Unit-1, Introduction

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Faculty

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Computer graphics

- It is the creation and manipulation of graphic images by means of a computer.
  - Computer graphics started as a technique to enhance the display of information generated by a computer.
  - This ability to interpret and represent numerical data in pictures has significantly increased the computer's ability to present information to the user in a clear and understandable form.
  - Large amount of data are rapidly converted into bar charts, pie charts, and graphs.

Application of computer graphics

- Computer Aided Design (CAD)
- Presentation Graphics
- Computer Art
- Entertainment
- Education and Training
- Visualization
- Image Processing
- Graphical User Interfaces (GUI‟s)
- Simulation
- Cartography

Computer Aided Design

- In CAD, graphics is used to design components and systems of mechanical, electrical, electro-mechanical and electronic devices including structures such as buildings, automobile bodies, airplane, VLSI chips, optical systems and telephone and computer networks.

# Computer Aided Design (CAD) ….

- Architects use computer graphics to layout floor plans that shows positioning of rooms, doors, windows, stairs, shelves and other building features. Electrical designers then try out arrangements for wiring, electrical outlets and other system to determine space utilization on a building.
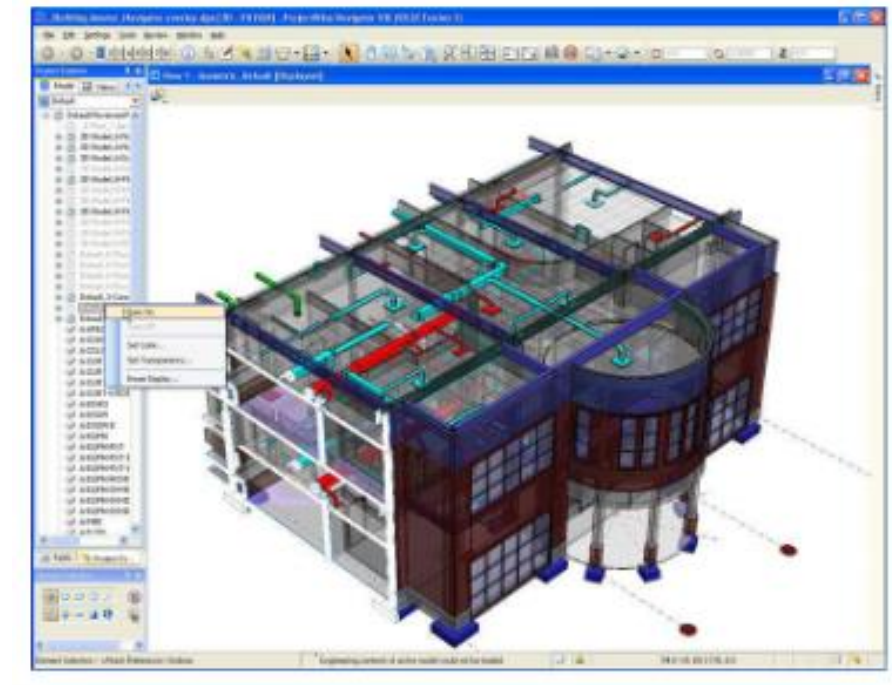
Computer Aided Design (CAD) ....

Computer Aided Design (CAD) ….
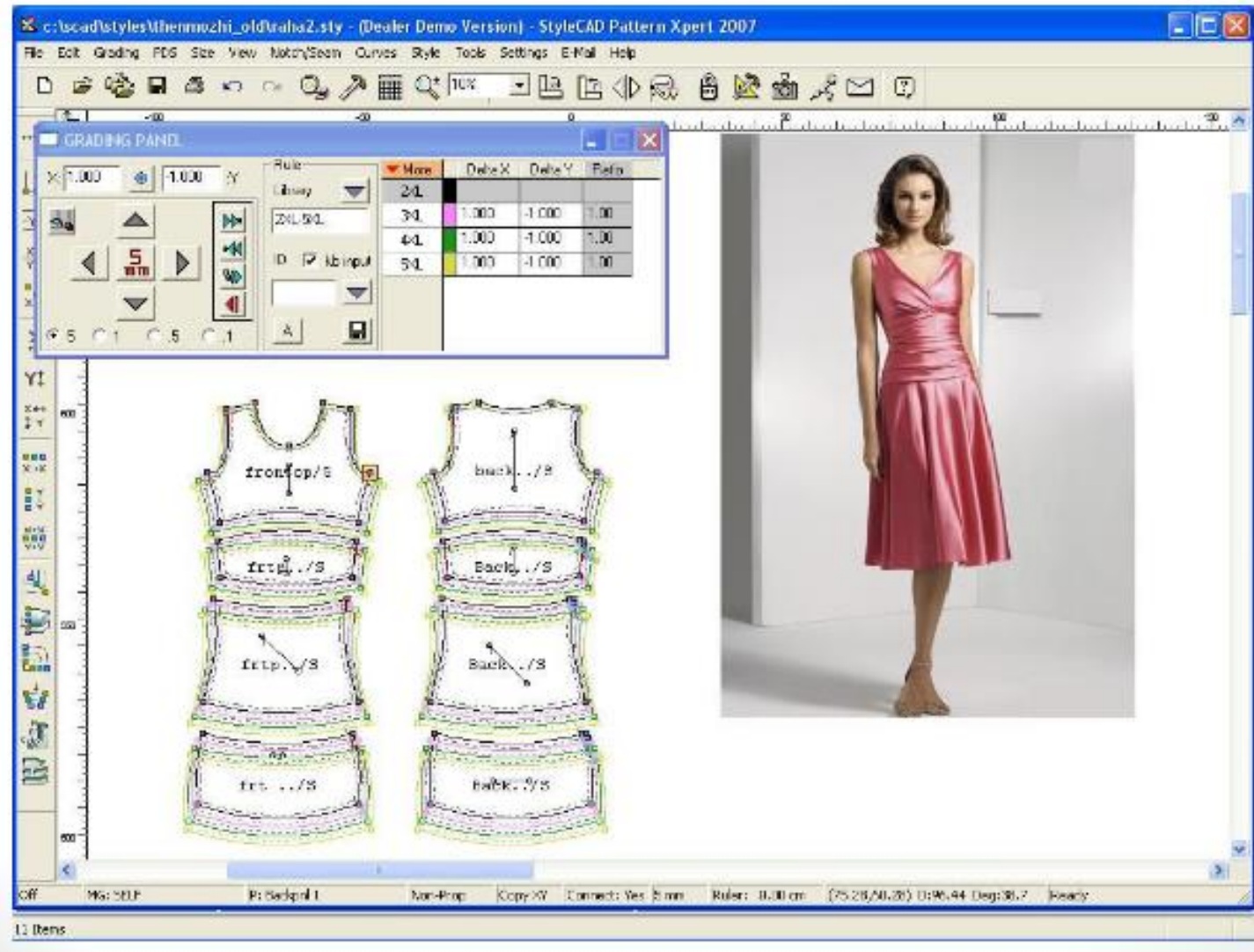
Presentation graphics

- Presentation Graphics is commonly used to summarize financial, statistical, mathematical, scientific and economic data for research reports, managerial reports and other types of reports.
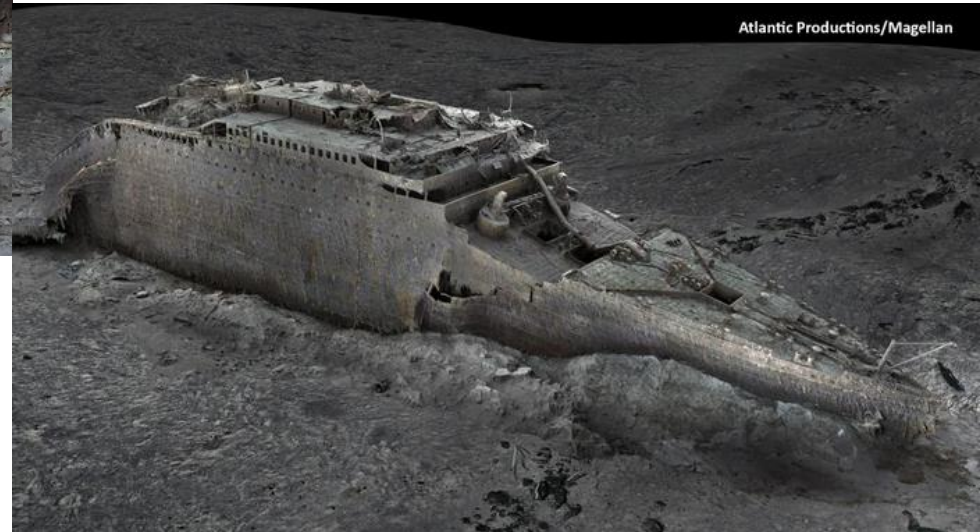

Economic Indicators

Presentation graphics …

- Typical examples are bar charts, line graphs, surface graphs, pie charts and other displays showing relationship between multiple variables.

Presentation graphics …

- The 3D graphics are usually used simply for effects; they can provide a more diagrammatic or more attractive presentation of data relationship.

Computer Art

- Computer graphics is used to generate arts.

Computer Art …

- Mathematics packages, CAD packages, desktop publishing software and animation packages providing facilities.

Entertainment and Gaming

- Computer graphics methods are new commonly used in making motion pictures, music videos and TV shows.

Entertainment and Gaming

- Images are drawn in wire-frame form and will be shaded with rendering methods to produce solid surfaces. Music videos use graphics in several ways.

Entertainment and Gaming

- Computer graphics are also used to introduce virtual characters to movies like character in "Lord of the Rings".

Education and Training

- Computer graphics is used in education and training for making it more effective and more illustrative.

Visualization

- Visualization is the process of visually representing the data.
- To visualize large amount of information graphical computer systems are used.
- Some methods generate very large amount of data/information, analysis the property of the whole amount of data is very difficult. Visualization simplifies the analysis of data by using graphical representation.
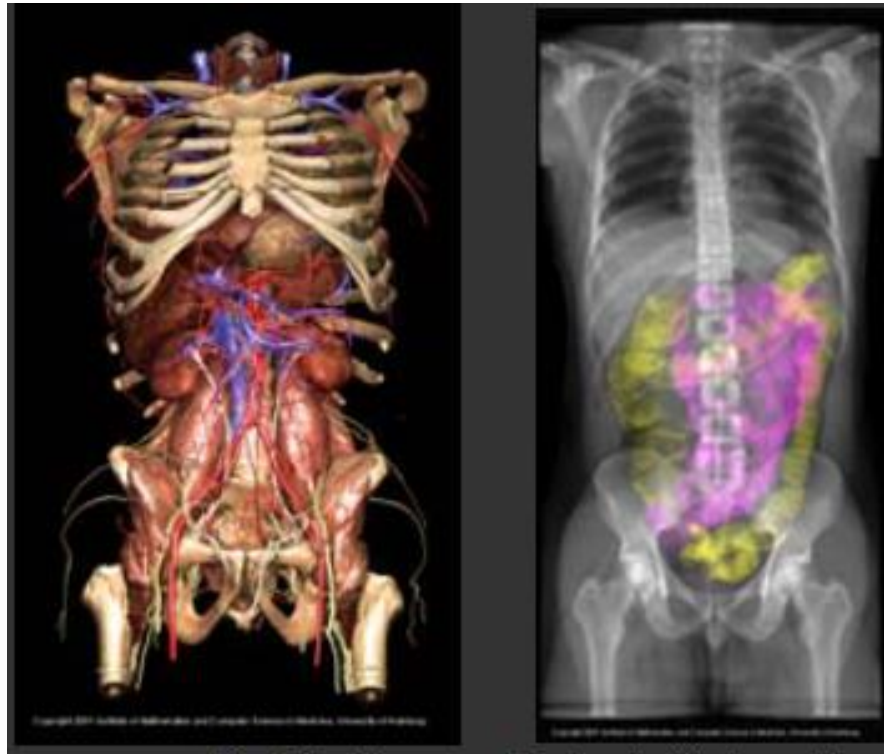
Image Processing

- Image can be created using simple point program or can be fed into computer by scanning the image. These picture/ images need to be changed to improve the quality.

- Form image/pattern recognition systems, images need to be changed in specified format so that the system can recognize the meaning of the picture.

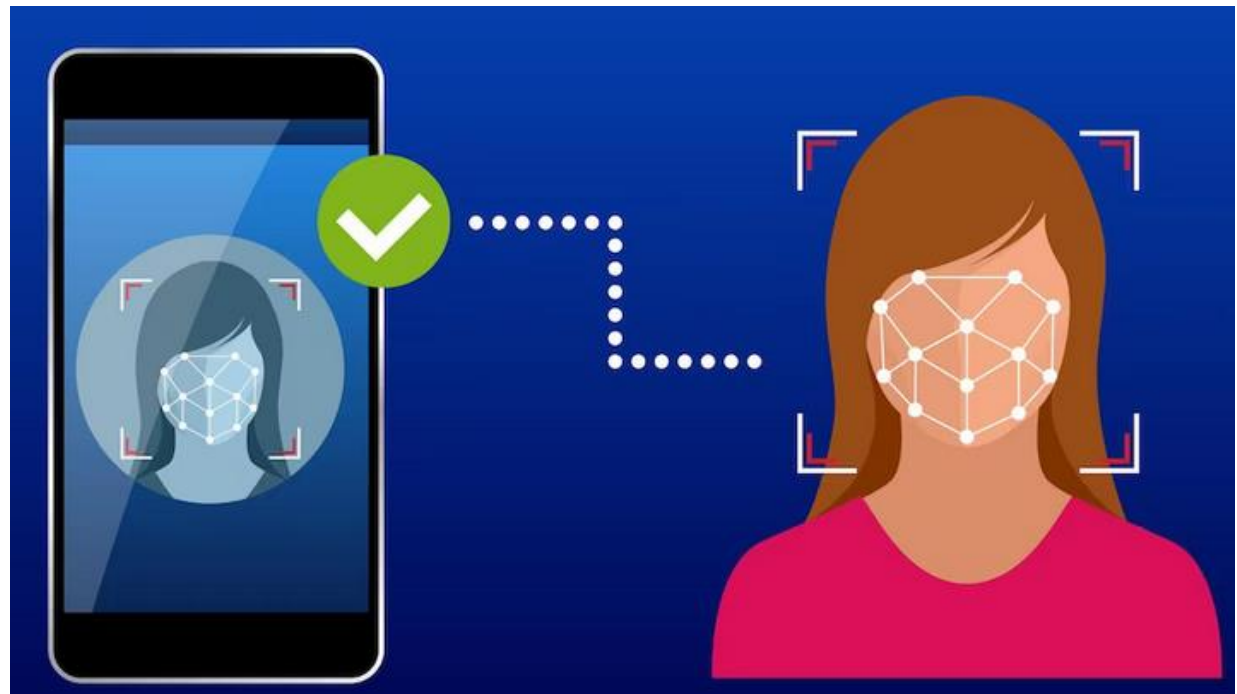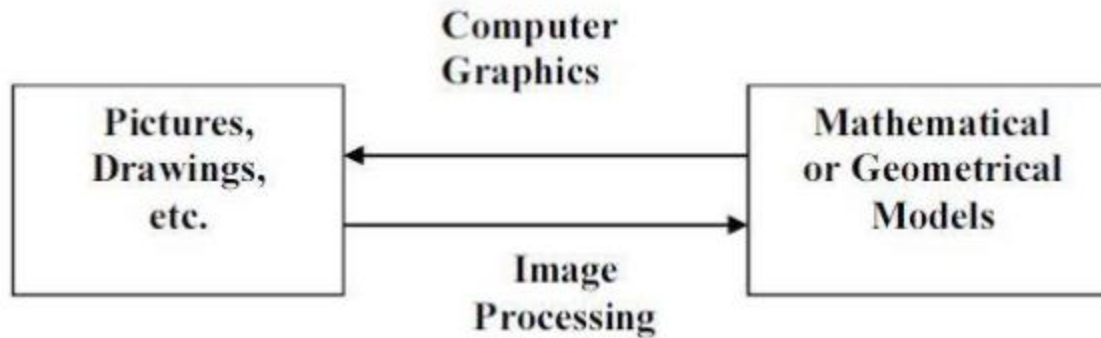- Currently computer graphics is widely used for image processing.

Image Processing …

Visualization (computer graphics) vs image processing

- Visualization is any technique to create an image while image processing involves the use of signals to result as an image.

- Visualization examples are cave drawings and paintings while photographs and video frames are examples of image processing.

Graphical User Interface (GUI)

- GUIs have become key factors for the success of the software or operating system.

- GUI provides point-and-click facilities to allow users to select menu items, icons, and objects on the screen.

- Word processing, spreadsheet, and desktop-publishing programs are typical applications that take advantage of user-interface technique.

Graphical User Interface (GUI) …

Simulation

- A representation of a problem, situation, etc. in mathematical terms, using a computer is called simulation.
- Computer Simulation is the process of mapping the real-world scenarios into mathematical model using computer graphics.
- Recently computer graphics is widely used to create simulated environment.
- E.g.; Robot Operation Simulation, Pilot Training, Military Training etc.

Simulation …

Cartography

- Cartography is the study and practice of designing maps using computer graphics.

- Computer graphics is used to produce both accurate and schematic representations of geographical and other natural phenomena from measurement data.

- Examples include geographic maps, exploration maps, for drilling and mining, oceanographic charts, weather maps etc.

Cartography …
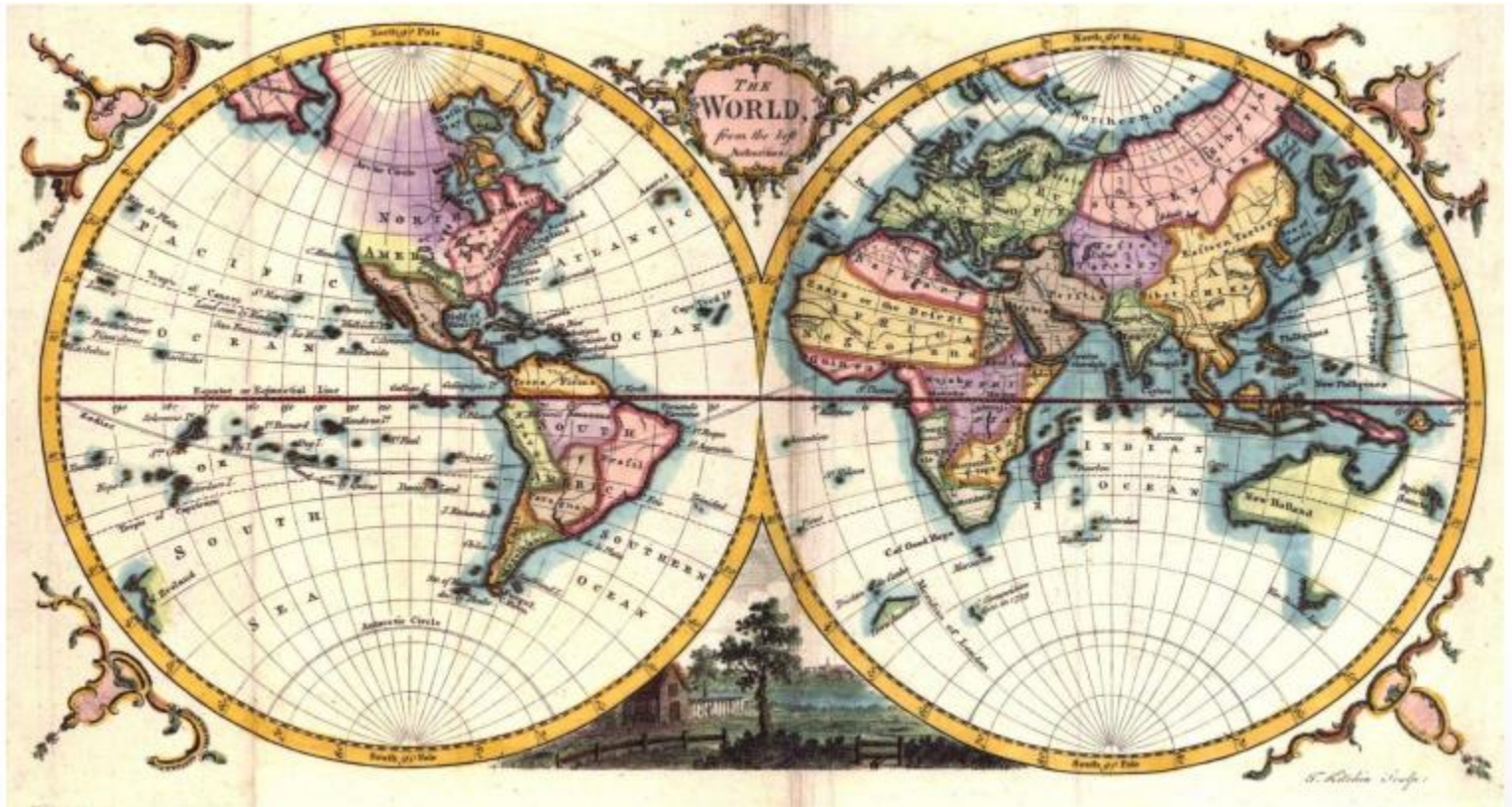
Basic Concept

- RASTER : A rectangular array of points or dots
- PIXEL (picture element) : One dot or picture element of the raster
- SCAN LINE : A row of pixels
- BITMAP :ones and zeros representation of the rectangular array points on screen
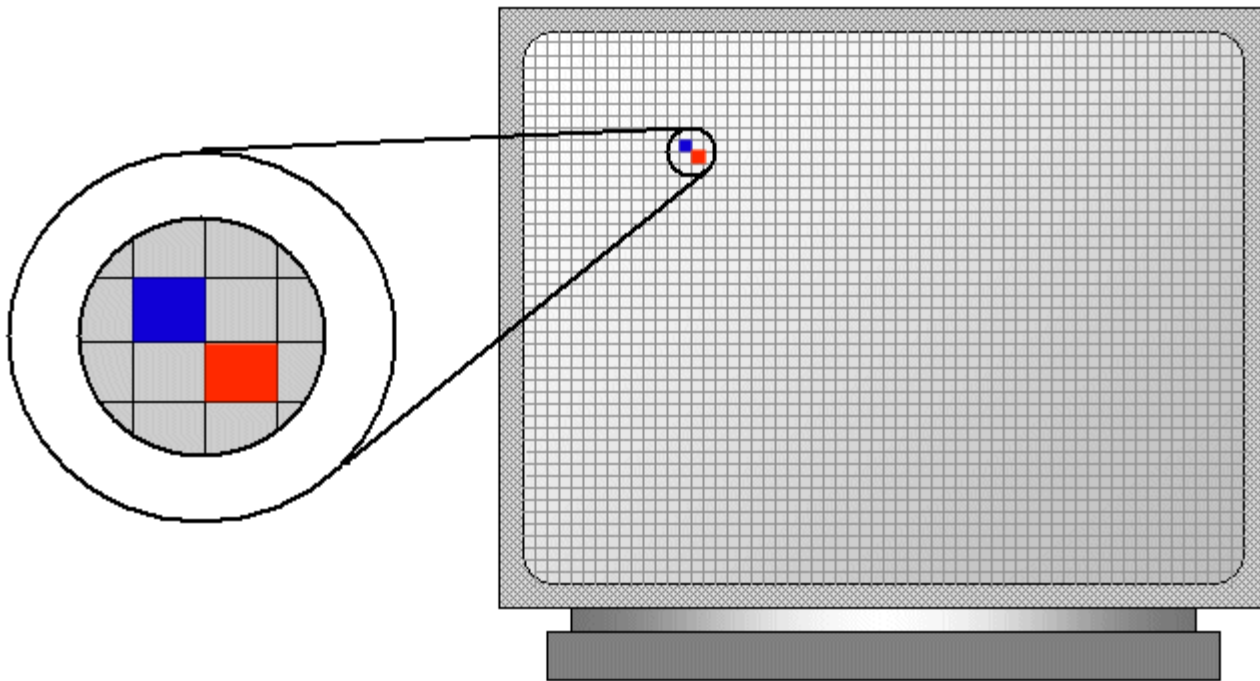 - Black and white :- bitmap
  - Pixmap :- color (colored raster image)

m X n Raster

Raster

- A rectangular array of points or dots.
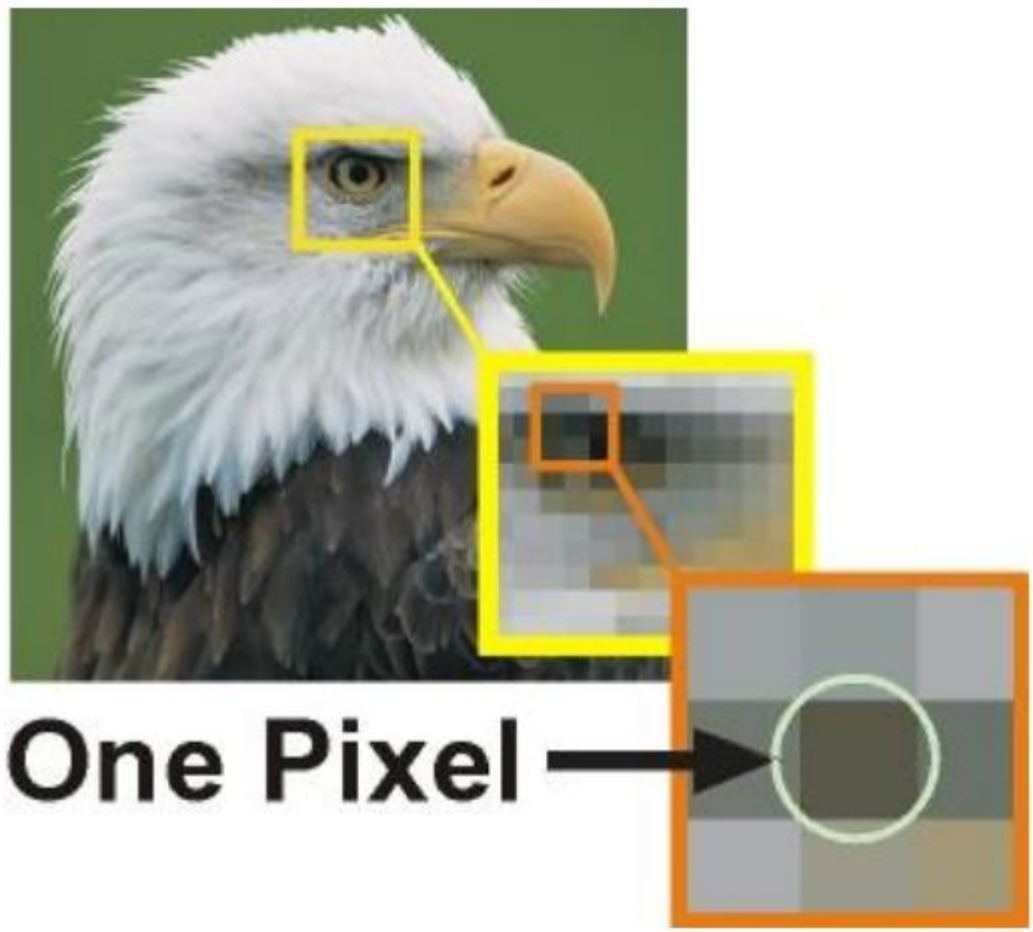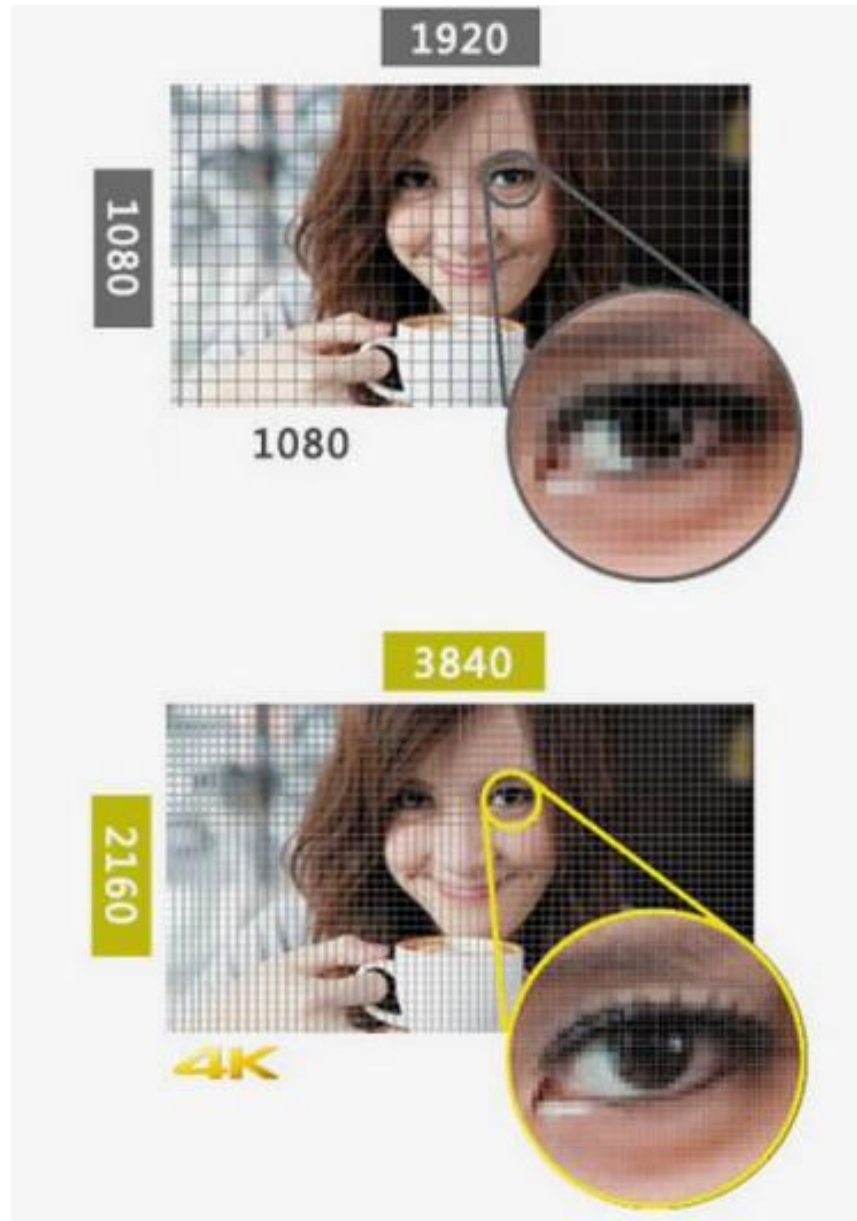
Raster

Rows

Columns
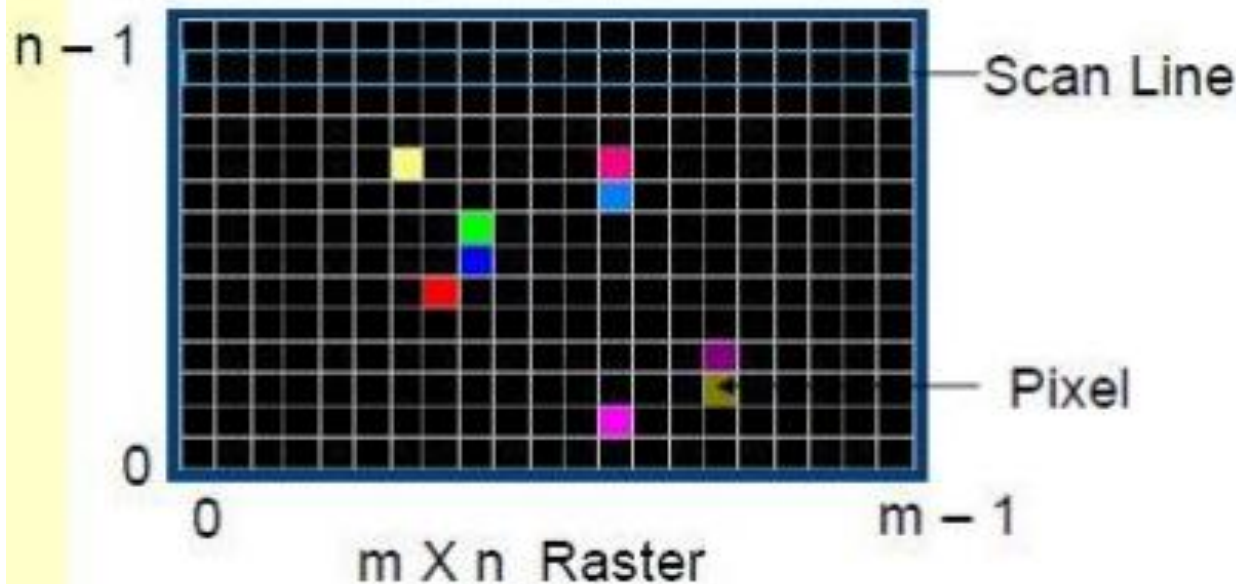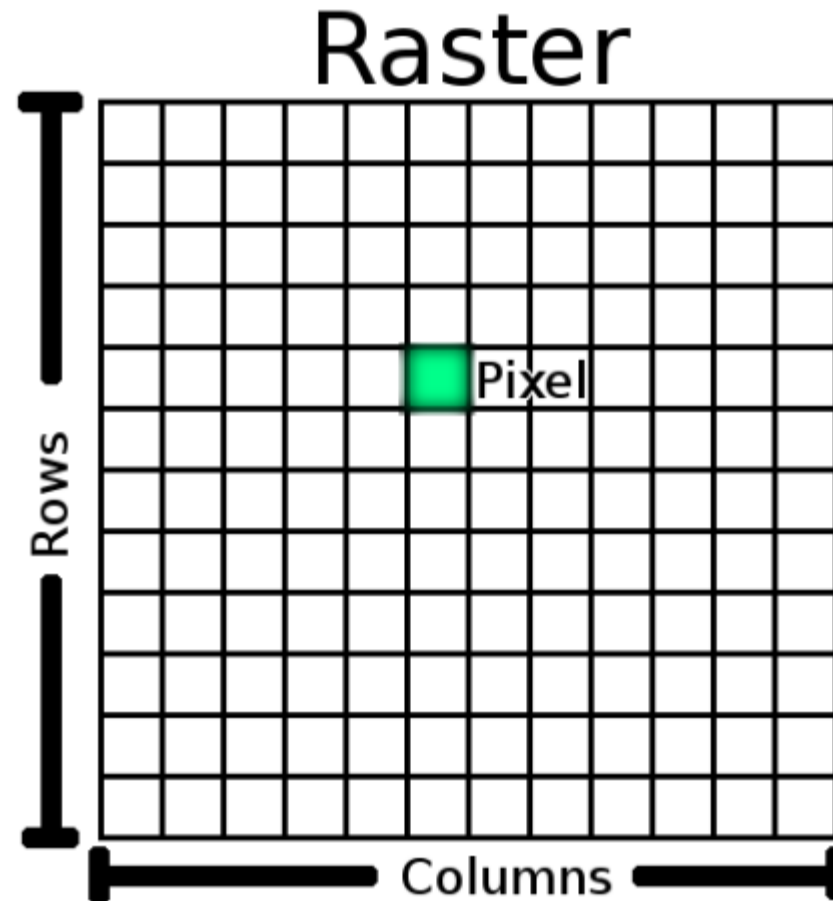
Pixel

Pixel

- One dot or picture element of the raster
- The pixel (a word invented from "picture element") is the basic unit of programmable color on a computer display or in a computer image
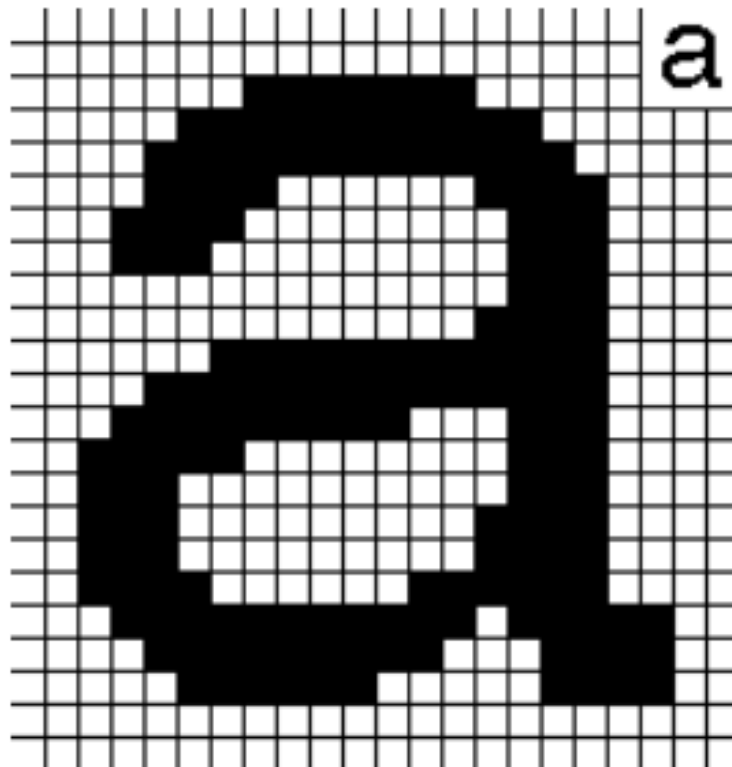
Pixel

One Pixel →

Pixel

Bitmap

ones and zeros representation of the rectangular array points on screen

- Black and white :- bitmap
- Pixmap :- color (colored raster image)

Vector

- Vector graphics is the creation of digital images through a sequence of commands or mathematical statements that place lines and shapes in a given two-dimensional or three dimensional space. In physics, a vector is a representation of both a quantity and a direction at the same time.
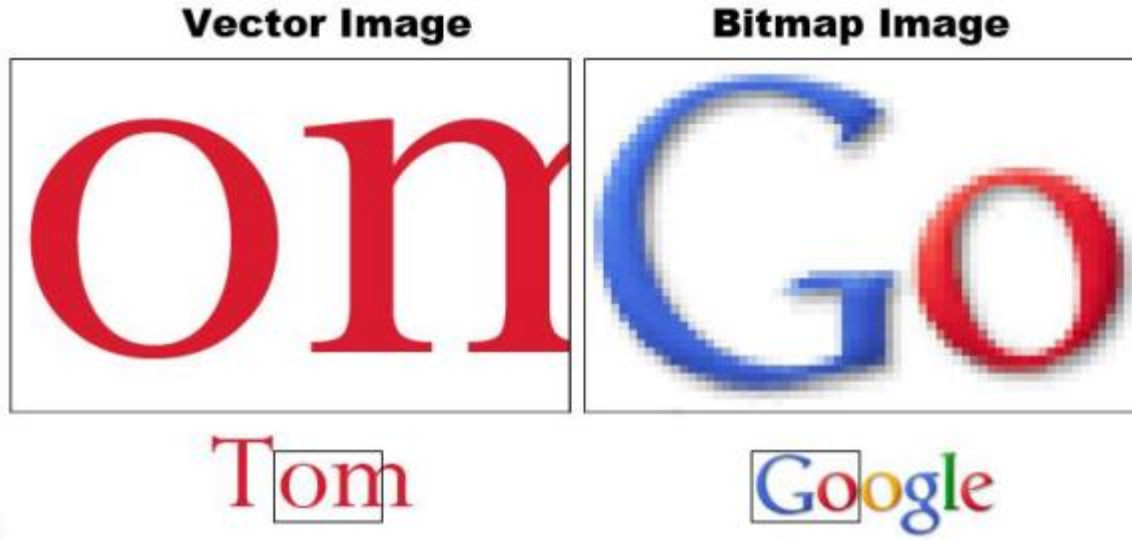
Vector

Vectors
Vectors are based on mathematical formulas and can be scaled infinitely without any loss in quality. Every line and shape has a value that changes when the image expands.

Bitmaps
Bitmaps rely on a series of square blocks called pixels, arranged on a grid. The quality of the images depends on the amount of pixels per square inch. The more pixels, the better the quality.
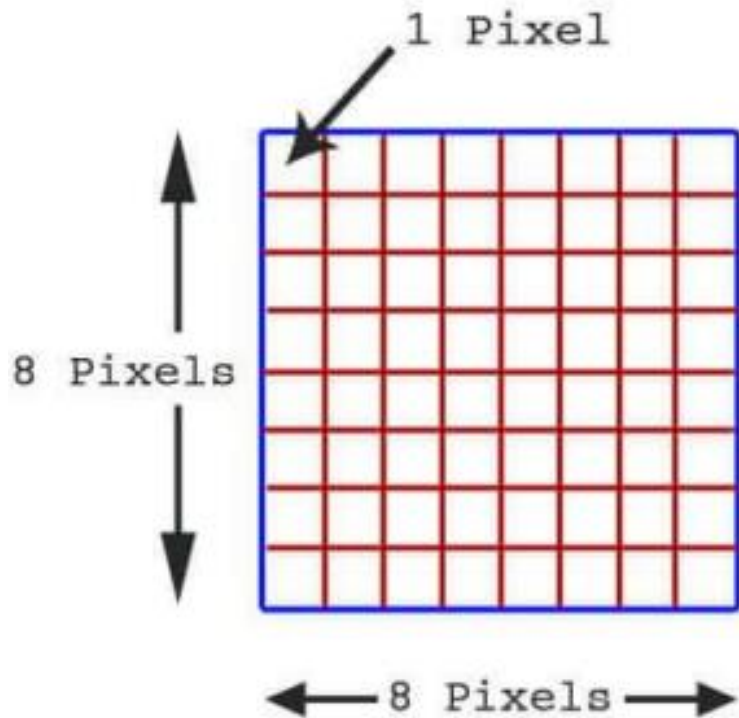
Resolution

- The maximum number of points (pixel) that can be displayed without overlap on a CRT is referred to as the resolution.
- It is also defined as the number of points per unit of measure (per centimeter or per inch) that can be plotted horizontally and vertically.
- Resolution is defined as the maximum member of points that can be displayed horizontally and vertically without overlap on a display device.

HIGH RESOLUTION   LOW RESOLUTION

Resolution

Resolution …

Here's a quick overview of the most common resolutions:
- SD: 480p / 576p
- HD: 720p / 1080p
- 4K: 2160p
- 8K: 4320p

In short, p stands for pixels.

In combination with the number, this designation gives you an idea of how many rows of pixels – from top to bottom – are contained in a video, TV set or screen. In case of High Definition (HD) for example, it means that videos or TV sets in HD typically have 720 rows of pixels, since it is referred to as 720p.

Aspect Ratio

- The aspect ratio of an image describes the proportional relationship between its width and its height.

- It is commonly expressed as two numbers separated by a colon, as in 16:9. For an x:y aspect ratio, no matter how big or small the image is, if the width is divided into x units of equal length and the height is measured using this same length unit, the height will be measured to be y units.

- In, for example, a group of images that all have an aspect ratio of 16:9, one image might be 16 inches wide and 9 inches high, another 16 centimeters wide and 9 centimeters high, and a third might be 8 yards wide and 4.5 yards high.

4:3   3:4   16:9   9:16   1:1

Aspect Ratio …

4:3
4 units wide
3 units tall
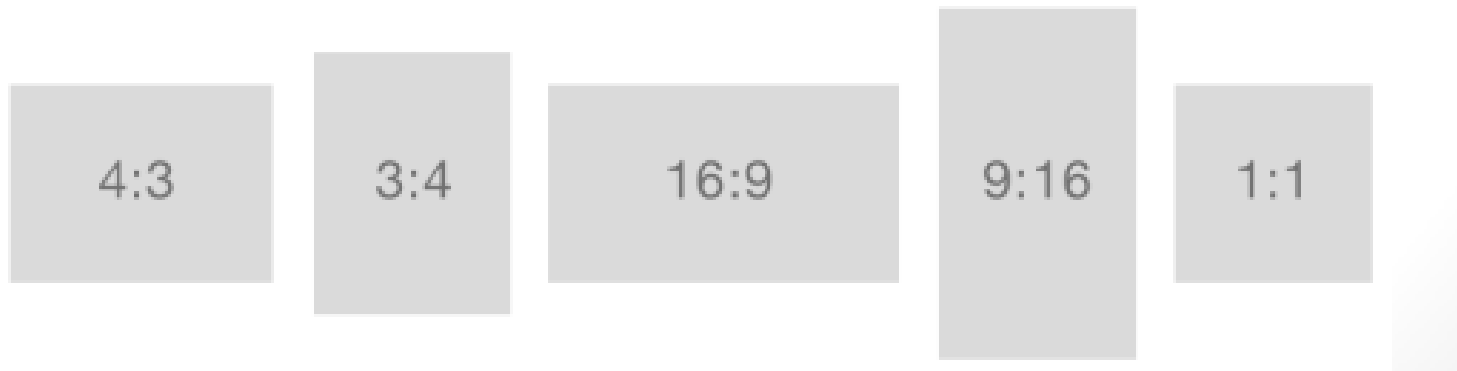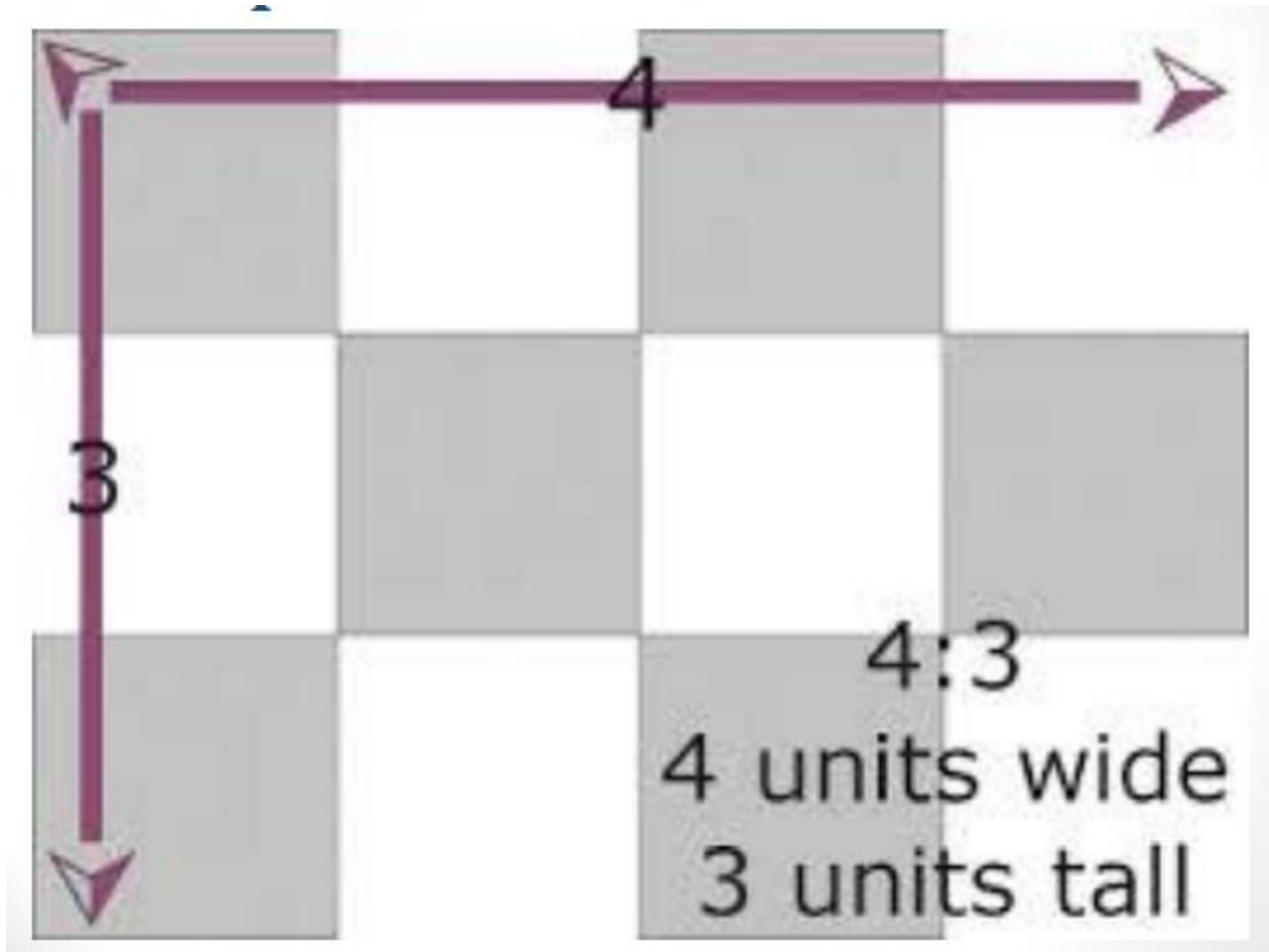
Aspect Ratio …
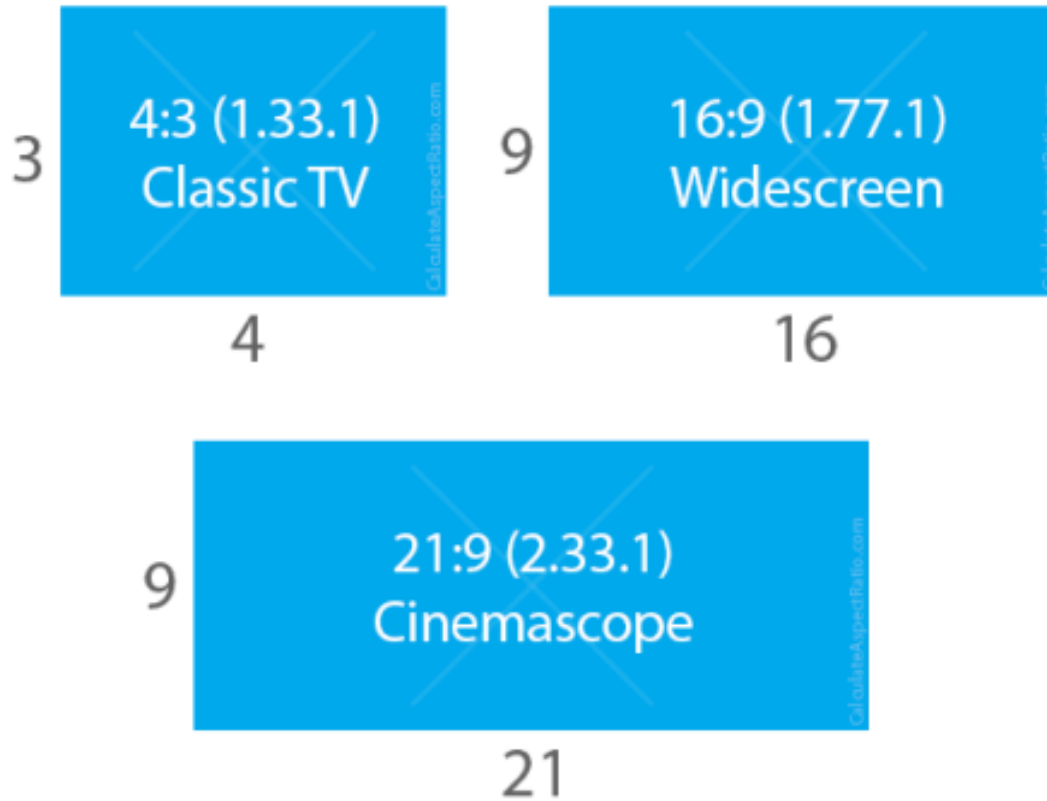
Persistence

- It means how long they continue to emit light after the electron beam is removed.
- Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity.
- Lower persistence phosphors require higher refresh rates to maintain a picture on the screen.
- A phosphor with lower persistence is useful for animation and a higher–persistence phosphor is useful for displaying highly complex static picture.
- Graphics monitor are usually constructed with the persistence 10 to 60 microseconds.

Refresh Rate

- The number of times the screen is redrawn each second.

- Higher refresh rates mean less flicker on the screen, which translates into less eyestrain.

Input Devices

- Mouse, Touch Screen, Light Pen, Data Glove, Tablet (Digitizer), Bar Code Reader.

Mouse

- A mouse is a small hand-held device used to position the cursor on the screen.
- Mouse are relative devices, that is, they can be picked up, moved in space, and then put down gain without any change in the reported position.
- Types
  - Mechanical mouse
  - Optical mouse

Data Glove

- Constructed with a series of sensors that can detect hand and finger motions. The transmitting and receiving antennas can be structured as a set of three mutually perpendicular cols, forming a three dimensional Cartesian coordinates system. Electromagnetic coupling between the three pairs of coil is used to provide information about the position and orientation of hand.

Output Devices

- The most common graphics output device is the video monitor which is based on the standard cathode ray tube (CRT) design, but several other technologies exist such as LCDs, LEDs, the direct view storage tube(DVST) etc.

CRT

- CRT are the most common display devices on computer today. A CRT is an evacuated glass tube, with a heating element on one end and a phosphor-coated screen on the other end.
- When a current flows through this heating element (filament) the conductivity of metal is reduced due to high temperature. These cause electrons to pile up on the filament.
- These electrons are attracted to a strong positive charge from the outer surface of the focusing anode cylinder.
- The forwarding fast electron beam is called Cathode Ray. A cathode ray tube is shown in figure below.
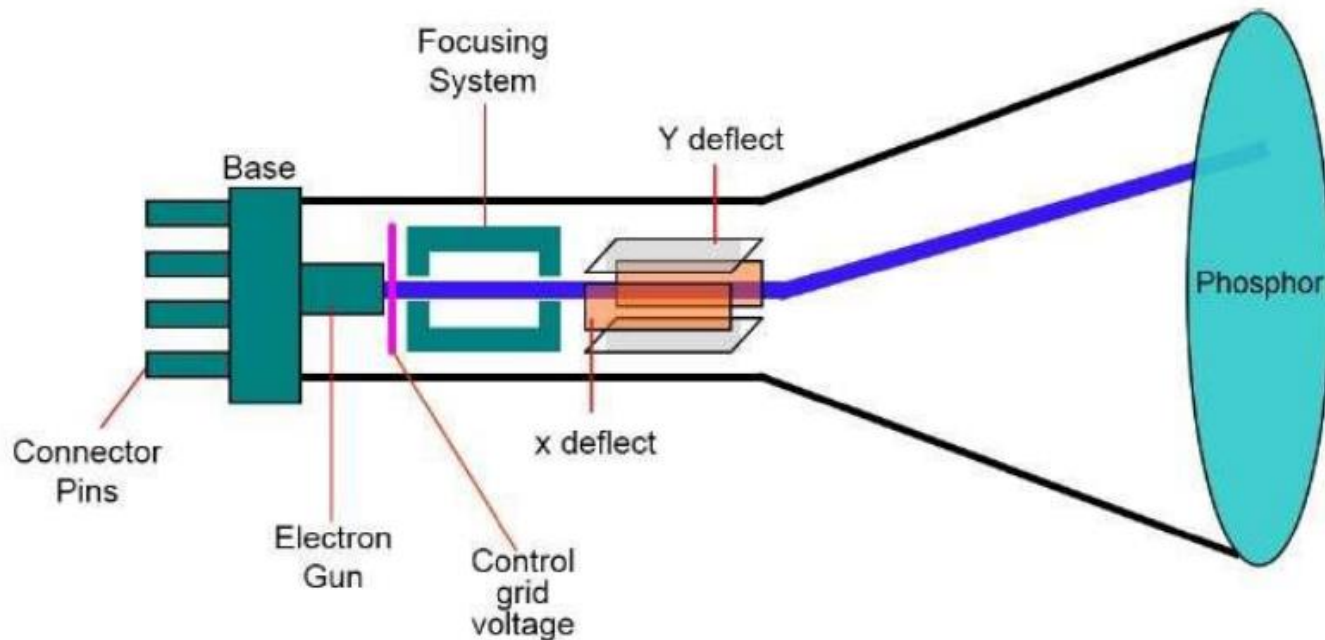
CRT ...

- The cathode ray tube (CRT) is a tube containing one or more electron guns (a source of electron) and a fluorescent screen used to view images. A beam of electrons (cathode rays) emitted by an electron gun, passes through focusing and deflection systems that direct the beam toward specified positions on the phosphor-coated screen. When the electrons hit the screen, the phosphor emits visible light.

- Because the light emitted by the phosphor decays very rapidly with time, so the entire picture must be refreshed (redrawn) many times per second by quickly directing the electron beam back over the same points. Therefore, also called a refresh CRT.
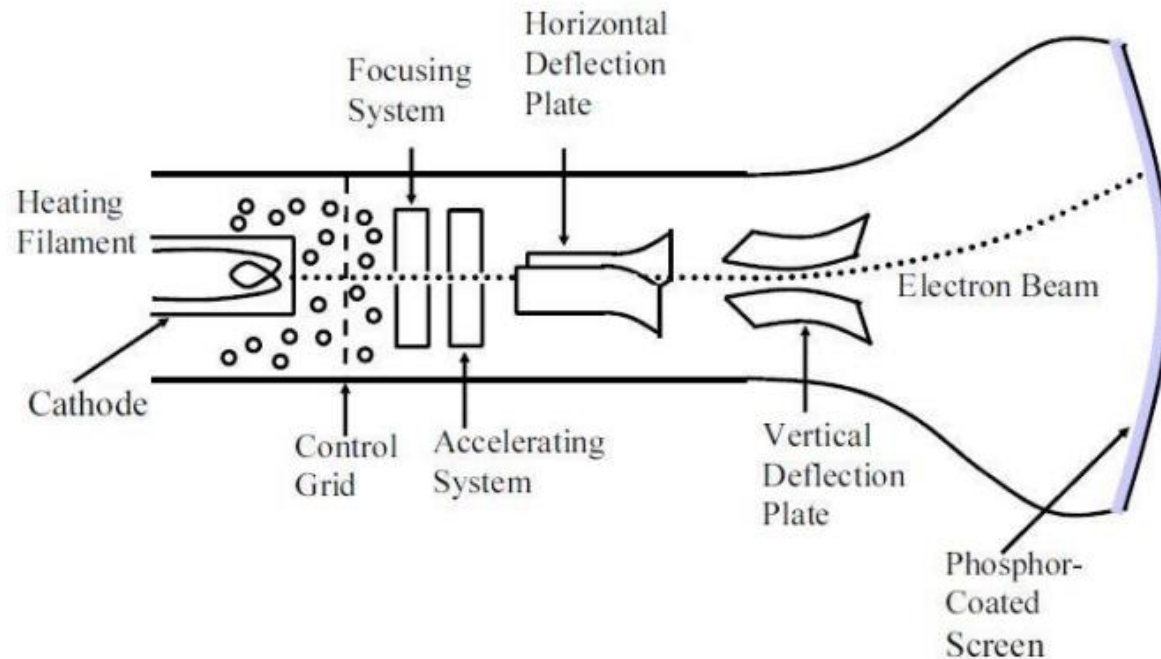
CRT...

- There are two sets of weakly charged deflection plates with oppositely charged, one positive and another negative. The first set displaces the beam up and down and the second displaces the beam left and right.

- The electrons are sent flying out of the neck of bottle (tube) until the smash into the phosphor coating on the other end.

- When electrons strike on phosphor coating, the phosphor then emits a small spot of light at each position contacted by electron beam. The glowing positions are used to represent the picture in the screen.

- The amount of light emitted by the phosphor coating depends on the no of electrons striking the screen. The brightness of the display is controlled by varying the voltage on the control grid.

Main components of CRT

- An electron gun
  - The primary components of an electron gun in a CRT are the heated metal cathode and a control grid.
    - Heated metal cathode: Heat is supplied to the cathode by directing the beam through a coil of wire called the filament inside the cylindrical cathode structure.
    - Control grid: Intensity of the electron beam is controlled by setting the voltage levels on the control grid, which is a metal cylinder that fits to the cathode.
- Focusing System & Accelerating Anode .
  - The focusing system in a CRT is needed to force the electron beam to converge into a small spot as it strikes the phosphor.
  - And the accelerating anode is used to accelerate electron beam towards the phosphor coated screen. Otherwise, the electron beam would not reach to the screen.
- Deflection System
  - It is used to control the vertical and horizontal scanning of the electron beam.

Types of Refresh CRT's

- Raster-Scan Displays
- Random-Scan Displays

Raster-Scan Displays

- The most common type of graphics monitor employing a CRT is the raster-scan display. In raster scan approach, the viewing screen is divided into a large number of discrete phosphor picture elements, called pixels. Row of pixels is called the scan line. The matrix of pixels or collection of scan lines constitutes the raster (shown in figure below).
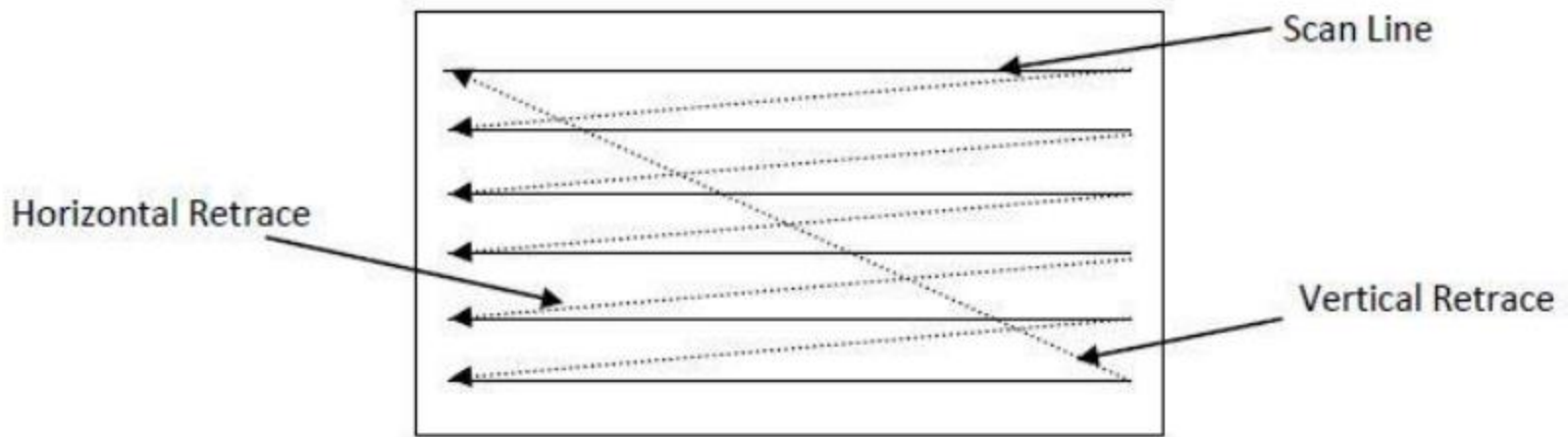
Raster-Scan Displays …

- Two types of Raster-scan systems:

  I.   Non-interlaced Raster-Scan System

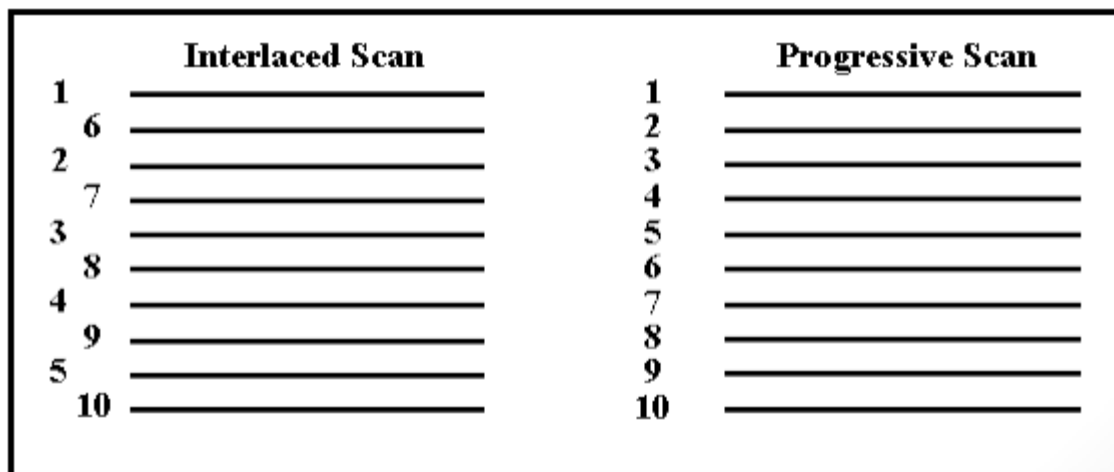 II. Interlaced Raster-Scan System

Non-Interlaced Raster-Scan Displays

- In a non-interlaced raster-scan system, the electron beam is swaps across the screen, one row at a time from top to bottom. As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.
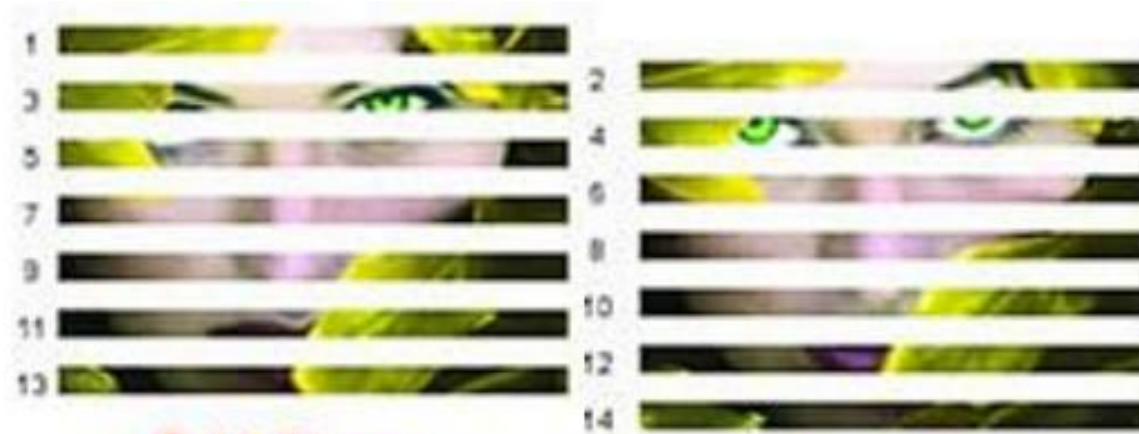
Non-Interlaced Raster-Scan Displays

- Picture definition is stored in a memory area, called the refresh buffer or frame buffer. This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and "painted" on the screen one row (scan line) at a time

- In monochromatic CRT"s (i.e., 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 often referred to as a pixmap

Interlaced Raster-Scan Displays

- On some raster-scan systems (and in TV sets), each frame is displayed in two passes using an interlaced refresh procedure. In the first pass, the beam sweeps across every other scan line from top to bottom.

- Then after the vertical re-trace, the beam sweeps out the remaining scan lines

- Interlacing is primarily used with slower refreshing rates. This is an effective technique for avoiding screen flickering.
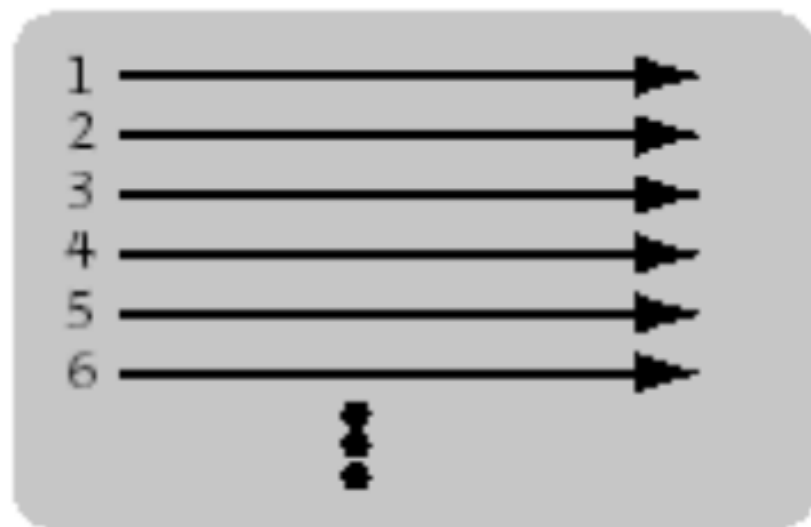
Interlaced Scan	Progressive Scan
1 6 2 7 3 8 4 9 5 10	1 2 3 4 5 6 7 8 9 10

Interlaced Raster-Scan Displays

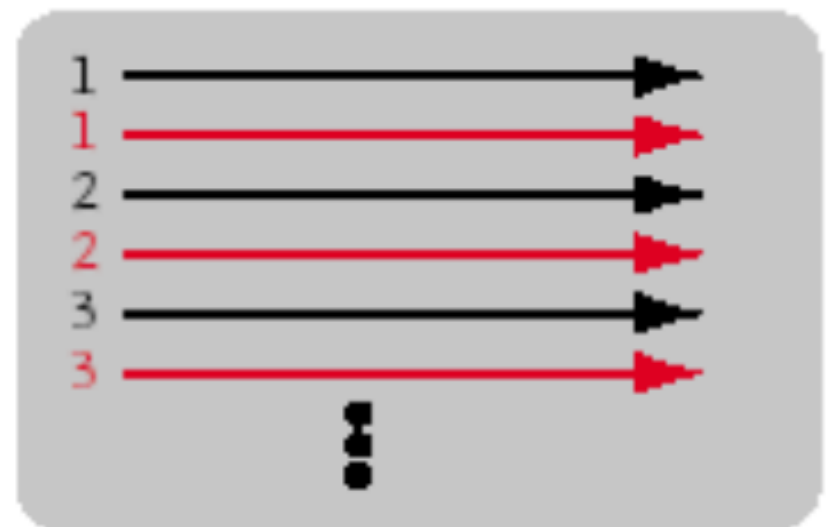**Odd lines Field 1**

Even lines Field 2

Field 1 + Field 2 = Frame (complete image)

Interlaced Raster-Scan System
VS
Non-interlaced Raster-Scan System

Non-interlaced

Interlaced

Architecture of Raster Scan System

- The raster graphics systems typically consists of several processing units. CPU is the main processing unit of computer systems. Besides CPU, graphics system consists of a special purpose processor called video controller or display processor. The display processor controls the operation of the display device.

- A fixed area of system memory is reserved for the frame buffer. The video controller has the direct access to the frame buffer for refreshing the screen.
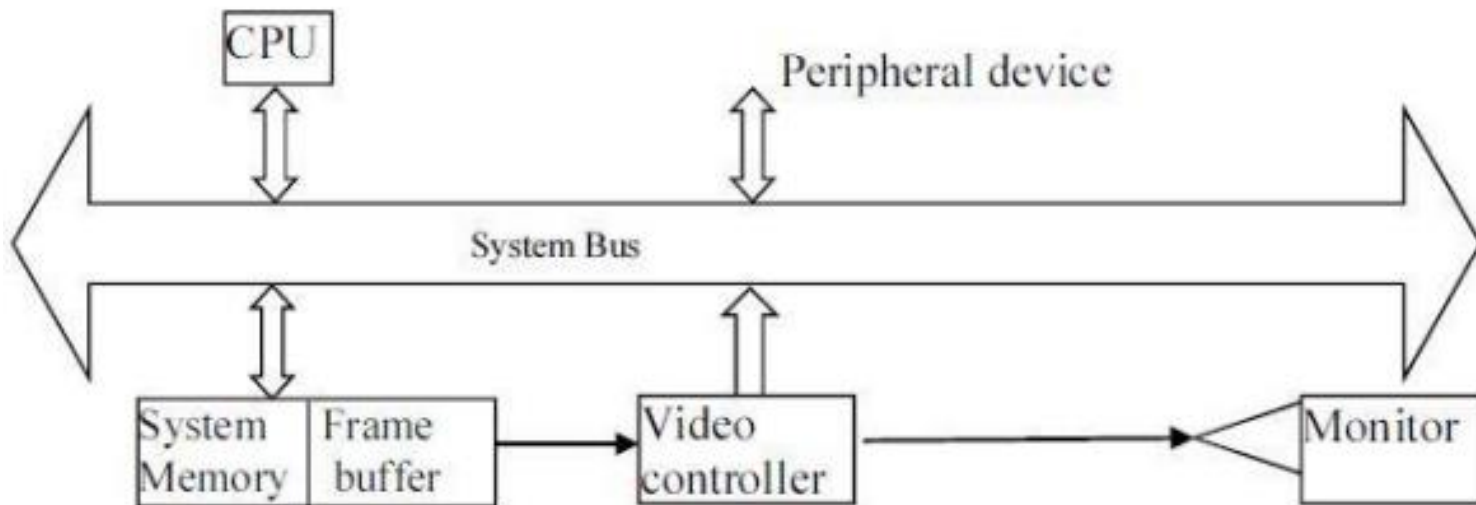
Figure: A simple Raster System.

Architecture of Raster-Scan Display Processor

- The display processor has its own separate memory called display processor memory.
  - System memory holds data and those programs that execute on the CPU, and the application program, graphics packages and OS.
  - The display processor memory holds data plus the program that perform scan conversion and raster operations.
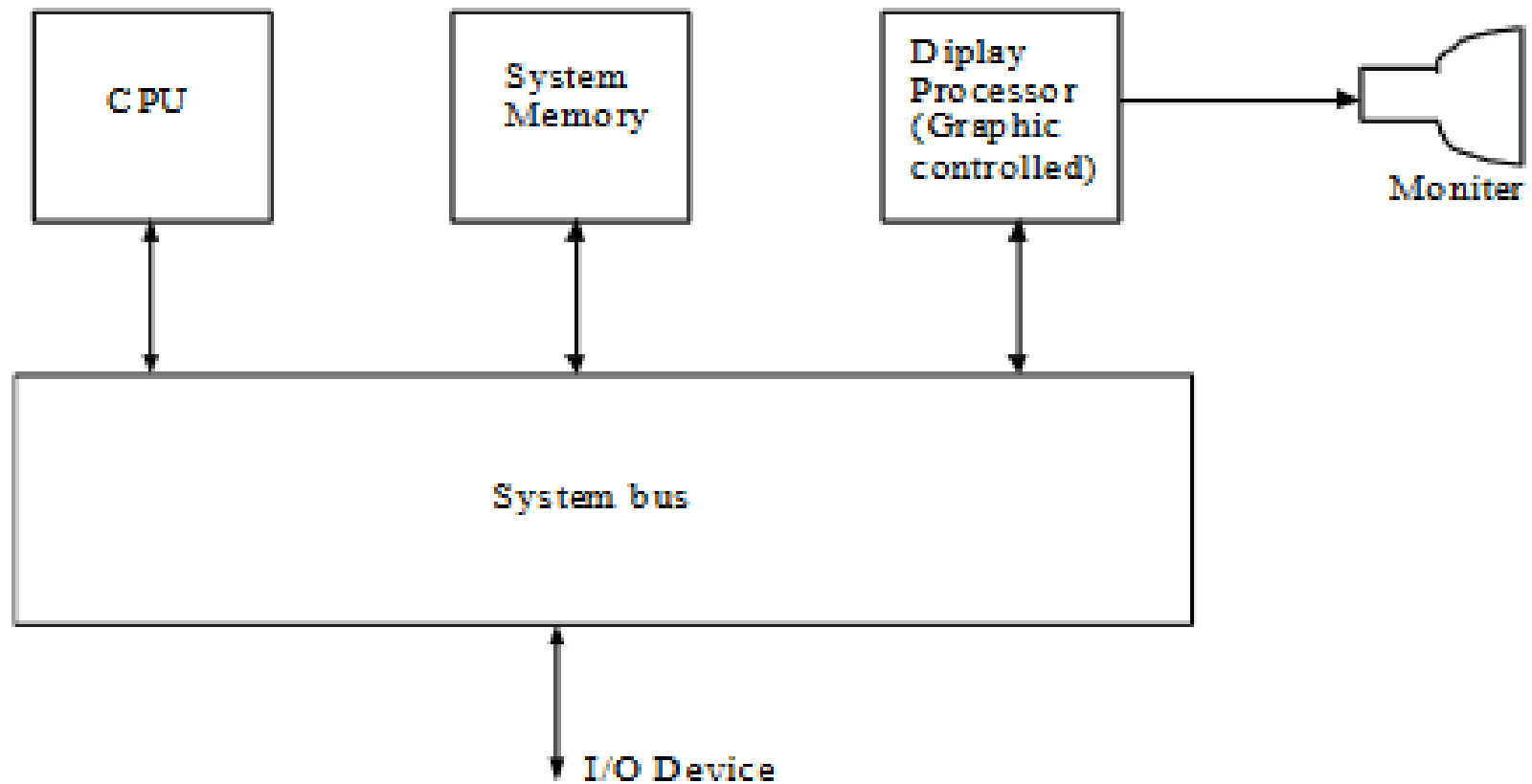 - The frame buffer stores displayable image created by scan conversion and raster operations
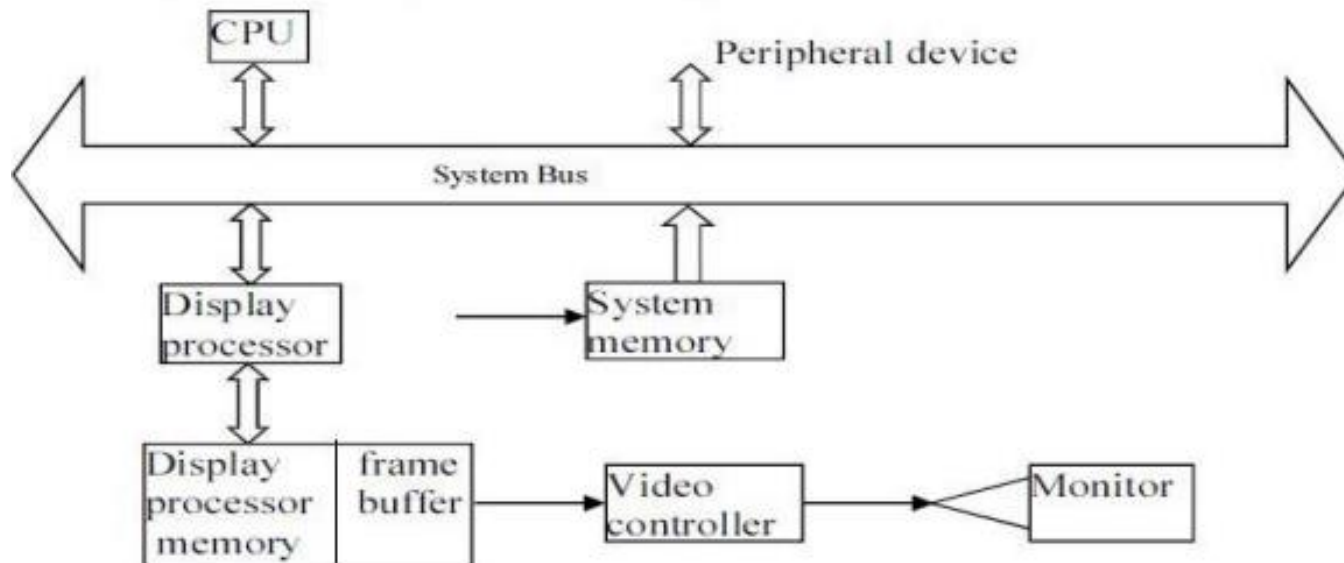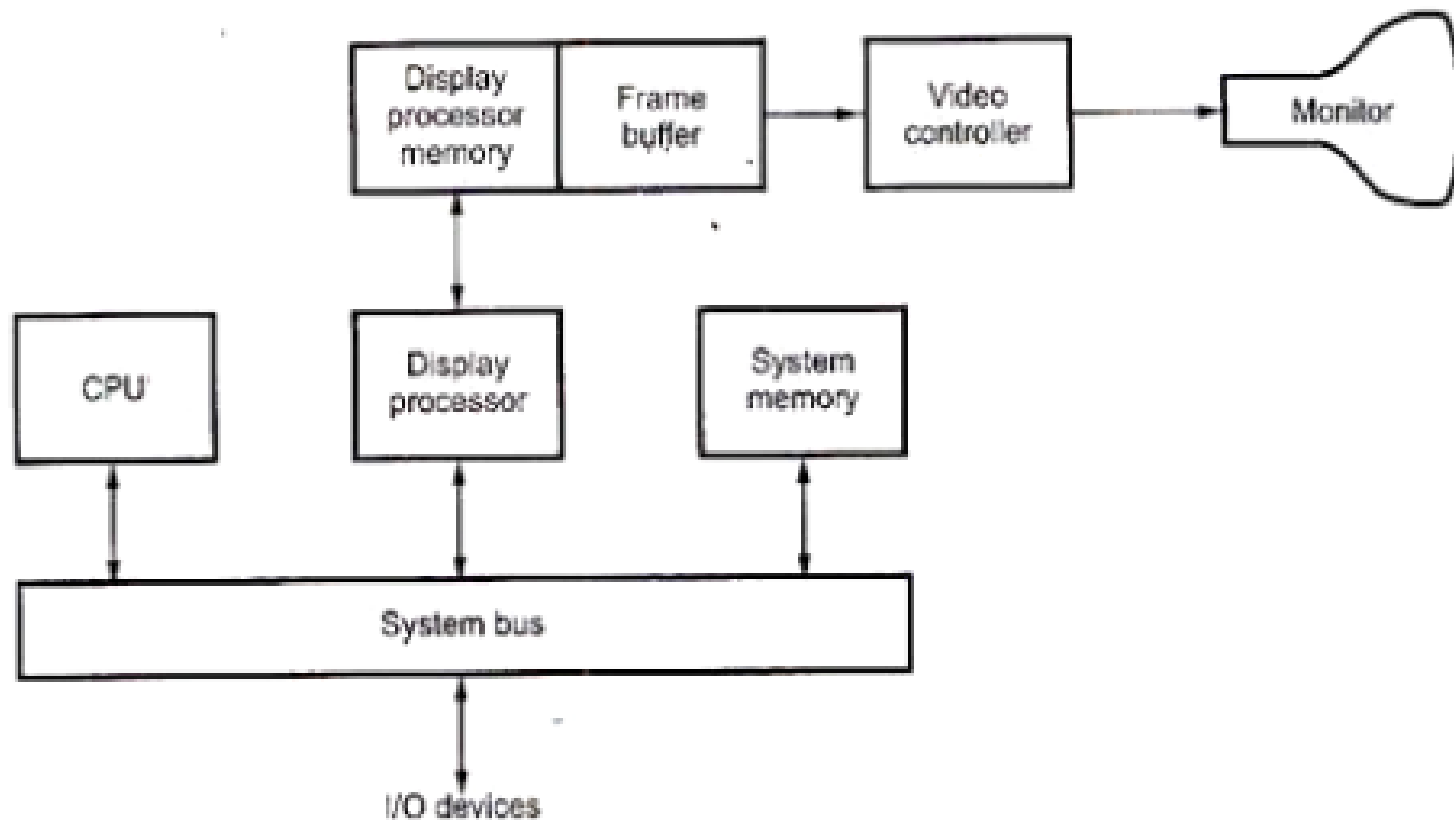
Fig: Raster scan display

Fig: Architecture of a raster-graphics system with a display processor

Vector Scan Display / Random-Scan Displays

- In a random scan display unit, electron beam directed towards 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 system uses an electron beam which operates like a pencil to create a line image on the CRT. The component line can be drawn or refreshed by a random scan display system in any specified order
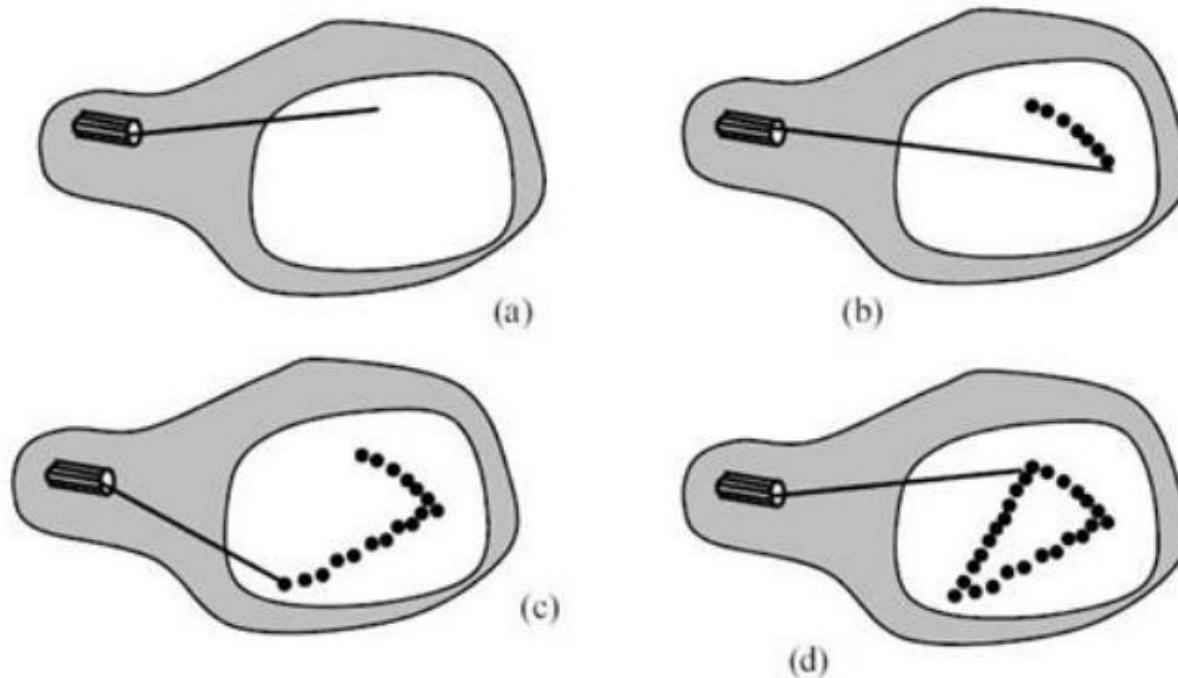
Random-Scan Displays

(a)   (b)

(c)   (d)

Figure: Random Scan Display

Example: *A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device*

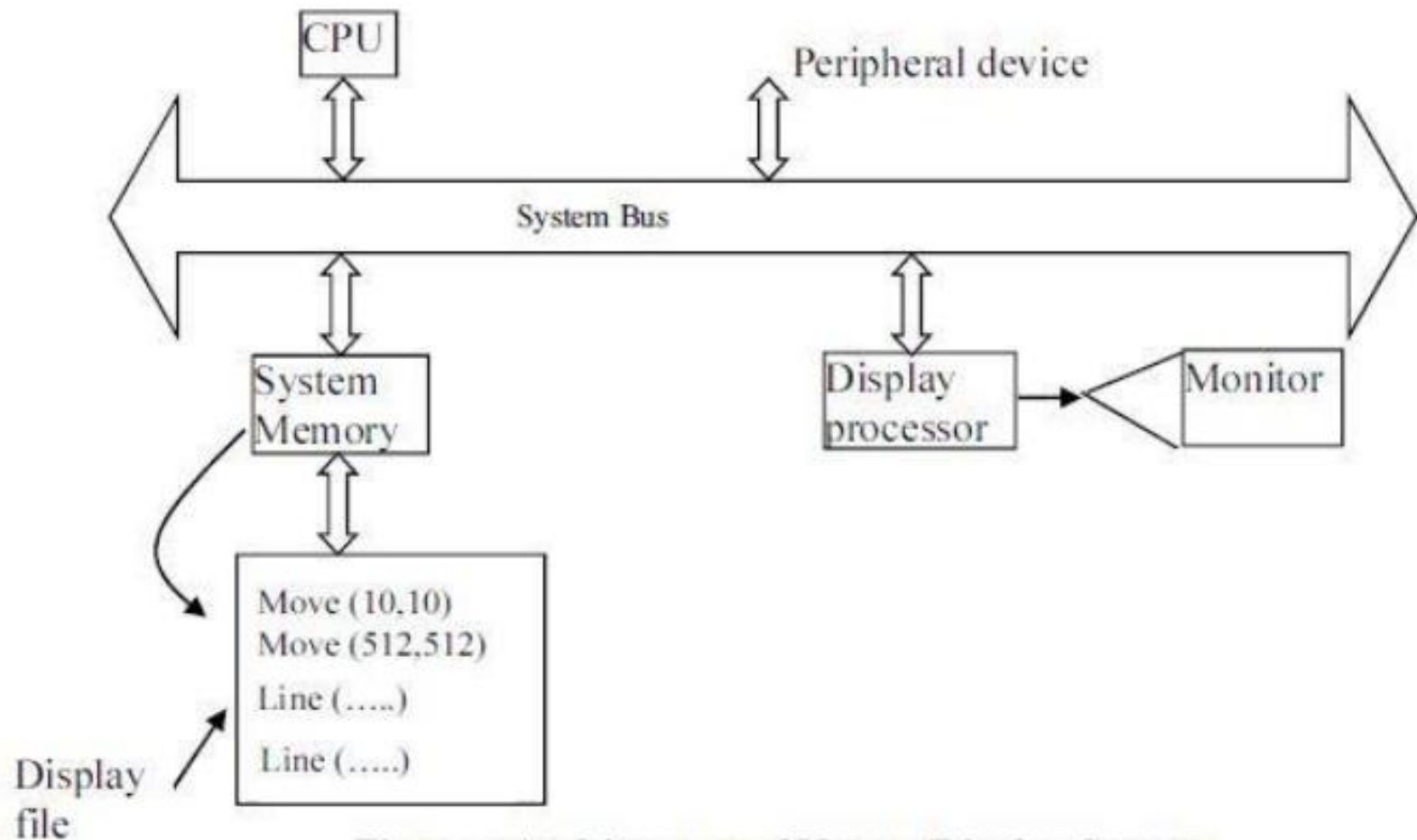# Architecture of Random Scan Display

Figure : Architecture of Vector Display System

Architecture of Random Scan Display

- Vector display system consists of several units along with peripheral devices. The display processor is also called as graphics controller.

- Graphics package creates a display list and stores in systems memory (consists of points and line drawing commands) called display list or display file.

- Refresh time around so cycle per second.

- Vector display technology is used in monochromatic or beam penetration color CRT.

- Graphics are drawn on a vector display system by directing the electron beam along component line.
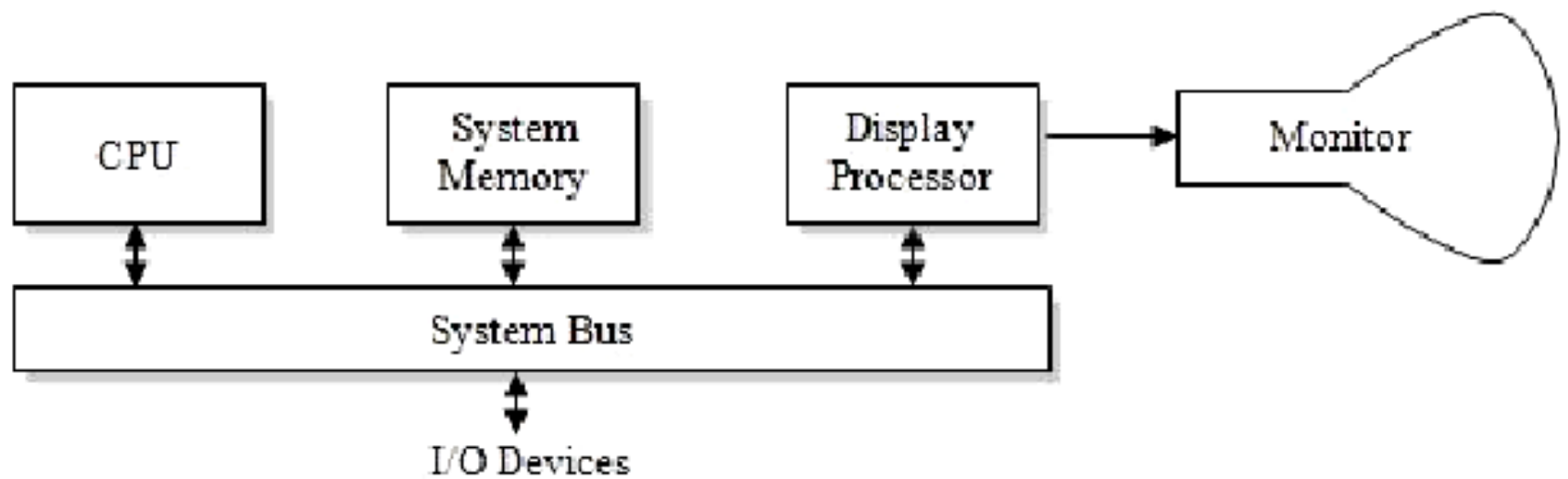
Fig: Architecture of Vector Display System
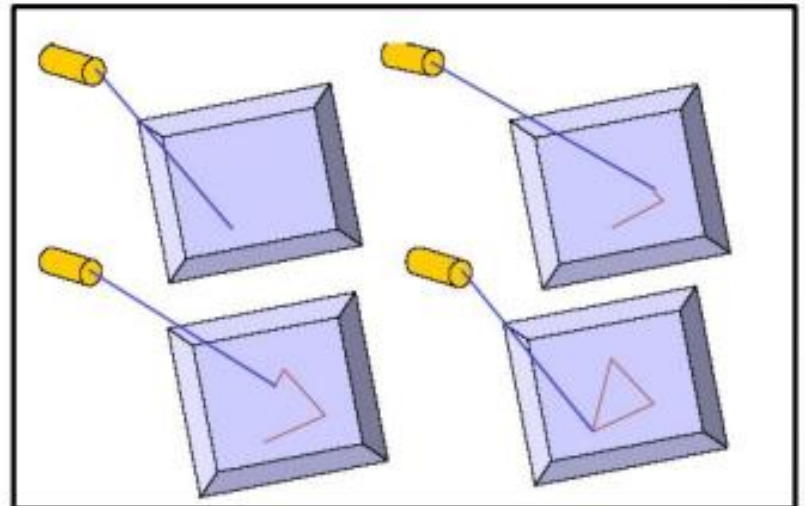
Raster VS Random

| Raster	Random
1.Refresh Rates : Refreshing on raster scan display is carried out at the rate of 60 to 80 frames per second. Sometimes, refresh rates are described in units of cycles per second, or **Hertz (Hz)**, where a cycle corresponds to one frame.	**1.Refresh Rates :** Generally, refreshing on random-scan display is carried out at the rate of 60 frames per second. Refresh rate on a random-scan system depends on the number of lines to be displayed. Picture definition is now stored as a set of line-drawing commands in an area of memory, referred to as the *refresh display file*.
2.Applications: i. For the realistic display of scenes containing subtle shading and color patterns. ii. Home television sets and printers are examples of raster-scan systems.	**2.Applications:** i. Random-scan systems are used in *line-drawing applications*. ii. Vector displays generally used to produce graphics with higher resolution.

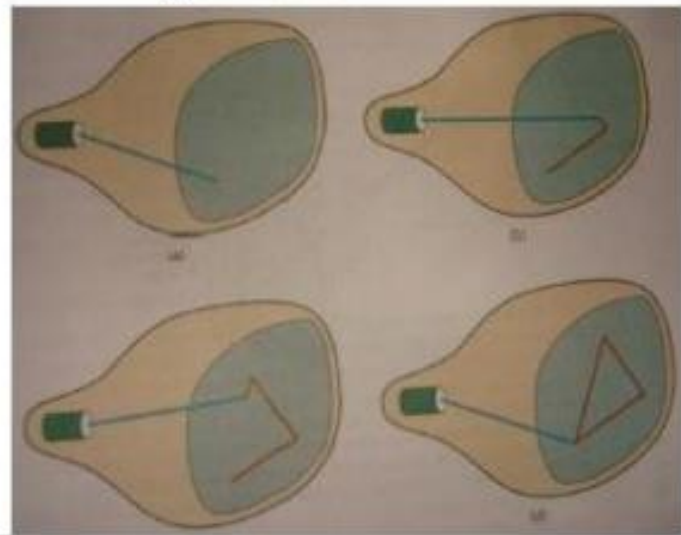# Raster VS Random

Raster
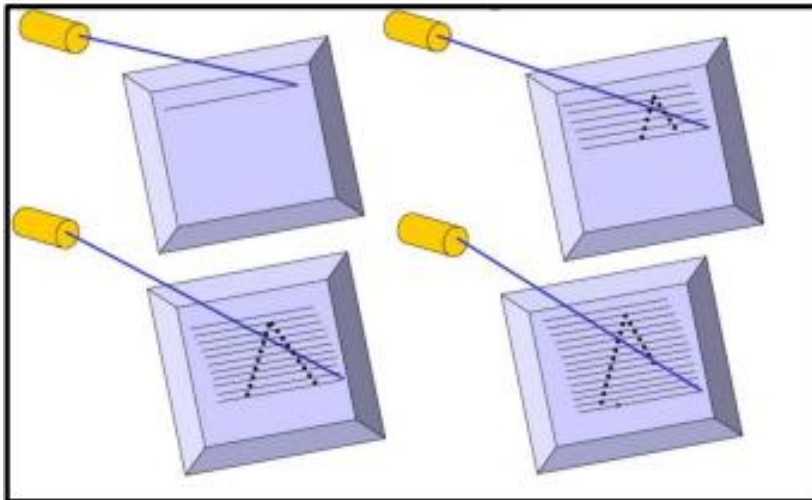
Random

Raster VS Random

- Raster Scan
  - Electron beam swept across the screen ,one row at a time from top to bottom. e.g. television
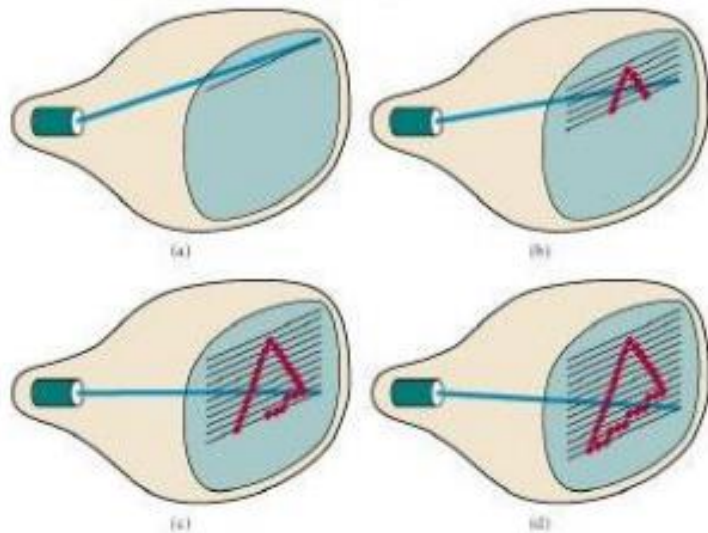
- Random or vector Scan
  - Electron beam directed only to parts of the screen where a picture is drawn. e.g. pen plotter

Color CRT

- A color CRT monitor displays color pictures by using a combination of phosphors that emit different-colored light. By combining the emitted light from the different phosphors, a range of colors can be generated. The two basic techniques for producing color displays with a CRT are;

  1. Beam Penetration Method
  2. Shadow Mask Method
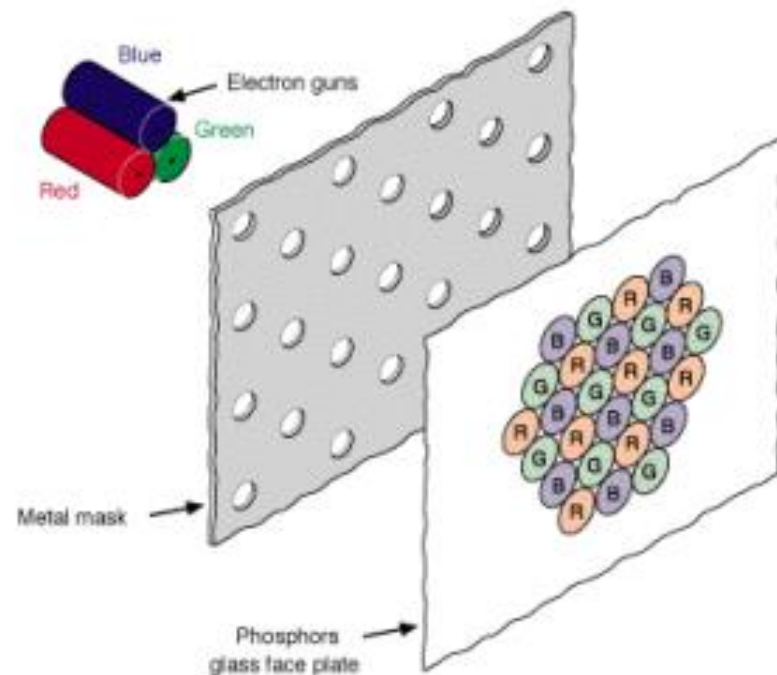
Beam Penetration Method

- It is a cheaper method and is used in Vector scan displays. In this method the inside section of CRT is coated with **red** (outer layer) and **green** (inner layer) phosphors. If the electrons are slow they penetrate only the outer layer thus emitting red light, and if the electrons are moving fast they penetrate the outer layer and the inner layer. The electrons speed is also adjusted in such a way that by combination of **red** and **green**, **orange** and **yellow** color are also produced. The limitation of this method is that only four colors can be displayed in the screen. Since we have only four colors the quality of image is diminished.

Beam Penetration Method…….

- Used with random-scan monitors
- Two layers of phosphor: red and green
- The displayed color depends on how far the electron beam penetrates into the phosphor layers.
- Only four colors are possible: red, green, orange, and yellow.
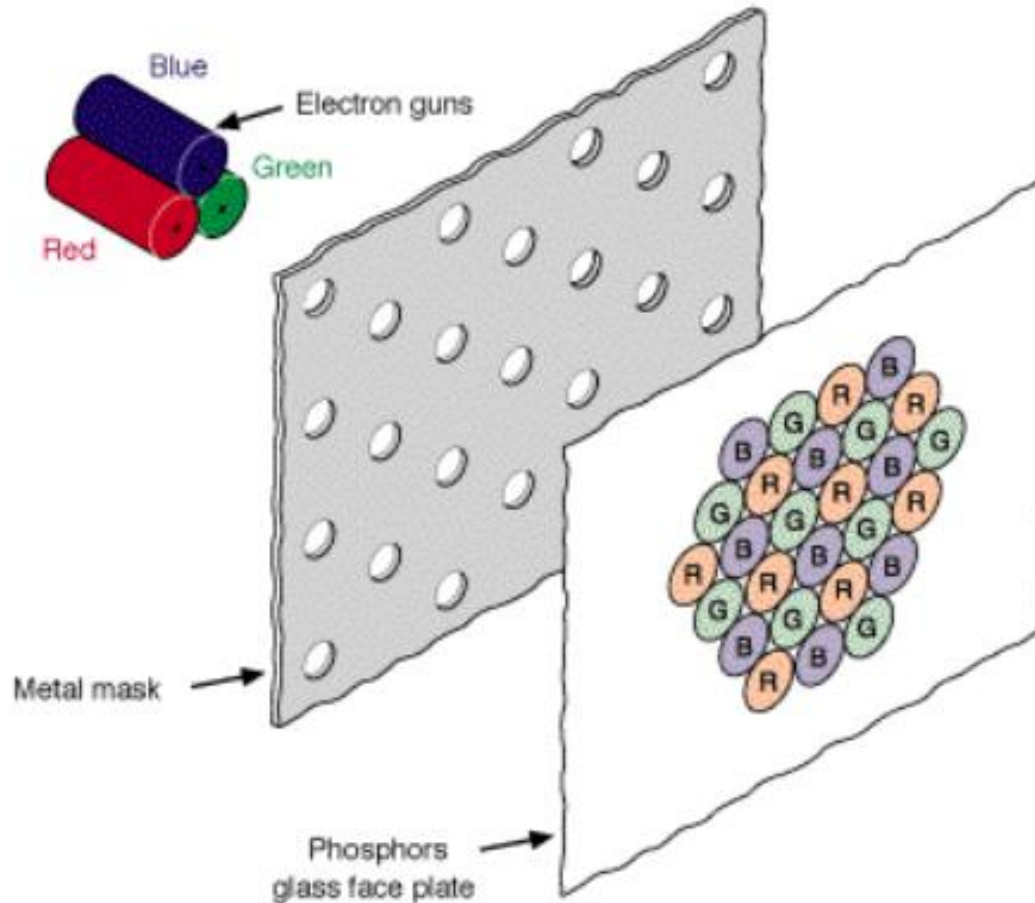
ADVANTAGE:

- Economical way to produce colors

LIMITATIONS:

- Generation of only four colors is possible
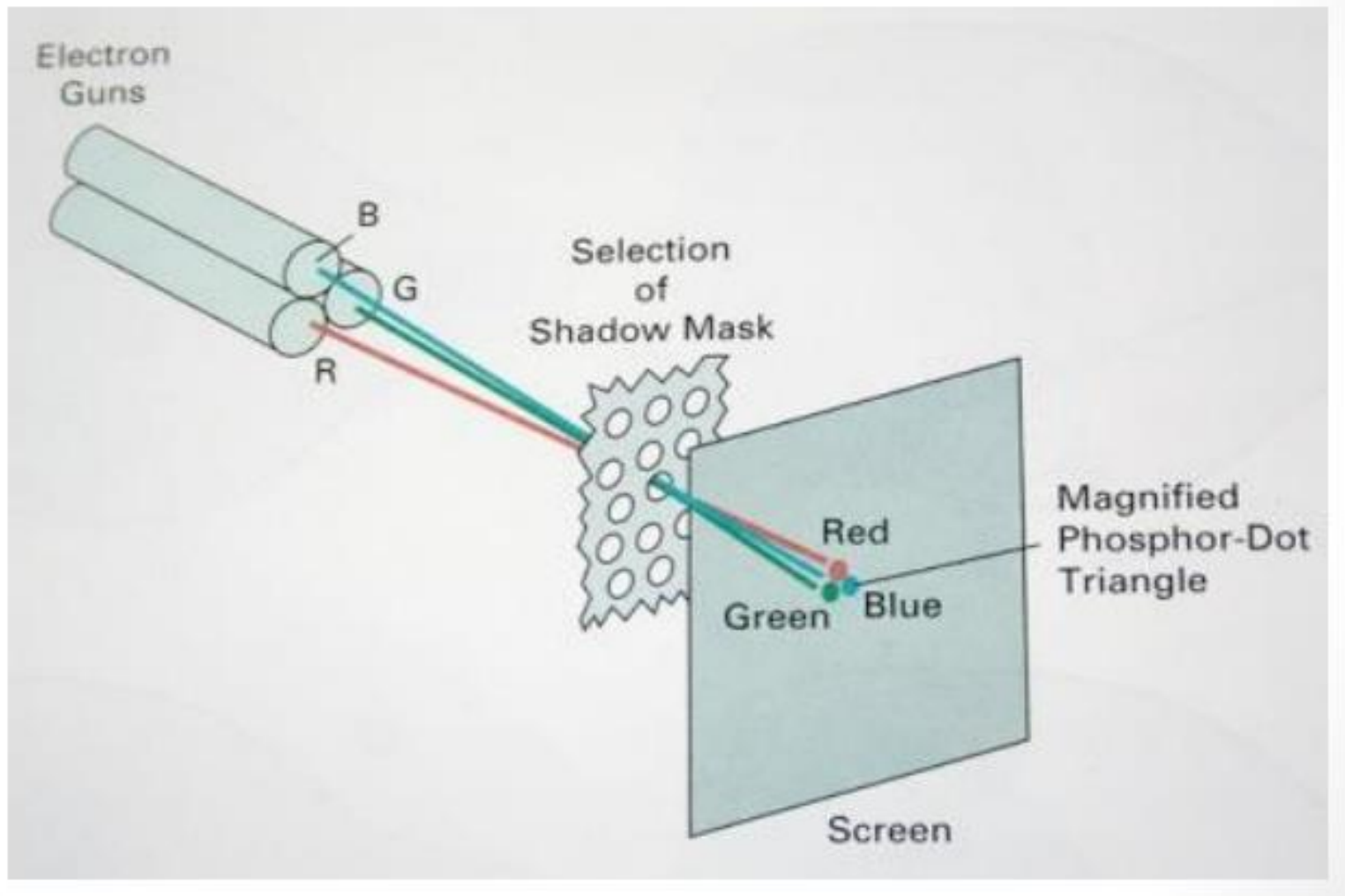- Poor picture quality

Shadow Mask Method

- Shadow-mask methods are commonly used in raster-scan systems (including color TV) because they produce a much wider range of colors than the beam-penetration method. This technique is used in raster scan display devices.

- It gives much wider range of colors than a beam penetration method.

- A shadow Mask CRT has three phosphor color dots at each pixel location. One phosphor dot emits a red light, another emits green light and the last one emits a blue light.

- This type of CRT also has three electron guns one for each color dot. A shadow mask grid is installed just behind the phosphor coated screen.

- The three electron beams are deflected and focused as a group onto the shadow mask, which contains a series of very fine 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. The color of pixel is controlled by light of intensity. Different colors can be obtained by varying the intensity levels.

Shadow Mask Method …

Shadow Mask Method ...

Thank You