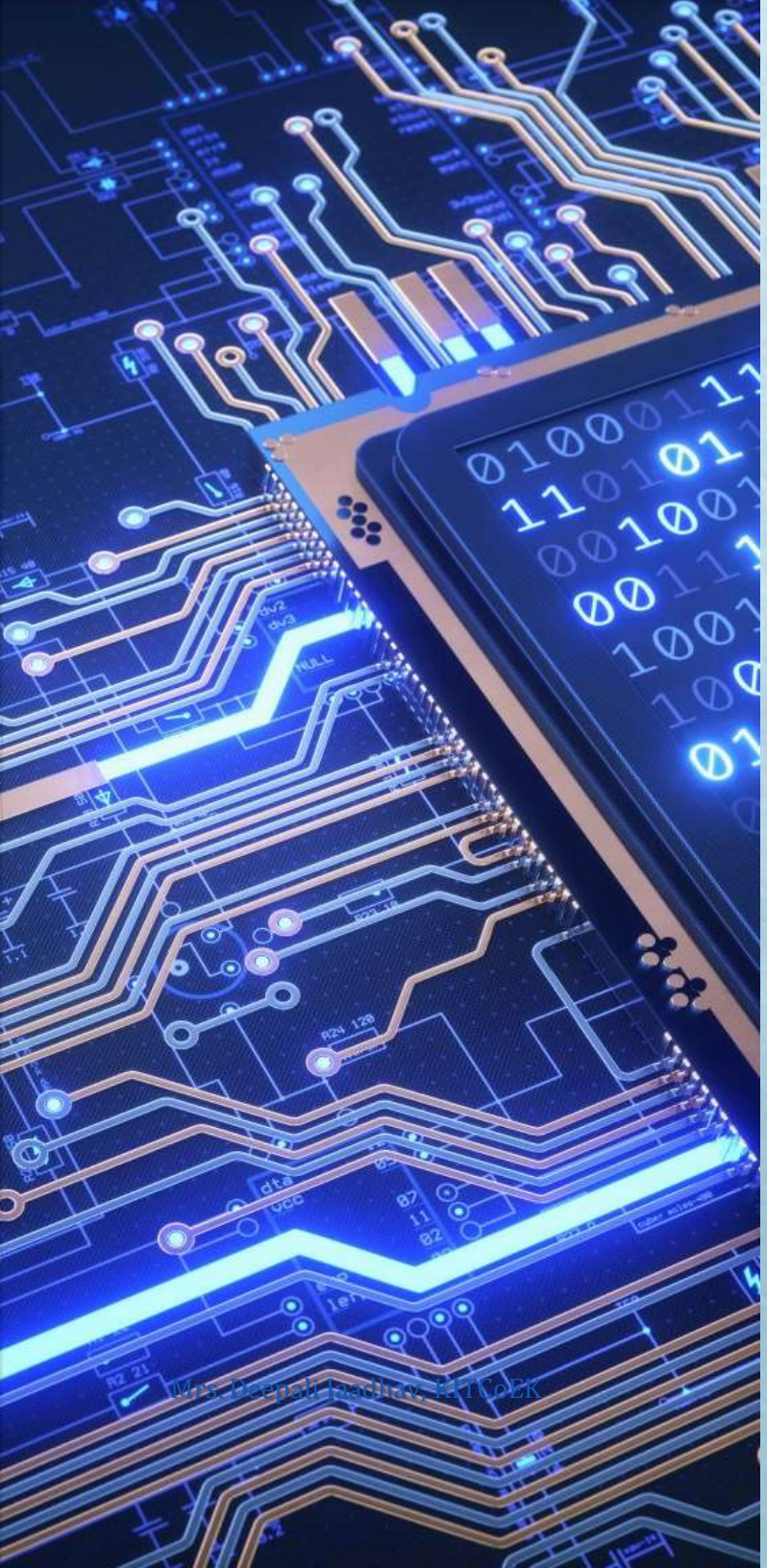
Unit 1

Introduction



Unit 1: Introduction

- Overview of graphics systems
- Applications of Computer Graphics
- Video display devices,
- Raster scan systems
- Random scan systems
- Input and output devices

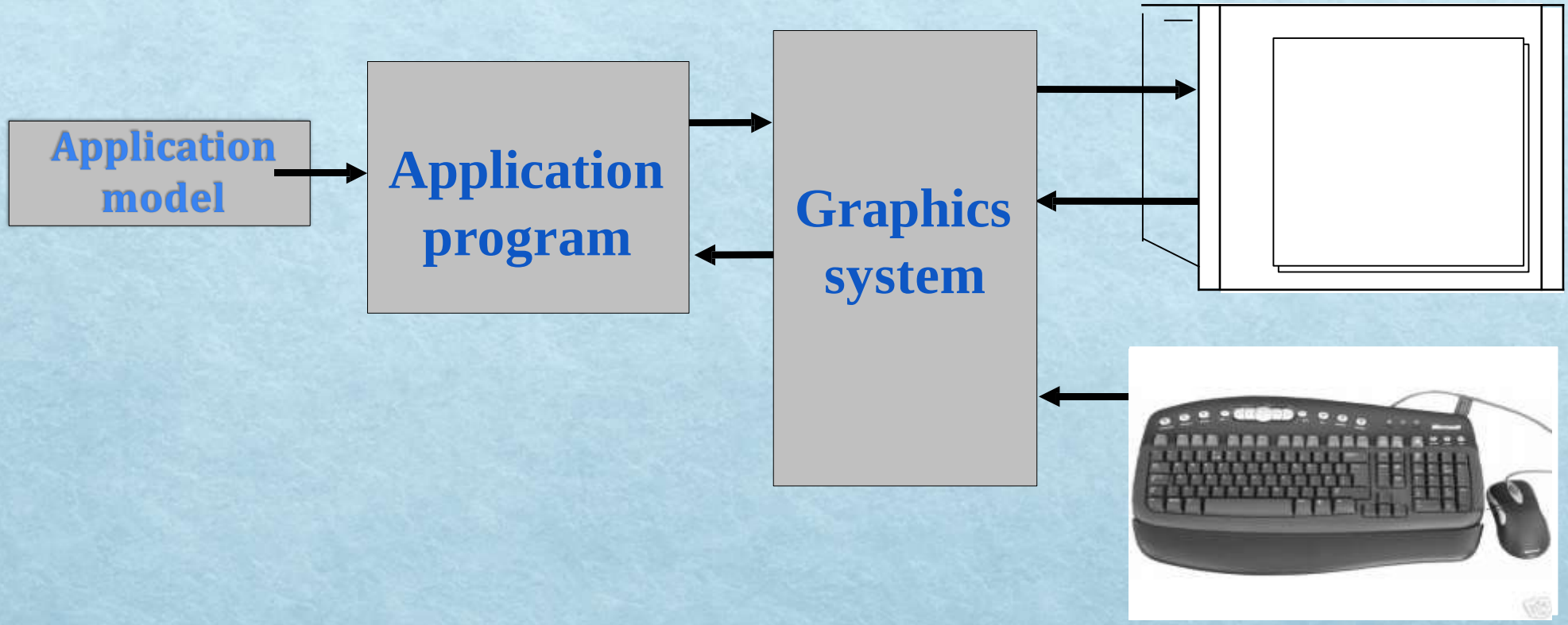
What is Computer Graphics?

- Computers have become a powerful tool for the rapid and economical production of pictures.
- Creation, Manipulation and Storage of geometric objects (modeling) & their images (rendering).
- Display those images on screens or hardcopy devices.

Introduction to Computer Graphics

- ***Computer Graphics*** involves display, manipulation and storage of pictures and experimental data for proper visualization using a computer.
- Typical graphics system comprises of a host computer with support of fast processor, large memory, frame buffer and
  - Display devices (color monitors),
  - Input devices (mouse, keyboard, joystick, touch screen, trackball)
  - Output devices (LCD panels, laser printers, color printers, plotters etc.)
  - Interfacing devices such as, video I/O, TV interface, etc.

INTRODUCTION TO COMPUTER GRAPHICS



Conceptual framework for interactive graphics

Applications of Computer Graphics

COMPUTER AIDED DESIGN (CAD)

PRESENTATION GRAPHICS

COMPUTER ART

ENTERTAINMENT (ANIMATION, GAMES, …)

EDUCATION & TRAINING

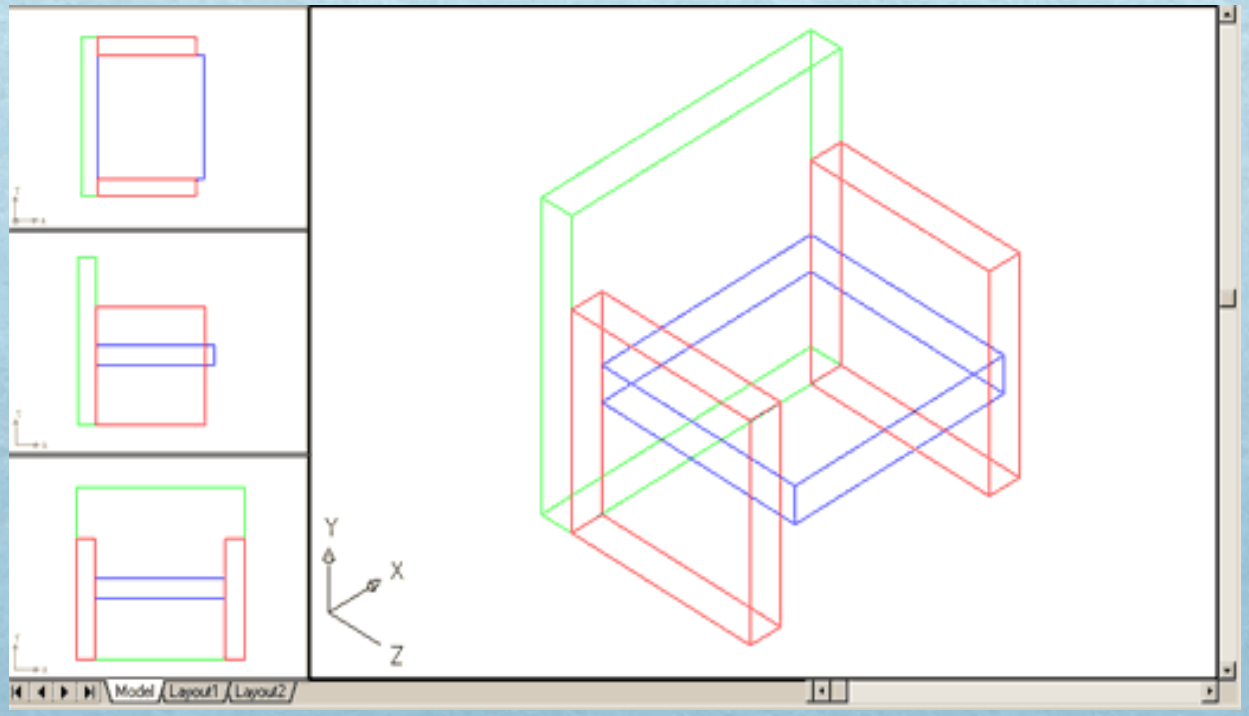
VISUALIZATION (SCIENTIFIC & BUSINESS)

IMAGE PROCESSING

GRAPHICAL USER INTERFACES

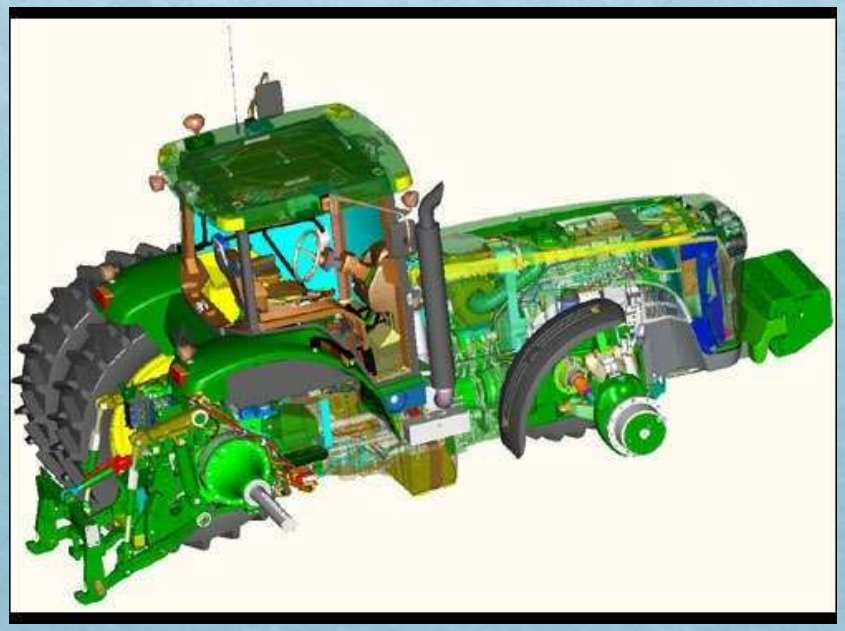
1. Computer Aided Design (CAD)

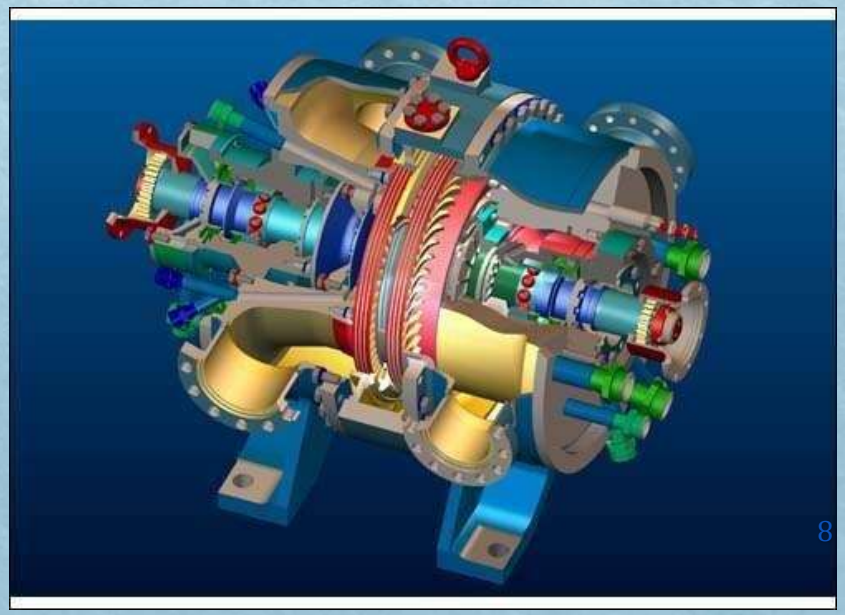
- Used in design of buildings, automobiles, aircraft, watercraft, spacecraft, computers, textiles & many other products.
- Objects are displayed in wire frame outline form.
- Software packages provide multi-window environment.



1. Computer Aided Design (CAD) cont…

- Graphics design package provides standard shapes (useful for repeated placements)
- Animations are also used in CAD applications.
- Realistic displays of architectural design permits simulated “walk” through the rooms (virtual-reality systems)





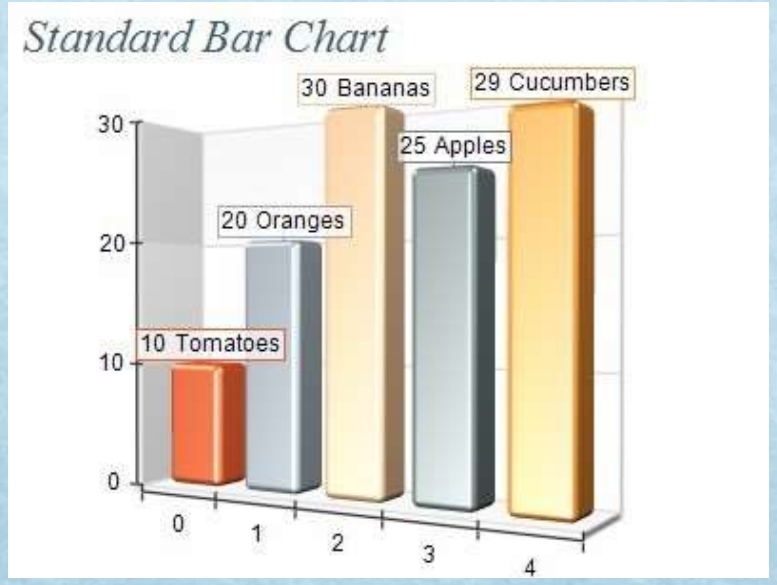
2. Presentation Graphics

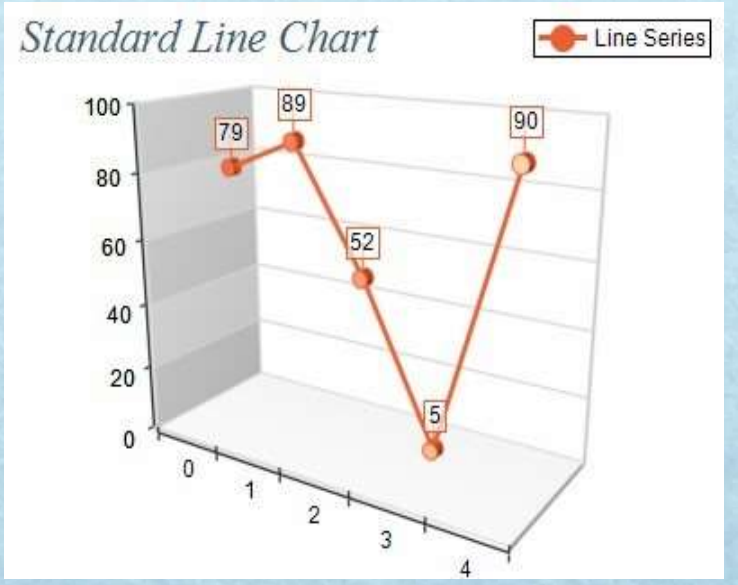
Used to produce illustrations for reports or generate slides for use with projectors

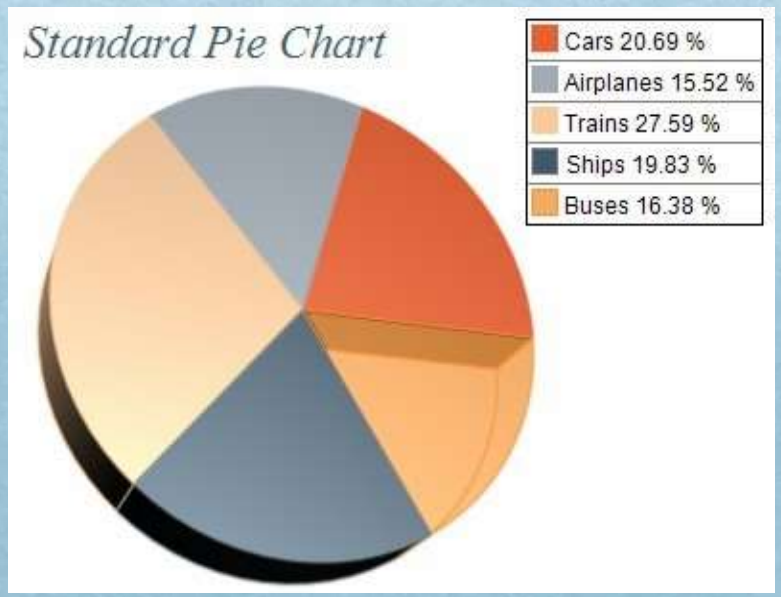
Commonly used to summarize financial, statistical, mathematical, scientific, economic data for research reports, managerial reports & customer information bulletins.

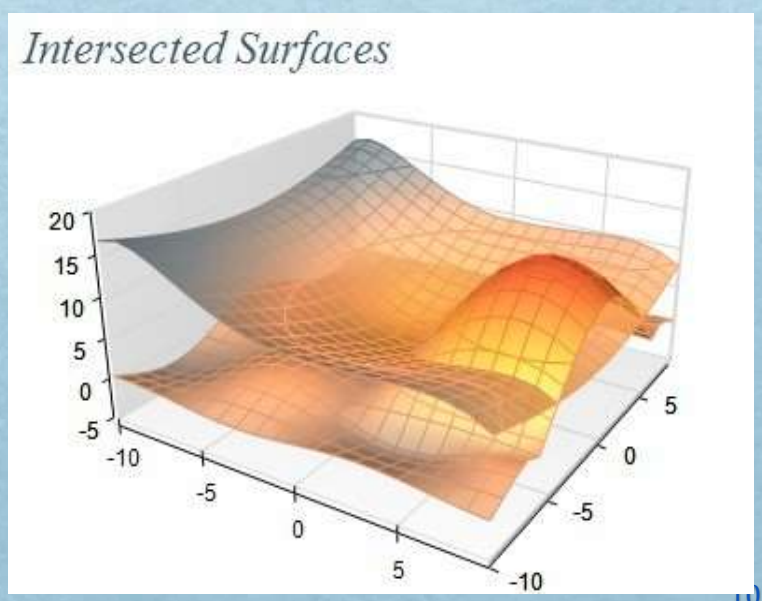
Examples : Bar charts, line graphs, pie charts, surface graphs, time chart

Examples of presentation graphics

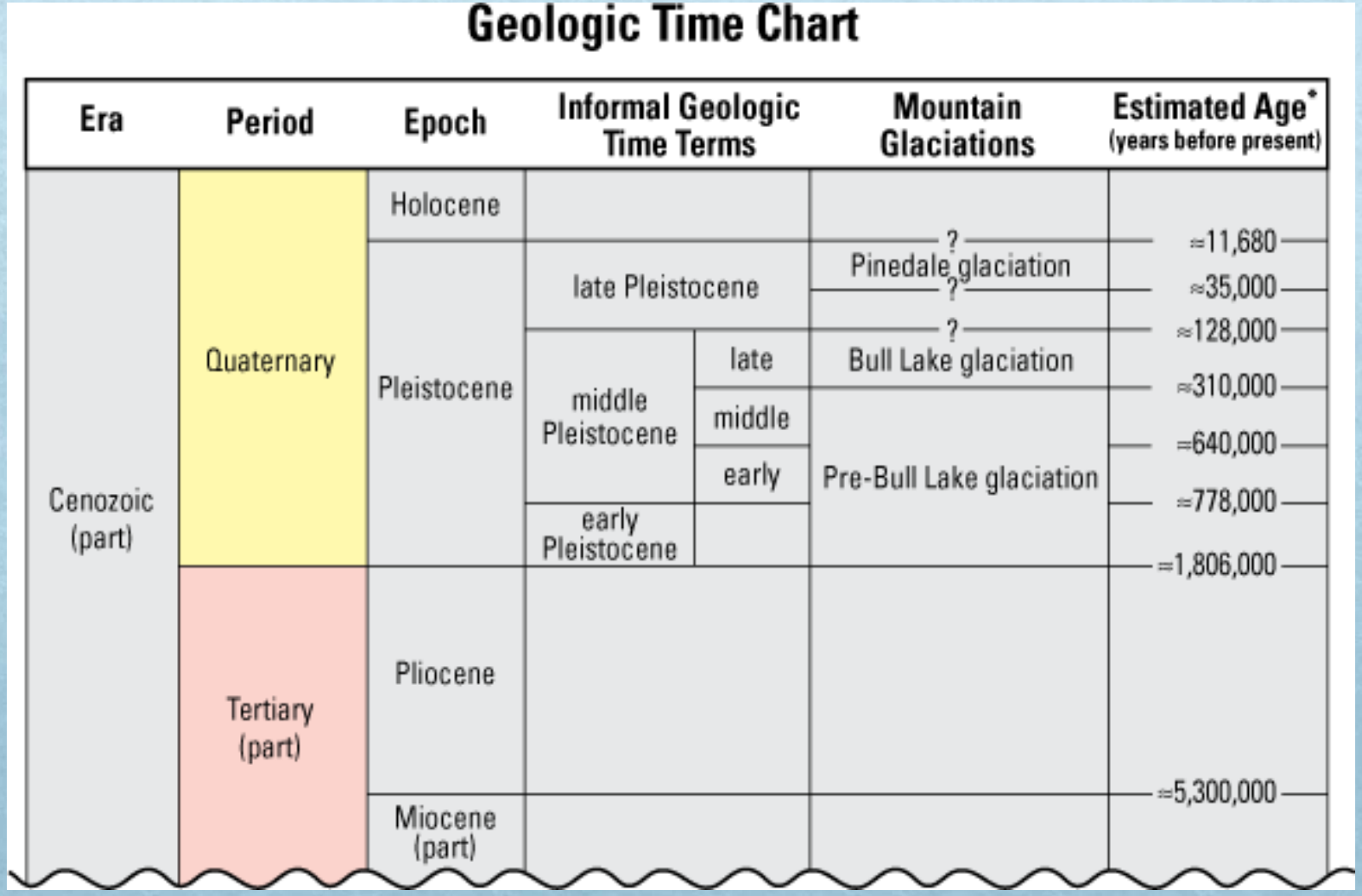








Examples of presentation graphics



Geologic Time Chart

Era	Period	Epoch	Informal Geologic Time Terms		Mountain Glaciations	Estimated Age* (years before present)
Cenozoic (part)	Quaternary	Holocene				
		Pleistocene	late Pleistocene		?	≈11,680
					Pinedale glaciation	
					?	≈35,000
					?	≈128,000
			middle Pleistocene	late	Bull Lake glaciation	≈310,000
				middle	Pre-Bull Lake glaciation	≈640,000
				early		≈778,000
			early Pleistocene			≈1,806,000
	Tertiary (part)	Pliocene				≈5,300,000
		Miocene (part)				

3. Computer Art

- Used in fine art & commercial art
  - Includes artist's paintbrush programs, paint packages, CAD packages and animation packages
  - These packages provides facilities for designing object shapes and specifying object motions.
  - Examples: Cartoon drawing, paintings, product advertisements, logo design

Examples of Computer Art


Easy Morph
File Objects Generate Display Settings Filmstrip View Help
Animate
Magnify
Generate
One Frame
End - Frogorig.tm
Start - Firegirl.tm
Tools
Result
Filmstrip
Frame
Speed
3 / 5
00:00.080
Ob (unselected At Stop Sequence

4.Entertainment

- **Movie Industry**
  - Used in motion pictures, music videos, and television shows.
  - Used in making of cartoon animation films

Computer Graphics is about Animation (films)

Computer Graphics is about Animation (films)

- **Game Industry**
  - Focus on interactivity
  - Cost effective solutions
  - Avoiding computations and other tricks

5.Education and Training

- Computer generated models of physical, financial and economic systems are used as educational aids.
- Models of physical systems, physiological systems, population trends, or equipment such as color-coded diagram help trainees to understand the operation of the system

5.Education and Training (cont...)

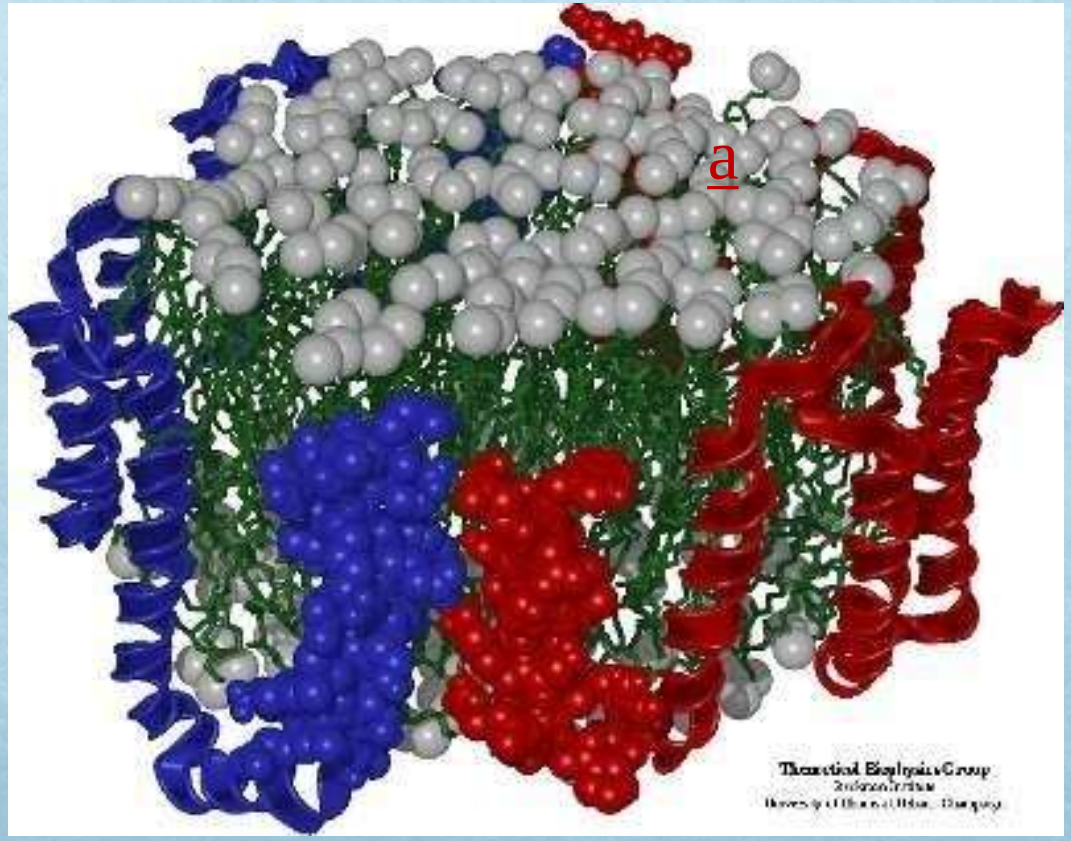
- Specialized systems used for training applications
  - simulators for practice sessions or training of ship captains, aircraft pilots.
  - Heavy equipment operators.
  - Air traffic-control.

Training

6. Visualization

- **Scientific Visualization**
  - Producing graphical representations for scientific, engineering, and medical data sets

Scientific Visualisation



6. Visualization (Cont...)

Business Visualization is used in connection with data sets related to commerce, industry and other non-scientific areas

Techniques used- color coding, contour plots, graphs, charts, surface renderings & visualizations of volume interiors.

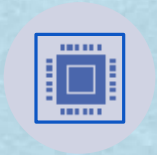


Image processing techniques are combined with computer graphics to produce many of the data visualizations.

7. Image Processing

- CG - Computer is used to create a picture
- Image Processing – applies techniques to modify or interpret existing pictures such as photographs and TV scans
- Medical applications
  - Picture enhancements
  - Tomography
  - Simulations of operations
  - Ultrasonics & nuclear medicine scanners
- Applications of image processing
  - Improving picture quality
  - Machine perception of visual information (Robotics)

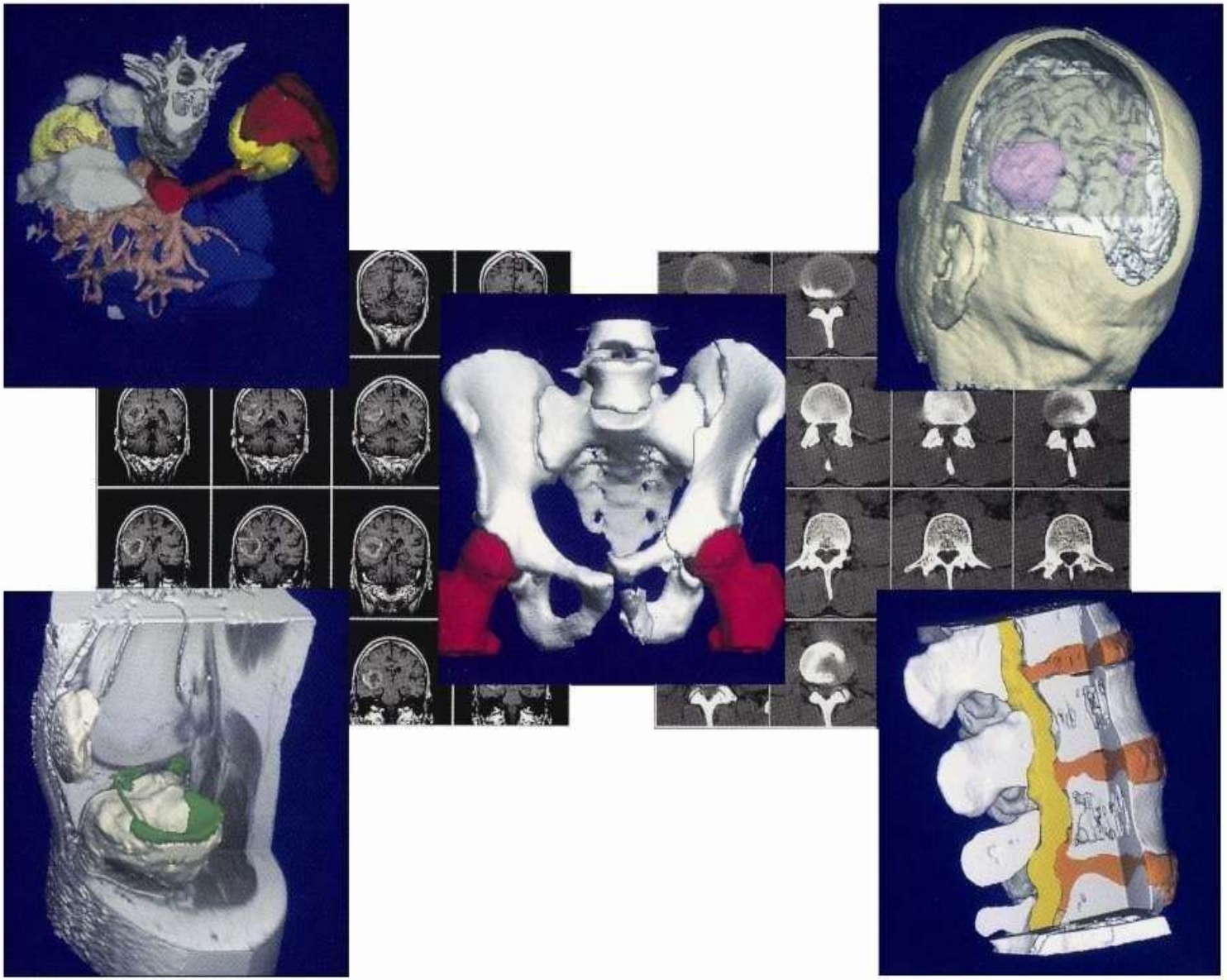
7. Image Processing (cont...)

- To apply image processing methods
  - Digitize a photograph (or picture) into an image file
  - Apply digital methods to rearrange picture parts to
    - Enhance color separations
    - Improve quality of shading

Tomography – technique of X-ray photography that allows cross-sectional views of physiological systems to be displayed

Computed X-ray tomography (CT) and position emission tomography (PET) use projection methods to reconstruct cross sections from digital data

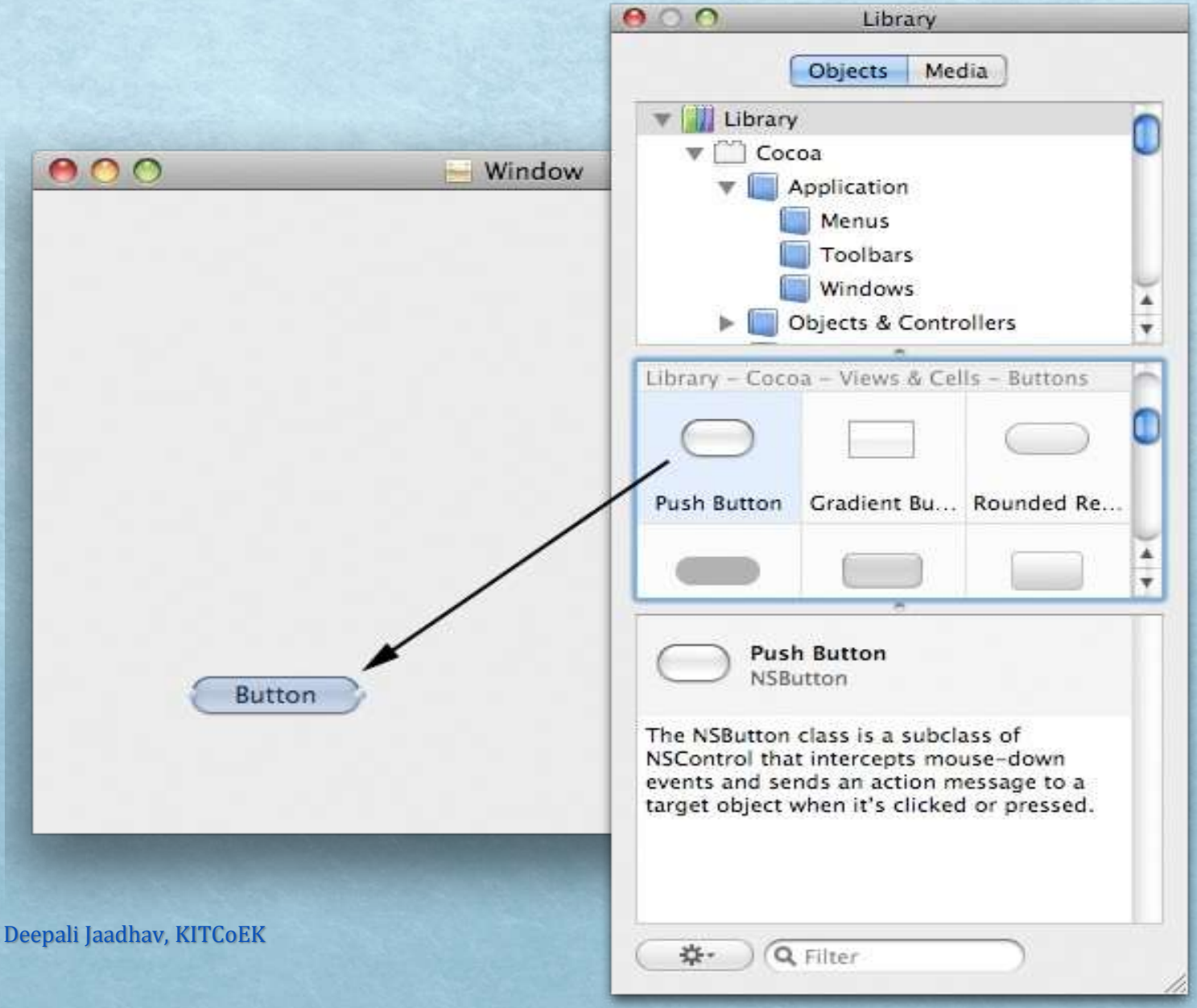
Computer-Aided Surgery is a medical application technique to model and study physical functions to design artificial limbs and to plan & practice surgery



8.Graphical User Interfaces

- Major component – Window manager (multiple-window areas)
- To make a particular window active, click in that window (using an interactive pointing device)
- Interfaces display – menus & icons
- Icons – graphical symbol designed to look like the processing option it represents
- Advantages of icons – less screen space, easily understood
- Menus contain lists of textual descriptions & icons

8. Graphical User Interfaces (cont...)



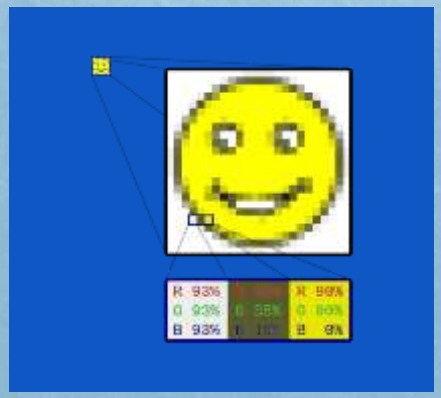
GUI – Graphical User Interface

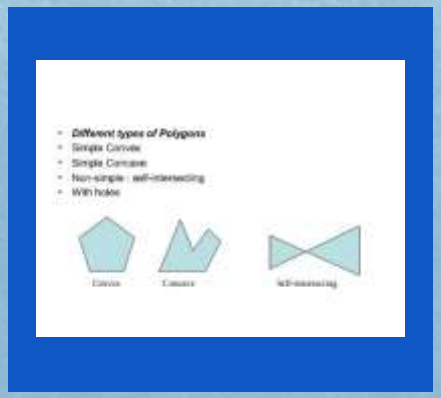
Typical Components Used:

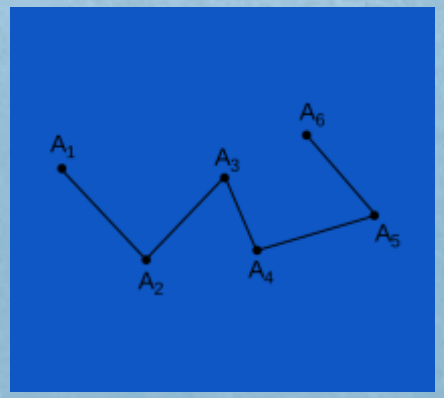
- Menus
- Icons
- Cursors
- Dialog Boxes
- Scroll Bars
- Buttons
- Valuators
- Grids
- Sketching
- 3-D Interface

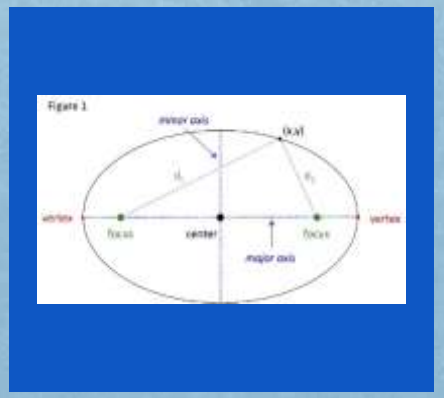
Basic Output Primitives (or Elements) for Drawing Pictures

- POLYLINE
- Filled POLYGONS (regions)
- ELLIPSE (ARC)
- TEXT
- Raster IMAGE





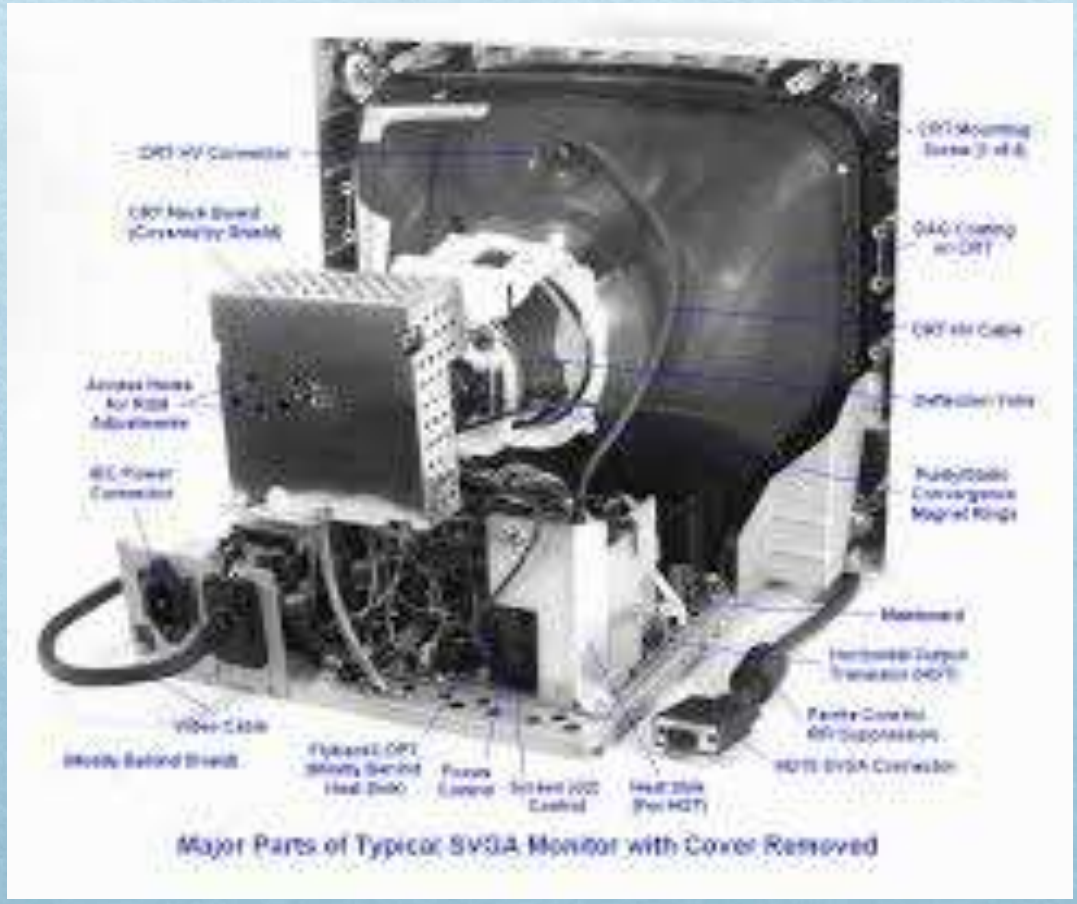




VIDEO DISPLAY DEVICES

- Refresh Cathode-Ray Tubes
- Raster-Scan Displays
- Random-Scan Displays
- Colour CRT Monitors
- Direct-View Storage Tubes
- Flat-Panel Displays
- Three-Dimensional Viewing Devices
- Stereoscopic and Virtual-Reality Systems
- Raster-Scan System
- Random-Scan Systems

Refresh Cathode-Ray Tubes



Refresh Cathode-Ray Tubes

A beam of electrons (*cathode rays*), emitted by an electron gun, passes through focusing and deflection systems.

Deflection systems direct the beam toward specified positions on the phosphor-coated screen.

The phosphor emits a small spot of light at each position contacted by the electron beam.

Phosphor fades rapidly, so to maintain the picture on the screen, the display is refreshed (*refresh CRT*) rapidly (*refresh rate*) and this type of display is called a **refresh CRT**.

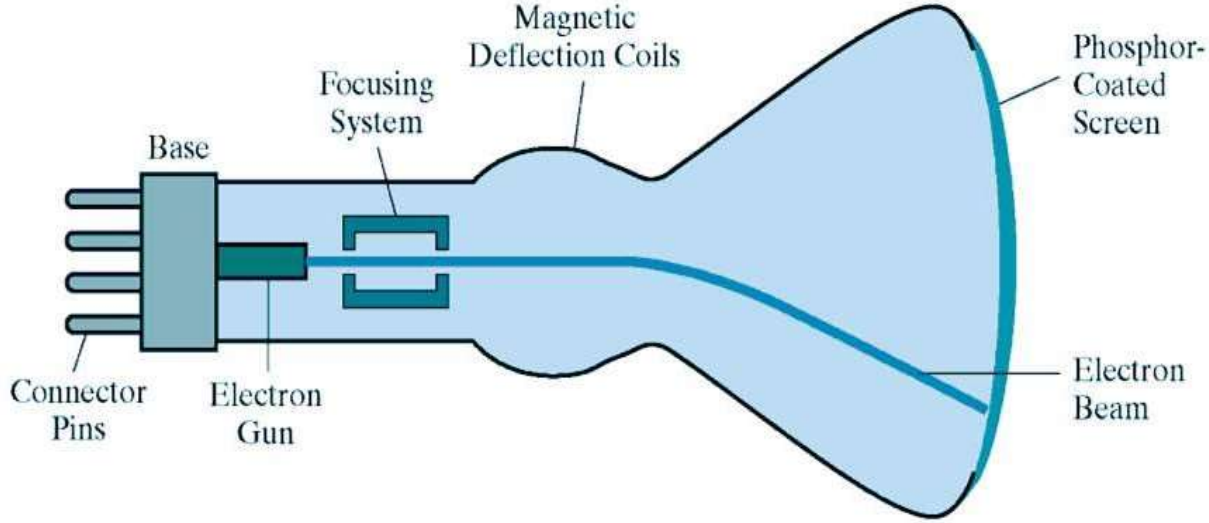


Figure 2-2

Basic design of a magnetic-deflection CRT.

Operation of an Electron Gun

- The primary components of an electron gun
  - Heated metal cathode and control grid
- When a current goes through filament, cathode surface is heated, electrons are "boiled off".
- These free, negatively charged electrons are accelerated towards phosphor coating by a high positive voltage.
- When the beam hits a phosphor dot, it glows with a brightness proportional to the strength of the beam and how long it is hit

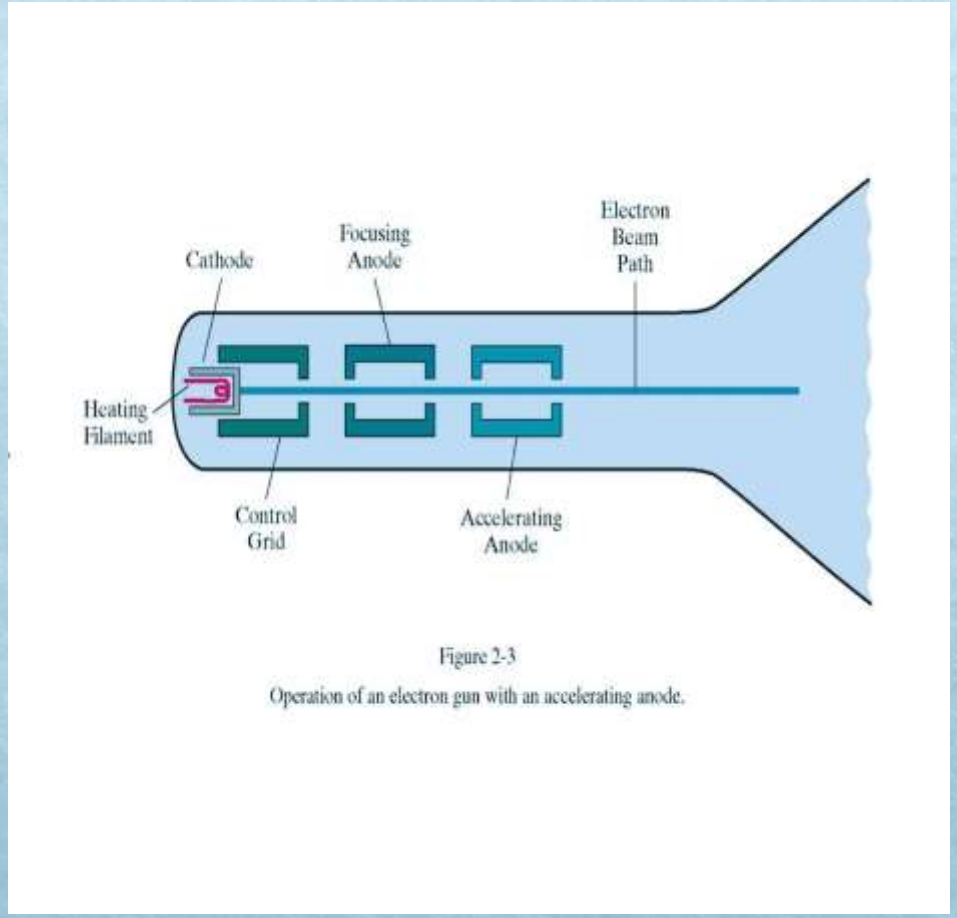


Figure 2-3
Operation of an electron gun with an accelerating anode.

Control Grid

- Controls the intensity of the electron beam.
  - High negative voltage applied to control grid shuts off the beam.
  - Smaller negative voltage decreases the number of electrons passing through it.
- Number of electrons on the phosphor screen is proportional to emitted light by the screen.
- Then, brightness of a point on the screen is controlled by varying the voltage applied to control grid.
- Graphics software commands can be used to do this.

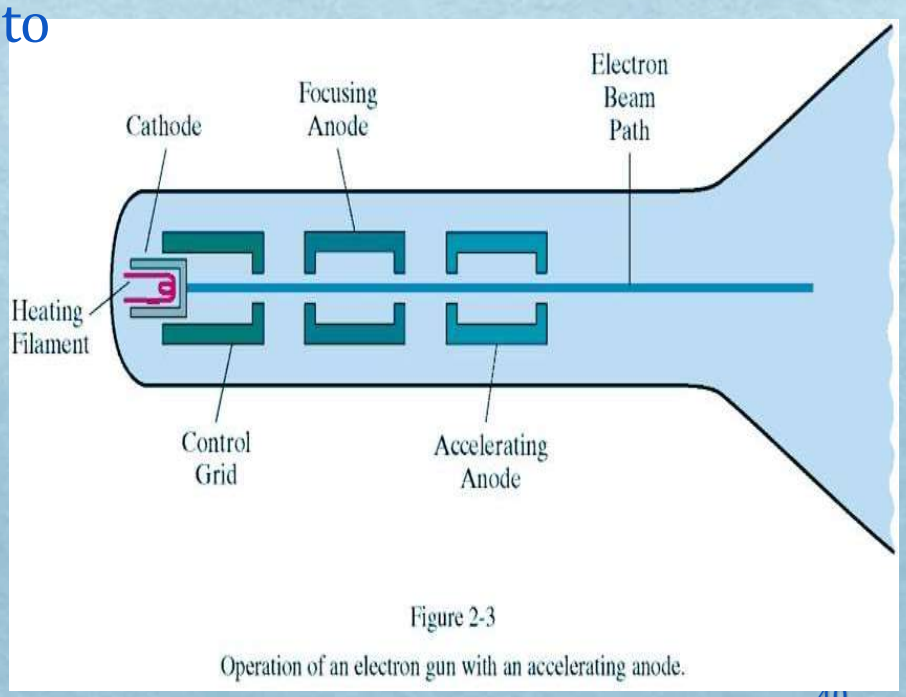


Figure 2-3

Operation of an electron gun with an accelerating anode.

Focusing System

Forces the electron beam to converge to a small cross section.

Accomplished with either electric or magnetic fields.

The electron beam is passed through a positively charged metal cylinder.

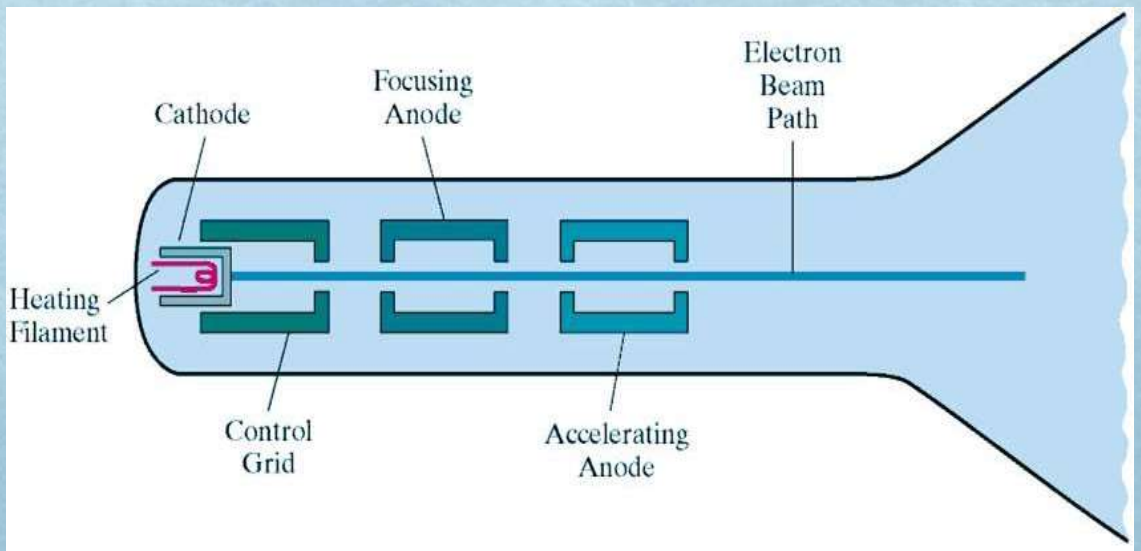


Figure 2-3

Operation of an electron gun with an accelerating anode.

Deflection of Electron Beam

- Two pairs of magnetic-deflection coils are mounted on the outside of the CRT envelope.
- The magnetic field is produced by each pair of coils.
- One pair of plates is mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control horizontal deflection.
- The field results in a transverse deflection force that is perpendicular to the direction of electron beam.
- The deflection of the beam is proportional to the current through the coils.
- videoplayback.mp4

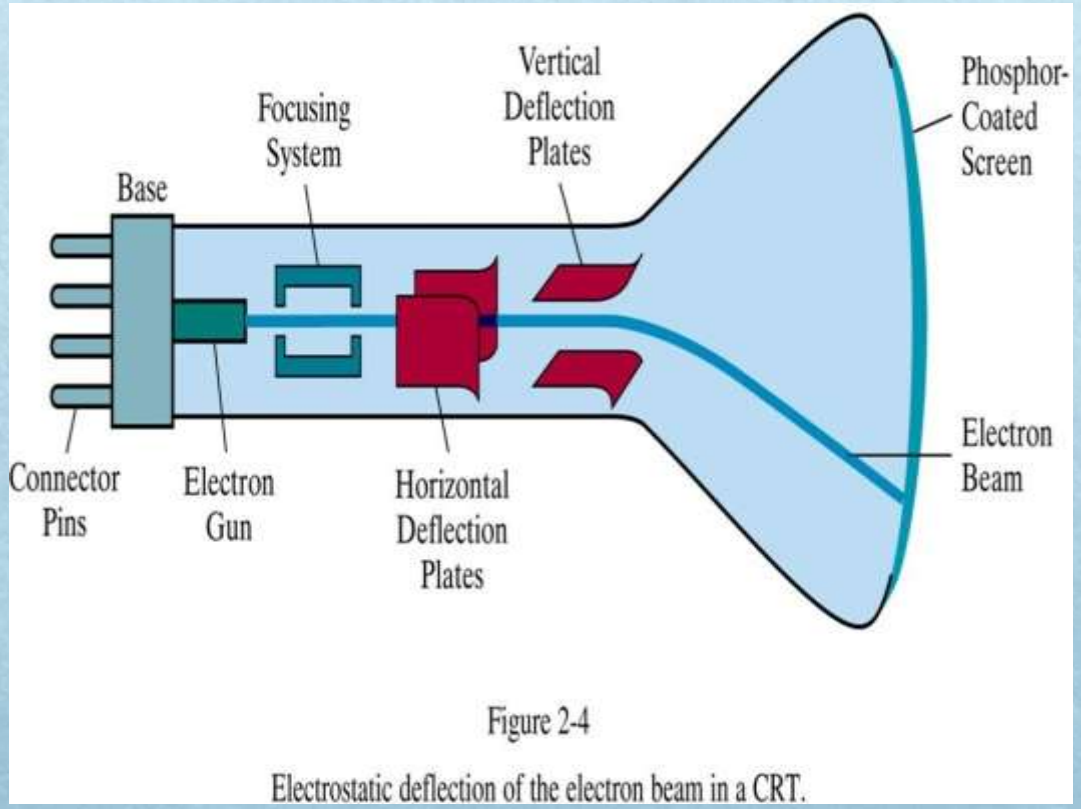


Figure 2-4

Electrostatic deflection of the electron beam in a CRT.

Refresh Cathode-Ray Tubes

- **Resolution** : The maximum number of points that can be displayed without overlap on a **CRT** is referred to as the resolution.
- A more precise definition of resolution is the number of points per centimetre that can be plotted horizontally and vertically, or
- The total number of points in each direction.
- **Aspect ratio** : This number gives the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen.

Raster-Scan Displays

- Based on television technology.
- The electron beam is swept across the screen, one row at a time, from top to bottom.
- Each row is called a scan line.
- Picture definition is stored in a memory called **refresh buffer** or **frame buffer.**
- Each screen spot is referred as **a pixel** or **pel**. Eg: TV, printers, etc
- Refreshed at 60 to 80 frames per second (fps) -60 HZ or higher to remove flickering.

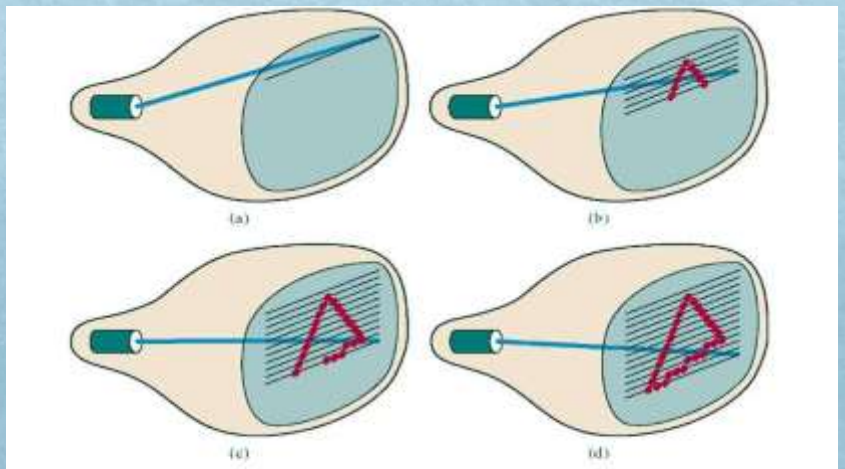


Figure 2-7
A raster-scan system displays an object as a set of discrete points across each scan line.

Raster-Scan Displays

In a simple black-and-white system, each screen point is either on or off, so only one bit per pixel is needed to control the intensity of screen positions.

A bit value of 1 indicates that the electron beam is to be turn on at that position, and a value of **0** indicates that the beam intensity is to be off.

Additional bits are needed when color and intensity variations can be displayed. Up to **24** bits per pixel are included in high-quality systems.

A system with **24** bits per pixel and a screen resolution of 1024 by 1024 requires 3 megabytes of storage for the frame buffer.

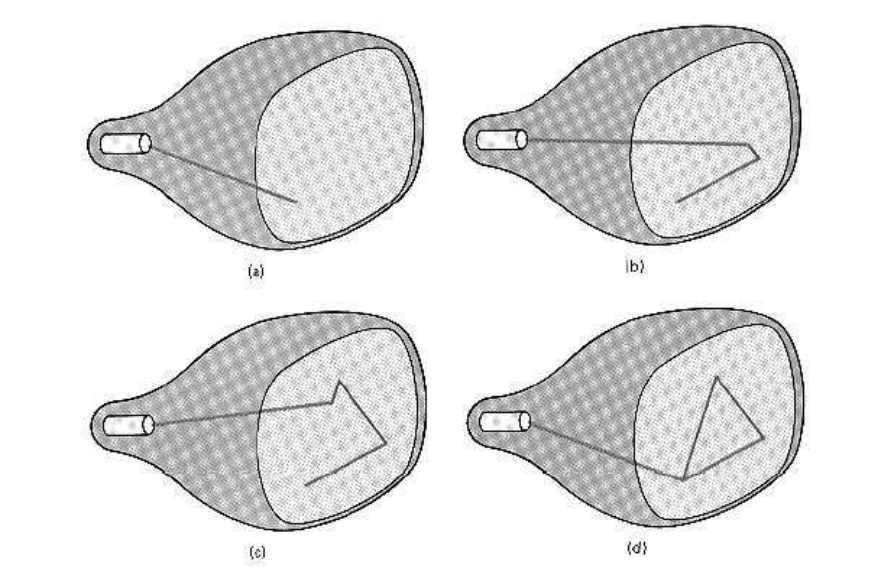
On a black-and-white system with one bit per pixel, the frame buffer is commonly called a **bitmap**.

For systems with multiple bits per pixel, the frame buffer is referred to as a **pixmap**.

RANDOM-Scan Displays

When operated as a random-scan display unit, a CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn.

Random-scan monitors draw a picture one line at a time and for this reason are also referred to as **vector displays** (or **stroke-writing** or **calligraphic displays**).



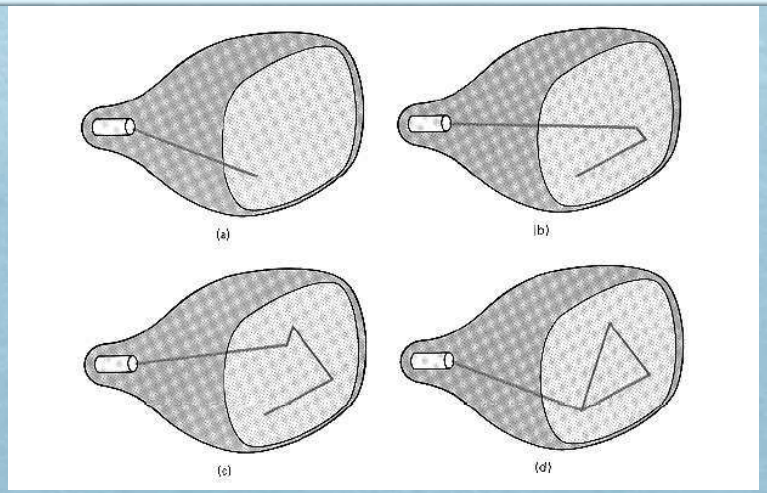
RANDOM-Scan Displays

Refresh rate depends on the number of lines to be displayed.

Picture definition is stored as a set of line drawing commands in an area of memory referred to as **refresh display file** (**display list**).

To display a picture, the system cycle through the **set of commands** in the display file, drawing each component line in turn.

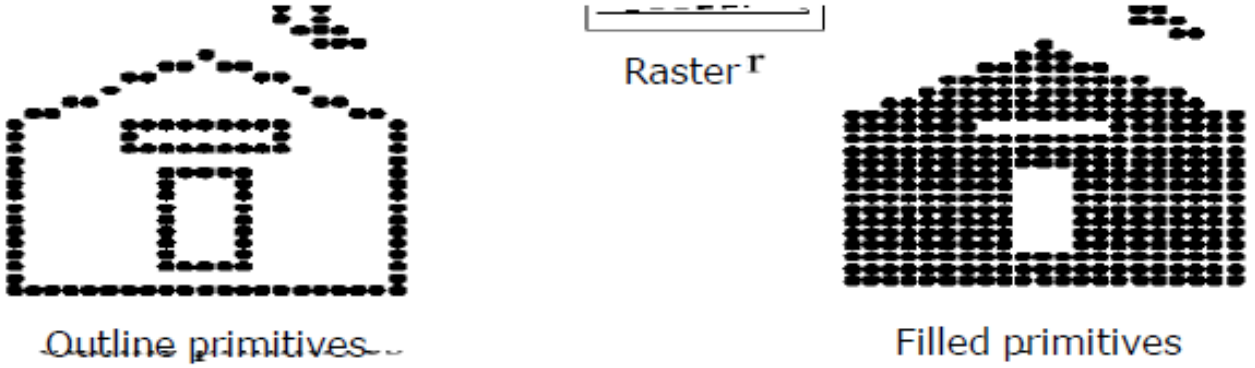
Random scan displays are designed to draw all the component lines of a picture 30 to 60 times each second



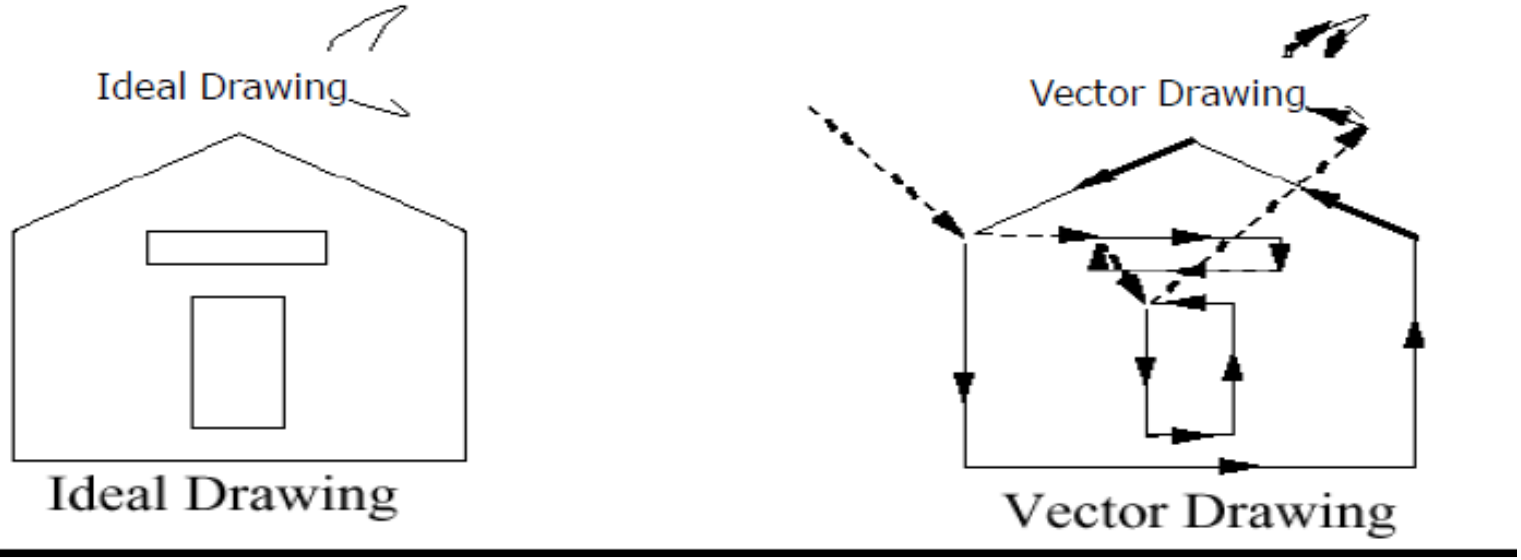
Difference between random scan and raster scan

Base of Difference	Raster Scan System	Random Scan System
Electron Beam	The electron beam is swept across the screen, one row at a time, from top to bottom.	The electron beam is directed only to the parts of screen where a picture is to be drawn.
Resolution	Its resolution is poor because raster system in contrast produces zigzag lines that are plotted as discrete point sets.	Its resolution is good because this system produces smooth lines drawings because CRT beam directly follows the line path.
Picture Definition	Picture definition is stored as a set of intensity values for all screen points, called pixels in a refresh buffer area.	Picture definition is stored as a set of line drawing instructions in a display file.
Realistic Display	The capability of this system to store intensity values for pixel makes it well suited for the realistic display of scenes contain shadow and color pattern.	These systems are designed for line-drawing and can't display realistic shaded scenes.
Draw an Image	Screen points/pixels are used to draw an image.	Mathematical functions are used to draw an image.

- A Raster system produces jagged lines that are plotted as discrete points sets.



- Vector displays product smooth line drawing



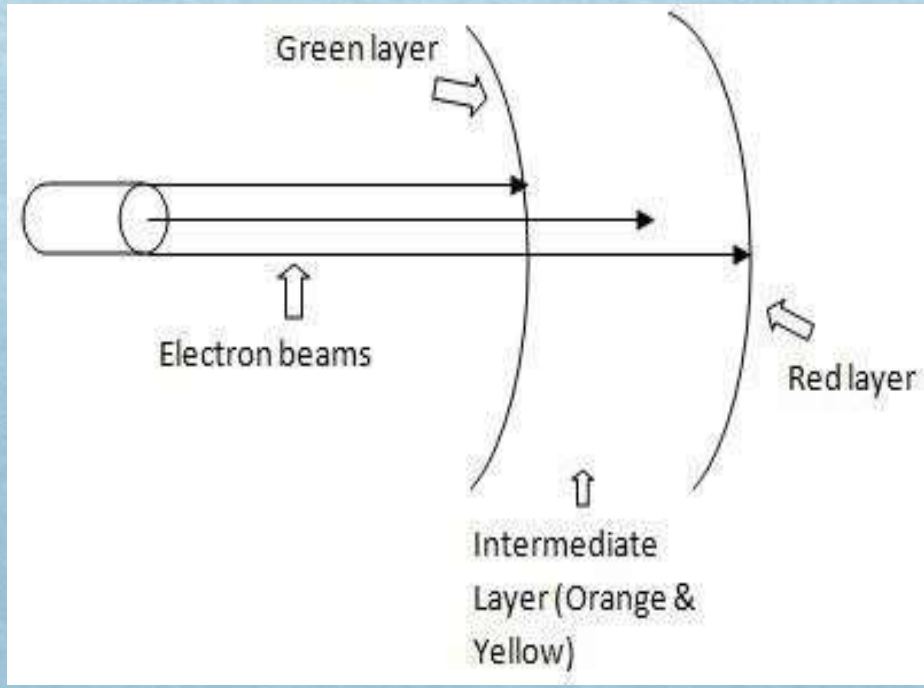
- Random scan displays are designed for **line-drawing applications** and can not display realistic shaded scenes

Color CRT Monitors

- A CRT monitor displays color pictures by using a combination of phosphors that emit different-coloured light.
- By combining the emitted light from the different phosphors, a range of colours can be generated..
- Two basic techniques for producing color displays with a CRT are
  - Beam-penetration method
  - Shadow-mask method

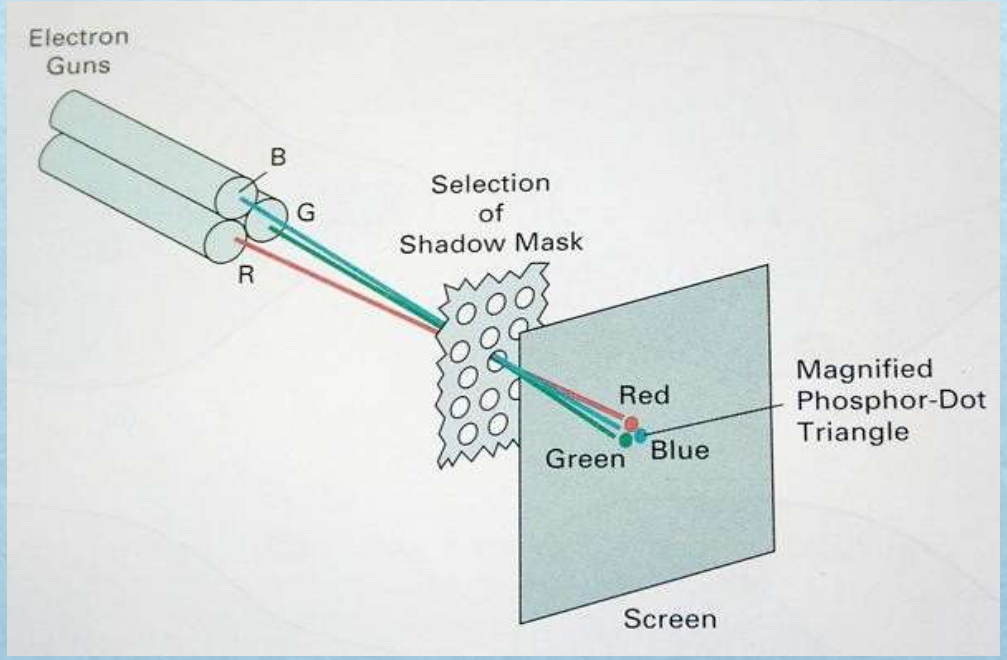
Beam-penetration method

- For displaying color, pictures has been used with random-scan monitors
- Two layers of phosphor, usually red and green, are coated onto the inside of the CRT screen, and the displayed color depends on how far the electron beam penetrates into the phosphor layers.
- A beam of slow electrons hits only the inner green layer.
- A beam of very fast electrons penetrates through the green layer and hitss the outer red layer.
- At intermediate beam speeds, combinations of red and green light are emitted to show two additional colors, orange and yellow.
- Only 4 colours are possible.
- Picture quality is not that much good.



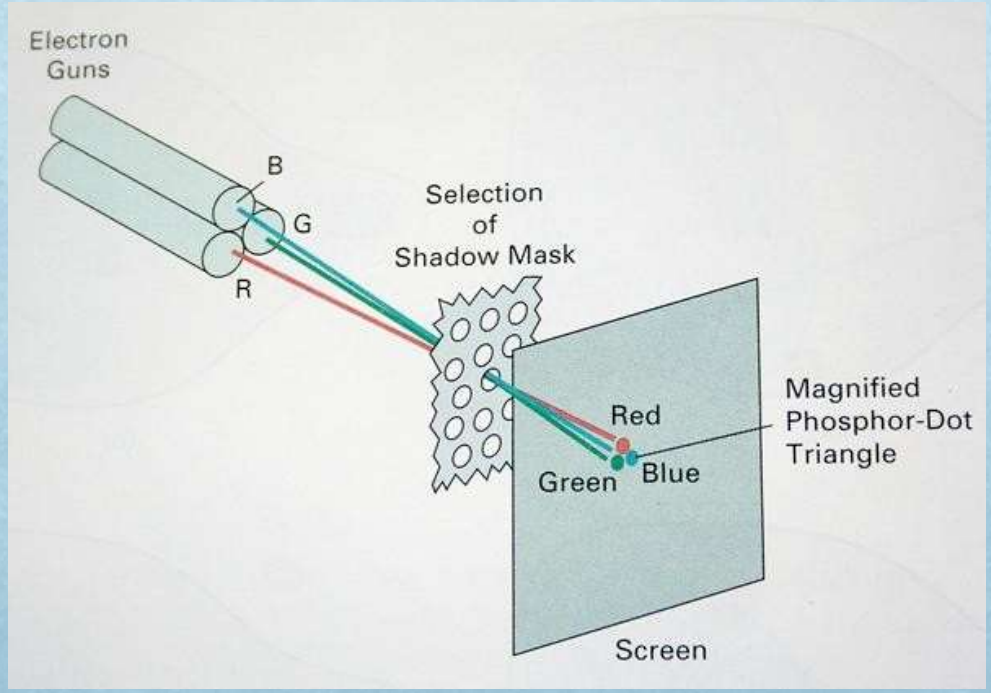
Shadow-mask method

- Commonly used in raster scan systems (including color TV) because they produce a much wider range of colors than the beam penetration method.
- A shadow-mask CRT has three phosphor color dots at each pixel position.
- One phosphor dot emits a **red** light, another emits a **green** light, and the third emits a **blue** light.
- This type of CRT has three electron guns, one for each color dot and a shadow-mask grid just behind the phosphor-coated screen.



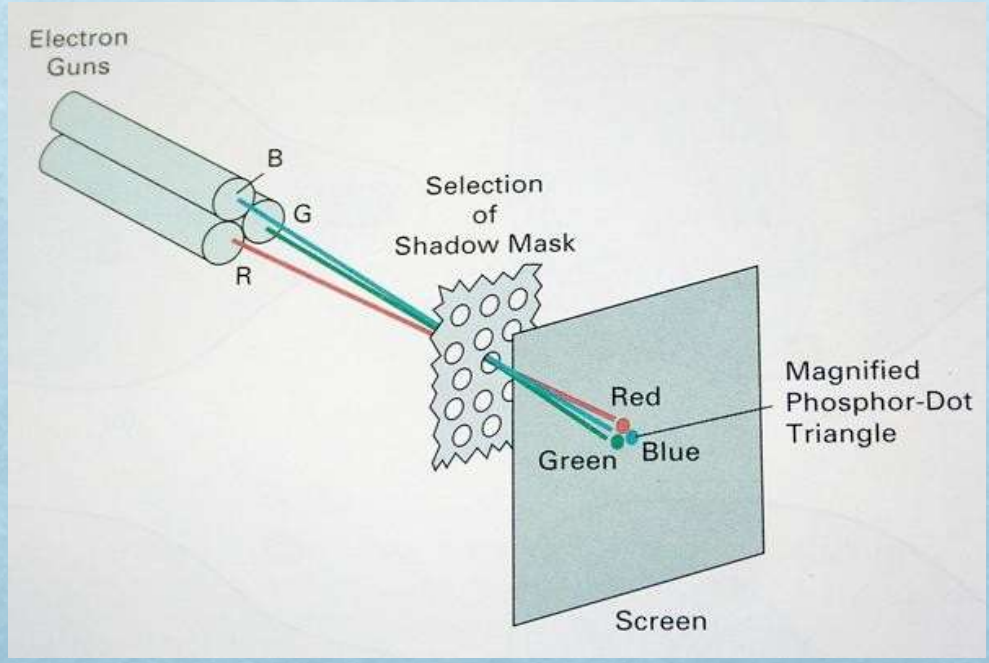
Shadow-mask method (Cont'd)

- The three electron beams are deflected and focused as a group onto the shadow mask, which contains a series of holes aligned with the phosphor-dot patterns.
- When the three beams pass through a hole in the shadow mask, they activate a dot triangle, which appears as a small color spot on the screen.
- We obtain color variations in a shadow-mask CRT by varying the intensity levels of the three electron beams.



Shadow-mask method (Cont'd)

- By turning off the red and green guns, we get only the color coming from the blue phosphor.
- A white (or gray) area is the result of activating all three dots with equal intensity.
- **Yellow** is produced with the **green and red** dots only, **magenta** is produced with the **blue and red** dots, and **cyan** shows up when **blue and green** are activated equally.
  - 256 voltage settings for each electron gun
  - Nearly 17 million colour choices.
- https://youtu.be/Gnl1vuwjHto



DVST - Direct View Storage Tube

- A direct-view storage tube (DVST) stores the picture information as a charge distribution just behind the phosphor-coated screen.
- Means picture information is stored inside the CRT instead of refreshing the screen.
- Two electron guns are used in a DVST. One, the primary gun, is used to store the picture pattern; the second, the flood gun, maintains the picture display.
- **Advantages**: Because no refreshing is needed, very complex pictures can be displayed at very high resolutions without flicker.
- **Disadvantages**: ordinarily do not display colour and that selected parts of a picture cannot he erased.
  - To eliminate a picture section, the entire screen must be erased and the modified picture redrawn.
  - The erasing and redrawing process can take several seconds for a complex picture.

Flat-Panel Displays

- The term Flat-panel display refers to a class of video devices that have reduced volume, weight and power requirements compared to a CRT.
- Ex: small TV monitors, calculators, pocket video games, laptop computers, etc
- We can separate flat-panel displays into two categories:

  1.Emissive displays

  2.Non emissive displays
- The **emissive displays** (or emitters) are devices that convert electrical energy into light.
  - Plasma panels, thin-film electroluminescent displays and Light-emitting diodes are examples of emissive displays.
- **Non emissive displays** (or non emitters) use optical effects to convert sunlight or light from some other source into graphics patterns.
  - LCD example of Non emissive display.

Emissive Displays - Plasma panels

- Also called **gas-discharge displays**, are constructed by filling the region between two glass plates with a mixture of gases that usually includes neon.
- A series of **vertical conducting ribbons** is placed on one glass panel, and a set of **horizontal ribbons** is built into the other glass panel.
- Firing voltages applied to a pair of horizontal and vertical conductors cause the gas at the intersection of the two conductors to **break down into a glowing plasma of electrons and ions.**

- Disadvantage of plasma panels has been that they were strictly monochromatic devices
- https://youtu.be/8lkuqybOjBw

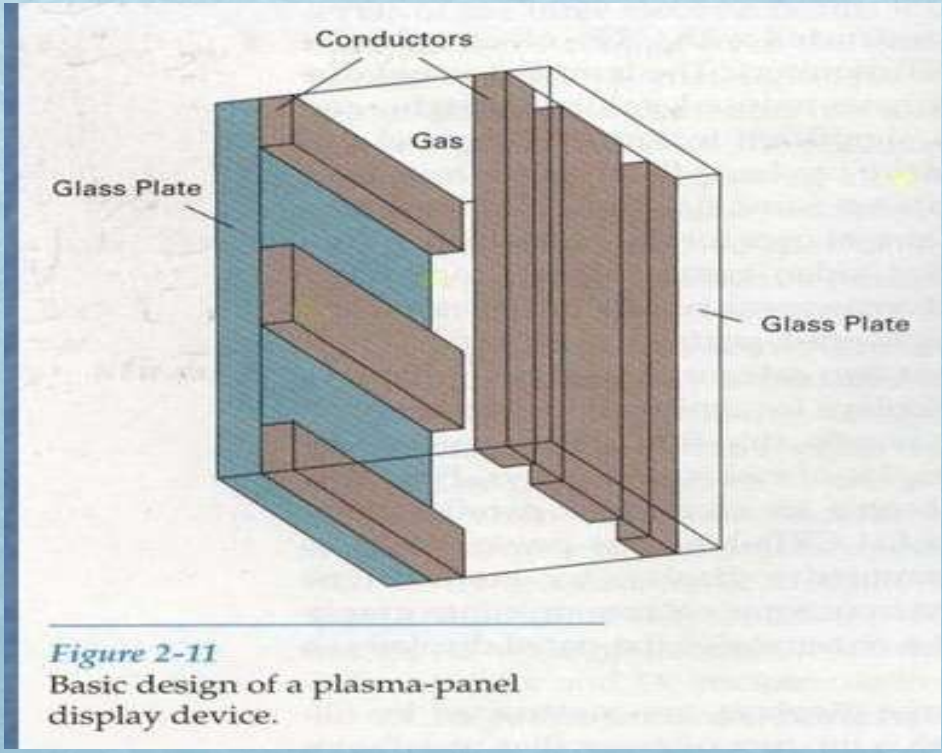


Figure 2-11
Basic design of a plasma-panel display device.

Emissive-Thin-film electroluminescent displays

- Similar in construction to a plasma panel.
- The difference is that the region between the glass plates is **filled with a phosphor**, such as zinc sulfide doped with manganese, instead of a gas.
- When a sufficiently high voltage is applied to a pair of crossing electrodes, the **phosphor becomes a conductor** in the area of the intersection of the two electrodes.
- Disadvantage : Electroluminescent displays require more power than plasma panels, and good color and gray scale displays are hard to achieve.

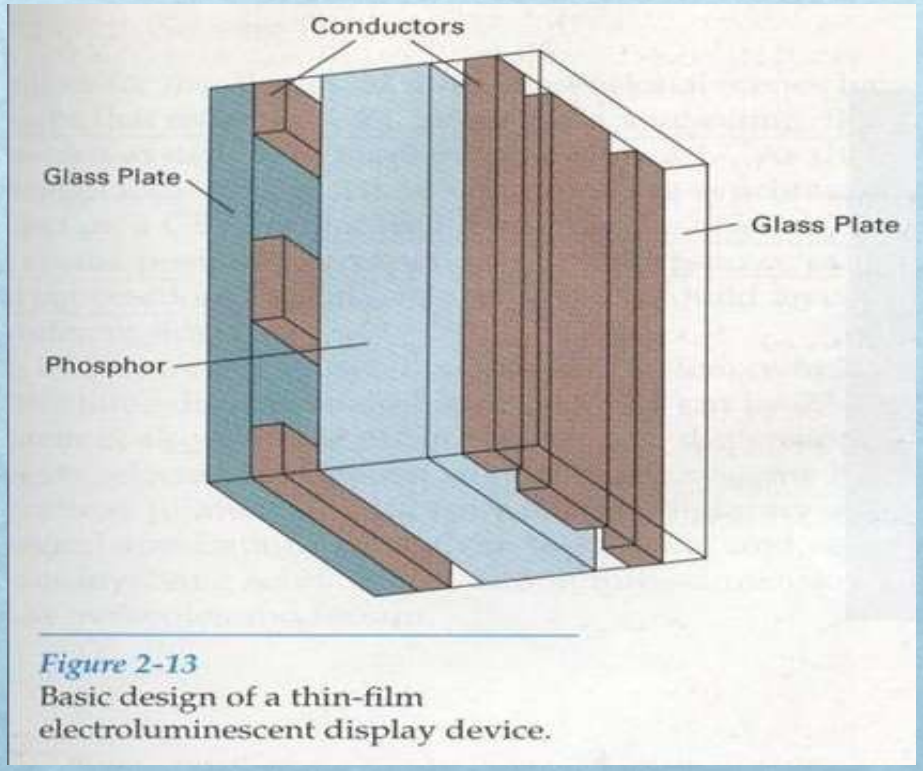
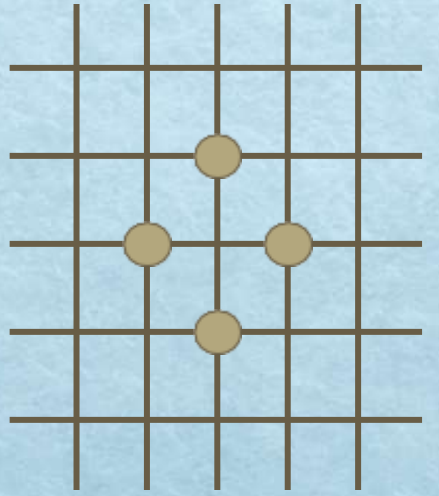


Figure 2-13
Basic design of a thin-film electroluminescent display device.

Emissive Displays - Light-emitting diode (LED)

- A matrix of diodes is arranged to form the pixel positions in the display, and **picture definition is stored in a refresh buffer**.
- Information is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light patterns in the display.
- https://youtu.be/eQ-yRKqB-IA



Non emissive displays - Liquid Crystal Displays

- LCDS are commonly used in **small systems**, such as calculators and portable, laptop computers.
- Produce a picture by **passing polarized light from the surroundings** or from an internal light source **through a liquid-crystal material** that can be aligned to either block or transmit the light.
- The term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid.

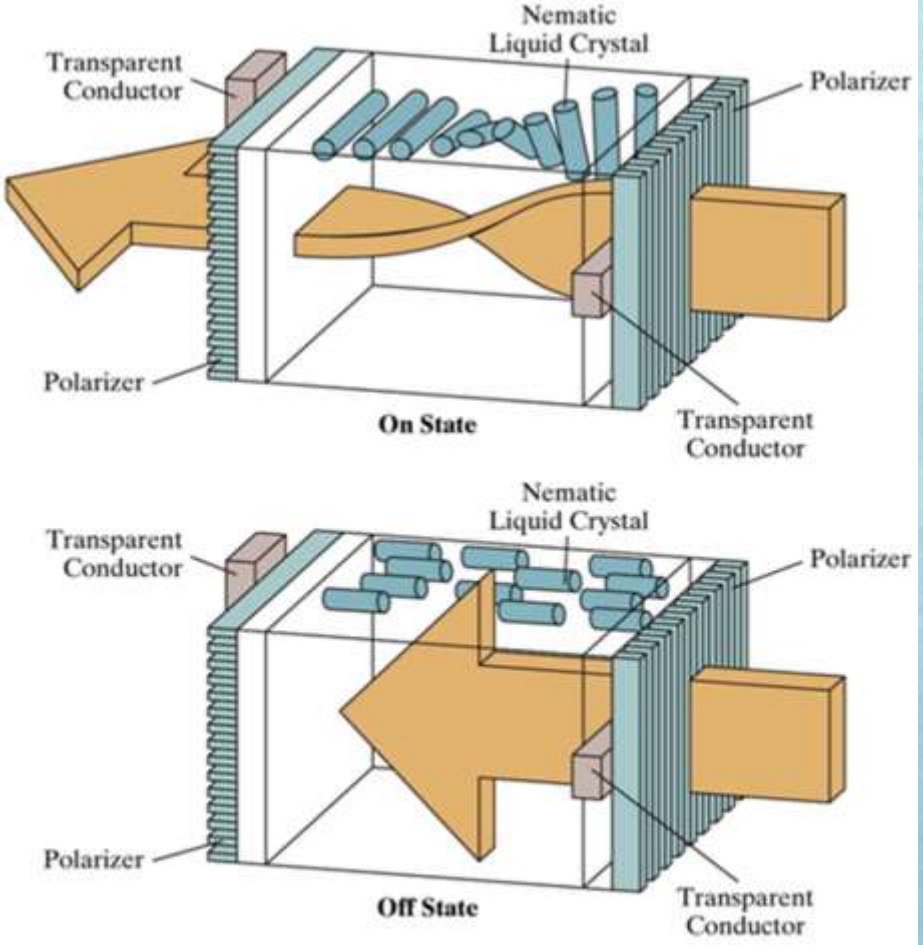


Figure2-15

The light-twisting, shutter effect used in the design of most liquid-crystal display devices.

Non emissive displays - Liquid Crystal Displays

- Two glass plates, each containing a light polarizer at right angles to the-other plate, sandwich the liquid-crystal material.
- Rows of horizontal transparent conductors are built into one glass plate, and columns of vertical conductors are put into the other plate.
- The **intersection of two conductors defines a pixel position**
- There are two states
  - ON state - light will transmit
  - OFF state - light will not transmit

https://youtu.be/82KaxKyuwV4

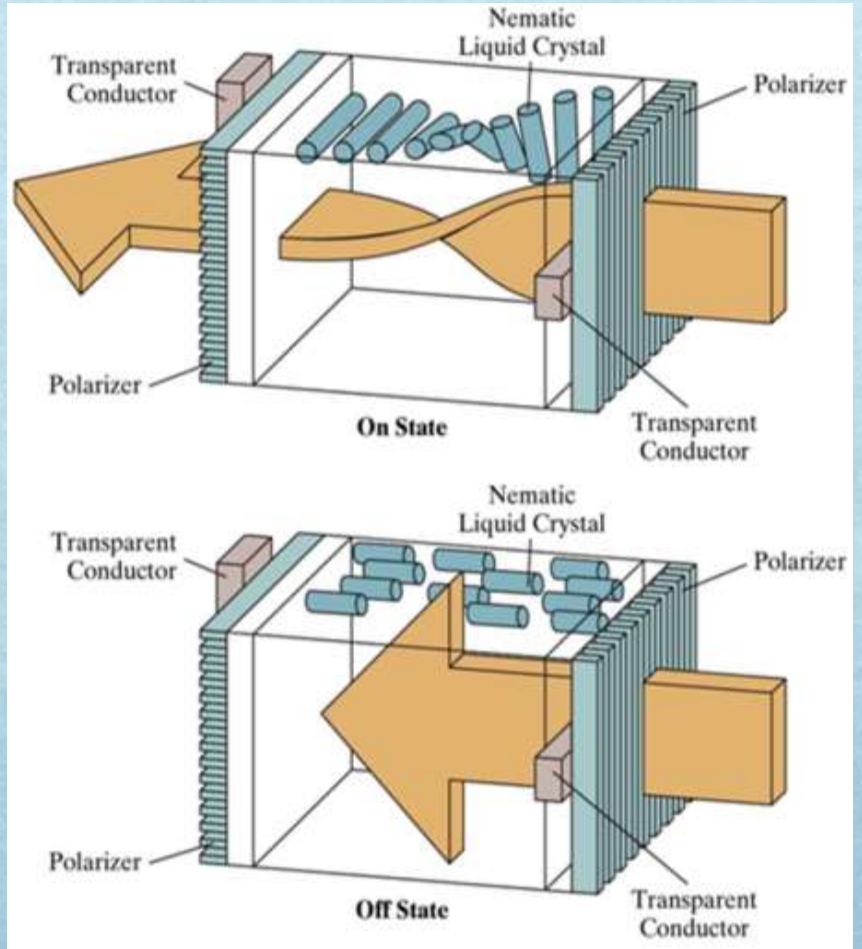


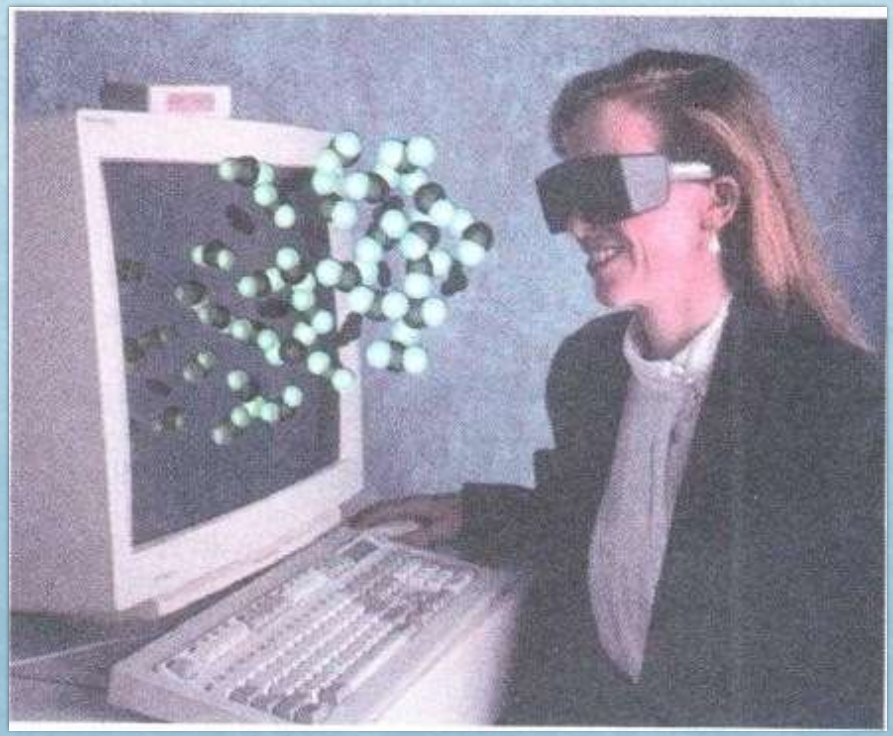
Figure2-15

The light-twisting, shutter effect used in the design of most liquid-crystal display devices.

Stereoscopic and virtual-reality systems

- **Stereoscopic system**
- Stereoscopic views does not produce three dimensional images, but it produce 3D effects by presenting different view.
- To obtain this we first need to obtain two views of object generated from viewing direction corresponding to each eye.
- We can construct the two views as computer generated scenes with different viewing positions or we can use stereo camera pair to photograph some object or scene.

- When we see simultaneously both the view as left view with left eye and right view with right eye then two views is merge and produce image which appears to have depth



Stereoscopic and virtual-reality systems

- **Virtual-reality:**
- Virtual reality is the system which produce images in such a way that we feel that our surrounding is what we are set in display devices but in actually it does not.
- In virtual reality user can step into a scene and interact with the environment.
- A head set containing an optical system to generate the stereoscopic views is commonly used.
- Sensor in the head set keeps track of the viewer's position so that the front and back of objects can be seen as the viewer "walks through" and interacts with the display.
- VID-20210106-WA0027.mp4

Raster scan system

Simple raster graphics system

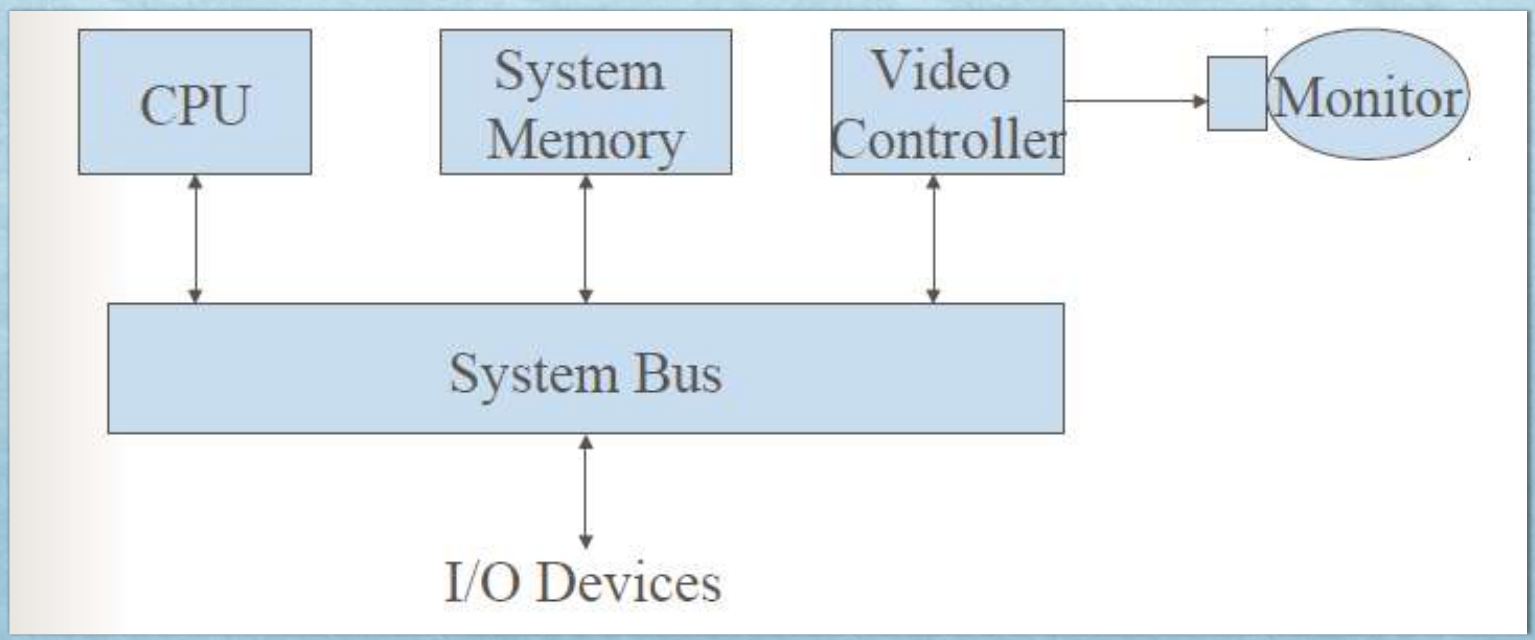
Raster graphics system with a fixed portion of the system memory reserved for the frame buffer

Basic refresh operation of video controller

Raster-graphics system with a display processor

Simple Raster Graphics System

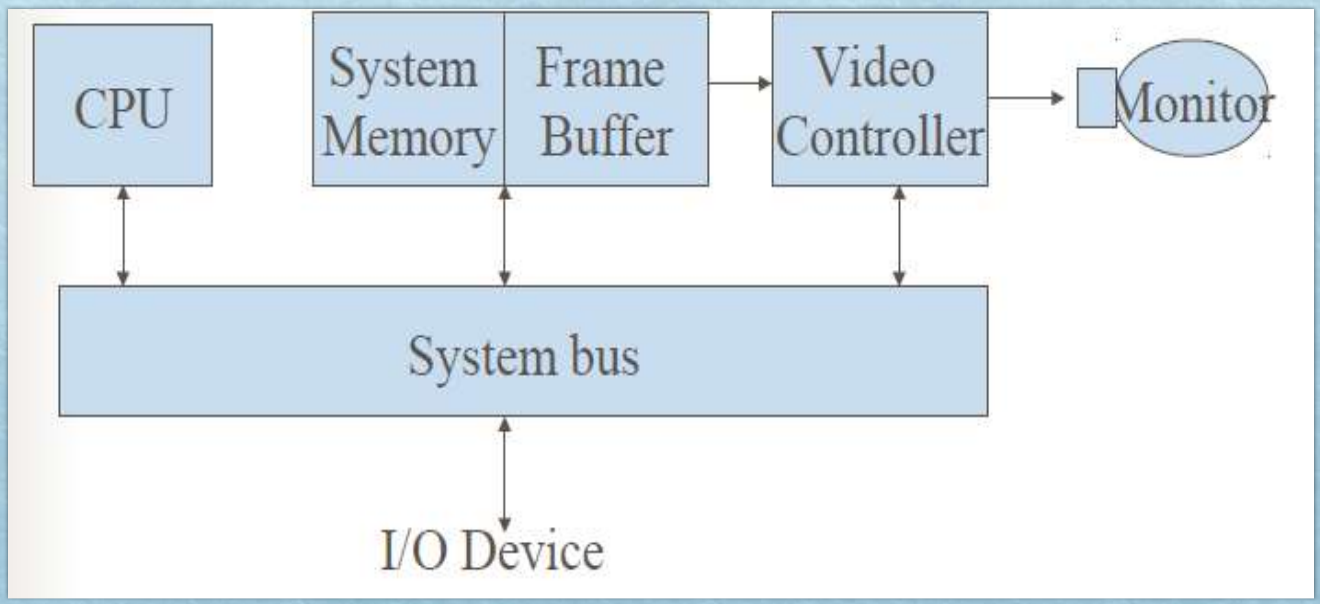
- Addition to the CPU, special purpose processor, Video Controller or display controller is used to control the operation of the display device.
- Frame buffer can be anywhere in the systems memory & video controller access the frame buffer to refresh the screen.



Architecture of a simple raster graphics system.

Raster Graphics System with A Fixed Memory Portion

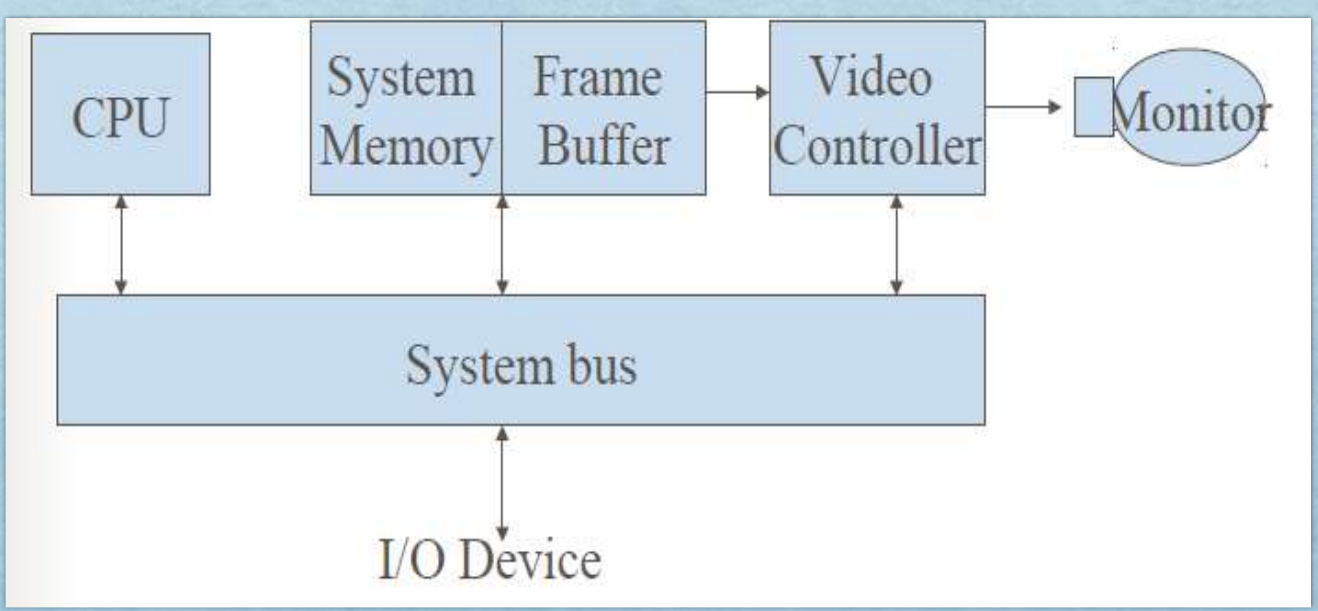
- A fixed area of the system memory is reserved for the frame buffer and the video controller can directly access that frame buffer memory.
- Frame buffer location and the screen position are referred in Cartesian coordinates.



Architecture of a raster graphics system with a fixed portion of the system memory reserved for the frame buffer.

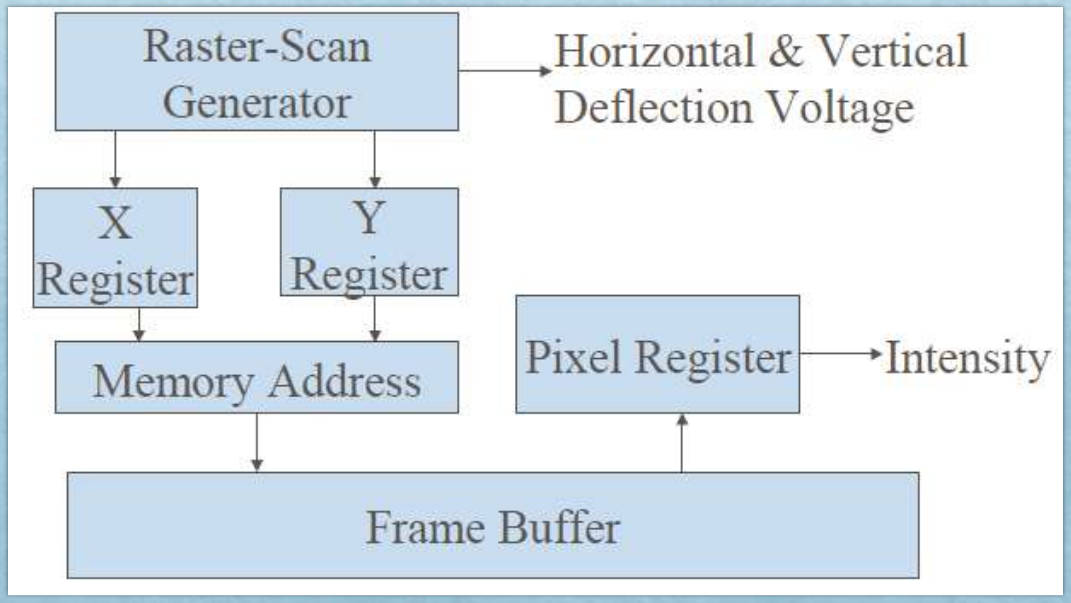
Raster Graphics System with A Fixed Memory Portion

- For many graphics monitors the coordinate origin is defined at the lower left screen corner.
- Screen surface is then represented as the first quadrant of the two-dimensional systems with positive X-value increases as left to right and positive Y-value increases bottom to top.



Basic Refresh Operation of Video Controller

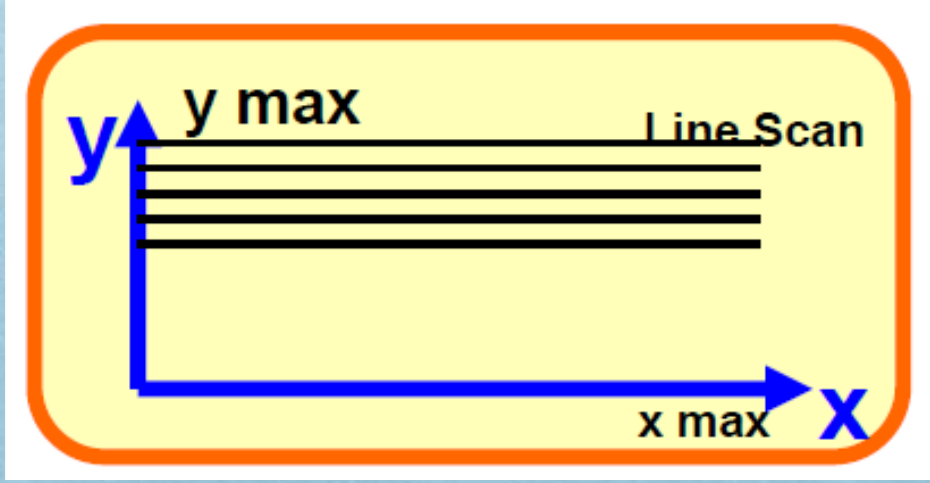
- On some personal computers, the coordinate origin is referenced at the upper left comer of the screen.
- Two registers are used to store the coordinates of the screen pixels which are X and Y
- Initially the X is set to 0 and Y is set to Y_{max}.
- The value stored in frame buffer for this pixel is retrieved and used to set the intensity of the CRT beam.



Basic video controller refresh operation

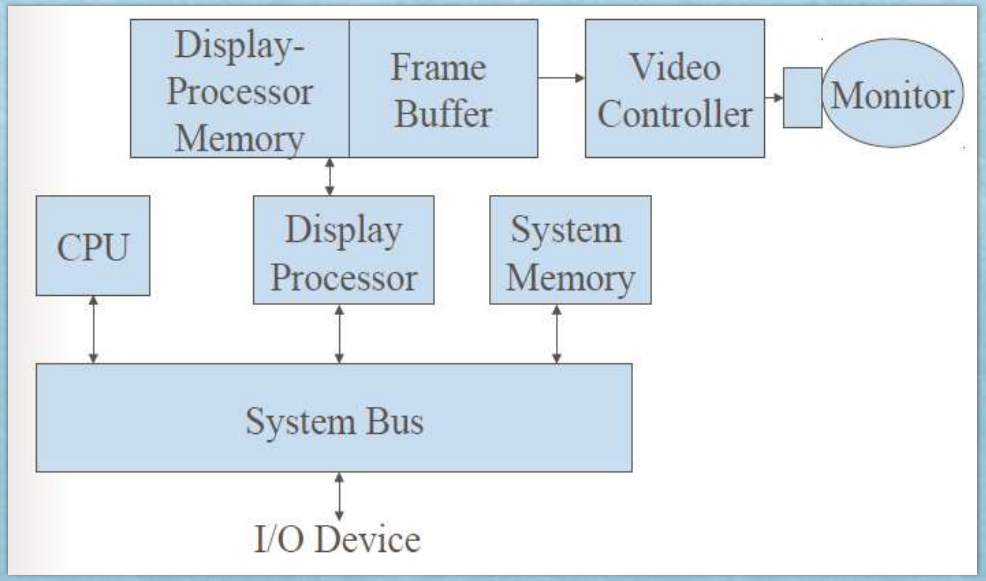
Basic Refresh Operation of Video Controller

- After this X register is incremented by one.
- This procedure is repeated till X becomes equals to Xmax.
- Then X is set to 0 and Y is decremented by one pixel and repeat above procedure.
- This whole procedure is repeated till Y is become equals to 0 and X becomes equals to Xmax. It completes the one refresh cycle. Then controller reset the register as top –left corner i.e. X=0 and Y=Ymax and refresh process start for next refresh cycle.



Raster-graphics System with A Display Processor

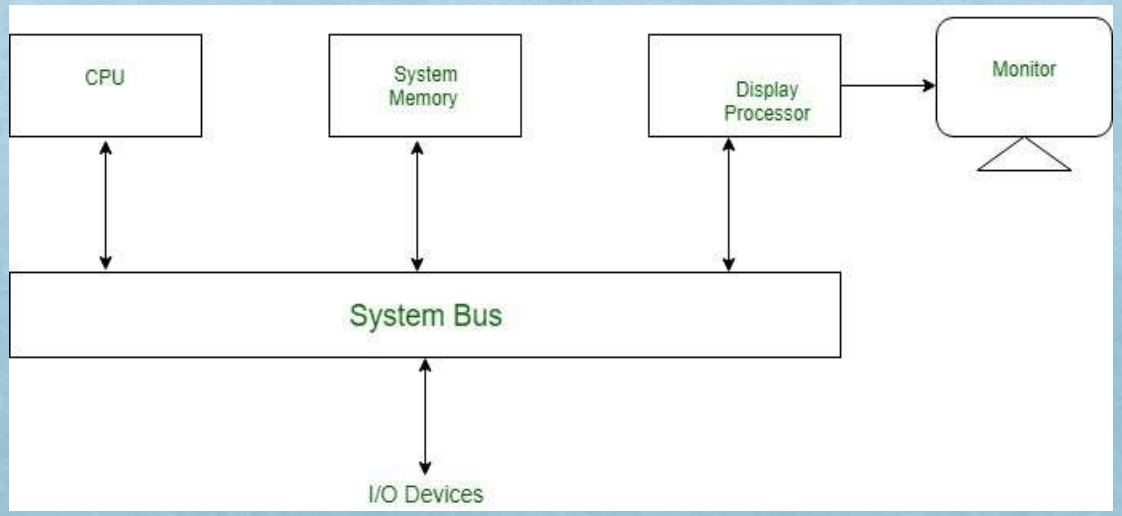
- One way to designing raster system is having separate display coprocessor.
- Purpose of display processor is to free CPU from graphics work.
- Display processors have their own separate memory for fast operation.
- Main work of display processor is digitalizing a picture definition given into a set of pixel intensity values for store in frame buffer.
- This digitalization process is scan conversion.



Raster-graphics system with a display processor

Random-Scan Systems

- An application program is input and stored in the system memory along with a graphics package.
- Graphics commands in the application program are translated by the graphics package into a display file stored in the system memory.
- This display file is then accessed by the display processor to refresh the screen.
- The display processor cycles through each command in the display file program once during every refresh cycle.
- Also known as a display processing unit or a graphics controller.



Architecture of a simple random scan system.