Introduction to Computer Graphics & Image Processing

SYLLABUS

Sr.No.	Module	Detailed content	Hours	CO	PO
1	Introduction to Computer Graphics	Introduction to Computer Graphics,Elements of Computer Graphics ,Graphics display systems.	2	CO1:Demonstrate the algorithm to implement output primitives of Computer Graphics	PO1,PO2,PO3,PO5
2	Output primitives & its Algorithms	Points and Lines, Line Drawing algorithms :DDA line drawing algorithm, Bresenham's drawing algorithm ,Circle and Ellipse generating algorithms : Mid-point Circle algorithm ,Mid-point Ellipse algorithm ,Parametric Cubic Curves :Bezier curves .Fill area algorithms: Scan line polygon fill algorithm ,Inside-Outside Tests, Boundary fill algorithms, Flood fill algorithms	15		
3	2D Geometric Transformations & Clipping	Basic transformations, Matrix representation and Homogeneous Coordinates, Composite transformation,shear & reflection. Transformation between coordinated systems. Window to Viewport coordinate transformation,Clipping operations – Point clipping Line clipping : Cohen – Sutherland line clipping, Midpoint subdivision,Polygon Clipping:Sutherland – Hodgeman polygon clipping ,Weiler – Atherton polygon clipping	12	CO2:Apply 2D transformation techniques	PO1,PO2,PO3,PO5
4	Basic 3D Concepts & Fractals	3D object representation methods: B-REP, sweep representations, CSG, Basic transformations,Reflection,shear. Projections – Parallel and PerspectiveHalftone and Dithering technique. Fractals and self-similarity: Koch Curves/snowflake, Sirpenski Triangle	6	CO3:Analyze 3D transformation techniques	
5	Introduction to Image Processing	Fundamental Steps in Digital Image Processing ,Components of an Image Processing System ,Basic Concepts in Sampling and Quantization, Representing Digital Images, Spatial and Gray-Level Resolution	5	CO4:Apply image processing techniques	PO1,PO2,PO3,PO5
6	Image Enhancement Techniques	Image Enhancement in the Spatial Domain: Some Basic Intensity Transformation Functions: Image Negatives, Log Transformations, and Power Law Transformations. Piecewise-Linear Transformation Functions: Contrast stretching, Gray-level slicing, Bit plane slicing. Introduction to Histogram, Image Histogram and Histogram Equalization, Image Subtraction, and Image Averaging	12		PO1,PO2,PO3,PO4,PO5

SYLLABUS:CG & IP LAB

Sr.No.	Module	Detailed content	Hours	CO	PO
1	Introduction	Introduction to graphics coordinates system and demonstration of simple inbuilt graphic functions	2	CO1:Implement the algorithm to draw output primitive of Computer Graphics	PO1,PO2,PO3,PO5
2	Output primitives & its Algorithms	Implementation of line generation A. A. DDA line B. Bresenhams line C. application of Line drawing algos.	6		
3	Output primitives & its Algorithms	Implementation of circle drawing A. Midpoint circle B. application of Circle drawing algos.	4		
4	Output primitives & its Algorithms	Implementation of ellipse drawing A. Midpoint Ellipse	4		
5	Output primitives & its Algorithms	Implementation of curve drawing A. Bezier Curve	2		
6	Output primitives & its Algorithms	Implementation of filling algorithms A. Boundary fill B. Flood fill C. Scan line D. application of Circle drawing algos.	8		
7	2D Geometric Transformations & Clipping	Implementation of two dimensional transformations A. Translation, Rotation & Scaling B. Shear & Reflection	6	CO2:Implement 2D transformation	PO1,PO2,PO3,PO5
8	2D Geometric Transformations & Clipping	Implementation of clipping algorithms A. Cohen Sutherland Line clipping B. Midpoint Subdivision C. Sutherland Hodgeman Polygon Clipping	10		
9	Basic 3D Concepts & Fractals	Implementation of 3D Transformations (only coordinates calculation)	2	CO3:Analyze 3D transformation techniques	PO1,PO2,PO3,PO5
10	Basic 3D Concepts & Fractals	Implementation of fractal generation A. Koch curve/Snowflake B. Sirepenski Triangle	6		
11	Introduction of Animation	Implementation of animation programs (using basic inbuilt Graphical functions)	4	CO2:Implement 2D transformation	PO1,PO2,PO3,PO5
12	Image Enhancement Techniques	Implementation of Basic Intensity Transformations A. Image negative B. Log transformation C. Power law Transformation	6	CO4:Analyze image processing techniques	PO1,PO2,PO3,PO4,PO5
13	Image Enhancement Techniques	Implementation of Piecewise-Linear Transformation Functions A. Contrast Stretching B. Grey level Slicing C. Bit plane slicing	8		
14	Image Enhancement Techniques	Implementation of histogram equalization A. Image histogram & histogram	10		

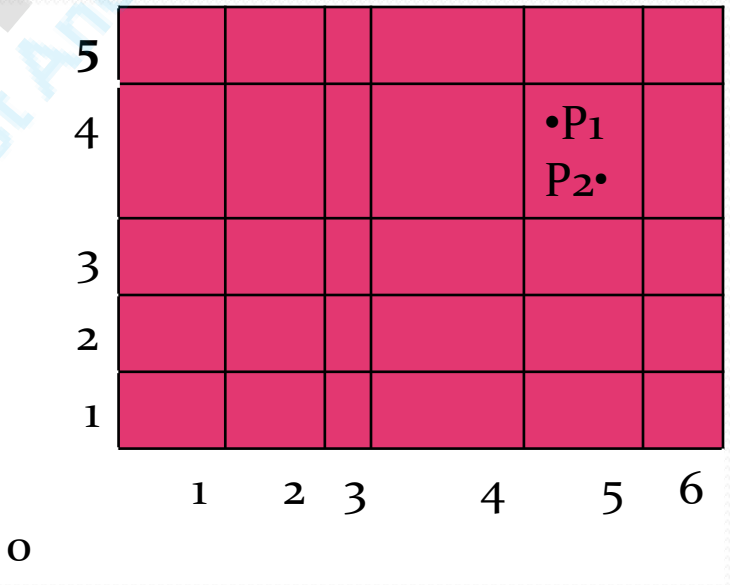
What is computer graphics?

- It is the field of computer science in which users can generate and displays objects and images such as pictures, charts, graphs and diagrams using pixels but not text or sound.
- It started with elementary programs like point, line and circle generation.
- But with the development of interactive input and output devices it is possible virtually to design anything on the computer system.
- Multimedia, CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing) have all been possible because of computer graphics.
- It is used to communicate the processed information to the user.
- The term computer graphics includes almost everything on computers that is not text or sound.

How pictures or graphics objects are represented in computer graphics

- In computer graphics objects are represented as a collection of discrete picture element called pixel.
- Pixel is **smallest addressable screen element**, which can be controlled by setting intensity and color of pixel.
- **Rasterization**: The process of determining appropriate pixel for representing picture or graphics object is known as rasterization.
- **Scan Conversion:** the process of representing continuous picture or graphics object as a collection of discrete picture is called scan conversion.

- Each pixel on the graphics display does not represent mathematical point. Rather, it represents a region which theoretically can contain an infinite number of points.
- For e.g. if we want to display point P1 whose coordinates are (4.2, 3.8) and point P2 whose coordinates are (4.8, 3.1) then P1 & P2 are represented by only one pixel(4, 3).
- In general, a point is represented by integer part of x and integer part of y, i.e. pixel(int(x), int(y)).



Resolution and Aspect Ratio

- Resolution:
  - Total number of pixels per unit area.
  - Image size is given as the total number of pixels in the horizontal direction times the total number of pixels in the vertical direction.
  - A 3 x 2 inch image at a resolution of 300 pixels per inch would have a total of 900 * 600 = 540,000 pixels.
- Aspect Ratio:
  - The ratio of an image's width to its height, measured in unit length or number of pixels.
  - A 2x2 inch image has a aspect ratio of 1/1.
  - A 6x4.5 inch image has a aspect ratio of 4/3.

Applications

- Computer Aided Design
- Computer Art
- Entertainment
- Education And Training
- Visualization
- Image Processing
- Graphical User Interface
- Desktop publishing
- Cartography : technique of making maps or charts.

Elements of computer graphics

- Elements of computer graphics include animation, interaction, rendering, and modeling, These elements include input and output devices, tools, interactions and environments.
- In traditional computing terms, the basic element of computer graphics is a pixel, the atomic (not divisible) unit of display. It can be "Off" (=of background color) or "On" in any other color.
- However, with today's very high resolution screens, the dimensions of an individual pixel hardly matter any more. Therefore, the basic elements of computer graphics of a modern computer system are points, straight and arced lines and triangles.

Graphics display system

- The combination of monitor and video adapter that makes a computer capable of displaying graphics.
- A video adapter is a board that plugs into a personal computer to give it display capabilities.
- The display capabilities of a computer, however, depend on both the logical circuitry (provided in the video adapter) and the display monitor.
- A monochrome monitor, for example, cannot display colors no matter how powerful the video adapter.

- Many different types of video adapters are available for PCs. Most conform to one of the video standards defined by IBM or VESA.
- Each adapter offers several different video modes.
- The two basic categories of video modes are text and graphics.
- In text mode, a monitor can display only ASCII characters.
- In graphics mode, a monitor can display any bit-mapped image. Within the text and graphics modes, some monitors also offer a choice of resolutions. At lower resolutions a monitor can display more colors.

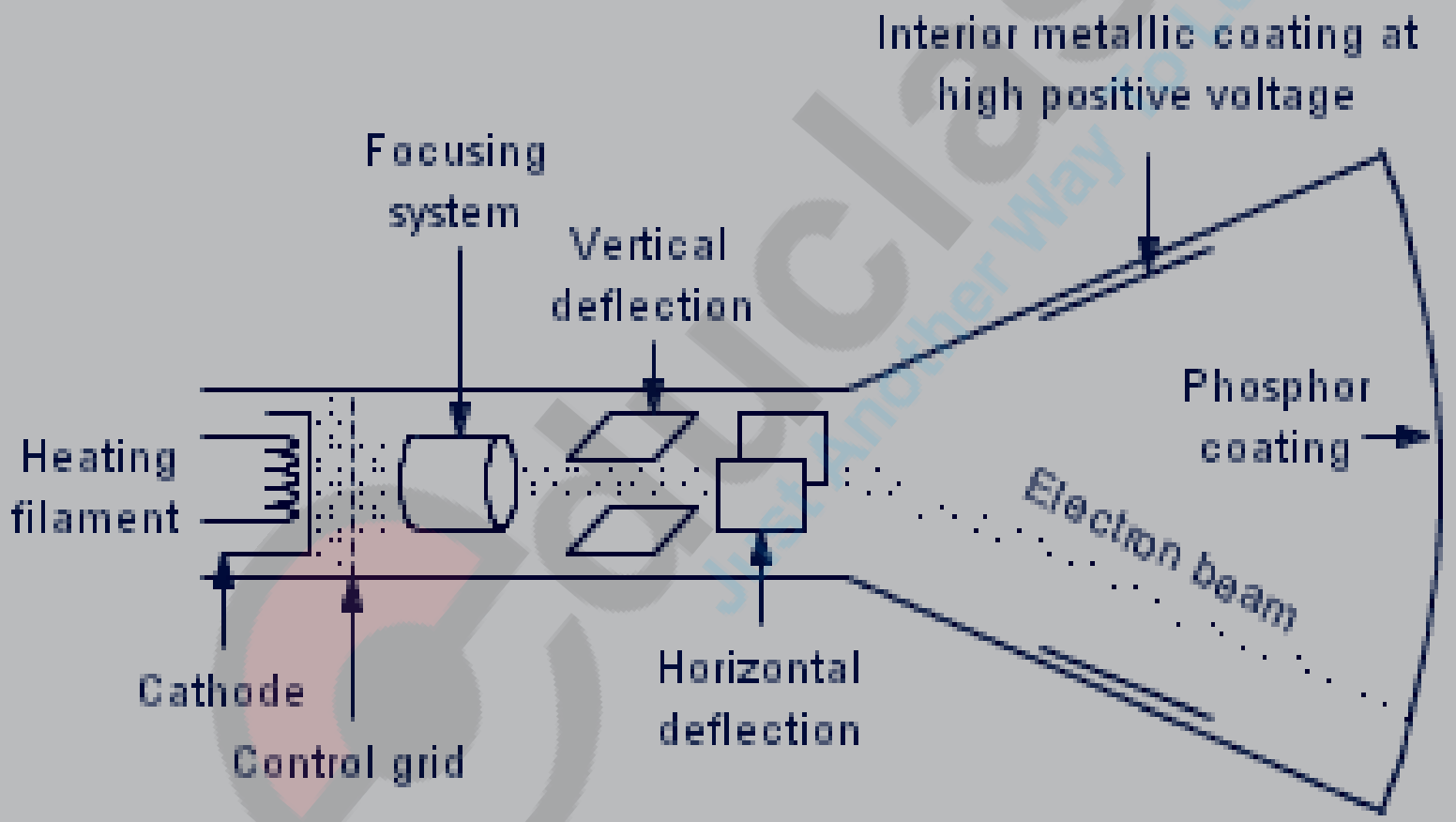
Video Display Devices

- A **display device** is an output device for presentation of information in visual form.
- It categories in the following devices :
  - Raster Scan Display
  - Random Scan Display
  - Cathode - Ray – Tubes
  - Color CRT Monitors

Cathode Ray Tube

- A CRT is an evacuated glass tube.
- An electron gun at the rear of the tube produces a beam of electrons which is directed towards the front of the tube (screen).
- The inner side of the screen is coated with phosphor substance which gives off light when it is stroked by electrons.
- It is possible to control the point at which the electron beam strikes the screen, and therefore the position of the dot upon the screen, by deflecting the electronic beam.

Basic Design of a CRT Tube



- The deflection system of the cathode-ray-tube consists of two pairs of parallel plates, referred to as the vertical and horizontal deflection plates.
- When electron beam passes to the horizontal and vertical deflection plates, it is bent or deflected by the electric fields between the plates.
- The horizontal plates control the beam to scan from left to right and retrace from right to left.
- The vertical plates control the beam to go from the first scan line at the top to the last scan line at the bottom and retrace from the bottom back to top.
- There are two techniques used for producing images on the CRT screen : **Vector scan or Random scan and Raster scan**

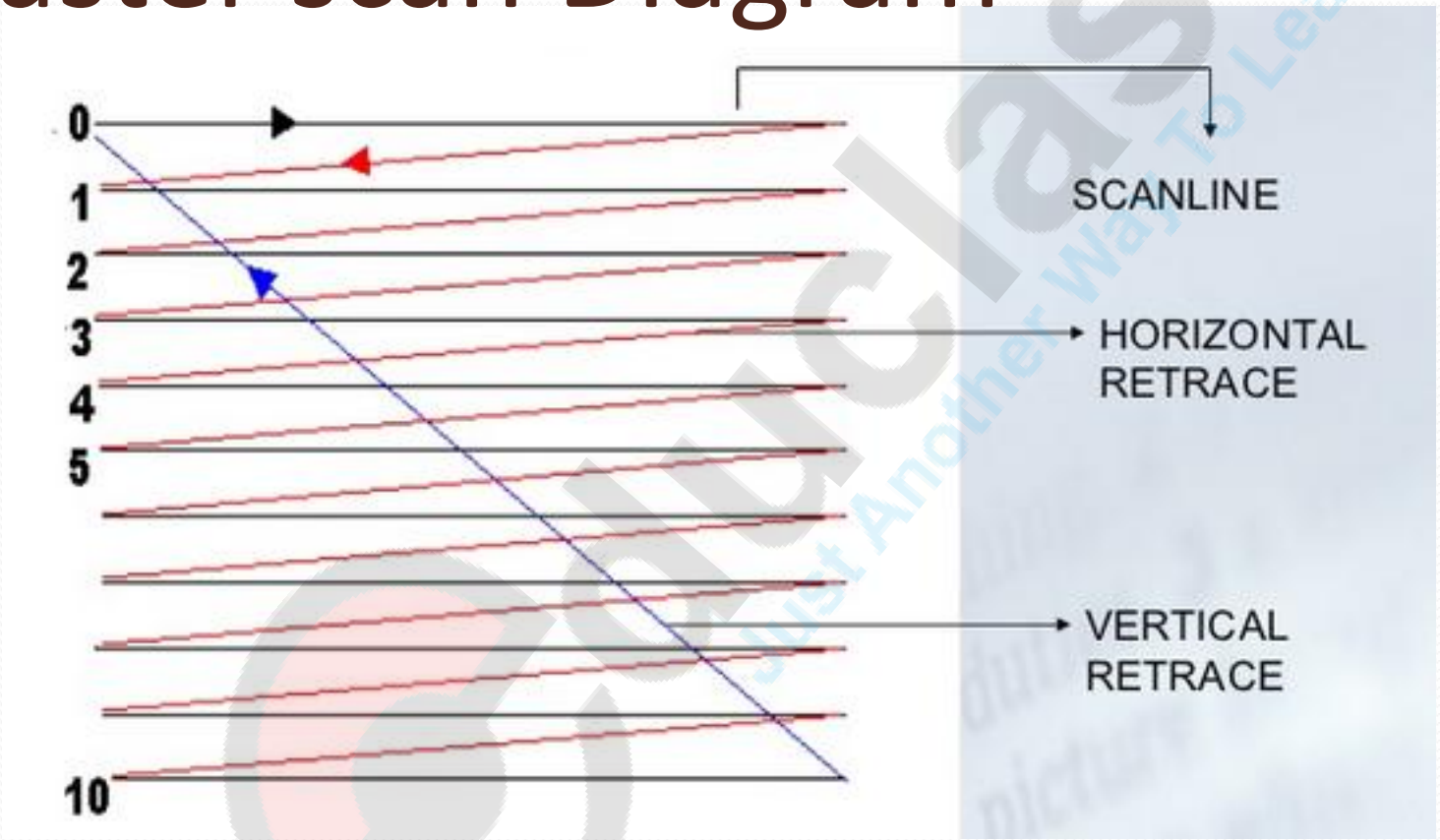
Raster scan

- It works much like television set.
- Light occurs when an electron beam stimulates a phosphor.

Principal of raster scan system

- In raster scan system , the electron beam from electron gun is swept horizontally across **the phosphor coated screen** .
- After each horizontal sweep the beam is moved to next line.
- After the bottom line is swept, the beam returns to the top and the sweep process begins again .
- i.e. it is swept across screen , one row at a time from top to bottom .

Raster scan Diagram

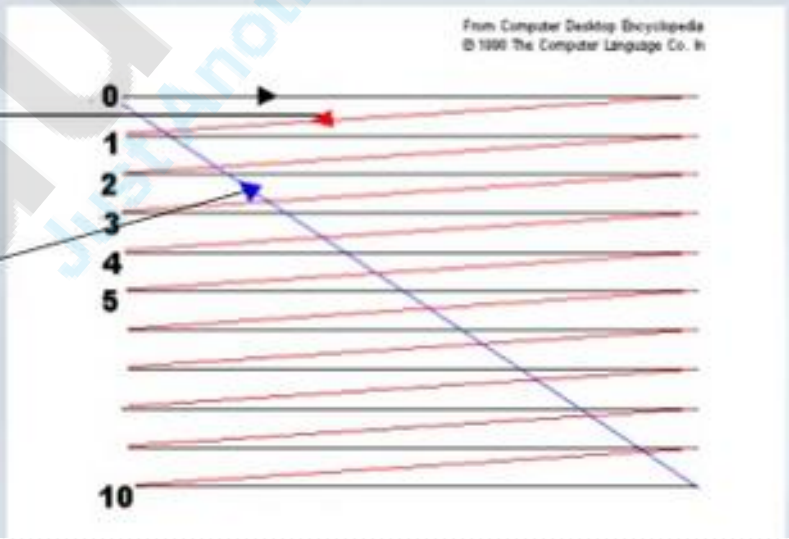


- As electron beam moves across each row , the beam intensity is turned ON and OFF to create a pattern of illuminated spots.
- Picture definition is stored in memory area called refresh buffer or frame buffer.
- This memory area holds the set of all intensity values for all the screen points.
- Stored intensity values are then retrieved from the refresh buffer and painted on the screen one row at a time.

- Refreshing is carried out at the rate of 60 to 80 frames per second.
- Refresh rate are described in units of cycles per seconds or Hertz (Hz). Where a cycle corresponds to one frame.

Horizontal and vertical retrace

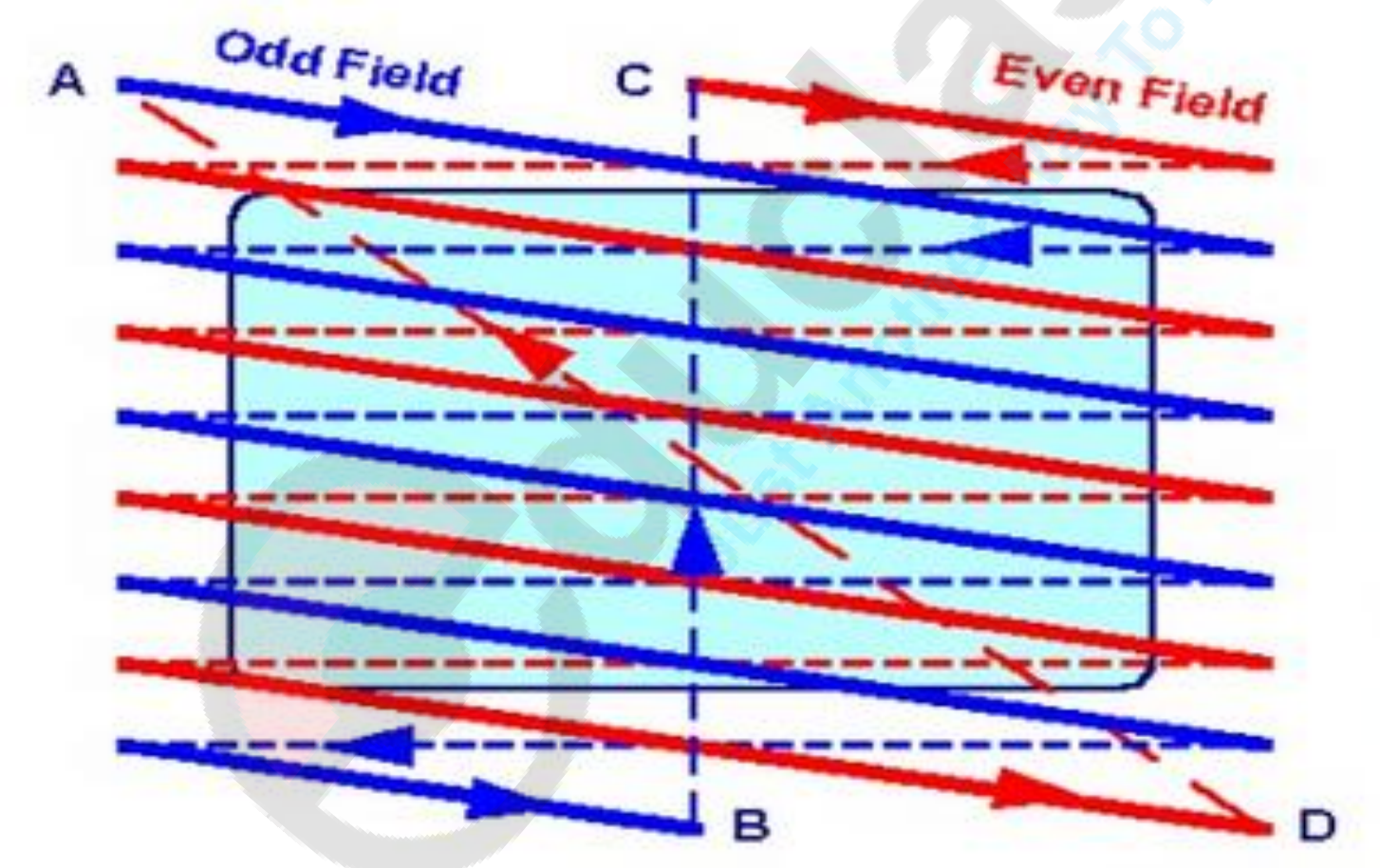
- **Horizontal retrace** is used to refer to the beam moving back to the left at the end of each line.
- **Vertical retrace** refers to the movement from bottom to top.



Interlacing

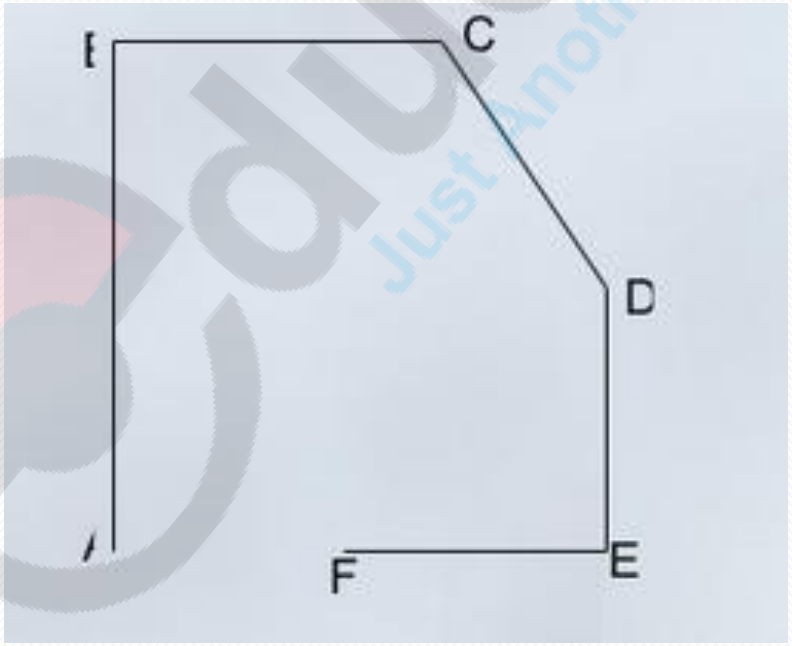
- The screen is painted 60 times per second but only half of the lines are painted per frame.
- For example: Every ODD number of lines , alternating back and forth between even and odd number of lines on each pass.
- Entire screen is painted in two passes in 30 times in every second.

Diagram



Random scan

- It is also called vector , stroke writing or calligraphic .
- The electron beam directly draws the picture.



WORKING

- Here the electron gun of a CRT illuminates points and / or straight lines in any order.
- The display processor repeatedly reads a variable 'display file' defining a sequence of X,Y coordinates the electron gun the whole display area is updated many times a second from image data held in raster memory.

Advantage of random scan system:

- Very high resolution.
- Easy animation. we have to just draw different position
- Requires little memory.

Disadvantages:

- Requires “ intelligent electronic beam, i.e. processor controlled
- Limited screen density before have flicker .
- Cant draw complex image.
- Limited color capability.

Differences between Vector Scan Display and Raster Scan Display

S. N	Vector Scan Display Randam Scan System	Raster Scan Display
1	In vector scan display the beam is moved between the end points of the graphics primitives .	In Raster scan display the beam is moved all over the screen one line at a time from top to bottom and then back to top.
2	Vector display flicker when the number of primitives in the buffer becomes too large	In raster scan the refresh process is independent of the complexity of the image .
3	Scan conversion is not required	Graphics primitives are specified in terms of their endpoints and must be scan converted into their corresponding pixels in the frame buffer
4	Scan conversion hardware is not required	Because each primitives must be scan converted , real time dynamics is more computational and require separate scan conversion hardware
5	Vector display draws a continuous and smooth lines.	Raster display can display mathematically smooth lines , polygons, and boundaries of curved primitives only by approximating them with pixels on the raster grid.
6	Cost is more	Cost is low
7	Vector display only draws lines and characters	Raster scan display has ability to display areas filled with solid colors or patterns

Color CRT Monitor

- A CRT monitor displays color pictures by using a combination of phosphors that emit different color light. The two basic techniques for producing color displays with a CRT are:
  - Beam Penetration method
  - Shadow mask method.

Beam Penetration Technique

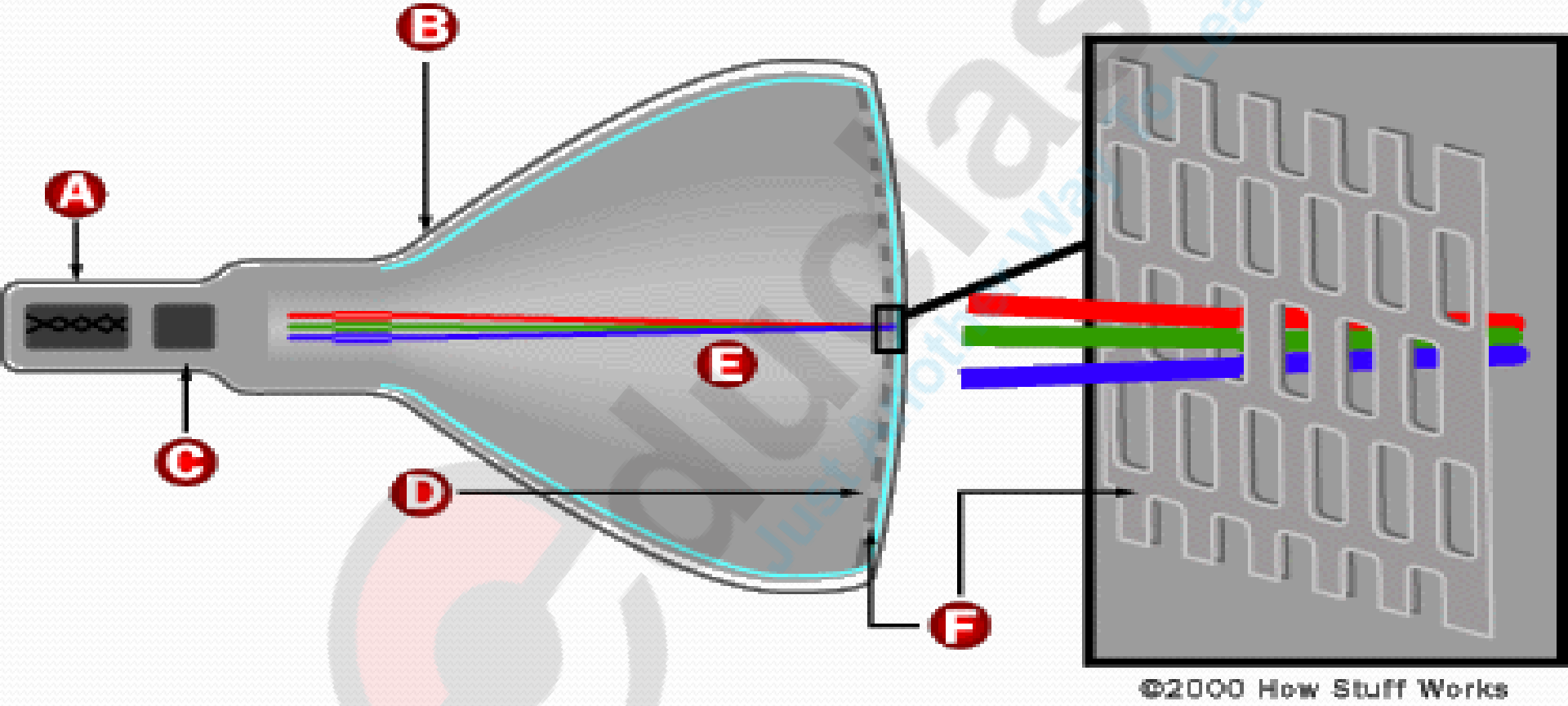
- In this technique, the inside part of CRT screen is coated with two layers of phosphor, usually red and green.
- The outer layer is of red phosphor and inner layer is of green phosphor.
- The displayed color depends on how fast the electrons beam penetrates into the phosphor layer.
  - A beam of slow electrons excites only the outer layer.
  - A beam of very fast electrons penetrates through the outer (red) layer and excites the inner green layer only.
  - At medium beam speeds, combinations of red and green light are emitted and two additional colors orange and yellow displayed.
- The speed of the electrons and hence the screen color at any point ,is controlled by the beam acceleration voltage.
- this technique is used in Random Scan Monitors.

Pros and cons :

- It is an inexpensive technique to produce color in random scan monitors.
- It can display only four colors
- The quality of picture produced by this technique is not as good as compared to other techniques.

Shadow Mask

- In a shadow mask technique, CRT has three phosphor color dots at each pixel position.
- One phosphor dot emits a red light, another emits green light and the third emits a blue light.
- It has three electron guns, 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 in the shadow mask, they excite a dot triangle.
- A dot triangle consists of three small phosphor dots of red, green and blue color.
- These phosphor dots are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.



A Cathode
B Conductive coating
C Anode
D Phosphor-coated screen
E Electron beams
F 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 varying the intensity of the three electron beams we can obtain different colors in the shadow mask CRT.
- It is used in Raster Scan System.

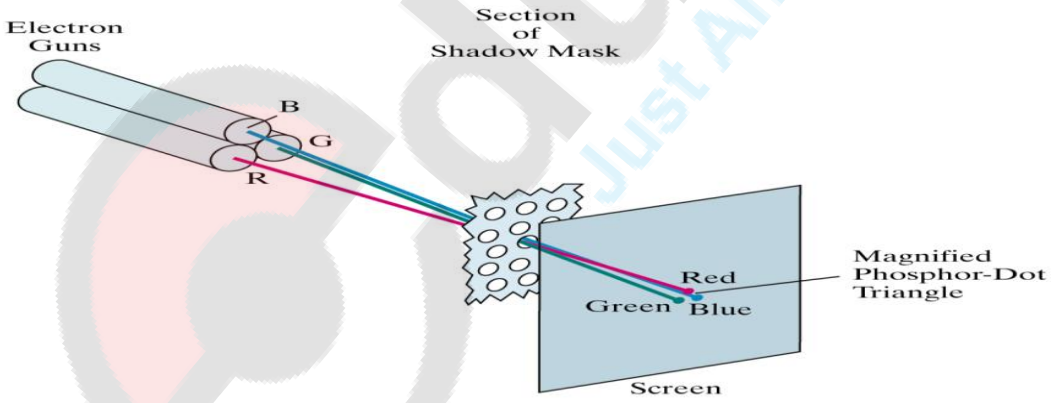


Figure 2-10

Operation of a delta-delta, shadow-mask CRT. Three electron guns, aligned with the triangular color-dot patterns on the screen, are directed to each dot triangle by a shadow mask.

Important Questions

1. How does a raster scan system works? How it is different from random scan system?
2. Explain the construction and working of CRT .
3. List and explain the methods for producing color displays in color CRT monitors.

Things before writing first program in Graphics Environment:

- **Header File:**graphics.h
- **initgraph:** initialize the graphics system.
- Declaration:

Void initgraph(int far *graphdriver,int far * graphmode,char far*pathdriver);

e.g. int gd=DETECT,gm;

Initgraph(&gd,&gm,"c:\\tc\\bgi");

- To start the graphics system we first call initgraph.
- It initializes the graphics system by loading a graphics driver from disk then putting the system into graphics mode.

- *graphdriver: integer that specifies the graphics driver to be used.
- *graphmode: integer that specifies the initial graphics mode.
- If *graphdriver=DETECT, initgraph set *graphmode to the highest resolution available for the detected driver.
- Pathtodriver:specifies the directory path where initgraph looks for graphics drivers(*.BGI) first
- If they are not there,initgraph looks in the current directory.
- Pathdriver is null, the ***driver files*** must be in current directory.