\_\_ command is used to recursively display disk usage for directories and subdirectories.
2. To check free space and inode usage on a filesystem, the \_\_\_\_\_ command is used.
3. The `-h` option in both `du` and `df` commands stands for \_\_\_\_\_ output.
4. The utility used to check and repair `ext2`, `ext3`, and `ext4` filesystems is \_\_\_\_\_.
5. The parameter \_\_\_\_\_ in `e2fsck` automatically fixes all errors without user interaction.
6. The \_\_\_\_\_ command allows tuning of `ext2`, `ext3`, and `ext4` filesystem parameters.
7. The \_\_\_\_\_ command repairs `XFS` filesystems and should not be run on mounted filesystems.
8. The `-exclude="PATTERN"` option in the \_\_\_\_\_ command omits specific files or directories from the output.
9. The `-T` option in the `df` command displays the type of the \_\_\_\_\_ being used by the filesystem.
10. The \_\_\_\_\_ command can be used to defragment `XFS` filesystems.

## 104.3 Control mounting and unmounting of filesystems

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 104.3
- Weight: 3

### Key Knowledge Areas

- Manually mount and unmount filesystems.
- Configure filesystem mounting at boot.
- Use labels and UUIDs for mounting filesystems.
- Awareness of systemd mount units.

### Important Commands and Files

- **mount**, **umount** -- mount and unmount filesystems.
- **blkid**, **lsblk** -- query disk information (UUIDs, labels, etc.).
- **/etc/fstab** -- configure persistent mounts.

## Lesson Overview

Linux requires filesystems to be mounted before access. Mounting can be done manually, automatically at boot, or managed dynamically using tools like **systemd**.

## 1. Mounting and Unmounting Filesystems

### 1. Manual Mounting (**mount**)

- Syntax: **mount -t TYPE DEVICE MOUNTPOINT**.
- Options:
  - **-r**: read-only.
  - **-o**: specify mount options (e.g., **noexec**, **ro**).

### 2. Unmounting (**umount**)

- Syntax: **umount DEVICE or MOUNTPOINT**.
- Options:
  - **-f**: force unmount.
  - **-a**: unmount all filesystems in **/etc/fstab**.

### 3. Handling Busy Filesystems

- Use **lsof DEVICE** to find open files.

## 2. Persistent Mounts with /etc/fstab

### 1. /etc/fstab Format

- Fields:
  - **FILESYSTEM**: Device, UUID, or label.
  - **MOUNTPOINT**: Where to mount.
  - **TYPE**: Filesystem type.
  - **OPTIONS**: Comma-separated mount options.
  - **DUMP**: Backup indicator (0 to ignore).
  - **PASS**: Check order during boot (0 to skip).

### 2. Examples

```
UUID=1234-5678 / ext4 defaults 0 1
LABEL=BackupDisk /mnt/backup ext4 noauto,user 0 2
```

## 3. Using UUIDs and Labels

### 1. Finding UUIDs and Labels

- Use `blkid` or `lsblk -f`.

### 2. Mounting by UUID or Label

Example:

```
mount UUID=1234-5678 /mnt/data
```

## 4. Mounting with systemd

### 1. Mount Units

Configuration file (`.mount`) example:

```
[Unit]
Description=External Data Disk

[Mount]
What=/dev/disk/by-uuid/1234-5678
Where=/mnt/data
Type=ext4

[Install]
WantedBy=multi-user.target
```

### 2. Automount Units

- Add `.automount` for on-demand mounting.

### 3. Commands

- Reload: `systemctl daemon-reload`.
- Start: `systemctl start UNIT_NAME`.
- Enable: `systemctl enable UNIT_NAME`.

## Workbook Exercises

### 1. Manual Mounting

- Mount `/dev/sdb1` to `/mnt/usb` using `mount`.
- Use `umount` to safely unmount.

### 2. Persistent Mounts

- Add an entry to `/etc/fstab` for a USB device by label.
- Test mounting with `mount -a`.

### 3. UUID Usage

- Find the UUID of a device using `blkid`.
- Use it to mount a disk.

### 4. Systemd Mount Units

- Create a `.mount` unit for `/mnt/external`.
- Enable automounting with `.automount`.

## Summary

- Filesystems must be mounted to access their contents.
- Use `/etc/fstab` for persistent mounting, with UUIDs or labels for reliable identification.
- `systemd` provides a flexible approach for managing mounts dynamically or on-demand.

## Multiple-Choice Questions for 104.3

1. Which command is used to manually mount a filesystem in Linux?
  - A) `mount`
  - B) `umount`
  - C) `blkid`
  - D) `lsblk`
2. Which command is used to unmount a filesystem?
  - A) `mount`
  - B) `unmount`
  - C) `umount`
  - D) `lsblk`
3. What does the `-t` option specify in the `mount` command?
  - A) The device name
  - B) The mount point
  - C) The options to be passed
  - D) The filesystem type
4. What does the `~` symbol represent in a mount point path?
  - A) The current user's home directory
  - B) The root directory
  - C) The system boot directory
  - D) The `/media` directory
5. What file contains the configuration for mounting filesystems during boot?
  - A) `/media/USER/LABEL`
  - B) `/mnt`
  - C) `/dev/UUID`
  - D) `/etc/fstab`
6. What does the `-o` option do in the `mount` command?
  - A) Mount all filesystems listed in `/etc/fstab`
  - B) Pass mount options as a comma-separated list
  - C) Mount the filesystem as read-only
  - D) Mount the filesystem as writable
7. Which parameter forces the unmounting of a filesystem?
  - A) `-f`
  - B) `-a`
  - C) `-r`
  - D) `-w`

8. Which command can be used to check which processes are accessing a filesystem?
- A) `lsof`
  - B) `ps`
  - C) `top`
  - D) `kill`
9. What is the default mount point for user-removable devices in modern Linux systems?
- A) `/media`
  - B) `/mnt`
  - C) `/dev`
  - D) `/home`
10. Which option in `/etc/fstab` specifies whether a filesystem should be considered for backup?
- A) `TYPE`
  - B) `MOUNTPOINT`
  - C) `OPTIONS`
  - D) `DUMP`
11. What does the `noatime` option do when mounting a filesystem?
- A) Enables access time updates
  - B) Disables access time updates
  - C) Enables write permissions
  - D) Disables write permissions
12. How can you specify a device by its UUID in the `mount` command?
- A) Use `-u` option
  - B) Use `UUID=` option
  - C) Use `-t UUID`
  - D) Use `-uuid`
13. Which command lists all block devices along with their filesystem labels and UUIDs?
- A) `blkid -u`
  - B) `mount -f`
  - C) `lsblk -o`
  - D) `lsblk -f`
14. What is the purpose of the `systemctl daemon-reload` command?
- A) Reload the kernel
  - B) Reload systemd configuration files
  - C) Restart all running services
  - D) Reload mount units
15. What is the recommended directory for manually mounting filesystems?
- A) `/dev`



- B) `/home`
  - C) `/mnt`
  - D) `/media`
16. What should the filename of a systemd mount unit match?
- A) The mount point
  - B) The UUID of the device
  - C) The label of the filesystem
  - D) The partition type
17. What does the `defaults` option in `/etc/fstab` imply?
- A) Read-write, auto-mount, async
  - B) Read-only, user-mount, sync
  - C) No-execute, auto-mount, async
  - D) Read-write, no-auto, async
18. Which option allows a user to mount a filesystem?
- A) `noexec`
  - B) `user`
  - C) `nouser`
  - D) `exec`
19. Which systemd target ensures a mount unit is active in multi-user mode?
- A) `default.target`
  - B) `graphical.target`
  - C) `basic.target`
  - D) `multi-user.target`
20. How can you enable a systemd mount unit to be active at boot?
- A) Use `systemctl start`
  - B) Use `systemctl reload`
  - C) Use `systemctl enable`
  - D) Use `systemctl restart`

## Fill-in-the-Blank Questions for 104.3

1. The command used to manually mount a filesystem is \_\_\_\_\_.
2. The file \_\_\_\_\_ contains configurations for filesystems that should be mounted during system boot.
3. The \_\_\_\_\_ command is used to unmount a filesystem.
4. The \_\_\_\_\_ directory is the default location for automatically mounted user-removable devices in modern Linux systems.
5. In the `/etc/fstab` file, the field that specifies the type of filesystem is \_\_\_\_\_.
6. To list processes accessing a specific filesystem, the command \_\_\_\_\_ can be used.
7. The \_\_\_\_\_ option in the `/etc/fstab` file disables updates to the file's access time, improving I/O performance.
8. The \_\_\_\_\_ utility displays information about block devices, including labels and UUIDs, with the `-f` parameter.
9. Systemd mount units should be saved in the directory \_\_\_\_\_.
10. The command \_\_\_\_\_ is used to reload the systemd daemon configuration after editing unit files.

## 104.5 Manage file permissions and ownership

Reference to LPI Objectives:

- **LPIC-1 v5, Exam 101, Objective 104.5**
- **Weight: 3**

### Key Knowledge Areas

- Manage file and directory permissions.
- Use **suid**, **sgid**, and sticky bit for security.
- Modify file ownership and group membership.
- Configure default permissions with **umask**.

### Important Commands and Files

- **chmod** -- change file permissions.
- **chown** -- change file ownership.
- **chgrp** -- change group ownership.
- **umask** -- set default file permissions.

## Lesson Overview

Linux files are secured using a permission system that controls read, write, and execute access for the file owner, group, and others. Special permissions such as **suid**, **sgid**, and the sticky bit enhance functionality and security.

## 1. File and Directory Permissions

### 1. Permission Groups

- **Owner (u)**: User who owns the file.
- **Group (g)**: Users in the file's group.
- **Others (o)**: All other users.

### 2. Permission Types

- **r**: Read (4).
- **w**: Write (2).
- **x**: Execute (1).

### 3. Examples

- **rw-r--r--**: Read/write for owner, read-only for group and others.
- Use **ls -l** to view permissions.

## 2. Changing Permissions

### 1. Symbolic Mode (`chmod`)

- Grant write to group: `chmod g+w file.txt`.
- Remove execute for all: `chmod a-x file.txt`.

### 2. Octal Mode (`chmod`)

- Set `rw-r--r--`: `chmod 644 file.txt`.
- Recursive change: `chmod -R 755 dir/`.

## 3. Special Permissions

### 1. Sticky Bit (`chmod +t`)

- Restricts deletion in directories.
- Example: `chmod 1777 /tmp`.

### 2. Set Group ID (SGID, `chmod g+s`)

- Files inherit group of the parent directory.

### 3. Set User ID (SUID, `chmod u+s`)

- Processes run with the owner's privileges.

## 4. File Ownership

### 1. Change Ownership (`chown`)

- Example: `chown user:group file.txt`.

### 2. Change Group (`chgrp`)

- Example: `chgrp group file.txt`.

### 3. Query Groups

- List all groups: `getent group`.
- Show user's groups: `groups username`.

## 5. Default Permissions with `umask`

### 1. Default Permissions

- Files: `rw-r--r--` (644).
- Directories: `rwxr-xr-x` (755).

## 2. Changing umask

- Example: `umask 0027` (removes write for group and all for others).

## Workbook Exercises

### 1. Modify Permissions

- Create a file, view permissions, and set them to `rw-r--r--` using `chmod`.

### 2. Test Special Permissions

- Add sticky bit to a directory and verify with `ls -ld`.
- Apply SGID to a directory and check group inheritance.

### 3. Change Ownership

- Use `chown` and `chgrp` to modify file ownership and group.

### 4. Configure umask

- Experiment with different `umask` values and observe changes in default permissions.

## Summary

- Use `chmod` to adjust file and directory permissions.
- Apply special permissions like `suid`, `sgid`, and sticky bit for added control.
- Modify ownership with `chown` and `chgrp`.
- Control default permissions with `umask`.

## Multiple-Choice Questions for 104.5

1. Which command is used to view detailed information about files and directories?
  - A) `ls -a`
  - B) `ls -h`
  - C) `ls -l`
  - D) `ls -s`
2. What does the first character in the `ls -l` output represent?
  - A) Permissions
  - B) File owner
  - C) File type
  - D) File size
3. In the `ls -l` output, what does `r-` signify?
  - A) Read and execute permissions
  - B) Read-only permissions
  - C) No write or execute permissions
  - D) Read, write, and execute permissions
4. Which permission is required to list files in a directory?
  - A) Execute
  - B) Write
  - C) Modify
  - D) Read
5. What does the sticky bit do when applied to a directory?
  - A) Prevents deletion of files by non-owners
  - B) Grants execute permission to all users
  - C) Allows only the owner to rename files
  - D) Limits read access to the directory
6. Which command is used to change the owner of a file?
  - A) `chown`
  - B) `chmod`
  - C) `umask`
  - D) `touch`
7. What does the command `chmod u+x file.sh` do?
  - A) Removes execute permission for the user
  - B) Adds read permission for the group
  - C) Adds execute permission for all users
  - D) Adds execute permission for the user

8. What is the symbolic representation for a file permission of 640?
- A) `rwX---`
  - B) `rw-r-r-`
  - C) `rw-r---`
  - D) `rwXr-r-`
9. Which command will recursively modify permissions for all files in a directory?
- A) `chmod -R`
  - B) `chmod -a`
  - C) `chmod -h`
  - D) `chmod -l`
10. How can you combine multiple parameters for the `ls` command?
- A) Use commas
  - B) Use semicolons
  - C) Combine them without spaces
  - D) Use brackets
11. What is the octal value of the execute permission?
- A) 4
  - B) 1
  - C) 2
  - D) 7
12. What is the default `umask` value for files with permissions `rw-r-r-`?
- A) 022
  - B) 644
  - C) 007
  - D) 755
13. Which permission is required to enter a directory?
- A) Execute
  - B) Write
  - C) Modify
  - D) Read
14. Which special permission is applied when using `chmod 4755` on a file?
- A) SGID
  - B) SUID
  - C) Sticky bit
  - D) No special permissions
15. What does the `-R` option in `chmod` do?
- A) Reverses permissions

- B) Removes permissions
  - C) Recursively applies changes
  - D) Lists permissions recursively
16. What command shows all hidden files in a directory?
- A) `ls -h`
  - B) `ls -lh`
  - C) `ls -R`
  - D) `ls -a`
17. What is the octal value of the permission set `rwxr-xr-x`?
- A) 640
  - B) 755
  - C) 622
  - D) 777
18. Which command changes a file's group ownership to `students`?
- A) `chown :students filename`
  - B) `chmod g+students filename`
  - C) `chgrp students filename`
  - D) `chmod g=students filename`
19. What does the SGID bit do for directories?
- A) Ensures all users can modify files
  - B) Sets group ownership for new files in the directory
  - C) Prevents non-owners from deleting files
  - D) Disables write permissions for others
20. Which file type is represented by the character `d` in `ls -l`?
- A) Socket
  - B) File
  - C) Directory
  - D) Symbolic link



## Fill-in-the-Blank Questions for 104.5

1. The command used to change the permissions of a file is \_\_\_\_\_.
2. To recursively modify the permissions of all files and directories, the `chmod` command must include the \_\_\_\_\_ option.
3. The octal value for the permission set `rw-r-r-` is \_\_\_\_\_.
4. The \_\_\_\_\_ command is used to change the owner of a file.
5. In symbolic mode, the character used to represent "others" when modifying permissions is \_\_\_\_\_.
6. The special permission that ensures a directory's files cannot be deleted by users who do not own them is called the \_\_\_\_\_.
7. The default permissions for newly created files are determined by the \_\_\_\_\_ value.
8. The file type for a symbolic link is represented by the character \_\_\_\_\_ in the output of `ls -l`.
9. The permission that allows a user to execute a file or enter a directory is \_\_\_\_\_.
10. The \_\_\_\_\_ command is used to view all hidden files in a directory.

## 104.6 Create and change hard and symbolic links

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 104.6
- Weight: 2

### Key Knowledge Areas

- Create hard and symbolic (soft) links.
- Understand the difference between hard and symbolic links.
- Use links effectively for system administration tasks.

### Important Commands and Files

- **ln** – create links.
- **ls** – inspect links and file information.

## Lesson Overview

Links in Linux are special file types that reference other files. Hard links point to the same inode as the target file, while symbolic links reference a file's path. Understanding links allows efficient file management and system administration.

## 1. Hard Links

### 1. Definition

- Hard links are additional names for the same file.
- All hard links share the same inode and file content.

### 2. Creating Hard Links

- Syntax: `ln TARGET LINK_NAME`.
- Example:

```
ln file.txt /path/hardlink
```

### 3. Managing Hard Links

- Use `ls -li` to view inode numbers.
- Deleting one hard link does not remove the file as long as other links exist.

## 2. Symbolic Links

### 1. Definition

- Symbolic links (soft links) point to a file path.
- Can reference files or directories, even across different filesystems.

## 2. Creating Symbolic Links

- Syntax: `ln -s TARGET LINK_NAME`.
- Example:

```
ln -s /path/target.txt softlink
```

## 3. Managing Symbolic Links

- Use `ls -lh` to view link targets.
- Broken links occur if the target is deleted or moved.

## 3. Key Differences: Hard vs. Symbolic Links

| Feature       | Hard Link                       | Symbolic Link                            |
|---------------|---------------------------------|------------------------------------------|
| Target Type   | Files only                      | Files or directories                     |
| File System   | Same filesystem only            | Can span filesystems                     |
| Dependence    | Independent of target existence | Breaks if the target is moved or deleted |
| Inode Sharing | Shares inode with target        | Separate inode                           |

## 4. Moving and Deleting Links

### 1. Hard Links

- Renaming/moving does not affect functionality.
- Deleted using `rm`.

### 2. Symbolic Links

- Relative paths can break when moved.
- Use absolute paths to avoid issues.

## Workbook Exercises

### 1. Create Links

- Create a hard link and a symbolic link to a file.
- Verify using `ls -li` and `ls -lh`.

### 2. Test Link Behavior

- Modify the file content via one link and observe changes in other links.
- Delete the original file and test the functionality of each link type.

### 3. Fix Broken Links

- Create a symbolic link with a relative path, move it, and fix it by recreating with an absolute path.

### 4. Use Links in System Administration

- Link common configuration files to shared directories for efficient updates.

## Summary

- Hard links share file content, while symbolic links reference file paths.
- Use `ln` to create links and `ls` to inspect them.
- Prefer symbolic links for flexibility, but use hard links when you need stability and redundancy.

## Multiple-Choice Questions for 104.6

1. What command is used to create a hard link in Linux?
  - A) `ln -s`
  - B) `ln`
  - C) `link`
  - D) `hardln`
2. What attribute does a hard link share with its target file?
  - A) File name
  - B) Inode number
  - C) File size
  - D) Permissions
3. What happens if you delete the original file of a hard link?
  - A) The hard link stops working.
  - B) The data remains accessible via the hard link.
  - C) Both the original file and hard link are deleted.
  - D) The file system becomes corrupted.
4. Which command parameter is used with `ln` to create symbolic links?
  - A) `-h`
  - B) `-i`
  - C) `-v`
  - D) `-s`
5. What does the inode number represent in a file system?
  - A) The size of a file
  - B) The permissions of a file
  - C) The attributes and location of a file's data
  - D) The file's last modification date
6. What is the default link count of a file in Linux?
  - A) 0
  - B) 1
  - C) 2
  - D) 3
7. What is the maximum scope for creating a hard link?
  - A) Across different file systems
  - B) Within the same file system
  - C) Between partitions
  - D) Across network file systems

8. What symbol indicates a symbolic link in `ls -lh` output?
- A) -
  - B) l
  - C) s
  - D) h
9. What happens when a symbolic link's target is deleted?
- A) The symbolic link automatically updates.
  - B) The symbolic link stops working.
  - C) The symbolic link is converted to a hard link.
  - D) Both the target and the symbolic link are deleted.
10. What does `ln -s target.txt softlink` create?
- A) A hard link named `softlink`
  - B) A symbolic link named `target.txt`
  - C) A symbolic link named `softlink`
  - D) A copy of `target.txt`
11. Which type of link allows cross-filesystem linking?
- A) Hard links
  - B) Symbolic links
  - C) Directory links
  - D) Junction points
12. What is a key difference between hard and symbolic links?
- A) Symbolic links are case-sensitive, but hard links are not.
  - B) Hard links can link directories, but symbolic links cannot.
  - C) Symbolic links can span different filesystems, but hard links cannot.
  - D) Hard links support multiple targets, but symbolic links do not.
13. What happens if a relative symbolic link is moved?
- A) It works as expected.
  - B) It breaks if the target path changes.
  - C) It changes to an absolute link.
  - D) The link is deleted automatically.
14. How can you create a hard link to a file named `file.txt` in the current directory?
- A) `ln -h file.txt`
  - B) `ln file.txt file_link`
  - C) `ln -i file.txt`
  - D) `ln -s file.txt file_link`
15. What file attribute is increased when a hard link is created?
- A) Inode number

- B) Link count
  - C) File permissions
  - D) File size
16. Which command shows the inode number of files?
- A) `ls -h`
  - B) `ln -i`
  - C) `ls -li`
  - D) `stat -i`
17. What happens when you use `mv` on a hard link?
- A) It breaks the link.
  - B) The link is moved, but its function remains unchanged.
  - C) It converts to a symbolic link.
  - D) The link stops pointing to the inode.
18. What is indicated by the output `lrwxrwxrwx` for a file in `ls -l`?
- A) A directory
  - B) A hard link
  - C) A symbolic link
  - D) A special file
19. What happens if you use `rm` on a symbolic link?
- A) Both the link and its target are deleted.
  - B) Only the symbolic link is deleted.
  - C) The target file is renamed.
  - D) The link converts to a hard link.
20. What command would create a symbolic link to `/etc/fstab` called `mylink`?
- A) `ln -h /etc/fstab mylink`
  - B) `ln /etc/fstab mylink`
  - C) `ln -s /etc/fstab mylink`
  - D) `link /etc/fstab mylink`

## Fill-in-the-Blank Questions for 104.6

1. A hard link is an additional entry in the filesystem that points to the same \_\_\_\_\_ as the target file.
2. The command to create a symbolic link is `ln` with the \_\_\_\_\_ option.
3. In the output of the `ls -li` command, the number before the file permissions represents the \_\_\_\_\_ number.
4. A symbolic link can point to files or directories, even across different \_\_\_\_\_.
5. To create a hard link, the \_\_\_\_\_ file must already exist.
6. When you delete a hard link, the data remains accessible if there is at least one other \_\_\_\_\_ pointing to the same inode.
7. The permissions displayed for a symbolic link in `ls` output always show \_\_\_\_\_ for all users.
8. The relative path of a symbolic link is interpreted as relative to the location of the \_\_\_\_\_.
9. Hard links cannot be created for \_\_\_\_\_, and both the link and target must reside on the same filesystem.
10. The `ln target.txt linkname` command creates a \_\_\_\_\_ link to the target file.



## 104.7 Find system files and place files in the correct location

Reference to LPI Objectives:

- LPIC-1 v5, Exam 101, Objective 104.7
- Weight: 2

### Key Knowledge Areas

- Understand the Filesystem Hierarchy Standard (FHS).
- Locate files and commands in a Linux system.
- Know the location and purpose of important directories.

### Important Commands and Files

- **find** – locate files with advanced search options.
- **locate**, **updatedb** – search files using a prebuilt database.
- **which**, **type**, **whereis** – find commands, binaries, and manuals.
- **/etc/updatedb.conf** – configuration for **updatedb**.

## Lesson Overview

The Filesystem Hierarchy Standard (FHS) defines a standardized directory structure for Linux, enabling consistent placement of system files. Tools like **find**, **locate**, and **which** assist in locating files and commands.

## 1. Filesystem Hierarchy Standard (FHS)

### 1. Common Directories

- **/**: Root directory, the base of the filesystem.
- **/bin**: Essential binaries for all users.
- **/etc**: Host-specific configuration files.
- **/var**: Variable data (logs, print queues, etc.).
- **/tmp**, **/var/tmp**: Temporary files.

### 2. Temporary Files

- **/tmp**: Cleared at boot, short-lived.
- **/var/tmp**: Persistent across reboots.
- **/run**: Runtime process data (cleared at boot).

## 2. Finding Files

### 1. Using find

- Syntax: `find START_DIR -name PATTERN`.
- Common options:
  - **-name**: Case-sensitive search.
  - **-iname**: Case-insensitive search.
  - **-perm**: Search by permissions.
  - **-size**: Search by file size (e.g., +1M).
  - **-mtime**/**-atime**: Search by modification/access time.

### 2. Using locate

- Faster than `find`, uses a database updated by `updatedb`.
- Syntax: `locate PATTERN`.
- Update database: `sudo updatedb`.

### 3. Other Commands

- **which**: Find executable in `PATH`.
- **type**: Show command type and location.
- **whereis**: Locate binaries, manuals, and source code.

## Workbook Exercises

### 1. Search Files with find

- Find all `.txt` files in `/home`:

```
find /home -name "*.txt"
```

- Locate files modified in the last 24 hours:

```
find / -mtime -1
```

### 2. Use locate for Quick Searches

- Search for `.jpg` files:

```
locate -i .jpg
```

- Update the database and repeat the search.

### 3. Identify Commands

- Locate the `bash` binary:

```
which bash
```

- Find the location of `ls` with manuals:

```
whereis ls
```

## Summary

- Use the FHS to understand file locations in Linux.
- Use `find` for deep searches, `locate` for quick results, and `which/whereis` for commands and binaries.
- Configure `updatedb` for efficient `locate` searches.

## Multiple-Choice Questions for 104.7

1. What is the root directory of the filesystem hierarchy in Linux?
  - A) `/home`
  - B) `/root`
  - C) `/boot`
  - D) `/`
2. Which directory contains host-specific configuration files?
  - A) `/usr`
  - B) `/etc`
  - C) `/var`
  - D) `/tmp`
3. What is the purpose of the `/dev` directory?
  - A) Contains essential binaries
  - B) Contains device files
  - C) Stores temporary files
  - D) Contains user home directories
4. Which directory is the home directory for the superuser?
  - A) `/root`
  - B) `/home`
  - C) `/etc`
  - D) `/usr`
5. Where are removable media devices, such as flash drives, typically mounted?
  - A) `/tmp`
  - B) `/media`
  - C) `/mnt`
  - D) `/run`
6. Which directory stores shared libraries required to boot the system?
  - A) `/lib`
  - B) `/usr`
  - C) `/boot`
  - D) `/var`
7. What is the purpose of the `/var/tmp` directory?
  - A) Temporary files that persist between reboots
  - B) Files related to running processes
  - C) Variable data written during system operation
  - D) Temporary files erased during boot-up

8. Which command is used to locate the binary for a specific command?
  - A) `whereis`
  - B) `locate`
  - C) `which`
  - D) `find`
9. Which file controls the behavior of the `updatedb` command?
  - A) `/etc/updatedb`
  - B) `/var/updatedb`
  - C) `/etc/updatedb.conf`
  - D) `/usr/updatedb.conf`
10. What is the purpose of the `-iname` parameter in the `find` command?
  - A) Limits the search depth
  - B) Performs a case-insensitive search
  - C) Matches executable files only
  - D) Matches empty files and directories
11. Which of the following matches files that are executable by the current user?
  - A) `-readable`
  - B) `-empty`
  - C) `-executable`
  - D) `-perm`
12. What does the `locate` command rely on to perform its searches?
  - A) Filesystem metadata
  - B) A pre-built database
  - C) Real-time file system scanning
  - D) System logs
13. What is the effect of the `-c` option in the `locate` command?
  - A) Searches case-insensitively
  - B) Counts matching files
  - C) Checks file existence before displaying
  - D) Limits the search depth
14. What does the `type` command display?
  - A) The type and location of a binary
  - B) A list of file types
  - C) The permissions of a file
  - D) The contents of the `PATH` variable
15. Which directory is reserved for application software packages?
  - A) `/srv`

- B) `/usr`
  - C) `/lib`
  - D) `/opt`
16. What does the `-size` parameter in the `find` command match?
- A) Files with a specific owner
  - B) Files of a specified size
  - C) Files of a specific type
  - D) Files with a specific name
17. Which `find` parameter searches for files that have been accessed 10 days ago?
- A) `-cmin`
  - B) `-amin`
  - C) `-atime`
  - D) `-mtime`
18. What command shows all paths to an executable?
- A) `locate`
  - B) `whereis`
  - C) `which -a`
  - D) `find`
19. What parameter prevents the `find` command from searching in mounted filesystems?
- A) `-maxdepth`
  - B) `-mount`
  - C) `-fstype`
  - D) `-iname`
20. Which directory is cleared during system boot-up by default?
- A) `/tmp`
  - B) `/var/tmp`
  - C) `/run`
  - D) `/media`

## Fill-in-the-Blank Questions for 104.7

1. The directory that serves as the root of the filesystem hierarchy in Linux is represented as \_\_\_\_\_.
2. The \_\_\_\_\_ directory contains host-specific configuration files for programs.
3. Temporary files that persist across reboots are stored in the \_\_\_\_\_ directory.
4. The command \_\_\_\_\_ is used to find the full path of an executable file on the system.
5. The \_\_\_\_\_ file controls the behavior of the `updatedb` command and allows you to configure ignored filesystems and paths.
6. Files under the \_\_\_\_\_ directory are used to store user-specific data and configurations.
7. The \_\_\_\_\_ command is used to search for files based on attributes like permissions, size, and last access time.
8. In the Filesystem Hierarchy Standard, device files such as `/dev/sda` are located in the \_\_\_\_\_ directory.
9. To search for files case-insensitively using the `find` command, the parameter \_\_\_\_\_ is used.
10. The directory \_\_\_\_\_ is used for user-mountable removable media, such as USB drives.

## Chapter 5

### Topic 105: Shells and Shell Scripting



## 105.1 Customize and use the shell environment

## Multiple-Choice Questions for 105.1

## Fill-in-the-Blank Questions for 105.1

## 105.2 Customize or write simple scripts

## Multiple-Choice Questions for 105.2

## Fill-in-the-Blank Questions for 105.2

## Chapter 6

### Topic 106: User Interfaces and Desktops

## 106.1 Install and configure X11



## Multiple-Choice Questions for 106.1

## Fill-in-the-Blank Questions for 106.1

## 106.2 Graphical Desktops

## Multiple-Choice Questions for 106.2

## Fill-in-the-Blank Questions for 106.2

## 106.3 Accessibility

## Multiple-Choice Questions for 106.3

## Fill-in-the-Blank Questions for 106.3



## Chapter 7

### Topic 107: Administrative Tasks

## 107.1 Manage user and group accounts and related system files

## Multiple-Choice Questions for 107.1

## Fill-in-the-Blank Questions for 107.1

## 107.2 Automate system administration tasks by scheduling jobs

## Multiple-Choice Questions for 107.2

## Fill-in-the-Blank Questions for 107.2

## 107.3 Localisation and internationalisation



## Multiple-Choice Questions for 107.3

## Fill-in-the-Blank Questions for 107.3

## Chapter 8

### Topic 108: Essential System Services

## 108.1 Maintain system time

## Multiple-Choice Questions for 108.1

## Fill-in-the-Blank Questions for 108.1

## 108.2 System logging

## Multiple-Choice Questions for 108.2



## Fill-in-the-Blank Questions for 108.2

## 108.3 Mail Transfer Agent (MTA) basics

## Multiple-Choice Questions for 108.3

## Fill-in-the-Blank Questions for 108.3

## 108.4 Manage printers and printing

## Multiple-Choice Questions for 108.4

## Fill-in-the-Blank Questions for 108.4

## Chapter 9

### Topic 109: Networking Fundamentals



## 109.1 Fundamentals of internet protocols

## Multiple-Choice Questions for 109.1

## Fill-in-the-Blank Questions for 109.1

## 109.2 Persistent network configuration

## Multiple-Choice Questions for 109.2

## Fill-in-the-Blank Questions for 109.2

## 109.3 Basic network troubleshooting

## Multiple-Choice Questions for 109.3



## Fill-in-the-Blank Questions for 109.3

## 109.4 Configure client side DNS

## Multiple-Choice Questions for 109.4

## Fill-in-the-Blank Questions for 109.4

## Chapter 10

### Topic 110: Security

## 110.1 Perform security administration tasks

## Multiple-Choice Questions for 110.1

## Fill-in-the-Blank Questions for 110.1



## 110.2 Setup host security

## Multiple-Choice Questions for 110.2

## Fill-in-the-Blank Questions for 110.2

## 110.3 Securing data with encryption

## Multiple-Choice Questions for 110.3

## Fill-in-the-Blank Questions for 110.3

# Answers

## Topic 101: System Architecture

### 101.1 Determine and Configure Hardware Settings

#### Multiple-Choice Questions (101.1)

1. A
2. C
3. D
4. B
5. A
6. B
7. C
8. A
9. C
10. B
11. B
12. C
13. C
14. D
15. B
16. C
17. C
18. C
19. D
20. C

### **Fill-in-the-Blank Questions (101.1)**

1. BIOS
2. lsmod
3. driver
4. udev
5. /proc
6. BIOS
7. SCSI
8. modprobe
9. /etc/modprobe.d
10. lsusb

### **101.2 Boot the System**

#### **Multiple-Choice Questions (101.2)**

1. C
2. A
3. D
4. B
5. A
6. C
7. B
8. B
9. B
10. D
11. C
12. C
13. D
14. A
15. D
16. A
17. D
18. C
19. A
20. B



### **Fill-in-the-Blank Questions (101.2)**

1. BIOS, UEFI
2. 440, MBR
3. EFI System Partition (ESP)
4. init
5. Kernel parameters
6. regenerate
7. kernel ring buffer
8. POST (Power-On Self-Test)
9. inittab
10. daemon

### **101.3 Change Runlevels / Boot Targets and Shutdown or Reboot System**

#### **Multiple-Choice Questions (101.3)**

1. A
2. A
3. B
4. C
5. A
6. C
7. D
8. B
9. C
10. A
11. B
12. D
13. C
14. A
15. B
16. D
17. C
18. B
19. A
20. D

### Fill-in-the-Blank Questions (101.3)

1. `/etc/inittab`
2. `telinit 1` or `telinit s`
3. `telinit q`
4. `/etc/init.d/`
5. `unit`
6.
  - `multi-user.target`
  - `graphical.target`
  - (Any valid `systemd` target name is acceptable here.)
7. `isolate`
8. `systemd`
9. `wall`
10. `shutdown`

### Topic 102: Linux Installation and Package Management

1. D
2. B
3. C
4. A
5. D
6. A
7. B
8. C
9. A
10. D
11. B
12. D
13. A
14. C
15. B
16. D
17. C
18. D
19. B
20. A

## **102.1 Design Hard Disk Layout**

### **Multiple-Choice Questions (102.1)**

1. C
2. A
3. D
4. B
5. B
6. D
7. A
8. C
9. B
10. C
11. A
12. D
13. C
14. B
15. D
16. A
17. D
18. C
19. B
20. A

### **Fill-in-the-Blank Questions (102.1)**

1. /home
2. /boot
3. partition
4. EFI System (or EFI System Partition / ESP)
5. mkswap
6. /var
7. mounting
8. Volume Group (VG)
9. swap file
10. LVM (Logical Volume Management)

## **102.2 Install a Boot Manager**

### **Multiple-Choice Questions (102.2)**

1. D
2. B
3. C
4. A
5. D
6. C
7. B
8. B
9. D
10. D
11. A
12. B
13. C
14. A
15. D
16. A
17. B
18. A
19. C
20. C

### **Fill-in-the-Blank Questions (102.2)**

1. boot loader
2. Master Boot Record (MBR)
3. vmlinuz
4. initrd.img (or initial RAM disk)
5. System.map
6. /etc/default/grub
7. update-grub (or grub-mkconfig)
8. /boot
9. /boot/grub/menu.lst
10. chainloading

## **102.3 Manage Shared Libraries**

### **Multiple-Choice Questions (102.3)**

#### **Fill-in-the-Blank Questions (102.3)**

1. ldd
2. LD\_LIBRARY\_PATH
3. /etc/ld.so.conf.d
4. static
5. LD\_LIBRARY\_PATH
6. soname
7. ldconfig
8. sudo ldconfig
9. shared libraries
10. .a

## **102.4 Use Debian Package Management**

### **Multiple-Choice Questions (102.4)**

1. D
2. C
3. D
4. B
5. C
6. B
7. C
8. D
9. A
10. B
11. A
12. A
13. D
14. A
15. D
16. A
17. B
18. C
19. B
20. C

### **Fill-in-the-Blank Questions (102.4)**

1. selections
2. sources
3. -f
4. information
5. cache
6. files
7. #
8. cache
9. clean
10. purge

### **102.5 Use RPM and YUM Package Management**

#### **Multiple-Choice Questions (102.5)**

1. B
2. D
3. A
4. C
5. D
6. B
7. A
8. A
9. C
10. B
11. D
12. B
13. A
14. D
15. C
16. D
17. B
18. A
19. C
20. C

### **Fill-in-the-Blank Questions (102.5)**

1. -e
2. apt
3. search, se
4. remove
5. /etc/yum.conf
6. all
7. check-update
8. info
9. dnf
10. -ql

### **102.6 Linux as a virtualization guest**

#### **Multiple-Choice Questions (102.6)**

1. D
2. C
3. D
4. D
5. A
6. D
7. D
8. C
9. B
10. B
11. B
12. C
13. B
14. A
15. A
16. B
17. C
18. C
19. A
20. A

### **Fill-in-the-Blank Questions (102.6)**

1. hypervisor
2. paravirtualized
3. qcow2
4. /etc/libvirt/qemu
5. dbus-uuidgen --ensure
6. /etc/machine-id
7. template
8. cloud-init
9. VirtualBox
10. Live migration

## **Topic 103: GNU and Unix Commands**

### **103.1 Work on the command line**

#### **Multiple-Choice Questions (103.1)**

1. D
2. B
3. D
4. C
5. B
6. A
7. A
8. A
9. B
10. B
11. B
12. A
13. C
14. B
15. B
16. D
17. A
18. D
19. D
20. D



### **Fill-in-the-Blank Questions (103.1)**

1. man
2. apropos
3. history
4. PATH
5. pwd
6. exit
7. echo
8. hash
9. .bash\_history
10. unset

### **103.2 Process text streams using filters**

#### **Multiple-Choice Questions (103.2)**

1. D
2. A
3. C
4. A
5. B
6. A
7. D
8. C
9. D
10. C
11. D
12. A
13. B
14. C
15. B
16. C
17. A
18. B
19. B
20. D

### **Fill-in-the-Blank Questions (103.2)**

1. zcat
2. grep
3. head
4. sed
5. »
6. md5sum
7. grep
8. less
9. bzip2
10. sha256sum

### **103.3 Perform basic file management**

#### **Multiple-Choice Questions (103.3)**

1. A
2. C
3. A
4. B
5. D
6. D
7. A
8. B
9. A
10. A
11. C
12. D
13. C
14. A
15. C
16. D
17. B
18. B
19. A
20. B

### **Fill-in-the-Blank Questions (103.3)**

1. mv
2. cp
3. ?
4. find
5. -cvf
6. -x
7. rmdir
8. tar archive
- 9.
10. gunzip

### **103.4 Use streams, pipes and redirects**

#### **Multiple-Choice Questions (103.4)**

1. C
2. D
3. A
4. B
5. B
6. B
7. C
8. C
9. C
10. C
11. A
12. C
13. B
14. A
15. B
16. B
17. B
18. A
19. C
20. B

### Fill-in-the-Blank Questions (103.4)

1. |
2. \$()
3. tee
4. -print0
5. -I
6. uniq
7. -a
8. 2>&1
9. sort -n
10. -exec

### 103.5 Create, monitor and kill processes

#### Multiple-Choice Questions (103.5)

1. B
2. A
3. C
4. A
5. D
6. C
7. A
8. B
9. B
10. B
11. C
12. C
13. A
14. C
15. D
16. B
17. B
18. B
19. D
20. B

### **Fill-in-the-Blank Questions (103.5)**

1. &
2. nohup.out
3. kill
4. fg
5. watch
6. Ctrl + b
7. screen -S
8. d
9. /.tmux.conf
10. %

### **103.6 Modify process execution priorities**

#### **Multiple-Choice Questions (103.6)**

1. B
2. C
3. C
4. C
5. D
6. B
7. D
8. A
9. C
10. B
11. A
12. A
13. C
14. D
15. B
16. C
17. C
18. C
19. A
20. C

**Fill-in-the-Blank Questions (103.6)**

1. nice
2. renice
3. 100, 139
4. 0, 99
5. 0
6. NI
7. nice
8. r
9. higher
10. root

**103.7 Search text files using regular expressions****Multiple-Choice Questions (103.7)**

1. A
2. B
3. C
4. B
5. B
6. C
7. D
8. D
9. A
10. B
11. A
12. C
13. C
14. A
15. D
16. C
17. B
18. D
19. D
20. D

### **Fill-in-the-Blank Questions (103.7)**

1. ^
2. [:print:]
3. |
4. +
5. -regextype posix-extended
6. sed
7. -i
8. egrep
9. -c
10. d

### **103.8 Basic file editing**

#### **Multiple-Choice Questions (103.8)**

1. C
2. C
3. A
4. C
5. C
6. B
7. B
8. B
9. D
10. B
11. B
12. C
13. A
14. D
15. C
16. B
17. C
18. B
19. B
20. A

### **Fill-in-the-Blank Questions (103.8)**

1. `vi +15`
2. `:wq`
3. insert mode
4. `dd`
5. `u`
6. `?`
7. `r`
8. `~/vimrc`
9. Meta-U
10. EDITOR

## **Topic 104: Devices, Linux Filesystems, Filesystem Hierarchy Standard**

### **104.1 Create partitions and filesystems**

#### **Multiple-Choice Questions (104.1)**

1. D
2. C
3. B
4. A
5. C
6. B
7. A
8. A
9. D
10. C
11. C
12. A
13. B
14. B
15. D
16. B
17. B



18. B
19. B
20. C

#### **Fill-in-the-Blank Questions (104.1)**

1. 4
2. n
3. 82
4. 128 or more
5. mkfs.ext4 -n
6. mkfs.btrfs
7. mklabel
8. subvolume
9. mkfs.vfat
10. mkswap

#### **104.2 Maintain the integrity of filesystems**

##### **Multiple-Choice Questions (104.2)**

1. D
2. A
3. C
4. D
5. D
6. C
7. D
8. C
9. C
10. A
11. A
12. A
13. A
14. B
15. B
16. C

17. B
18. B
19. C
20. D

#### **Fill-in-the-Blank Questions (104.2)**

1. du
2. df
3. human-readable
4. e2fsck
5. -y
6. tune2fs
7. xfs\_repair
8. du
9. filesystem
10. xfs\_fsr

### **104.3 Control mounting and unmounting of filesystems**

#### **Multiple-Choice Questions (104.3)**

1. A
2. C
3. D
4. A
5. D
6. B
7. A
8. A
9. A
10. D
11. B
12. B
13. D
14. B
15. C

16. A
17. A
18. B
19. D
20. C

#### **Fill-in-the-Blank Questions (104.3)**

1. mount
2. /etc/fstab
3. umount
4. /media
5. fs\_type
6. lsof
7. noatime
8. blkid
9. /etc/systemd/system
10. systemctl daemon-reload

### **104.5 Manage file permissions and ownership**

#### **Multiple-Choice Questions (104.5)**

1. C
2. A
3. B
4. D
5. C
6. A
7. D
8. C
9. A
10. C
11. B
12. C
13. A
14. B

15. C
16. D
17. B
18. B
19. C
20. C

#### **Fill-in-the-Blank Questions (104.5)**

1. chmod
2. -R
3. 644
4. chown
5. o
6. sticky bit
7. umask
8. l
9. execute
10. ls -a

#### **104.6 Create and change hard and symbolic links**

##### **Multiple-Choice Questions (104.6)**

1. B
2. B
3. B
4. D
5. C
6. C
7. B
8. B
9. B
10. C
11. B
12. C
13. B

14. B
15. B
16. C
17. B
18. C
19. B
20. C

**Fill-in-the-Blank Questions (104.6)**

1. inode
2. -s
3. inode
4. filesystems
5. target
6. link
7. rwx
8. link
9. directories
10. hard

**104.7 Find system files and place files in the correct location**

**Multiple-Choice Questions (104.7)**

1. D
2. B
3. B
4. A
5. B
6. A
7. A
8. C
9. C
10. B
11. C
12. B

13. B
14. A
15. D
16. B
17. C
18. C
19. A
20. A

**Fill-in-the-Blank Questions (104.7)**

1. /
2. /etc
3. /var/tmp
4. which
5. /etc/updatedb.conf
6. /home
7. find
8. /dev
9. -iname
10. /media

## Topic 105: Shells and Shell Scripting

### 105.1 Customize and use the shell environment

Multiple-Choice Questions (105.1)

Fill-in-the-Blank Questions (105.1)

### 105.2 Customize or write simple scripts

Multiple-Choice Questions (105.2)

Fill-in-the-Blank Questions (105.2)

## Topic 106: User Interfaces and Desktops

### 106.1 Install and configure X11

Multiple-Choice Questions (106.1)

Fill-in-the-Blank Questions (106.1)

### 106.2 Graphical Desktops

Multiple-Choice Questions (106.2)

Fill-in-the-Blank Questions (106.2)

### 106.3 Accessibility

Multiple-Choice Questions (106.3)

Fill-in-the-Blank Questions (106.3)

## Topic 107: Administrative Tasks

### 107.1 Manage user and group accounts and related system files

Multiple-Choice Questions (107.1)

Fill-in-the-Blank Questions (107.1)

### 107.2 Automate system administration tasks by scheduling jobs

Multiple-Choice Questions (107.2)

Fill-in-the-Blank Questions (107.2)

### 107.3 Localisation and internationalisation

Multiple-Choice Questions (107.3)

Fill-in-the-Blank Questions (107.3)

## Topic 108: Essential System Services

### 108.1 Maintain system time

Multiple-Choice Questions (108.1)

Fill-in-the-Blank Questions (108.1)

### 108.2 System logging

Multiple-Choice Questions (108.2)

Fill-in-the-Blank Questions (108.2)

### 108.3 Mail Transfer Agent (MTA) basics

Multiple-Choice Questions (108.3)