Unit 2 : Graphics Hardware

Graphics hardware consists of various input devices that allow users to interact with a computer system. These are particularly used in in graphics-intensive applications such as design, gaming, and multimedia production. Some of the input devices are:

- Keyboard
- Mouse (Mechanical and Optical)
- Light Pen
- Touchscreen
- Tablet Input Hardware
- Joystick

Keyboard, Mouse(Mechanical and Optical), lightpen, touchscreen, tablet input hardware, joystick

Keyboard

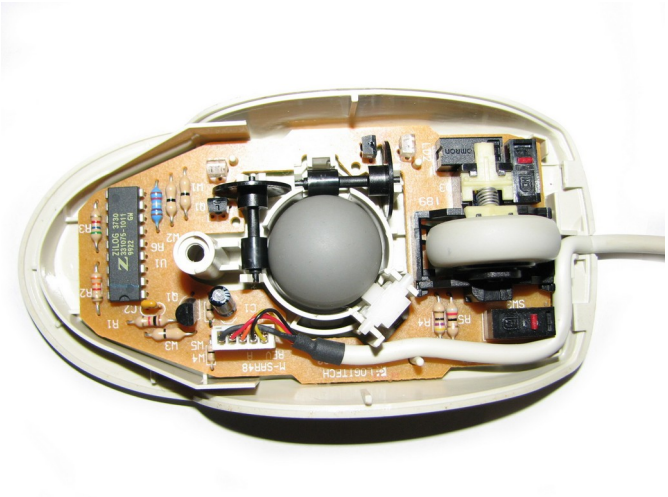
A keyboard is a primary input device used to enter text, commands, and other data into a computer or other digital devices. It consists of a set of keys arranged in a specific layout, typically following the QWERTY design, which is the most common keyboard layout. Each key corresponds to a specific character, symbol, or function, and when pressed, it sends a signal to the computer, which processes the input accordingly. Keyboards are essential for typing, gaming, programming, and navigating software interfaces.

- Most keyboards use the QWERTY layout, but other layouts like AZERTY (French) and Dvorak are also available.
- Keyboards can connect via USB, or wirelessly (Bluetooth or RF).
- Key in the keyboard Includes
  - alphanumeric keys (letters and numbers),
  - function keys (F1-F12),
  - modifier keys (Shift, Ctrl, Alt),
  - navigation keys (arrow keys), and
  - special-purpose keys (Enter, Esc, Spacebar).

Mouse

A mouse is a handheld input device used to control the movement of a cursor or pointer on a computer screen. It allows users to interact with graphical user interfaces (GUIs) by pointing, clicking, dragging, and scrolling. The mouse has evolved over time, with two primary types being mechanical mice and optical mice. Both serve the same purpose but differ in their underlying technology and mechanisms.

Mechanical Mouse



A mechanical mouse, also known as a ball mouse, was one of the earliest designs. It uses a rubber or metal ball embedded in its underside to detect movement. As the ball rolls, it moves internal rollers that translate the motion into electrical signals, which are then sent to the computer to move the cursor. Mechanical mice are simple, inexpensive, and work on most surfaces (though not glass or highly reflective surfaces). However, they are prone to dirt and dust accumulation, which can affect performance. They require regular cleaning of the ball and rollers and are less precise compared to optical mice. They have a bulky design due to the ball mechanism. Components of a mechanical mouse include:

- Rubber or metal ball.
- Internal rollers and sensors.
- Buttons (left, right, and sometimes a scroll wheel).

Optical Mouse

An optical mouse is a modern pointing device that uses a light-emitting diode (LED) or laser to detect movement. It works by capturing thousands of images per second of the surface beneath it, using a tiny camera. These images are processed by a digital signal processor (DSP) to determine the direction and speed of movement, which is then translated into cursor movement on the screen. Optical mice are highly precise, work on a wide variety

of surfaces (including glass, depending on the model), and are less prone to mechanical failures since they have no moving parts. They are also easier to maintain, as they do not accumulate dirt or dust like mechanical mice. However, they may struggle on highly reflective or transparent surfaces. Components of an optical mouse include:

- LED or laser light source (to illuminate the surface).
- Image sensor (to capture surface images).
- Digital Signal Processor (DSP) (to analyze movement).
- Buttons (left, right, and often a scroll wheel).
- Optional additional buttons (for extra functionality).

Light Pen

A light pen is an input device that allows users to interact directly with a computer screen by pointing at or drawing on the display. It works by detecting the light emitted from the screen's pixels when the pen is pressed against the surface. The pen sends a signal to the computer, which calculates the position of the pen based on the timing of the light pulses. Light pens were commonly used in early graphical user interfaces and computer-aided design (CAD) systems. They provide precise input and are particularly useful for tasks requiring detailed drawing or selection. Light pens are lightweight and easy to use but require a compatible display and are less common today due to the popularity of touchscreens and other input devices. Components of a light pen include:

- Light-sensitive sensor (to detect screen illumination).
- Tip (for pointing or drawing on the screen).
- Button (for clicking or selecting).
- Cable or wireless connection (to communicate with the computer).

Touchscreen

A touchscreen is an input and output device that allows users to interact directly with a display by touching it with fingers or a stylus. It detects the presence and location of touch within the display area, enabling users to perform actions like selecting, scrolling,

zooming, or typing. Touchscreens are widely used in smartphones, tablets, ATMs, and other interactive systems. They provide a user-friendly interface, eliminating the need for external input devices like a mouse or keyboard. Touchscreens come in various technologies, such as resistive, capacitive, infrared, and surface acoustic wave, each with its own advantages and limitations. Components of a touchscreen include:

- Touch-sensitive layer (to detect touch input).
- Controller (to process touch signals).
- Display panel (to show visual output).
- Protective glass or film (to shield the screen from damage).
- Software interface (to interpret touch gestures and commands).

Tablet Input Hardware

Tablet input hardware are those components and devices used to interact with a tablet, enabling users to input data, navigate interfaces, and perform various tasks. Tablets primarily rely on touchscreens as their main input method, but they can also support additional input hardware for enhanced functionality. These devices are designed to be portable, intuitive, and user-friendly, making them ideal for tasks like drawing, note-taking, browsing, and multimedia consumption. Tablet input hardware is versatile and caters to a wide range of user needs, from casual use to professional applications. Components of tablet input hardware include:

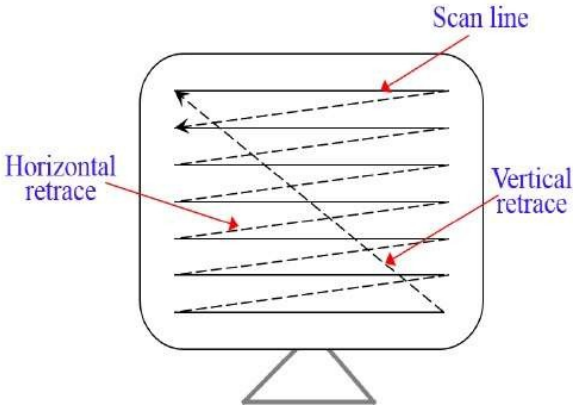
- Touchscreen
- Stylus/Pen:
- On-screen Keyboard
- External Keyboard:
- Touchpad
- Voice Input
- Cameras

Joystick

A joystick is an input device used to control the movement of objects or characters in a computer program, typically in gaming, simulation, or industrial applications. It consists of a stick that pivots on a base, allowing users to move it in multiple directions to provide directional input. Joysticks often include additional buttons, triggers, or switches for performing actions or commands. They are widely used in flight simulators, video games, robotics, and machinery control due to their precision and ease of use. Joysticks can be connected to a computer or console via USB, Bluetooth, or other interfaces.

Raster display architecture

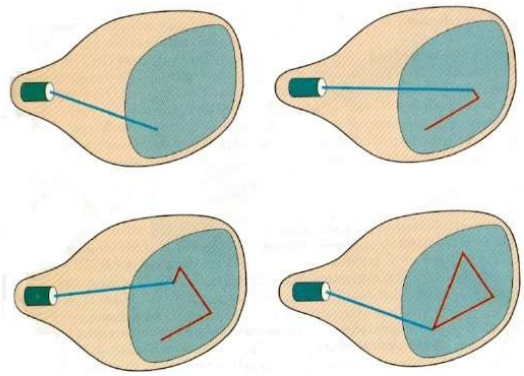
Raster display architecture refers to the design and structure of a display system that uses a grid of pixels to render images, videos, and text. Raster displays are the most common type of display technology used in modern monitors, televisions, and digital screens. They work by dividing the screen into a fixed number of rows and columns, forming a pixel matrix. Each pixel can be individually controlled to display a specific color, allowing for detailed and high-resolution images. Raster displays rely on a refresh process, where the screen is repeatedly redrawn to maintain the image.



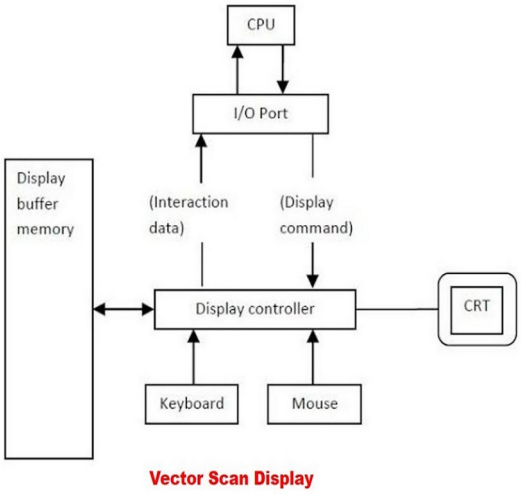
- Frame Buffer: Memory storing pixel data for the entire screen, including color and intensity information.
- Video Controller: Converts frame buffer data into display signals and manages timing and synchronization.
- Display Processor: Handles rendering, scaling, and effects before sending data to the frame buffer.
- CRT/LCD/LED/OLED Panel: Physical screen technology determining display characteristics like brightness and contrast.
- Scanning Mechanism: Draws images line by line, using progressive or interlaced scanning methods.
- Color Look-Up Table (CLUT): Maps pixel values to specific colors for optimized color representation and memory usage.

Vector displays architecture

Vector display architecture is also known as random scan display. It refers to the design and structure of a display system that generates images using geometric shapes, such as lines and curves, rather than a grid of pixels. Vector displays were commonly used in early computer graphics systems, such as oscilloscopes, radar systems, and early arcade games. Instead of storing pixel data, vector displays draw images by directing an electron beam to trace shapes directly onto the screen. This method allows for high-resolution and smooth graphics, particularly for line-based images.



Random-scan displays are designed to draw all the component lines of a picture 30 to 60 times each second.



Vector Scan Display

Components of random scan display are,

- CPU
- I/O Port
- Display buffer memory: Memory used to store the image data that is to be displayed on the screen.
- Display command
- Display controller
- CRT
- Keyboard
- Mouse

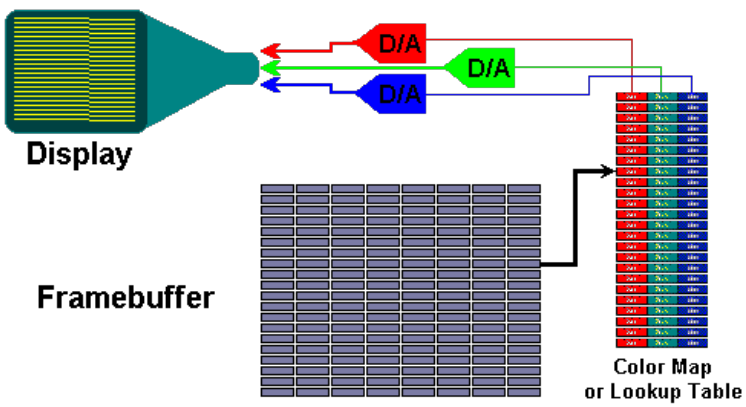
Difference between raster graphics and vector graphics.

S.No.	Raster	Vector
1.	Raster images are constructed through pixels.	Vector images are constructed through lines, curves, and fills.
2.	Raster prefers graphic formats like GIF, JPEG,PNG and PCX, etc.	Vector uses graphic formats like EPS, WMF, TrueType, PICT etc.
3.	Raster are not that scalable.	Vectors are scalable to any size.
5.	They work best when it comes to editing photos.	They work best when it comes to drawings, illustrations, and logos.
6.	We can use rasters in GIMP, Photoshop, and paint shops.	We can use vectors in CorelDraw, Illustrator and Inkscape.
7.	It is complex and time consuming to transform a raster file to a vector photograph.	We can easily convert a vector image into a raster image.
8.	When the spot colours are limited, it becomes challenging to print raster images	It is easy to print vector images as the number of colours can be modified anytime during printing.
9.	We can easily convert a raster file into any file format.	We cannot change the vector files.

Frame Buffer

The frame buffer is a critical component in computer graphics systems, responsible for storing the pixel data that is displayed on the screen. It acts as a memory buffer that holds the color and intensity information for each pixel in a raster display. The architecture of the frame buffer is designed to efficiently manage and render images, ensuring smooth and accurate display output.

Below is an explanation of the architecture of the frame buffer in computer graphics:



Components of Frame Buffer Architecture

Color map/ Lookup table

The frame buffer is essentially a block of memory (RAM) organized as a 2D array. Where each cell corresponds to a pixel color information typically represented in binary form (e.g., 8-bit, 16-bit, 24-bit, or 32-bit depth).

Pixel

Each pixel in the frame buffer stores data about its color and intensity. This is often represented using:

- RGB (Red, Green, Blue): Three separate values for each color channel.
- RGBA (Red, Green, Blue, Alpha): Includes an additional alpha channel for transparency.
- Indexed Color: A color palette is used, and the pixel stores an index to the palette.
- Color Depth
    - The color depth (or bit depth) determines how many colors can be represented. For example:
    - 8-bit: 256 colors.
    - 24-bit: 16.7 million colors (True Color).
    - 32-bit: Includes an alpha channel for transparency.

Display Controller

The display controller reads data from the frame buffer and sends it to the display device (e.g., monitor or screen).

It manages the timing and synchronization of the display process, ensuring that the image is refreshed at the correct rate (e.g., 60 Hz).

Video RAM (VRAM)

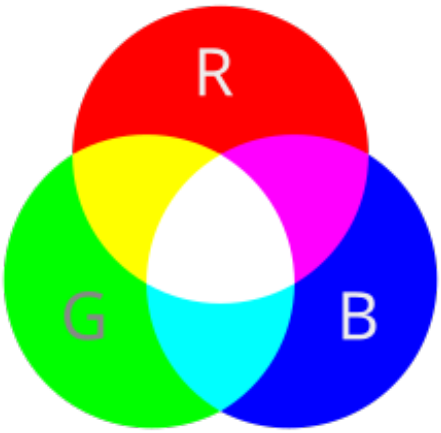
The frame buffer is often implemented using specialized memory called Video RAM (VRAM), which is optimized for high-speed access by the display controller. It allows simultaneous read and write operations, enabling the CPU to update the frame buffer while the display controller reads from it.

Color Modes

Color modes are systems used to represent and organize colors in digital and print media. They define how colors are created, displayed, or printed by combining specific primary colors or attributes. Types of color modes are: RGB, CMYK, HSV, etc.

RGB(Red, Green, Blue)

RGB (Red, Green, Blue) is a color model widely used in digital displays, cameras, and graphics software to represent and display colors. It is an **additive** color model, meaning that colors are created by combining varying intensities of red, green, and blue light. By mixing these three primary colors in different proportions, a wide range of colors can be produced. RGB is the standard color mode for electronic displays, such as monitors, TVs, and smartphone screens.



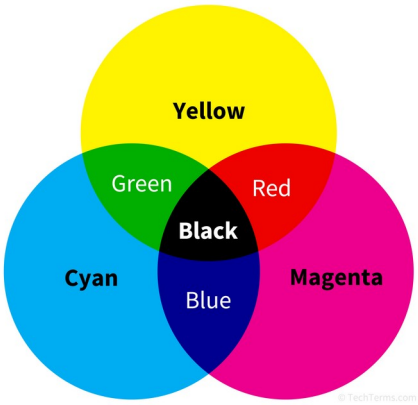
- Red, Green, and Blue are the primary colors in the RGB model.
- Each color is represented as a value ranging from 0 to 255 (in 8-bit systems), where 0 means no intensity and 255 means full intensity.
- Colors are created by combining different intensities of red, green, and blue. For example:
  - Red (255, 0, 0): Full red, no green or blue.
  - Green (0, 255, 0): Full green, no red or blue.
  - Blue (0, 0, 255): Full blue, no red or green.
  - White (255, 255, 255): Full intensity of all three colors.
  - Black (0, 0, 0): No intensity of any color.
- The number of bits used to represent each color channel determines the color depth.
  - 8-bit per channel (24-bit total): 16.7 million colors (True Color).
  - 10-bit per channel (30-bit total): Over 1 billion colors (Deep Color).

Applications of RGB Color Mode

- Digital Displays:
- Graphics Software
- Web Design
- Gaming

CMYK Color Mode

CMYK (Cyan, Magenta, Yellow, Key/Black) is a color model widely used in printing and graphic design to represent and reproduce colors. It is a subtractive color model, meaning that colors are created by subtracting varying percentages of cyan, magenta, yellow, and black ink from white light. By combining these four colors in different proportions, a wide range of colors can be produced. CMYK is the standard color mode for printed materials, such as posters, and magazines.



- Cyan, Magenta, Yellow, and Black are the primary colors in the CMYK model.
- Each color is represented as a percentage ranging from 0% to 100%, where 0% means no ink and 100% means full ink coverage.
- Colors are created by combining different percentages of cyan, magenta, yellow, and black. For example:
  - Cyan (100%, 0%, 0%, 0%): Full cyan, no magenta, yellow, or black.
  - Magenta (0%, 100%, 0%, 0%): Full magenta, no cyan, yellow, or black.
  - Yellow (0%, 0%, 100%, 0%): Full yellow, no cyan, magenta, or black.
  - Black (0%, 0%, 0%, 100%): Full black, no cyan, magenta, or yellow.
  - White (0%, 0%, 0%, 0%): No ink, representing the white of the paper.
- ***Black is added to the model to improve depth and contrast, as combining cyan, magenta, and yellow alone often results in a muddy brown rather than a true black.***

Applications of CMYK Color Mode

- Printing
- Graphic Design
- Marketing Collateral