CS 100

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Contents

1 Lesson 1: An Overview of the Computer System

A computer is an electronic device designed to process data into information that is useful to people. A complete computer system comprises four distinct parts: Hardware, Software, Data, and Users.

1.1 The Parts of a Computer System

- **Hardware:** Refers to the physical, electronic devices that make up the computer system. These are the parts you can see and touch.
- **Software:** Consists of organized sets of instructions, also known as programs, that control the computer.
  - *System Software:* Helps the computer manage its own tasks and devices (e.g., operating system).
  - *Application Software:* Enables users to perform specific tasks, such as creating documents.
- **Data:** Represents raw facts that the computer can manipulate and process into useful information. Computerized data is inherently *digital*, meaning it has been reduced to numbers (digits). Computers store and read all data as numbers, specifically as discrete units called *bits* (either on or off). For example, a CD player reads digital audio data and translates it into analog sound. Although stored digitally, computers convert data into forms people can understand, such as text, numerals, sounds, and images.
- **Users:** Are the operators of the computer. While some computers can operate autonomously, personal computers are specifically designed for human interaction.

1.2 Looking Inside the Machine: Types of Hardware

Computer hardware devices are generally categorized as processors, memory, input/output (I/O) devices, and storage devices.

1.2.1 Processing

The process of transforming raw data into useful information is called processing, primarily handled by the computer's processor and memory.

- **The CPU (Central Processing Unit):** Often referred to as the processor, it is the primary component that manages all computer devices and performs the actual data processing. The CPU consists of one or more chips attached to the computer's main circuit board, known as the motherboard.
- **Memory (RAM):** Memory chips are also located on the motherboard. This memory, specifically Random Access Memory (RAM), holds data and program instructions while the CPU actively works with them. RAM is *volatile*; its contents are lost when the power is turned off.
- **How Memory is Measured:**
  - The smallest usable unit of memory is the *byte*, which can hold one character (like 'A' or '2').
  - Larger chunks of data are measured in multiples of bytes, based on powers of 1024:
    - Kilobyte (KB): 1,024 bytes (approx. 1,000)
    - Megabyte (MB): 1,048,576 bytes (approx. 1,000,000)
    - Gigabyte (GB): 1,073,741,824 bytes (approx. 1,000,000,000)
    - Terabyte (TB): 1,099,511,627,776 bytes (approx. 1,000,000,000,000)

1.2.2 Input and Output Devices

- **Input Devices:** Accept data and instructions from the user or another computer system. Examples include keyboards and mice.
- **Output Devices:** Return processed data back to the user or another computer system. Examples include printers and monitors.
- **Communications Devices:** Such as modems and network interface cards, perform both input and output functions, enabling computers to share information.

1.2.3 Storage Devices

Storage devices hold data not actively being used by the CPU. Data is commonly stored on magnetic or optical disks, each using a specialized medium for data storage.

- A *disk drive* is a device that reads data from and writes data to a disk.
- Common types include floppy disk drives, hard disk drives, and optical disk drives.
- The most common optical storage devices are CD-ROM and DVD-ROM drives.

2 Lesson 2: The Shapes of Computers Today

Computers are categorized by their power, size, and typical applications.

- **Supercomputers:** These are the most powerful computers, designed for problems requiring highly complex calculations (e.g., weather forecasting, scientific research). Due to their immense size and expense (e.g., Cray T90), they are relatively rare and primarily used by universities, government agencies, and large businesses.
- **Mainframe Computers:** Capable of supporting hundreds or even thousands of users simultaneously, mainframes handle massive amounts of input, output, and storage. They are used in large organizations where many users require access to shared data and programs, and also function as e-commerce servers for handling internet transactions.
- **Minicomputers:** These are smaller than mainframes but larger than microcomputers. Minicomputers typically support multiple terminals and can serve as network or internet servers.
- **Workstations:** Powerful single-user computers optimized for tasks requiring significant number-crunching power, such as product design, scientific simulations, and computer animation. They are often used as network and internet servers.
- **Microcomputers (Personal Computers - PCs):** More commonly known as personal computers, the term "PC" is applied to IBM-PCs and compatible systems.
  - *Full-size Desktop Computers:* The most common type of PC.
  - *Notebook (Laptop) Computers:* Offer desktop system power with added portability.
  - *Handheld PCs (PDAs):* Lack the full power of desktops or notebooks but provide limited functions in a small, portable size.

3 Lesson 3: Standard Methods of Input

This lesson covers common input devices: the keyboard and mouse, along with their variants.

3.1 The Keyboard

A standard computer keyboard typically has around 100 keys and most use the QWERTY layout. Keys are arranged into five main groups:

1. **Alphanumeric Keys:** Letters, numbers, and symbols.
2. **Numeric Keypad:** A section for entering numbers quickly.
3. **Function Keys:** (F1-F12) Perform specific operations depending on the software.
4. **Modifier Keys:** (Shift, Ctrl, Alt) Used in combination with other keys.
5. **Cursor-Movement Keys:** (Arrows, Home, End, Page Up/Down) For navigating documents.

3.1.1 Ergonomic Keyboards

Designed to reduce the risk of injuries from prolonged keyboard use, ergonomic keyboards promote more natural hand and wrist positions. Proper keyboarding practices are also crucial to prevent strain.

3.1.2 How a Keyboard Works

When a key is pressed:

1. The *keyboard controller* detects the keystroke.
2. The controller places a *scan code* (a unique code for each key) into the *keyboard buffer*.
3. The keyboard sends an *interrupt request* to the CPU, signaling that it needs attention.
4. The system software responds to the interrupt by reading the scan code from the keyboard buffer.
5. The system software then passes the scan code to the CPU for processing.

3.2 The Mouse

A mouse is a pointing device used to move a graphical pointer on the screen. It can issue commands, draw, and perform other input tasks.

3.2.1 Mouse Techniques

Using a mouse involves five essential techniques:

1. **Pointing:** Moving the mouse to position the on-screen pointer.
2. **Clicking:** Pressing and releasing the left mouse button once to select an item or activate a command.
3. **Double-clicking:** Pressing and releasing the left mouse button twice in quick succession to open an item or perform an action.
4. **Dragging:** Holding down the left mouse button while moving the pointer to select text, move objects, or draw.
5. **Right-clicking:** Pressing and releasing the right mouse button to open a context-sensitive menu.

3.2.2 Variants of the Mouse

- **Trackballs:** Essentially an upside-down mouse. Users move an exposed ball with their thumb or fingers and press buttons to control the pointer.
- **Trackpads (Touchpads):** Touch-sensitive pads common on laptops. Users glide a finger across the surface to move the pointer. They include buttons that function similarly to mouse buttons.
- **Integrated Pointing Devices:** Small joysticks built into the keyboard, usually found on some laptops. Users move the joystick to control the pointer, and accompanying buttons function like mouse buttons.

4 Lesson 4: Alternative Methods of Input

Beyond the standard keyboard and mouse, various other input devices are available for specific needs or preferences.

4.1 Devices for the Hand

- **Pens:** Electronic pens are used with pen-based systems to write directly on the screen, select commands, or draw. They are common with handheld computers (PDAs) and are suitable for notes or command selection, rather than extensive text input.
- **Touch Screens:** These monitors accept input directly through touch. Sensors detect finger touches, making them useful in environments where keyboards or mice might be impractical (e.g., kiosks, industrial settings) and for menu selection.
- **Game Controllers:**
  - *Joysticks:* Popular for flight simulators and driving games, offering precise control through a movable stick.
  - *Game Pads:* Typically provide controls designed for use with both hands.

4.2 Optical Input Devices

- **Bar Code Readers:** These devices read patterns of printed bars (bar codes). They emit light that reflects off the code and into a detector, which translates the code into numbers. Flatbed readers are common in retail, while handheld readers are used by courier services.
- **Image Scanners and OCR:**
  - *Image Scanners:* Digitize printed images, converting them into a format suitable for computer storage and manipulation. A scanner shines light onto the image and interprets the reflection.
  - *Optical Character Recognition (OCR) Software:* Can translate scanned text from images into editable electronic documents.

4.3 Audio-Visual (Multimedia) Input Devices

- **Microphones and Speech Recognition:**
  - *Microphones:* Accept auditory input. A sound card is required in the PC to digitize analog sound signals (convert them to digital) and later convert digital sound back to analog form for output. *Speech Recognition Software:* Allows users to dictate text, navigate programs, and issue commands using their voice through a microphone.
- **Video Input:**
  - *PC Video Cameras:* Digitize full-motion images.
  - *Digital Cameras:* Capture still images. These cameras break images into *pixels* (picture elements) and store data about each pixel.
  - *Video Compression:* Video images are often compressed to conserve memory and storage space.
  - **How Digital Cameras See:**
    1. Light passes through the lens and focuses on a **CCD (Charge-Coupled Device)** array.
    2. The CCD generates a continuous analog electrical signal.
    3. This signal is converted to digital information by an **ADC (Analog-to-Digital Converter)**.
    4. The digital information is sent to a **DSP (Digital Signal Processor)**, which manipulates (adjusts contrast, detail) and compresses the image data.
    5. The compressed data is then sent to the camera's storage medium.

5 Lesson 5: Monitors and Sound Systems

This lesson focuses on common output devices: monitors and sound systems.

5.1 Monitors

Monitors are categorized by their display technology and color capabilities.

5.1.1 Categories of Monitors

- **By Technology:**
  - *Cathode Ray Tube (CRT) Monitors:* Traditional, bulky monitors.
  - *Flat-Panel Displays:* Slimmer, modern monitors.
- **By Color Display:**
  - *Monochrome:* Displays one color on a black background.
  - *Grayscale:* Displays shades of gray on a white or off-white background.
  - *Color:* Capable of displaying a wide range of colors, from 16 to 16 million unique colors.

5.1.2 CRT Monitors

In CRT monitors, electron guns fire streams of electrons at phosphor dots on the screen. These dots are grouped into *pixels*, which glow when struck by electrons. In color CRTs, each pixel contains a red, green, and blue dot, which glow at varying intensities to produce a full spectrum of color images.

5.1.3 Flat-Panel Monitors

Most flat-panel monitors use Liquid Crystal Display (LCD) technology.

- **Passive Matrix LCDs:** Use a transistor for each row and column of pixels.
- **Active Matrix LCDs:** Use a transistor for each individual pixel on the screen, offering better image quality.
- **Thin-Film Transistor (TFT) Displays:** A type of active matrix LCD that uses multiple transistors per pixel.

Flat-panel monitors offer the advantage of taking up less desk space.

5.1.4 Comparing Monitors

When evaluating monitors, consider four key features:

1. **Size:** Measured diagonally across the screen's face in inches. While 15-inch monitors (with about a 13-inch viewing area) were standard, 17-inch monitors (with about a 15-inch viewing area) are now common. Larger monitors are available but can be expensive.
2. **Resolution:** The number of pixels displayed on the screen, expressed as a matrix (e.g., 600x800). A 17-inch monitor can offer resolutions from 640x480 up to 1280x1024. The Video Graphics Array (VGA) standard is 640x480, while Super VGA (SVGA) monitors offer higher resolutions like 800x600 or 1024x768. Higher resolution is important for graphics, page layout, and CAD (Computer-Aided Design).
3. **Refresh Rate:** The number of times per second that the electron guns scan the screen's pixels. Measured in Hertz (Hz). A refresh rate of 72 Hz or higher is recommended to prevent eyestrain; faster scanning leads to a quicker refresh and less flicker.
4. **Dot Pitch:** The distance between the phosphor dots that make up a single pixel. In color monitors, three dots (red, green, and blue) comprise each pixel. A dot pitch no greater than .28 millimeter generally provides crisper displays.

5.1.5 Video Controllers

The video controller acts as the interface between the monitor and the CPU. It significantly influences a monitor's performance, determining aspects like resolution and the number of colors displayed. Video controllers include their own on-board processor and memory, known as Video RAM (VRAM), which is crucial for graphic-intensive applications like games.

5.2 PC Projectors

PC projectors connect to a computer and project images onto a large screen, commonly used for presentations. Many projectors offer resolutions and color levels comparable to high-quality monitors. Digital Light Processing (DLP) projectors utilize a microchip with tiny mirrors to produce very sharp and bright images.

5.3 Sound Systems

Modern multimedia PCs are equipped with a sound card, speakers, and a CD-ROM or DVD drive.

- A *sound card* translates digital audio signals into analog signals that drive the speakers.
- **How Sound Systems Work:**
  1. Electric current from the sound card is applied to an electromagnet.
  2. The changing magnetic field pushes and pulls a permanent magnet within the speaker.
  3. This magnet is attached to the speaker cone.
  4. The moving speaker cone creates changes in air pressure, which your brain interprets as sound.
- With appropriate software, users can edit sounds and create special sound effects.

6 Lesson 6: Devices that Output Hard Copy (Printers)

Printers are output devices that produce physical, hard-copy documents.

6.1 Overview of Printers

6.1.1 Categorizing Printers

Printers broadly fall into two main categories:

- **Impact Printers:** Use a device to strike an inked ribbon, pressing ink onto the paper to form characters or images.
- **Non-Impact Printers:** Employ different methods to place ink or another substance onto the page without physical contact.

6.1.2 Evaluating Printers

When assessing printers, four key criteria are considered:

1. **Image Quality:** Measured in dots per inch (dpi). Most printers produce resolutions between 300 and 600 dpi.
2. **Speed:** Measured in pages per minute (ppm) for continuous text or characters per second (cps) for character-based printers.
3. **Initial Cost:** Consumer printers are typically $250 or less, while professional-grade printers can cost thousands of dollars.
4. **Cost of Operation:** Refers to the ongoing expense of supplies, such as ink, toner, and paper.

6.2 Dot Matrix Printers

- **How They Work:** Dot matrix printers are a common type of impact printer. Their print head contains a cluster of small pins that can be rapidly pushed out to form patterns. These pins strike an inked ribbon against the paper, creating an image made of dots. Lower-resolution models typically use nine pins, while higher-resolution models have 24 pins.
- **Performance:** Speed is measured in characters per second (cps), with some models printing up to 500 cps.

6.3 Ink Jet Printers

- **How They Work:** Ink jet printers are non-impact printers that create images by spraying tiny droplets of ink onto the paper. They are available for both color and black-and-white printing.
- **Performance:** Offer speeds of 2–4 pages per minute (ppm) and resolutions comparable to low-end laser printers (300–600 dpi). Ink jet printers are generally inexpensive to purchase and have low operating costs.

6.4 Laser Printers

- **How They Work:** Laser printers are non-impact printers that use heat and pressure to bond particles of toner (a fine powder) to paper. They are available for both color and black-and-white printing.
  1. A stack of paper is in the input tray.
  2. Paper is given a static charge.
  3. A rotating mirror reflects a laser, which projects an image of the page onto a rotating drum, neutralizing the charge in specific areas.
  4. Toner is transferred to the charged paper by the drum.
  5. Hot rollers bond the toner to the paper.
- **Performance:** Provide higher resolutions, ranging from 300 to 1200 dpi and beyond. Black-and-white laser printers typically produce 4–16 ppm. While offering higher print quality than ink jet printers, they are generally more expensive.

6.5 Snapshot Printers

These are specialized, small-format printers designed to print digital photographs. They are popular among digital camera users but are generally slower and can be more expensive to operate than general-purpose printers.

6.6 Other High-Quality Printers

Print shops and publishers use various high-quality printers to produce professional-grade color images:

- **Thermal-wax Printers:** Use heat to melt colored wax onto paper.
- **Dye-sublimation Printers:** Use heat to transfer dye onto special paper, producing continuous-tone images.
- **Fiery Controllers:** Refer to specialized print server technologies used with high-end digital printers for advanced color management and workflow.
- **IRIS Printers:** High-end ink jet printers known for their exceptional color fidelity.
- **Plotters:** Use mechanical, ink jet, or thermal technology to create large-format images, typically for architectural or engineering designs.

7 Lesson 9: Types of Storage Devices

Storage devices allow computers to retain data even when powered off.

7.1 Categorizing Storage Devices

- A **storage medium** is the physical material that holds data (e.g., the surface of a floppy disk).
- A **storage device** is the hardware that writes data to or reads data from a storage medium (e.g., a floppy disk drive).
- The two primary storage technologies are **magnetic** and **optical**.

7.2 Magnetic Storage Devices

The primary types of magnetic storage include diskettes (floppy disks), hard disks, high-capacity floppy disks, disk cartridges, and magnetic tape.

7.2.1 How Magnetic Storage Works

A magnetic disk's medium contains iron particles. Data is stored by polarizing these particles (giving them a magnetic charge) in one of two directions, representing binary 1s (on) or 0s (off). A disk drive uses *read/write heads* containing electromagnets to create these magnetic charges on the medium. As the medium rotates, the read/write head writes the data.

7.2.2 Formatting

Before a magnetic disk can be used, it must be *formatted*. This process maps the disk's surface and determines how data will be stored by:

- Creating circular *tracks* around the disk's surface.
- Dividing each track into *sectors*.
- The operating system (OS) then organizes these sectors into groups called *clusters* and tracks each file's location according to the clusters it occupies.

7.2.3 Disk Areas

When a disk is formatted, the OS creates four main areas on its surface:

- **Boot Sector:** Stores the master boot record, a small program that initiates the computer's startup (boot) process.
- **File Allocation Table (FAT):** A log that records each file's location on the disk and the status of each sector (e.g., free, in use, bad).
- **Root Folder:** Enables users to store data on the disk in a logical, hierarchical way.
- **Data Area:** The largest portion of the disk, where the actual user data is stored.

7.2.4 Diskettes (Floppy Disks)

Diskette drives (floppy disk drives) read and write data to diskettes (floppy disks). They are commonly used for transferring files between computers, distributing software, and as a backup medium. Diskettes historically came in two sizes: 5.25-inch and 3.5-inch.

7.2.5 Hard Disks

Hard disks use multiple platters stacked on a spindle. Each platter typically has two read/write heads (one for each side). Hard disks use higher-quality media and rotate at much faster speeds than diskettes. Removable hard disks offer high capacity with the convenience of portability.

7.2.6 Disk Capacities

- Diskettes generally store 1.44 MB of data.
- Hard disks store significantly larger amounts of data, with new PCs commonly featuring capacities of 10 GB (Gigabytes) and higher.

7.2.7 Other Magnetic Storage Devices

- **High-capacity Floppy Disks:** Offer capacities up to 250 MB while maintaining the portability of standard floppy disks (e.g., Zip drives).
- **Disk Cartridges:** Similar to small removable hard disks, these can store up to 2 GB.
- **Magnetic Tape Systems:** Offer very slow data access but provide large storage capacities at a low cost. Due to their sequential access (long access times), they are primarily used for backups.

7.3 Optical Storage Devices

Optical storage devices use light (lasers) to read and write data, offering high capacities. The primary types include CD-ROM, DVD-ROM, CD-Recordable (CD-R), CD-Rewritable (CD-RW), and PhotoCD.

7.3.1 How Optical Storage Works

An optical disk is a high-capacity storage medium where data is represented by tiny dents called *pits* and flat spots called *lands* on its metal surface. An optical drive uses reflected light (a laser beam) to read data:

- When the laser shines into a **pit**, the light is scattered and cannot be reflected back to the sensor, representing a binary value of **0 (off)**.
- When the laser shines on a **land**, the light is reflected back to the sensor, representing a binary value of **1 (on)**.

7.3.2 CD-ROM (Compact Disc Read-Only Memory)

- The most commonly used optical storage technology in PCs.
- A standard CD-ROM disk can store up to 650 MB of data or about 70 minutes of audio.
- Data written to a CD-ROM disk cannot be altered or overwritten.

7.3.3 CD-ROM Speeds and Uses

- Early CD-ROM drives were "single speed," reading data at 150 KBps. Modern CD-ROM drives can transfer data at much faster speeds, up to 7800 KBps (52X speed).
- CD-ROMs are typically used to store software programs, audio, video, text, and program instructions.

7.3.4 DVD-ROM (Digital Video Disc Read-Only Memory)

- A variation of CD-ROM, DVD-ROMs are increasingly replacing CD-ROMs in newer PCs.
- Standard DVD disks can store up to 9.4 GB of data, enough for an entire movie. Dual-layer DVD disks can store even more, up to 17 GB.
- DVDs achieve higher capacities by utilizing both sides of the disk and employing sophisticated data compression technologies.

7.3.5 Other Optical Storage Devices

- **CD-Recordable (CD-R):** Drives allow users to record their own CDs. However, once data is recorded, it cannot be overwritten.
- **CD-Rewritable (CD-RW):** Drives enable users to record data to a CD and then write new data over the previously recorded data multiple times.
- **PhotoCD:** A technology specifically used for storing digital photographs on compact discs.