Introduction of Computer Graphics

Unit 1

Introduction to Computer Graphics

- ✓ Computer Graphics is a field related to the generation of graphics using computers.
- ✓ Computer graphics are graphics created using computers and the representation of image data by a computer specifically with help from specialized graphic hardware and software.
- ✓ It includes the creation, storage, and manipulation of images of objects .
- ✓ These objects come from diverse fields such as physical, mathematical, engineering, architectural, abstract structures and natural phenomenon.

Areas of applications

Following are the areas of applications of Computer Graphics

1. Computer Aided Design (CAD)
2. Presentation Graphics
3. Computer Art
4. Entertainment
5. Education and Training
6. Visualization
7. Image Processing
8. Graphical User Interfaces (GUI)
9. Simulation
10. Cartography

Advantage of Computer Graphics

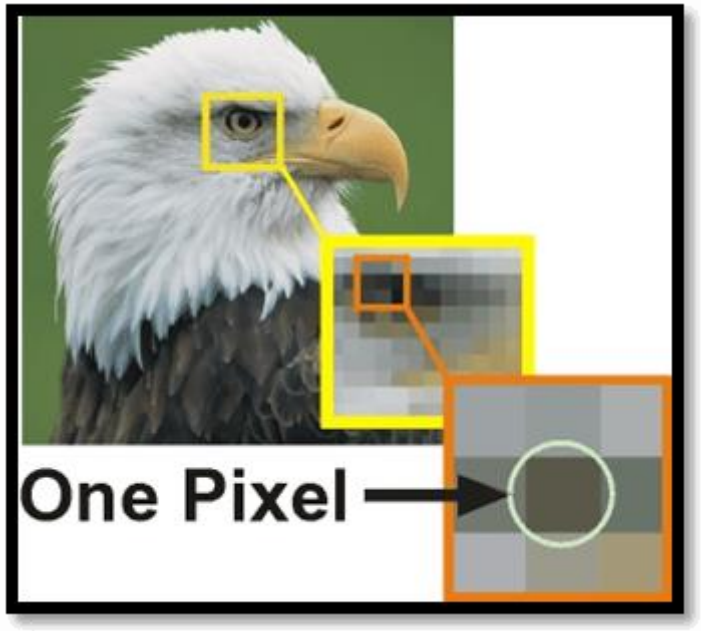
1. A high quality graphics displays of personal computer provide one of the most natural means of communicating with a computer.
2. It has an ability to show moving pictures, and thus it is possible to produce animations with computer graphics.
3. With computer graphics use can also control the animation by adjusting the speed, the portion of the total scene in view, the geometric relationship of the objects in the scene to one another, the amount of detail shown and so on.
4. The computer graphics also provides facility called update dynamics. With update dynamics it is possible to change the shape, color or other properties of the objects being viewed.
5. With the recent development of digital signal processing (DSP) and audio synthesis chip the interactive graphics can now provide audio feedback along with the graphical feedbacks to make the simulated environment even more realistic.

Some Terminology

1. Pixel
2. Resolution
3. Aspect Ratio
4. Raster
5. Persistence
6. Refresh Rate

What is Pixel?

- ✓ The full form of the pixel is “Picture Element”. It is also known as “PEL”.
- ✓ Pixel is the smallest element of an image on a computer display, whether they are LCD or CRT monitors.
- ✓ A screen is made up of a matrix of thousands or millions of pixels.
- ✓ A pixel is represented with a dot or a square on a computer screen.



Concept of Bits Per Pixel

- ✓ BPP or Bits per Pixel is used to denote the number of bits per pixel and the number depends on the depth of color.

Image storage requirements

Size of an Image = rows * cols * bpp

Example: Let row be 3000 and columns be 1687, and it has 256 shades of bpp.

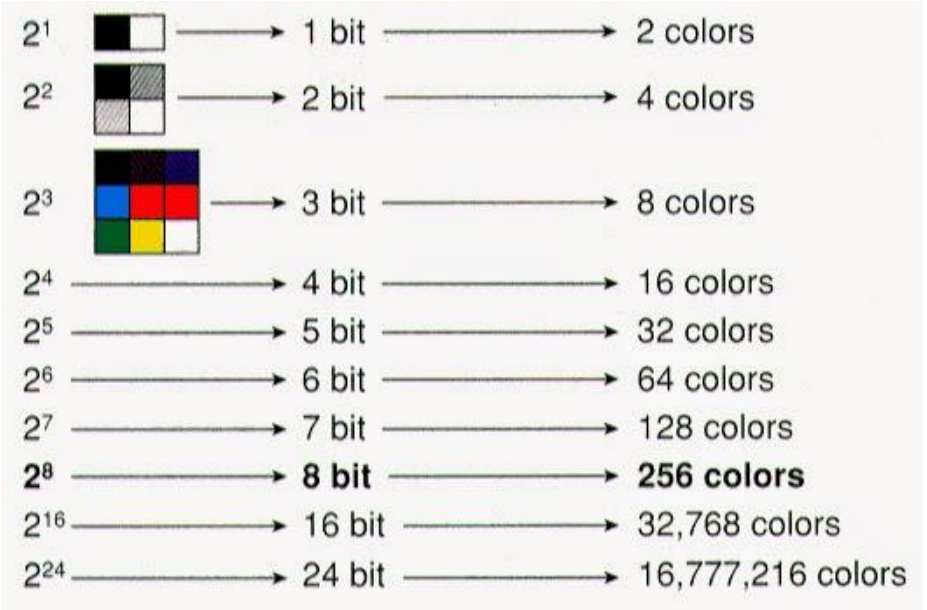
Size of an image = rows * cols * bpp
=3000 * 1687 * 8
=40488000 bits

As it is not a standard answer so we can convert it in the following ways:

Converting it into bytes = 8388608 / 8 = 5061000 bytes.

Converting into kilo bytes = 5061000 / 1024 = 4942kb.

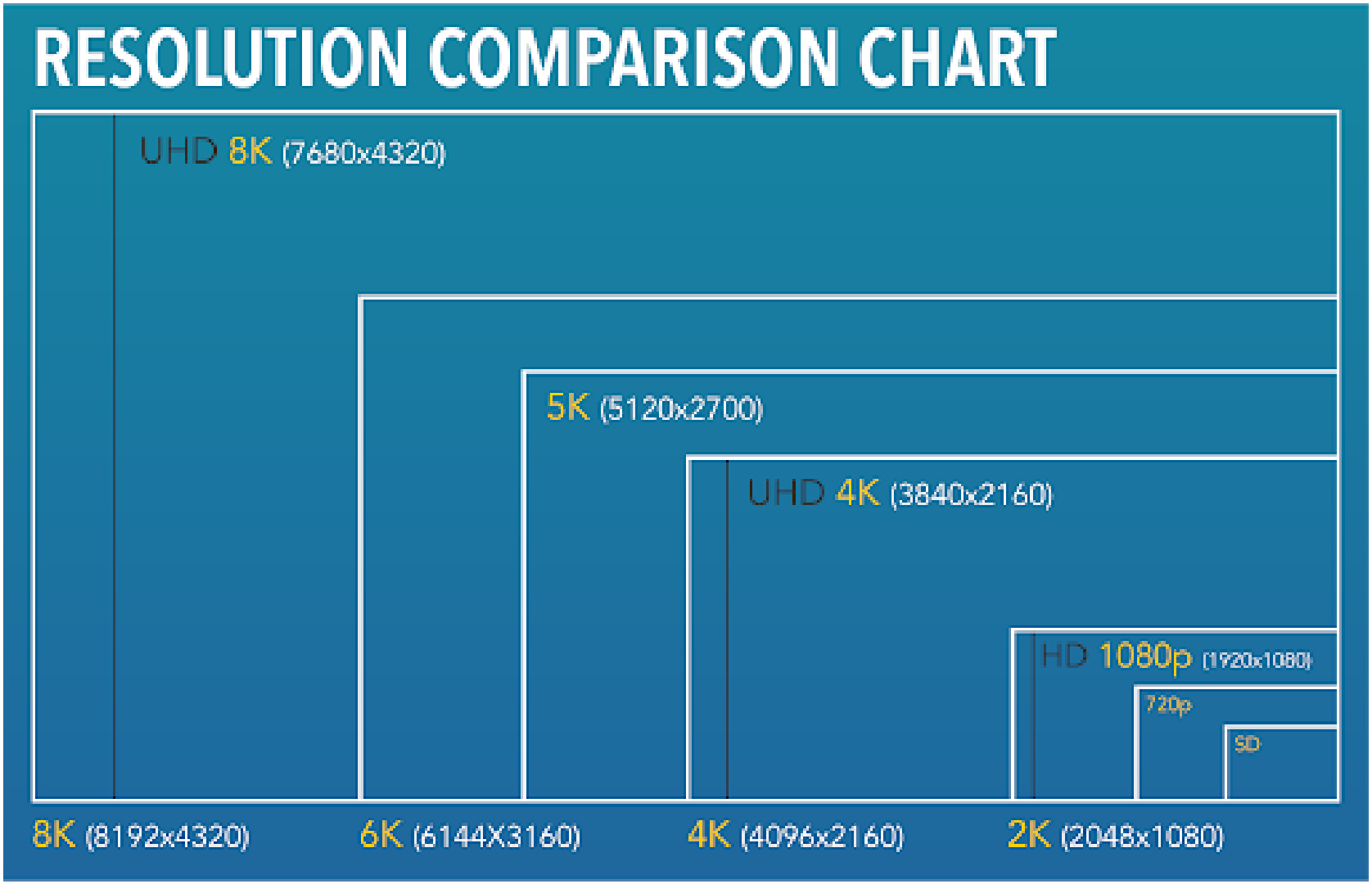
Converting into Mega bytes = 4942 / 1024 = 4 Mb.



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.

Resolution

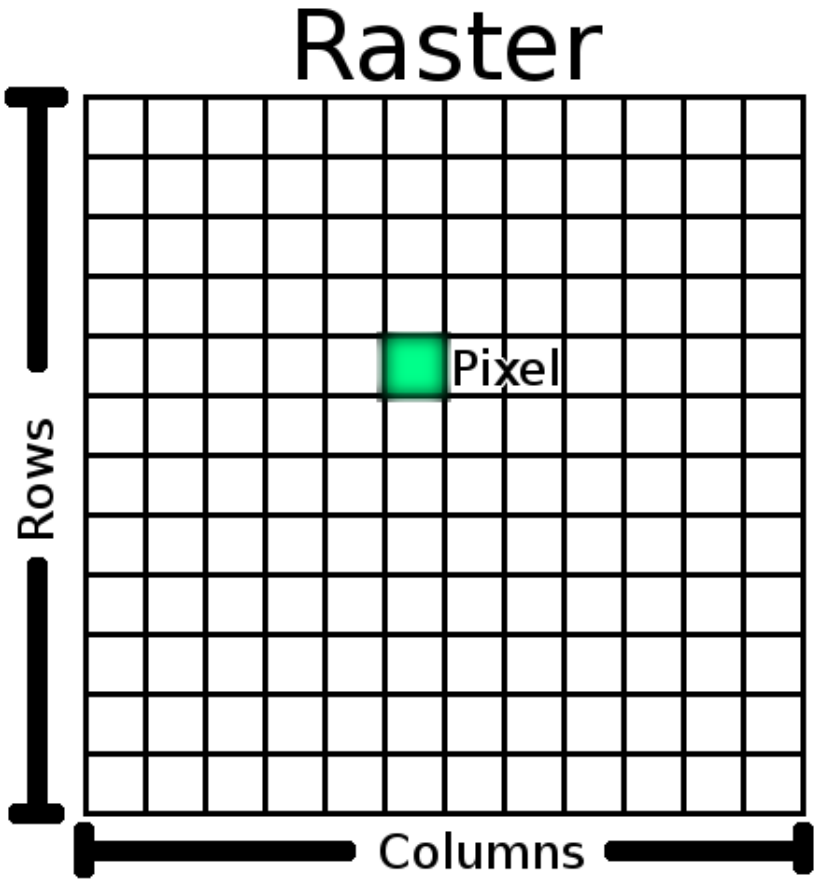

RESOLUTION COMPARISON CHART
UHD 8K (7680x4320)
5K (5120x2700)
UHD 4K (3840x2160)
HD 1080p (1920x1080)
720p
SD
8K (8192x4320)
6K (6144X3160)
4K (4096x2160)
2K (2048x1080)

Aspect ratio

- ✓ Aspect ratio is the ratio between height and width of an image.
- ✓ A colon is used to separate two numbers.
- ✓ 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.

Raster

- ✓ A rectangular array of points or dots.
- ✓ A row of pixels is called *Scan Line*.

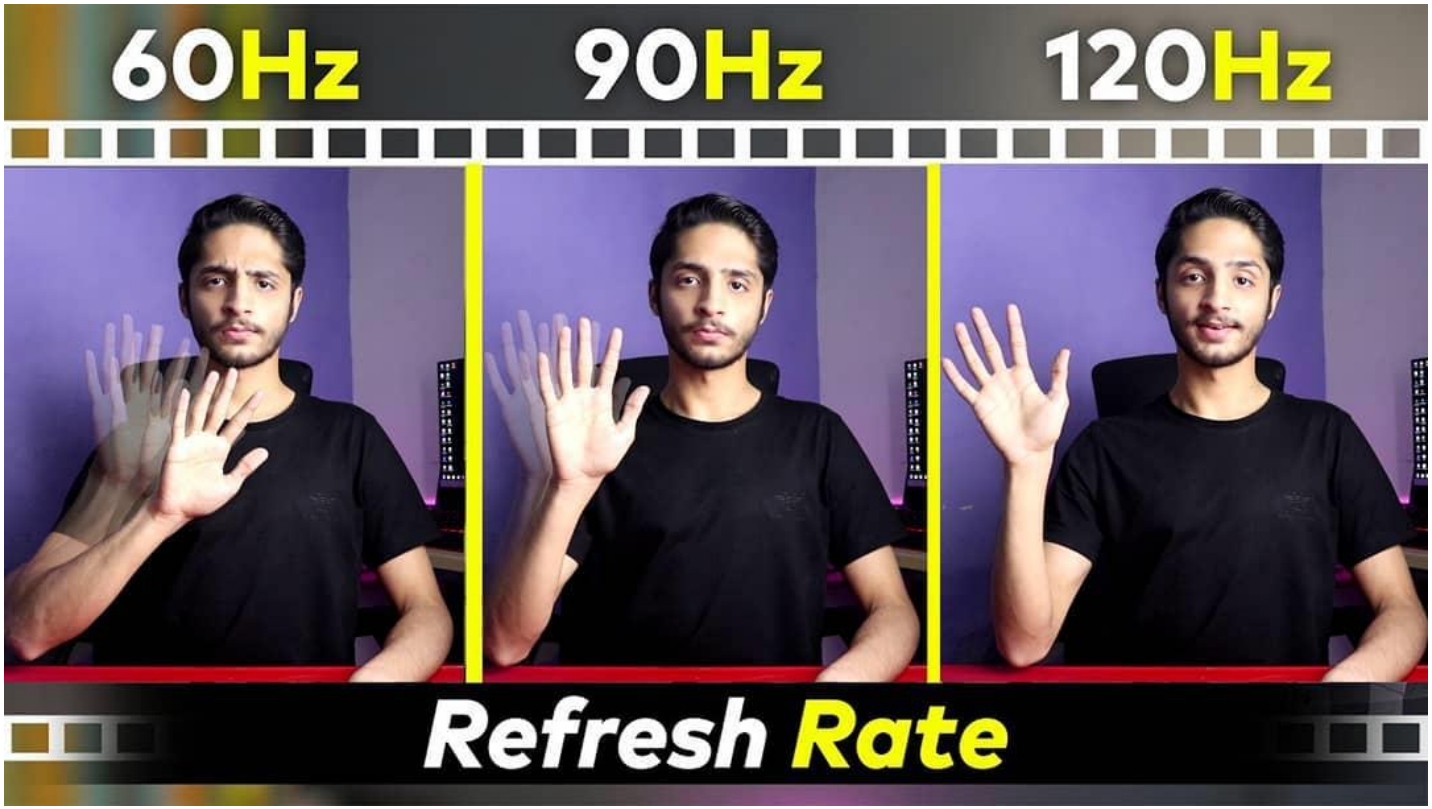


Persistence

- ✓ 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.



Cathode Ray Tube (CRT)

- ✓ CRT stands for Cathode Ray Tube.
- ✓ CRT is a technology used in traditional computer monitors and televisions.
- ✓ The image on CRT display is created by firing electrons from the back of the tube of phosphorus located towards the front of the screen.
- ✓ Once the electron heats the phosphorus, they light up, and they are projected on a screen.

Components of CRT

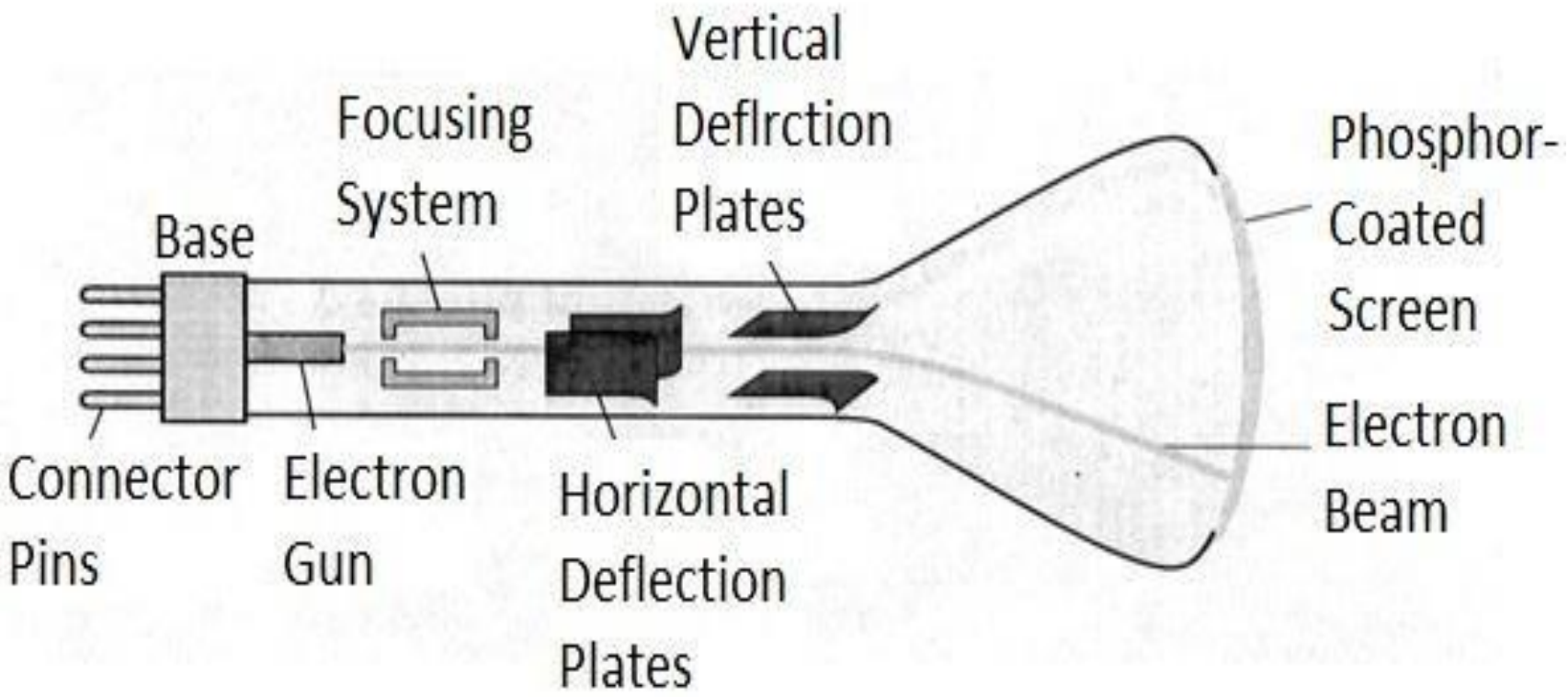


Fig: Cathode ray tube

Components of CRT

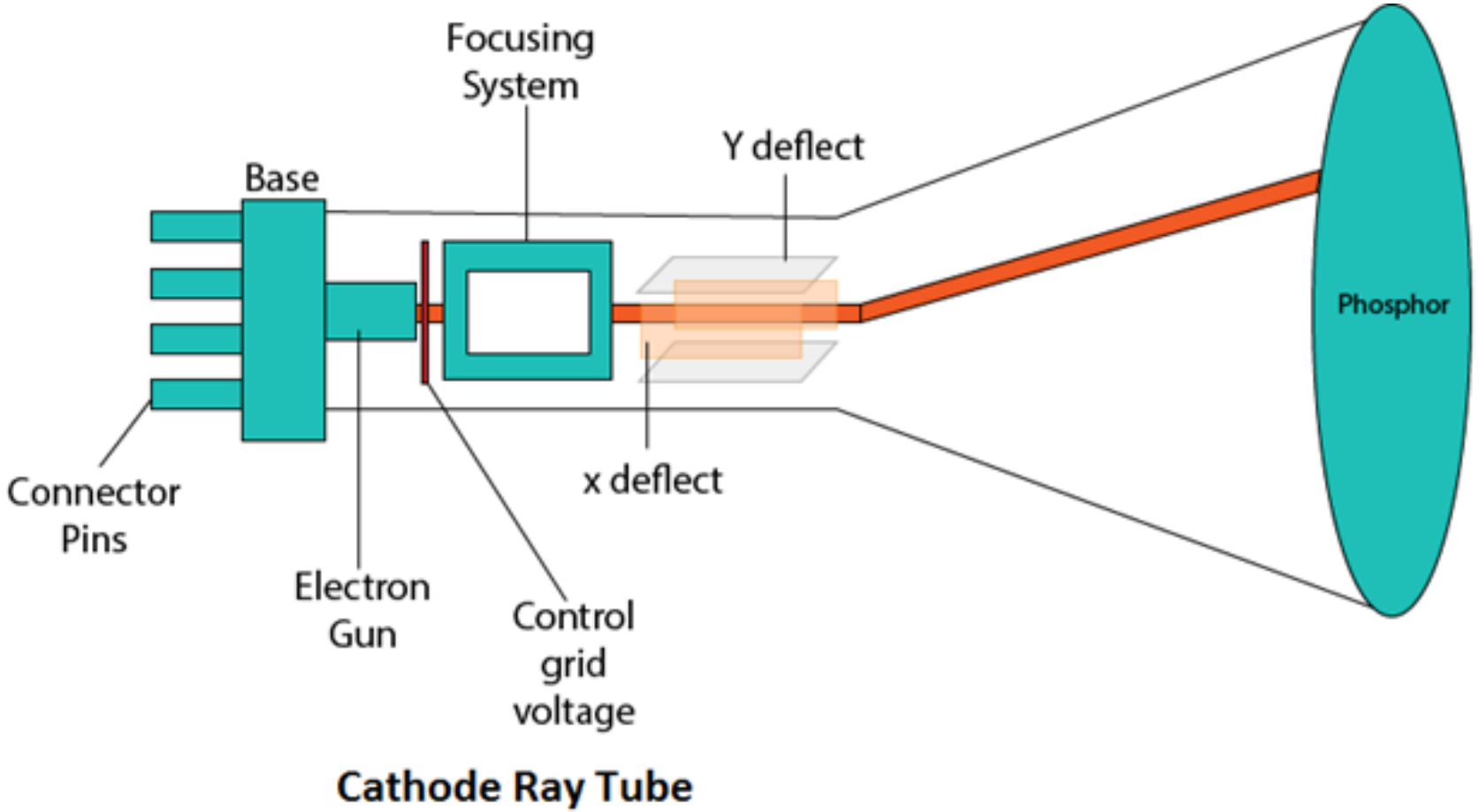


Fig: Cathode ray tube

Components of CRT

Main Components of CRT are:

1. *Electron Gun:* Electron gun consisting of a series of elements, primarily a heating filament (heater) and a cathode. The electron gun creates a source of electrons which are focused into a narrow beam directed at the face of the CRT.
2. *Control Grid:* Control grid controls velocity of electrons before they hit the phosphor. The control grid voltage determines how many electrons are actually in the electron beam. Thus control grid controls Intensity of the spot where beam strikes the screen.
3. *Focusing system:* It is used to create a clear picture by focusing the electrons into a narrow beam.
4. *Deflection Plate:* It is used to control the direction of the electron beam. It creates an electric or magnetic field which will bend the electron beam as it passes through the area.
5. *Phosphorus-coated screen:* Inner side screen is coated with phosphor substance which gives light when it is stroke by electrons.

Producing Image on the CRT

- ✓ There are two techniques used for producing images on the CRT screen:
  1. Raster scan display
  2. Vector scan/Random scan display

Raster scan display

- ✓ The most common type of graphics monitor employing a CRT is the raster-scan display.
- ✓ In a raster scan system, the electron beam is swept 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.
- ✓ Picture definition is stored in 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 (scanline) at a time as shown in the following illustration.
- ✓ On a black and white system with one bit per pixel the frame buffer is commonly called a **Bitmap.** And for systems with multiple bits per pixel, the frame buffer is often referred as a **Pixmap.**

Raster scan display

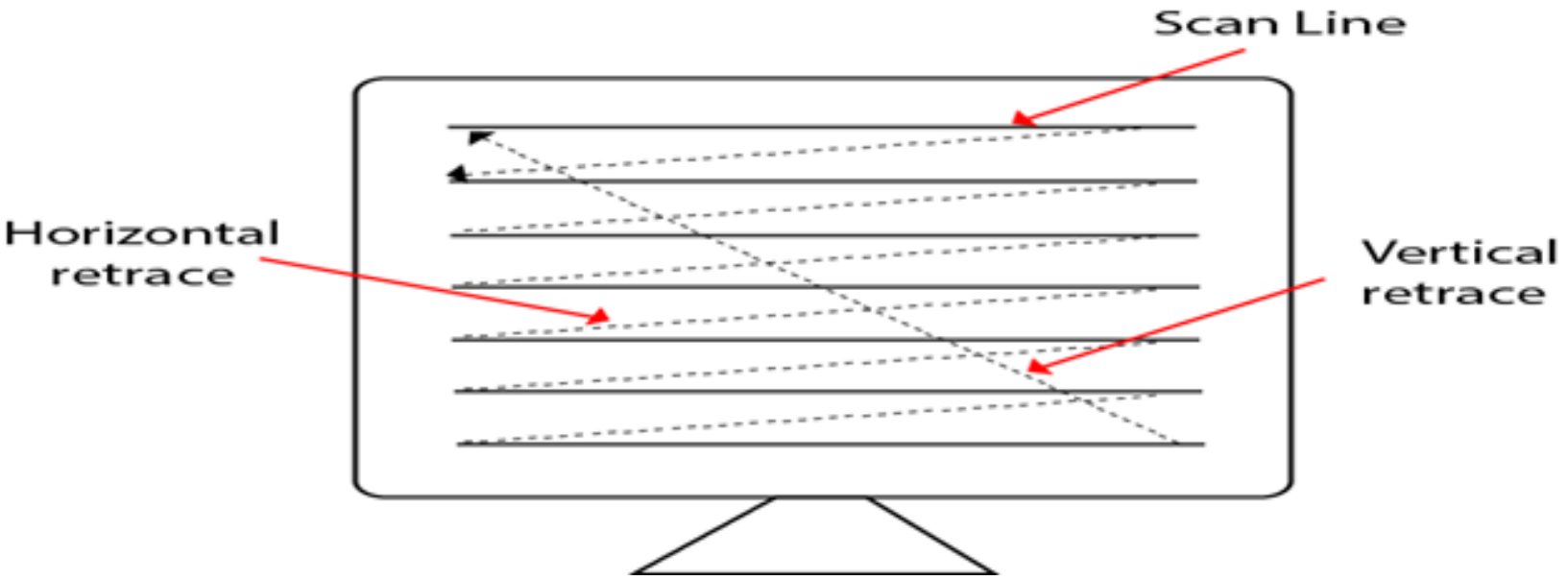


Figure: Raster Scan

Architecture of Raster scan display

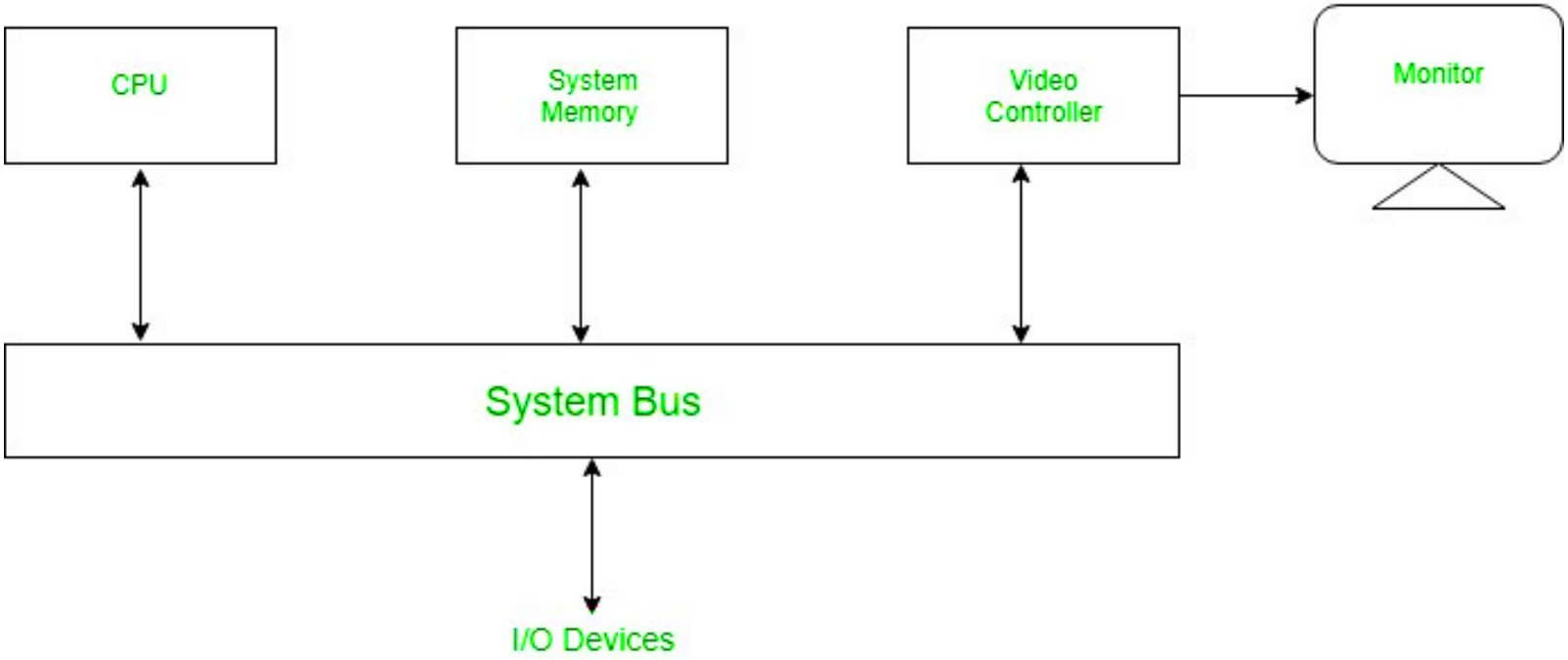


Figure: Architecture of a simple raster graphics system.

Architecture of Raster scan display

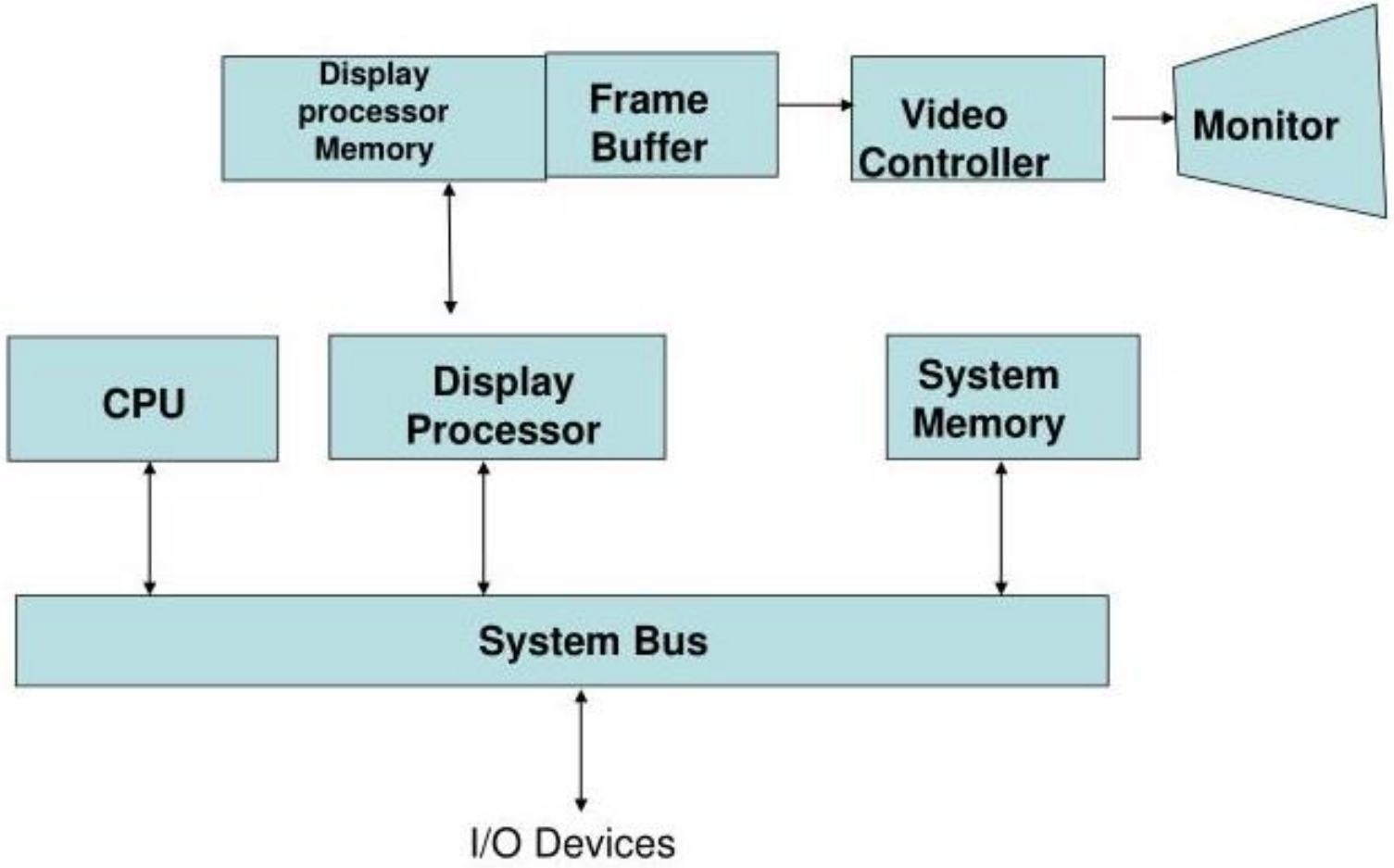


Figure: Architecture of raster graphics system with display processor.

Architecture of Raster scan display

- ✓ Interactive raster graphics systems typically employ several processing units.
- ✓ In addition to the central processing unit, a special-purpose processor, called the Video Controller or Display Controller, is used to control the operation of the display device.
- ✓ The Frame buffer can be anywhere in the system memory, and the video controller accesses the frame buffer to refresh the screen.
- ✓ In addition to the video controller, more sophisticated raster systems employ other processors as co-processors and accelerators to implement various graphics operations.

Types of Raster-scan systems

1. Interlaced Scanning
2. Non-Interlaced Scanning

- ✓ 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.
- ✓ 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.

Types of Raster-scan systems

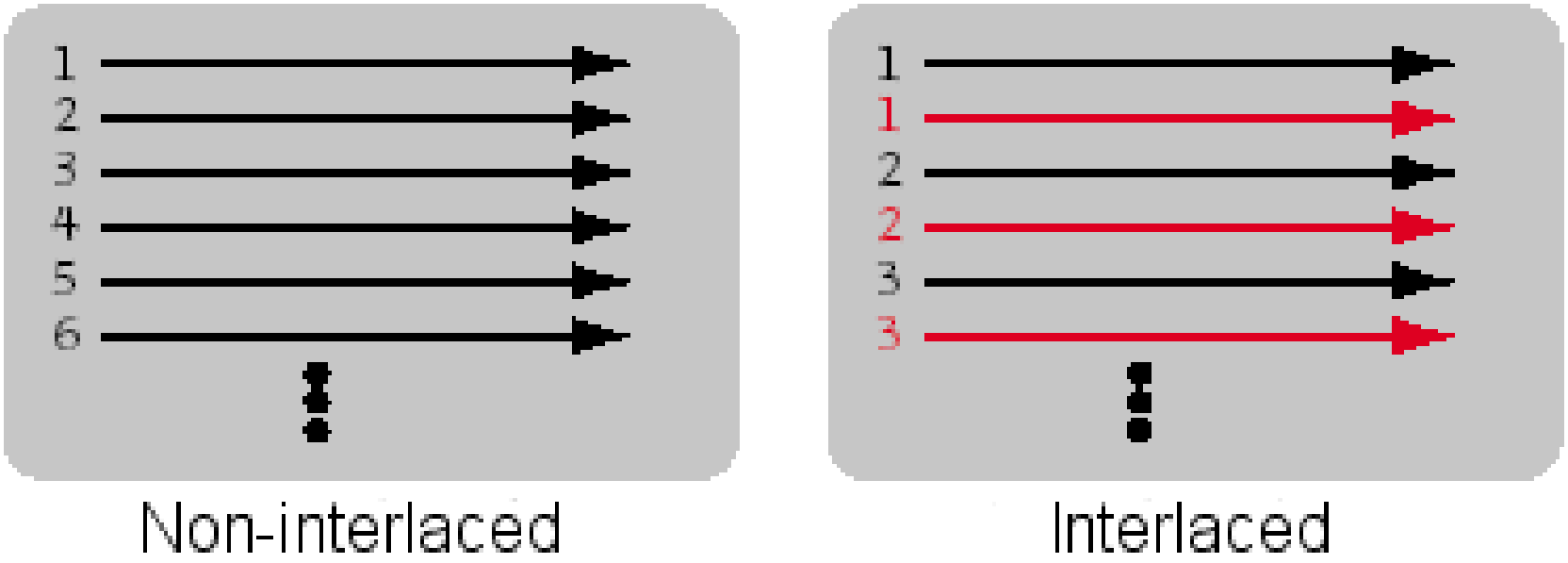


Figure: Interlaced and non-interlaced scan system.

Advantages and Disadvantages of Raster Scan

Advantages:

- Realistic image
- Million Different colors to be generated
- Shadow Scenes are possible.

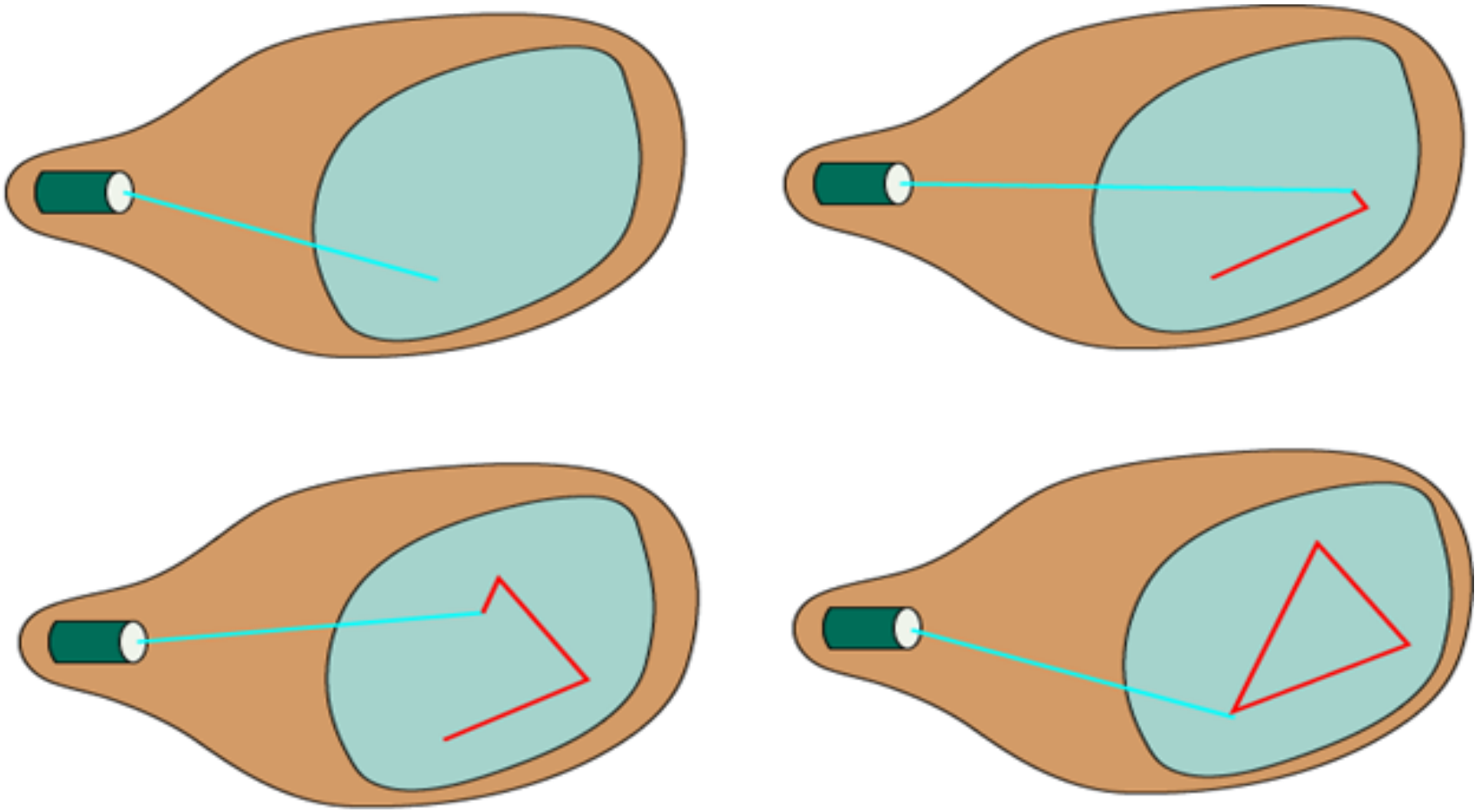
Disadvantages:

- Low Resolution
- Expensive

Vector scan/Random scan display

- ✓ Random Scan System uses an electron beam which operates like a pencil to create a line image on the CRT screen.
- ✓ The picture is constructed out of a sequence of straight-line segments.
- ✓ Each line segment is drawn on the screen by directing the beam to move from one point on the screen to the next, where its x & y coordinates define each point.
- ✓ Random-scan monitors are also known as vector displays or stroke-writing displays or calligraphic displays.

Vector scan/Random scan display



Architecture of Vector scan/Random scan display

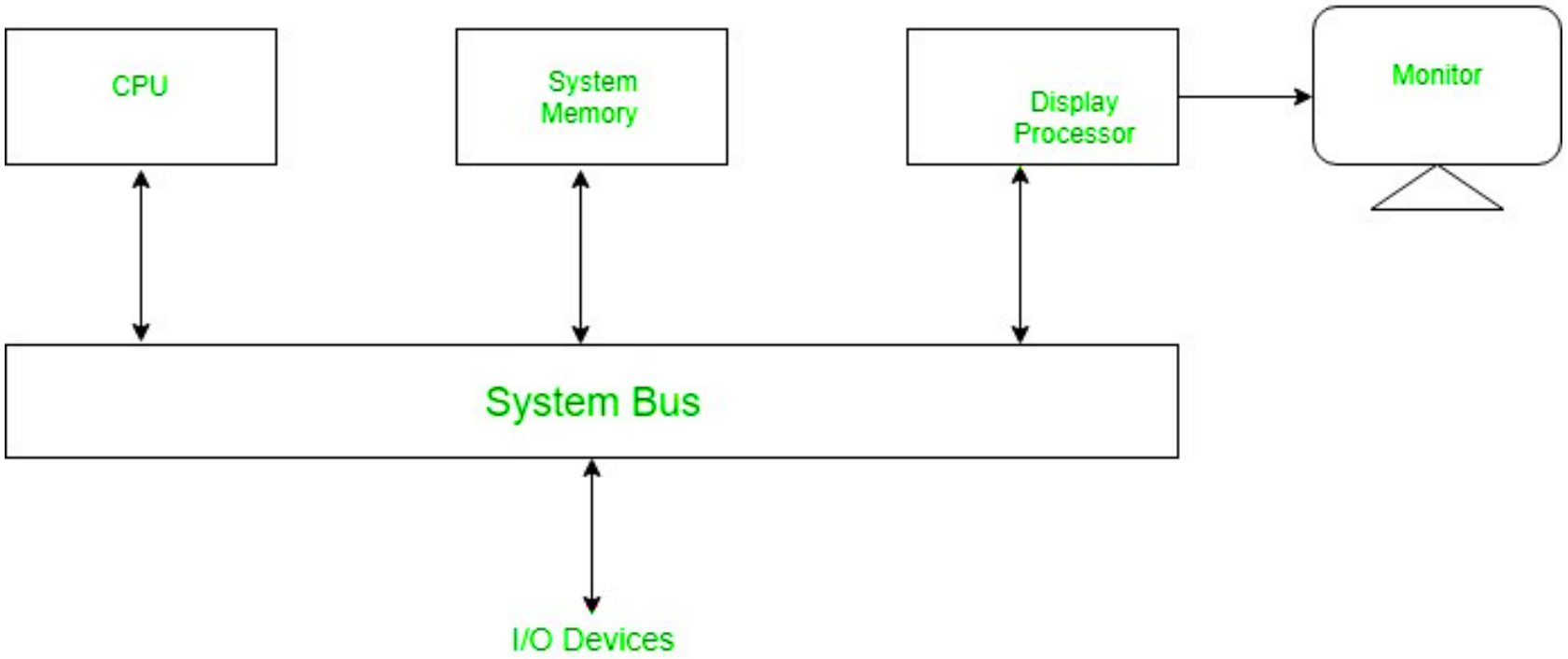


Figure: Architecture of a simple raster graphics system.

Architecture of Vector scan/Random scan display

- ✓ It consists of display processor (also called display controller or graphics controller or display processing unit), CPU, display buffer memory and CRT.
- ✓ Display controller is connected as an I/O peripheral to the CPU.
- ✓ Display buffer stores computer produced display list or display program.
- ✓ The Program contains point & line plotting commands with end point co-ordinates as well as character plotting commands.
- ✓ Display controller interprets command and sends digital and point co-ordinates to a vector generator.
- ✓ Vector generator then converts the digital co-ordinate value to analog voltages for beam deflection circuits that displace an electron beam which points on the CRT's screen.
- ✓ In this technique beam is deflected from end point to end point hence this techniques is also called random scan.
- ✓ We know as beam strikes phosphors coated screen it emits light but that light decays after few milliseconds and therefore it is necessary to repeat through the display list to refresh the screen at least 30 times per second to avoid flicker.
- ✓ As display buffer is used to store display list and used to refreshing, it is also called *refresh buffer*.

Advantages and Disadvantages of Random Scan Display

Advantages:

- A CRT has the electron beam directed only to the parts of the screen where an image is to be drawn.
- Produce smooth line drawings.
- High Resolution

Disadvantages:

- Random-Scan monitors cannot display realistic shades scenes.

Differentiate between Random and Raster Scan Display

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.

Color CRT monitors

- ✓ A CRT monitors displays color pictures by using a combination of phosphors that emit different colored light.
- ✓ It produces range of colors by combining the light emitted by different phosphors.
- ✓ There are two basic techniques for color display:
  1. Beam-penetration technique
  2. Shadow-mask technique

Color CRT monitors

Beam-penetration technique

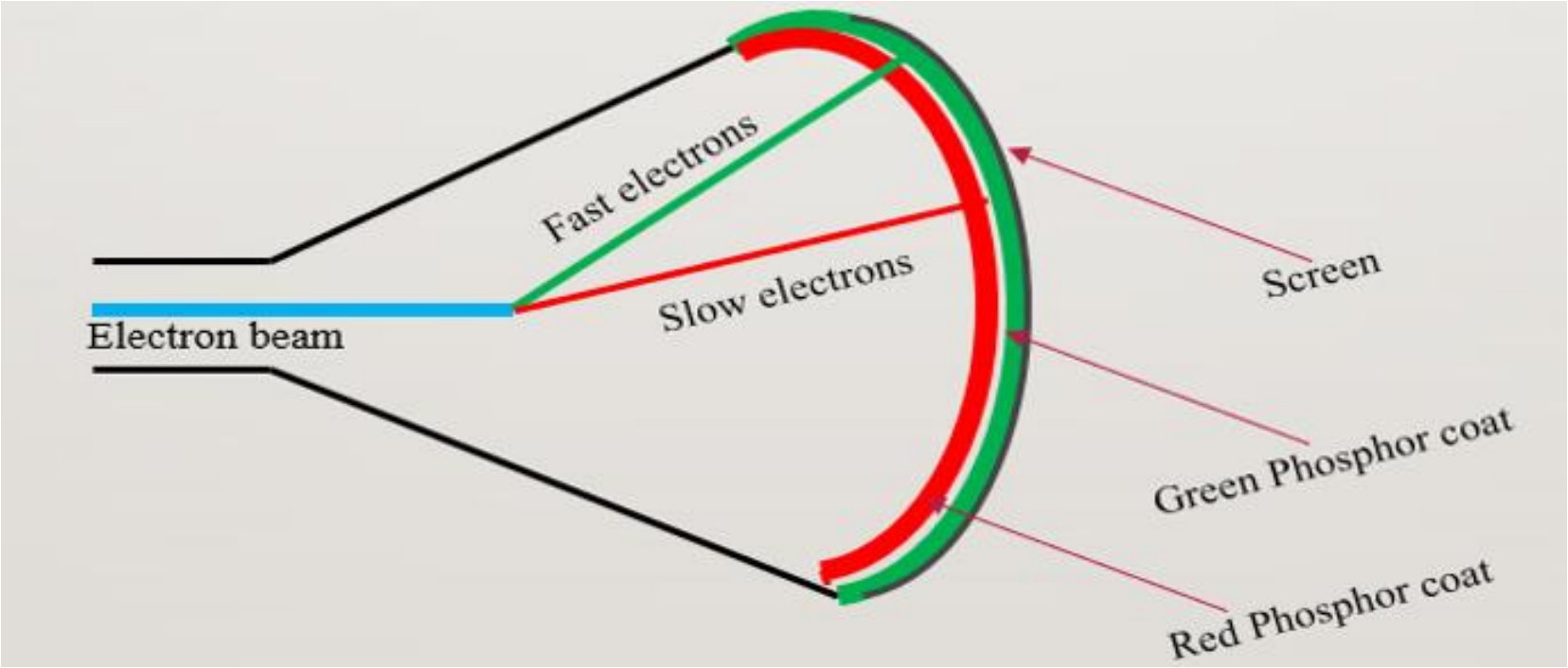


Figure: Beam-penetration CRT

Color CRT monitors

Beam-penetration technique

- ✓ This technique is used with random scan monitors.
- ✓ In this technique inside of CRT coated with two phosphor layers usually red and green. The outer layer of red and inner layer of green phosphor.
- ✓ The color depends on how far the electron beam penetrates into the phosphor layer.
- ✓ A beam of fast electron penetrates more and excites inner green layer while slow electron excites outer red layer.
- ✓ At intermediate beam speed we can produce combination of red and green lights which emit additional two colors orange and yellow.
- ✓ The beam acceleration voltage controls the speed of the electrons and hence color of pixel.
- ✓ It is a low cost technique to produce color in random scan monitors.
- ✓ It can display only four colors.
- ✓ Quality of picture is not good compared to other techniques.

Color CRT monitors

Shadow-mask technique

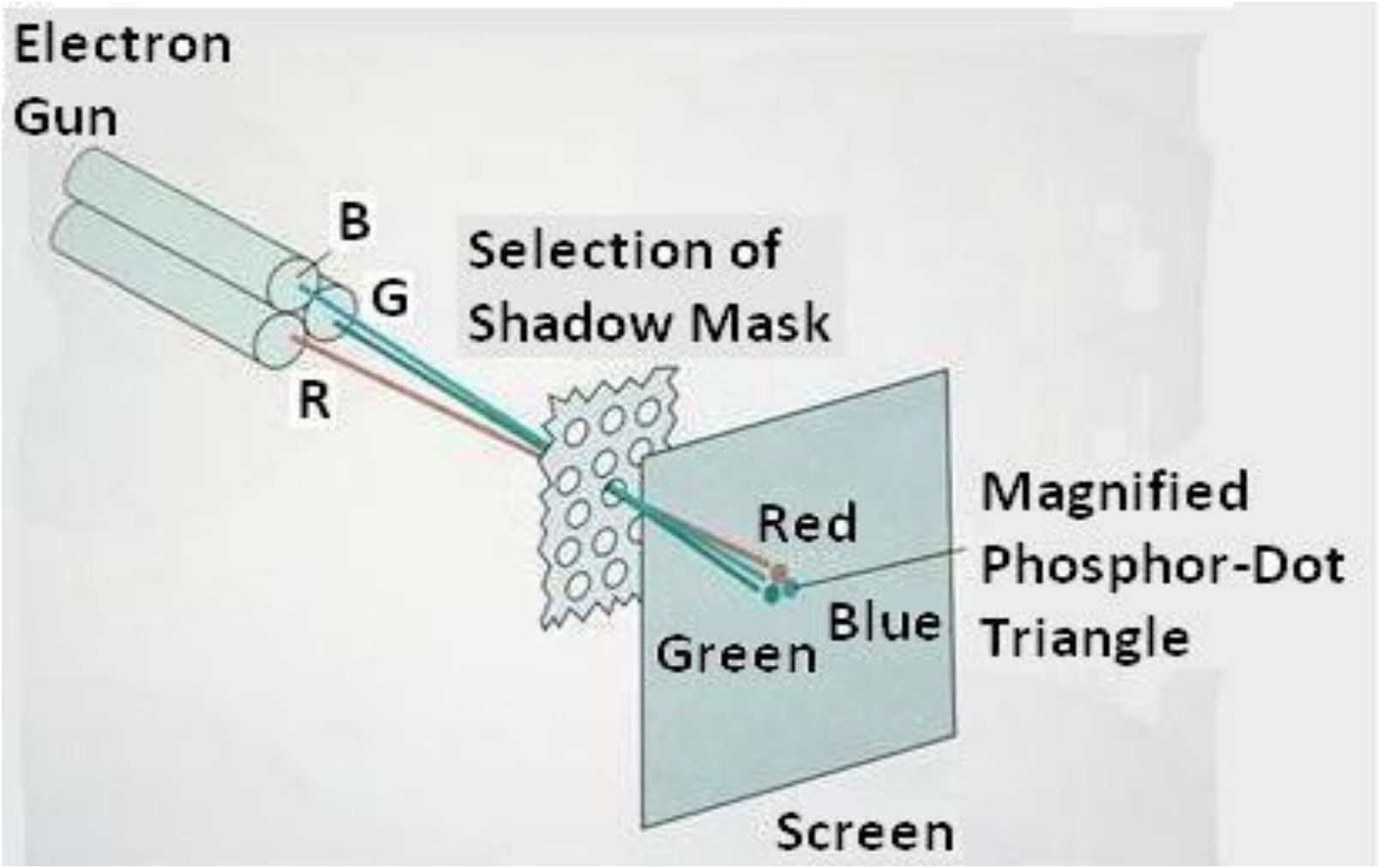


Figure: Shadow-mask CRT.

Color CRT monitors

Shadow-mask technique

- ✓ It produces wide range of colors as compared to beam-penetration technique.
- ✓ This technique is generally used in raster scan displays. Including color TV.
- ✓ In this technique CRT has three phosphor color dots at each pixel position. One dot for red, one for green and one for blue light. This is commonly known as **Dot Triangle.**
- ✓ Here in CRT there are three electron guns present, one for each color dot. And a shadow mask grid just behind the phosphor coated screen.
- ✓ The shadow mask grid consists of series of holes aligned with the phosphor dot pattern.
- ✓ Three electron beams are deflected and focused as a group onto the shadow mask and when they pass through a hole they excite a dot triangle.
- ✓ In dot triangle three phosphor dots are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.
- ✓ A dot triangle when activated appears as a small dot on the screen which has color of combination of three small dots in the dot triangle.
- ✓ By changing the intensity of the three electron beams we can obtain different colors in the shadow mask CRT.

Direct-view storage tubes (DVST)

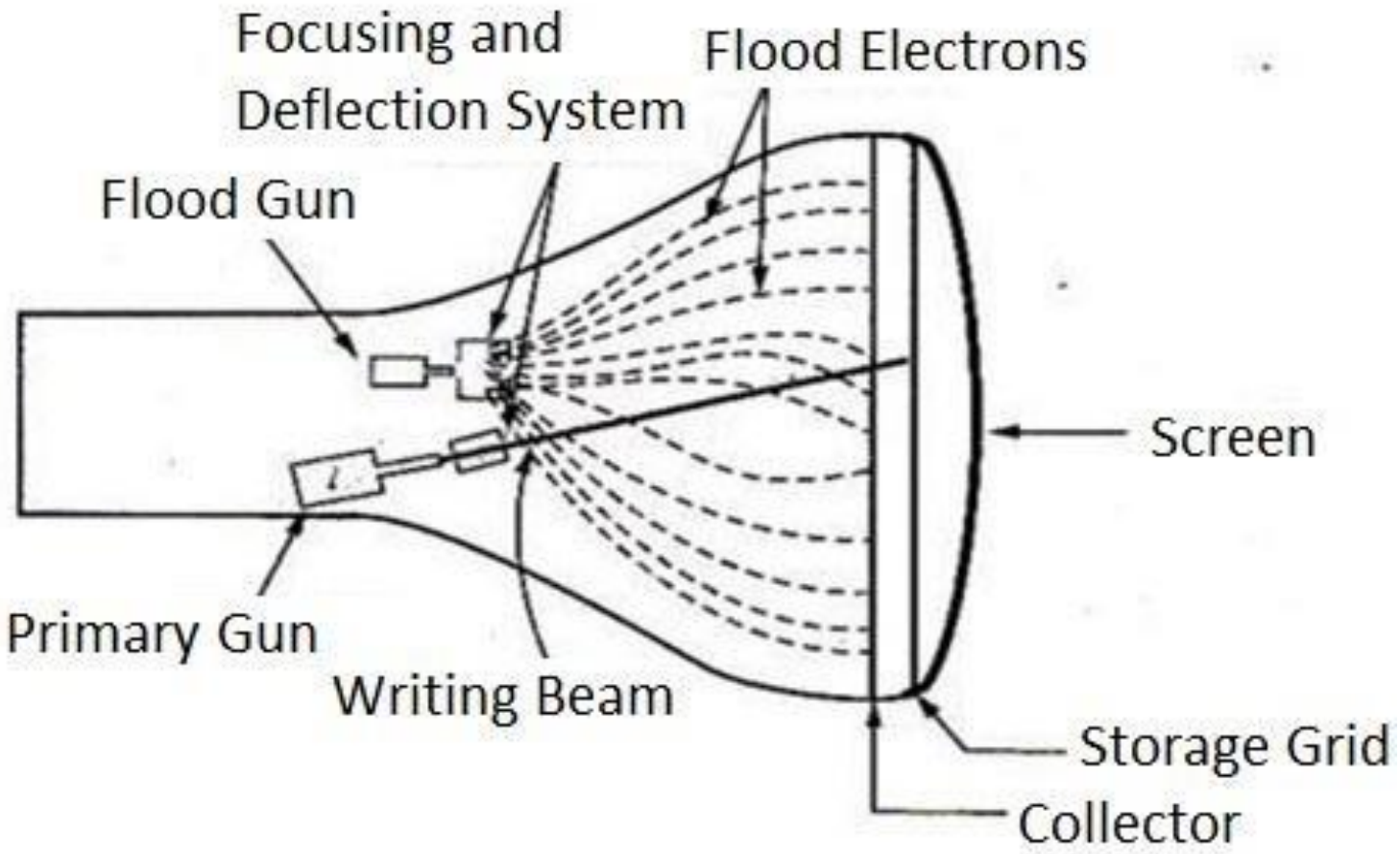


Figure: Direct-view storage tube.

Direct-view storage tubes (DVST)

- ✓ In raster scan display we do refreshing of the screen to maintain a screen image.
- ✓ DVST gives alternative method for maintaining the screen image.
- ✓ DVST uses the storage grid which stores the picture information as a charge distribution just behind the phosphor coated screen.
- ✓ DVST consists two electron guns a primary gun and a flood gun.
- ✓ A primary gun stores the picture pattern and the flood gun maintains the picture display.
- ✓ A primary gun emits high speed electrons which strike on the storage grid to draw the picture pattern.
- ✓ As electron beam strikes on the storage grid with high speed, it knocks out electrons from the storage grid keeping the net positive charge.
- ✓ The knocked out electrons are attracted towards the collector.
- ✓ The net positive charge on the storage grid is nothing but the picture pattern.
- ✓ The continuous low speed electrons from flood gun pass through the control grid and are attracted to the positive charged area of the storage grid.
- ✓ The low speed electrons then penetrate the storage grid and strike the phosphor coating without affecting the positive charge pattern on the storage grid.
- ✓ During this process the collector just behind the storage grid smooth out the flow of flood electrons.

Advantages and Disadvantages of DVST

Advantage of DVST

- ✓ Refreshing of CRT is not required.
- ✓ Very complex pictures can be displayed at very high resolution without flicker.
- ✓ Flat screen.

Disadvantage of DVST

- ✓ They do not display color and are available with single level of line intensity.
- ✓ For erasing it is necessary to removal of charge on the storage grid so erasing and redrawing process take several second.
- ✓ Erasing selective part of the screen cannot be possible.
- ✓ Cannot used for dynamic graphics application as on erasing it produce unpleasant flash over entire screen.
- ✓ It has poor contrast as a result of the comparatively low accelerating potential applied to the flood electrons.
- ✓ The performance of DVST is somewhat inferior to the refresh CRT.

Flat Panel Display(FPD)

- ✓ They are far lighter and thinner than traditional cathode ray tube (CRT) television sets and video displays and are usually less than 10 centimeters (3.9 in) thick.
- ✓ Sometimes abbreviated as **FPD**, a **flat-panel display** is a thin screen display found on all portable computers and is the new standard for desktop computers.
- ✓ Unlike (CRT) monitors, flat- panel displays use liquid-crystal display (LCD) or light-emitting diode (LED) technology to make them much lighter and thinner compared to a traditional monitor
- ✓ Types
  - LCD (liquid-crystal display)
  - LED (light-emitting diode)

LCD(Liquid-crystal display)

- A **liquid-crystal display** (**LCD**) is a flat-panel display or electronic visual display that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly.
- LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and indoor and outdoor signage.
- Small LCD screens are common in portable consumer devices such as digital cameras, watches , calculators ,and mobile telephones, including smartphones.

How LCD work

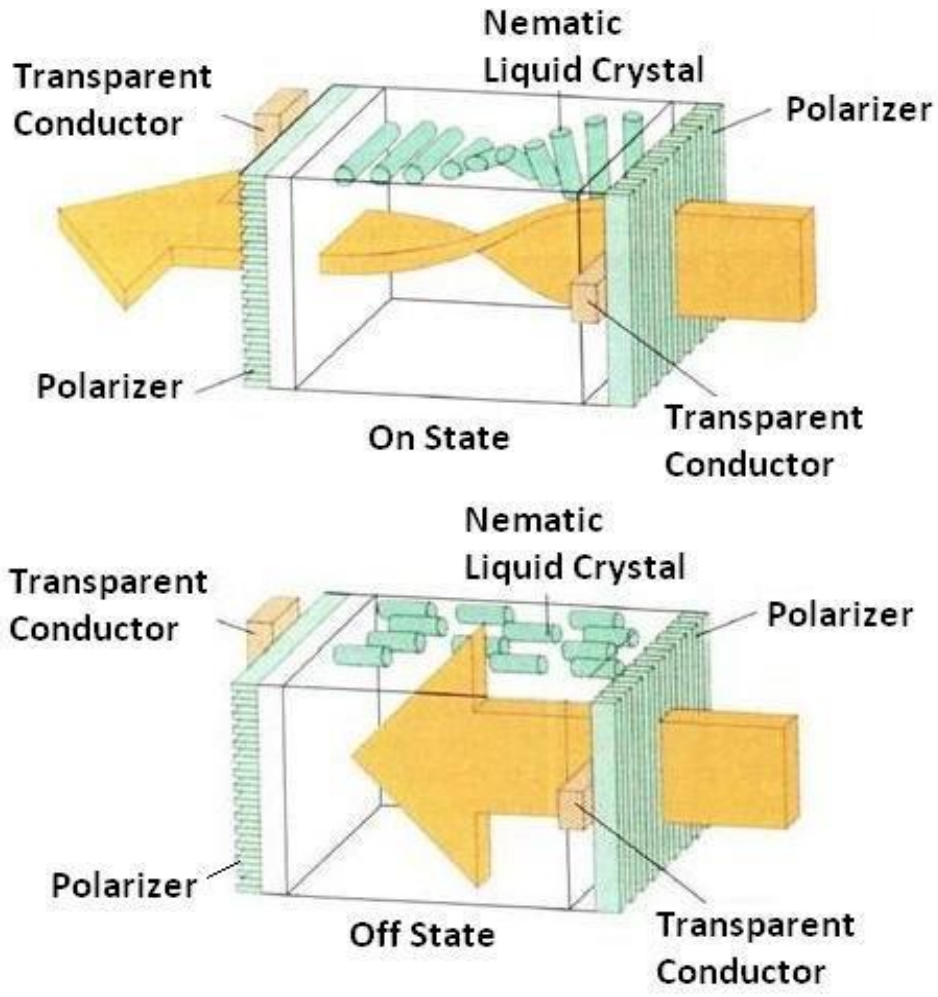


Figure: Light twisting shutter effect used in design of most LCD.

How LCD work

- ✓ LCD uses the liquid-crystal material between two glass plates; each plate is the right angle to each other between plates liquid is filled.
- ✓ One glass plate consists of rows of conductors arranged in vertical direction.
- ✓ Another glass plate is consisting of a row of conductors arranged in horizontal direction.
- ✓ The pixel position is determined by the intersection of the vertical & horizontal conductor.
- ✓ This position is an active part of the screen.

Advantages and Disadvantages of LCD

Advantage:

- ✓ Low power consumption.
- ✓ Small Size
- ✓ Low Cost

Disadvantage:

- ✓ LCDs are temperature-dependent (0-70°C)
- ✓ LCDs do not emit light; as a result, the image has very little contrast.
- ✓ LCDs have no color capability.
- ✓ The resolution is not as good as that of a CRT

Hard Copy Devices

- ✓ Following are Output Devices:
  1. Printers
  2. Plotters

Input Devices

1. Keyboards
2. Mouse
3. Trackball and Spaceball
4. Joysticks
5. Data glove
6. Digitizer
7. Image Scanner
8. Touch Panels
9. Light pens
10. Voice systems

Graphics Software

- ✓ There are two general classifications for graphics software:
  1. general programming packages and
  2. special-purpose applications packages

General programming package

- A general programming package provides an extensive set of graphics function that can be used in high level programming language such as C or FORTRAN.
- It includes basic drawing element shape like line, curves, polygon, color of element transformation etc.
- Example: - GL (Graphics Library).

Special-purpose application package

- Special-purpose application package are customize for particular application which implement required facility and provides interface so that user need not to worry about how it will work (programming).
- User can simply use it by interfacing with application.
- Example: - CAD, medical and business systems.

Coordinate representations

- ✓ Except few all other general packages are designed to be used with *Cartesian coordinate* specifications.
- ✓ If coordinate values for a picture are specified is some other reference frame they must be converted to Cartesian coordinate before giving input to graphics package.
- ✓ Special-purpose package may allow use of other coordinates which suits application.
- ✓ In general several different Cartesian reference frames are used to construct and display scene.
- ✓ We can construct shape of object with separate coordinate system called *modeling coordinates or sometimes local coordinates or master coordinates*.
- ✓ Once individual object shapes have been specified we can place the objects into appropriate positions called *world coordinates.*

Coordinate representations

- ✓ Finally the World-coordinates description of the scene is transferred to one or more output device reference frame for display. These display coordinates system are referred to as *Device Coordinates or Screen Coordinates.*
- ✓ Generally a graphic system first converts the *world-coordinates* position to *normalized device coordinates*. In the range from 0 to 1 before final conversion to specific device coordinates.
- ✓ An initial modeling coordinates position (Xmc, Ymc) in this illustration is transferred to a device coordinates position (Xdc, Ydc) with the sequence

$$(Xmc, Ymc) \rightarrow (Xwc, Ywc) \rightarrow (Xnc, Ync) \rightarrow (Xdc, Ydc)$$

Coordinate representations

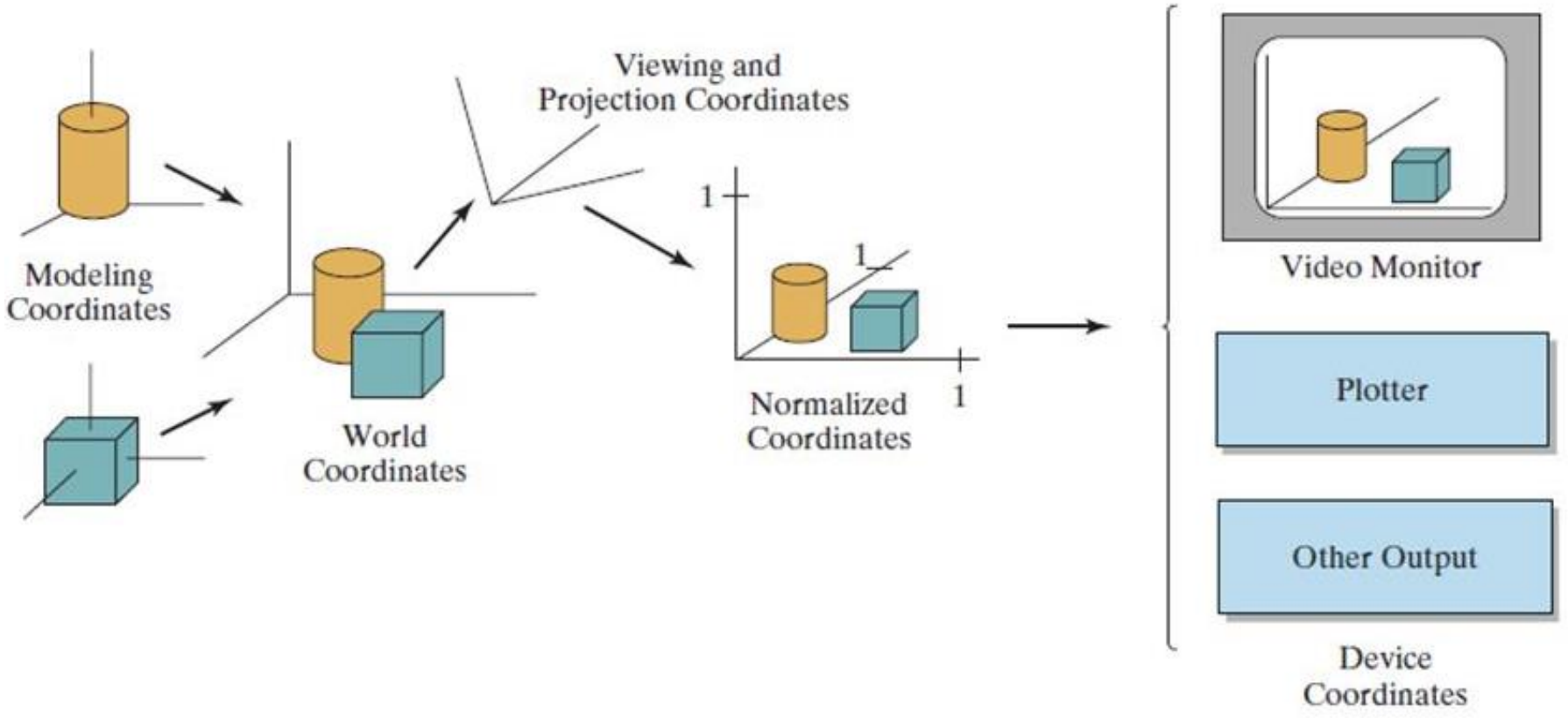


Figure: The transformation sequence from modeling coordinates to device coordinates for a two dimensional scene.

Graphic Functions

- ✓ A general purpose graphics package provides user with Varity of function for creating and manipulating pictures.
- ✓ The basic building blocks for pictures are referred to as output primitives. They includes character, string, and geometry entities such as point, straight lines, curved lines, filled areas and shapes defined with arrays of color points.
- ✓ Input functions are used for control & process the various input device such as mouse, tablet, etc.
- ✓ Control operations are used to controlling and housekeeping tasks such as clearing display screen etc.
- ✓ All such inbuilt function which we can use for our purpose are known as graphics function

Software Standards

- ✓ Primary goal of standardize graphics software is portability so that it can be used in any hardware systems & avoid rewriting of software program for different system.
- ✓ Some of these standards are:
  1. Graphical Kernel System (GKS)
  2. PHIGS (Programmer's Hierarchical Interactive Graphic Standard)
  3. Computer Graphics Interface (CGI)
  4. Computer Graphics Metafile (CGM)

Software Standards

Graphical Kernel System (GKS)

- This system was adopted as a first graphics software standard by the international standard organization (ISO) and various national standard organizations including ANSI.
- GKS was originally designed as the two dimensional graphics package and then later extension was developed for three dimensions.

PHIGS (Programmer's Hierarchical Interactive Graphic Standard)

- PHIGS is extension of GKS. Increased capability for object modeling, color specifications, surface rendering, and picture manipulation are provided in PHIGS.
- Extension of PHIGS called **"PHIGS+"** was developed to provide three dimensional surface shading capabilities not available in PHIGS.

Computer Graphics Interface (CGI)

- Standardization for device interface method is given.

Computer Graphics Metafile (CGM)

- Specifies standards for archiving and transporting pictures.

PHIGS Workstations

- ✓ Generally, the term workstation refers to a computer system with a combination of input and output devices that is designed for a single user.
- ✓ In PHIGS and GKS, however, the term workstation is used to identify various combinations of graphics hardware and software.
- ✓ A PHIGS workstation can be a single output device, a single input device, a combination of input and output devices, a file, or even a window displayed on a video monitor.
- ✓ Any number of workstations can be open in a particular application, with input coming from the various open input devices and output directed to all the open output devices.

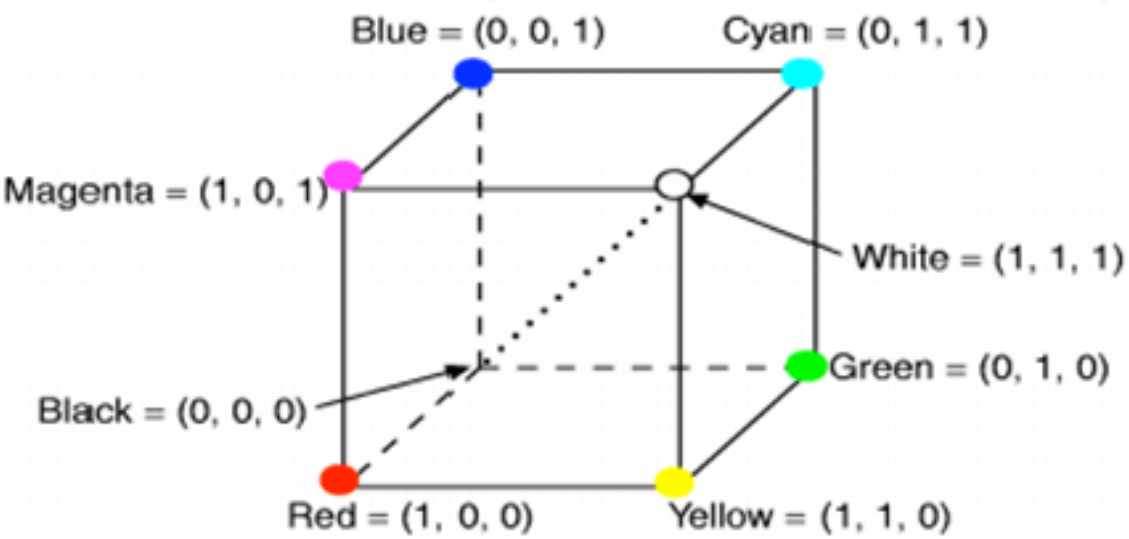
Color models

- ✓ A color model is a visualization that depicts the color spectrum as a multidimensional model.
- ✓ Most modern color models have 3 dimensions (like RGB), and can therefore be depicted as 3D shapes, while other models have more dimensions (like CMYK).
- ✓ Some of color models are:
  - RGB
  - CMYK
  - HSV
  - HLS
  - CIE XYZ

Color models

RGB

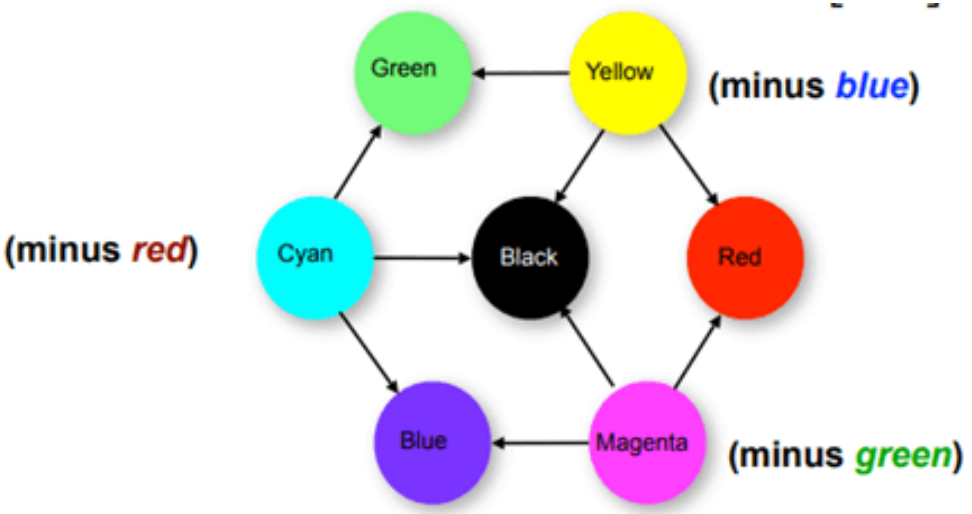
- ✓ RGB is a color model with three dimensions – red, green, and blue – that are mixed to produce a specific color.
- ✓ When defining colors in these dimensions, one has to know the sequence of colors in the color spectrum, e.g. that a mix of 100% red and green produces yellow.
- ✓ The RGB color model is often depicted as a cube by mapping the red, green, and blue dimensions onto the x, y, and z axis in 3D space.



Color models

CMYK

- ✓ *CMYK* stands for *Cyan*, *Magenta*, *Yellow* and *Black*.
- ✓ CMYK color model is used in electrostatic and ink-jet plotters which deposits the pigmentation on paper.
- ✓ In these model, specified color is subtracted from the white light rather than adding blackness.
- ✓ It follows the Cartesian coordinate system and its subset is a unit cube.



Color models

HSV

- HSV stands for Hue, Saturation, and Value (brightness). It is a hexcone subset of the cylindrical coordinate system.
  - ***Hue*** specifies the angle of the color on the RGB color circle. A 0° hue results in red, 120° results in green, and 240° results in blue.
  - ***Saturation*** controls the amount of color used. A color with 100% saturation will be the purest color possible, while 0% saturation yields grayscale.
  - ***Value*** controls the brightness of the color. A color with 0% brightness is pure black while a color with 100% brightness has no black mixed into the color.

Color models

HSV

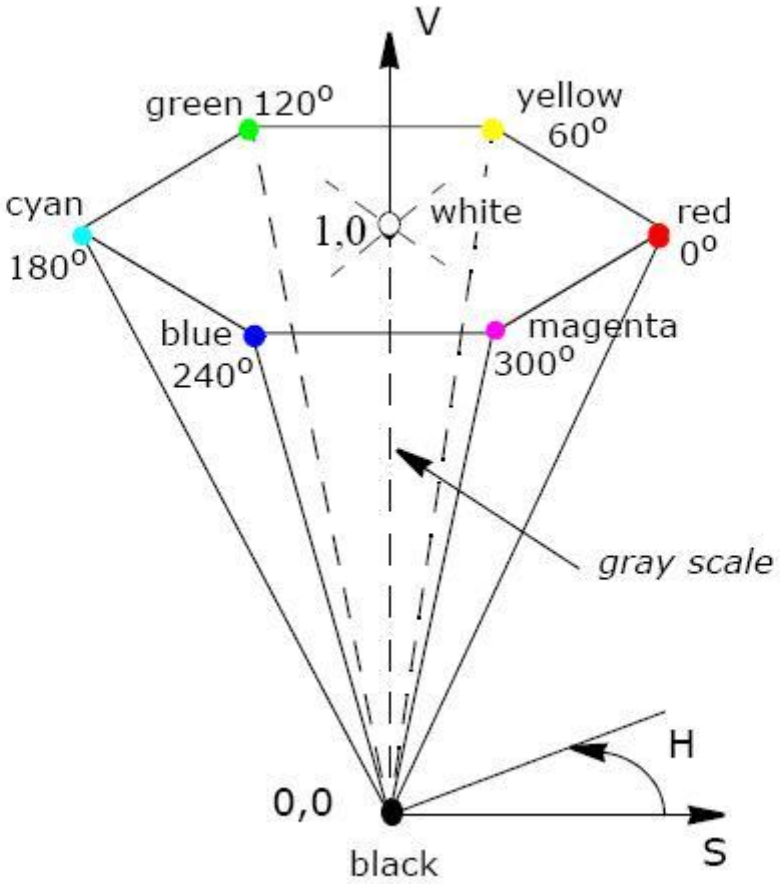
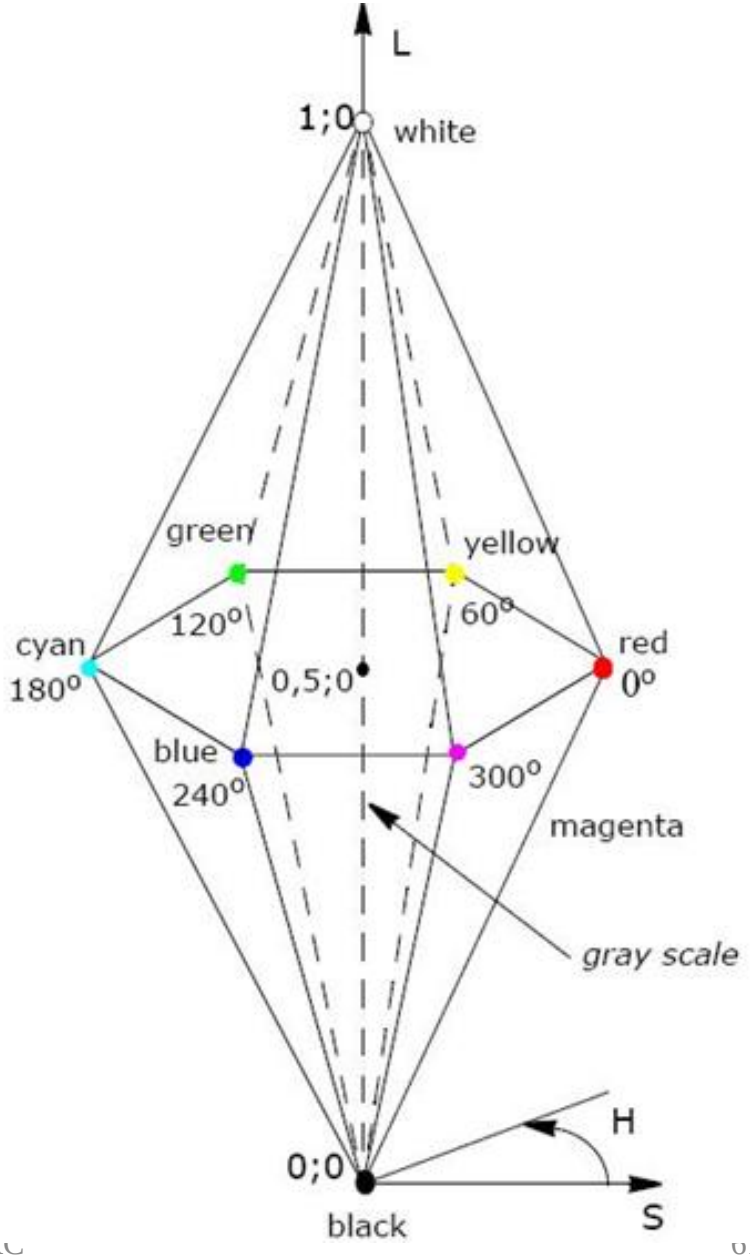


Figure: HSV

Color models

HLS

- ✓ HLS stands for Hue Light Saturation.
- ✓ It is a double hexcone subset.
- ✓ The maximum saturation of hue is S= 1 and L= 0.5.
- ✓ It is conceptually easy for people who want to view white as a point.



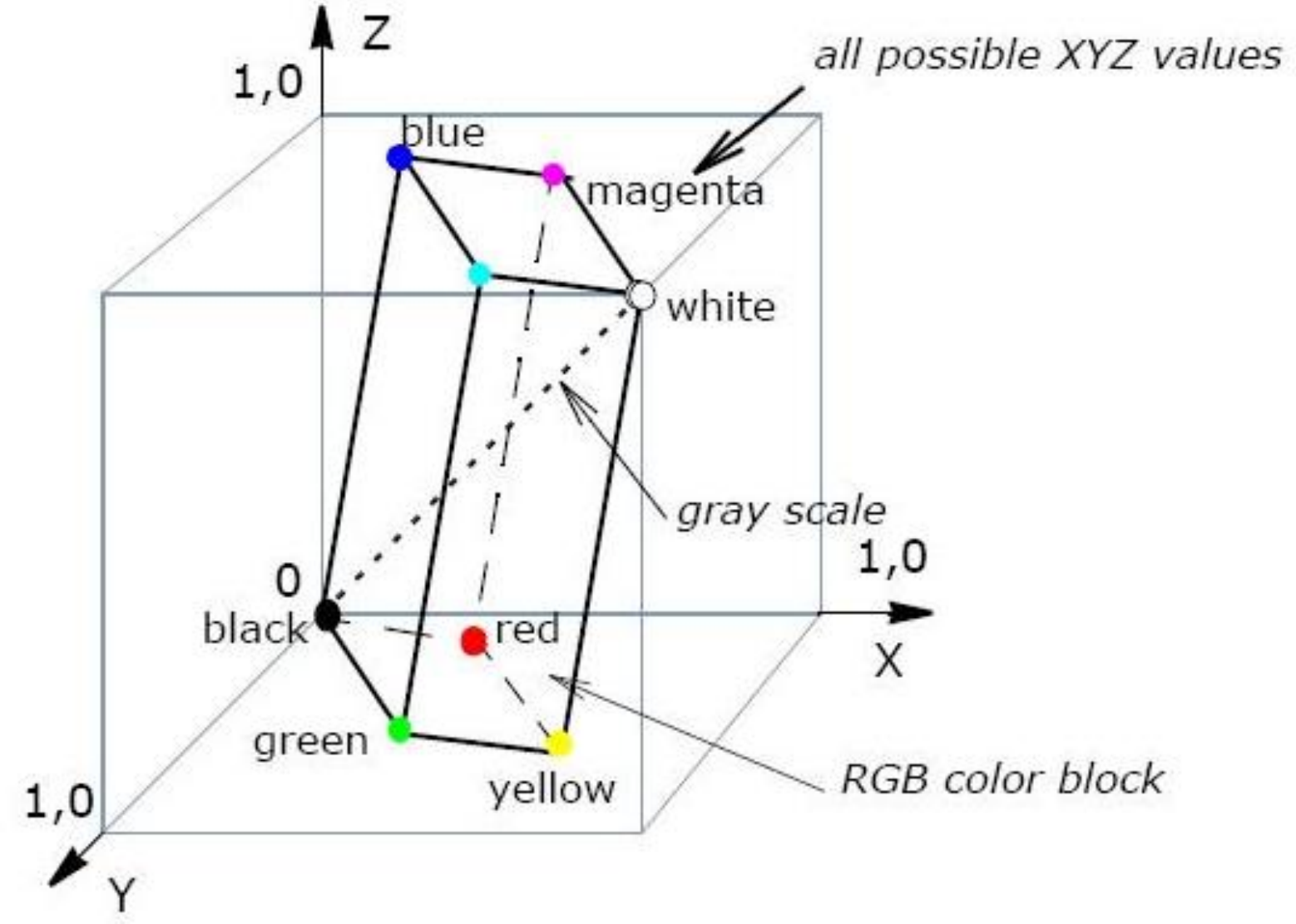
Color models

CIE XYZ

- ✓ The XYZ color space is an international standard developed by the CIE (International Commission on Illumination).
- ✓ This model is based on three hypothetical primaries, XYZ, and all visible colors can be represented by using only positive values of X, Y, and Z.
- ✓ The CIE XYZ primaries are hypothetical because they do not correspond to any real light wavelengths.
- ✓ The Y primary is intentionally defined to match closely to luminance, while X and Z primaries give color information.
- ✓ The main advantage of the CIE XYZ space (and any color space based on it) is that this space is completely device-independent.

Color models

CIE XYZ



Some Numerical Problems

1. Consider three different raster systems with resolutions of 640 by 480, 1280 by 1024, and 2560 by 2048. What size of frame buffer (in bytes) is needed for each of these systems to store 12 bits per pixel? How much storage (in bytes) is required for each system if 24 bits per pixel are to be stored?
2. Suppose an RGB raster system is to be designed using an 8-inch by 10-inch screen with a resolution of 100 pixels per inch in each direction. If we want to store 6 bits per pixel in the frame buffer, how much storage (in bytes) do we need for the frame buffer?
3. Suppose we have a video monitor with a display area that measures 12 inches across and 9.6 inches high. If the resolution is 1280 by 1024 and the aspect ratio is 1, what is the diameter of each screen point?

Assignment #1

1. Explain about the three dimensional viewing devices.
2. Explain Stereoscopic and virtual-reality systems.
3. Explain about need of machine independent graphics language.
4. What is Human visual system? Explain basic of how we perceived the world and also explain strength and weakness of the human visual system.