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PROGRESSIVE THEORY TEST I / II / 2

4 Pages (1)

To be filled in by the candidate

Subject :

Course : CM / IF / EJ / EX

Year : I / II / III

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Ch. 1 Basics of Computer Graphics.

How ⇒ Computer Graphics is a study of techniq to improve the communication between the user and computer.

⇒ Computer graphics is a very powerful tool which has made computer more powerful to be responsible for rapid and economical production of picture.

There are two types of Computer Graphics :-

1) Non-Interactive CG or Passive CG :-

The observer has no control over the image.
eg Titles shown on TV.

2) Interactive CG :-

This involves two-way communication between computer and user & allows comm^n. through picture chain and diagrams.

* Origin of Computer Graphics :-

In 1950, the computer driven display attached to Whirl-wind I computer was used to generate simple pictures. This display made use of CRT. Several years earlier, CRT has been used by late f-William as an information storage device. This technique was incorporated in many low cost interactive graphics terminal.

During 1950's, interactive computer Graphics made little progress and their computers were to perform lengthy calculations for physicist and missile designers.

In 1962, IVAN E-SUTHERLAND had promoted interactive computer Graphics through his thesis entitled "Sketch Pad" and golden age of Computer Graphics had driven.

* How the interactive computer Graphics display works ?

⇒ Graphics display consists of three components :-

1) Semiconductor memory or frame buffer in which displayed image is stored as a matrix of intensity values.

2) Television / Monitor without tunning & recieving circuits to diplay an image or object.

3) Display Controller :-

It reads the content from the frame buffer and passes to the monitor repeatedly at a rate of 30 frames per second or more, in order to maintain steady picture on the screen.

If the frame rate is less, then the flicker will occur.

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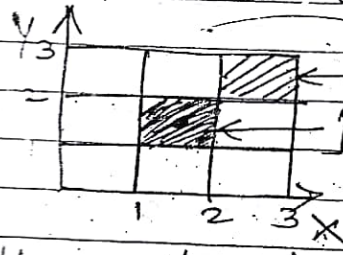
Flicker can be avoided by using interlacing and non-interlacing techniques.

* Frame buffer :-

Frame buffer is a random access & semi-conductor memory & implemented using shift registers. Shift registers work on the principle of FIFO stack. If the stack is full, and new data bit added to the top of the stack, the first data bit are pushed out of the bottom. Data pushed out of the stack can be interpreted as the intensity of a pixel on a scan line.

* Pixel :-

It is the smallest addressable screen-element whose brightness can be controlled. The co-ordinate (x, y) will represent column & row of a pixel element.



pixel.

X → columns
Y → rows.

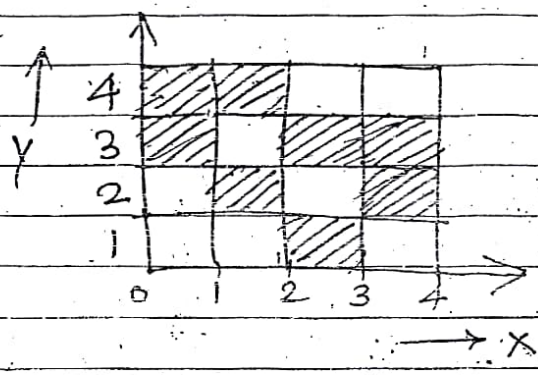
Shift register frame buffer can be implemented using one shift register for pixel with each shift register as long as no. of scan lines. Fig. shows 4-line display with 4 pixels per scan line. Frame buffer is implemented with 4 shift registers for each 4 bit long.

Data in

1 →	0	0	1	0
2 →	0	1	0	1
4 →	1	1	0	0
3 →	1	0	1	1

Data out

* Display Pattern :-



* Flicker :-

The image will appear like ON and OFF. When such type of flashing occurs, it is called as flicker.

* Refresh Rate :-

Everytime, electron beam goes through a complete cycle of raster, the CRT is said to be refreshed.

* Persistance :-

Persistance is defined as time taken by electrons to emit a light from the screen to decay to 1/10 th of its original intensity

Most of the display devices are classified on the basis of persistance :-

1) High Persistance Display OR long Persistance :

High persistance phosphor is useful for displaying highly complex static pictures.

eg Direct View Storage Tube (DVST)

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2) Short Persistance or low persistance :-

It requires high refresh rate to maintain a picture on screen without flicker. It is useful for the animation.
eg. Raster Scan Display, Random Scan Display.

Resolution :-

Maximum no. of pixels that can be displayed without overlapping on CRT is referred to as resolution.

640 →

Aspect Ratio :-

This gives the ratio of vertical points to horizontal points necessary to produce equal length lines in both the directions on the screen.

Analog Input Devices :-

Paddal Control, Mouse, Track-Ball, Joystick, Scanner.

* Digital Input Devices :—

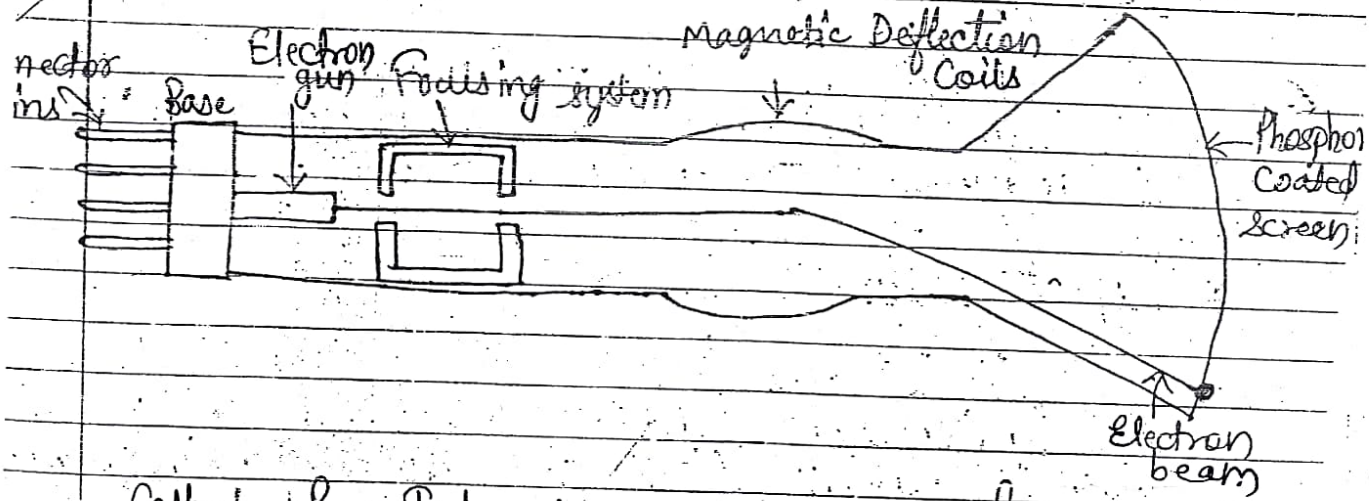
Keyboard, Light Pen, Magnetic Pens and tablets, Touch-sensitive screen, Digitizers.

* Graphical Output Devices :—

1) Random Scan Display
2) Raster Scan Display
3) Liquid Crystal Display (LCD)
4) Direct View Storage Tube (DVST)
5) Printer
6) Plasma Panel Display
7) Plotters
8) CRT (Cathode Ray Tube)

* Display Devices :—

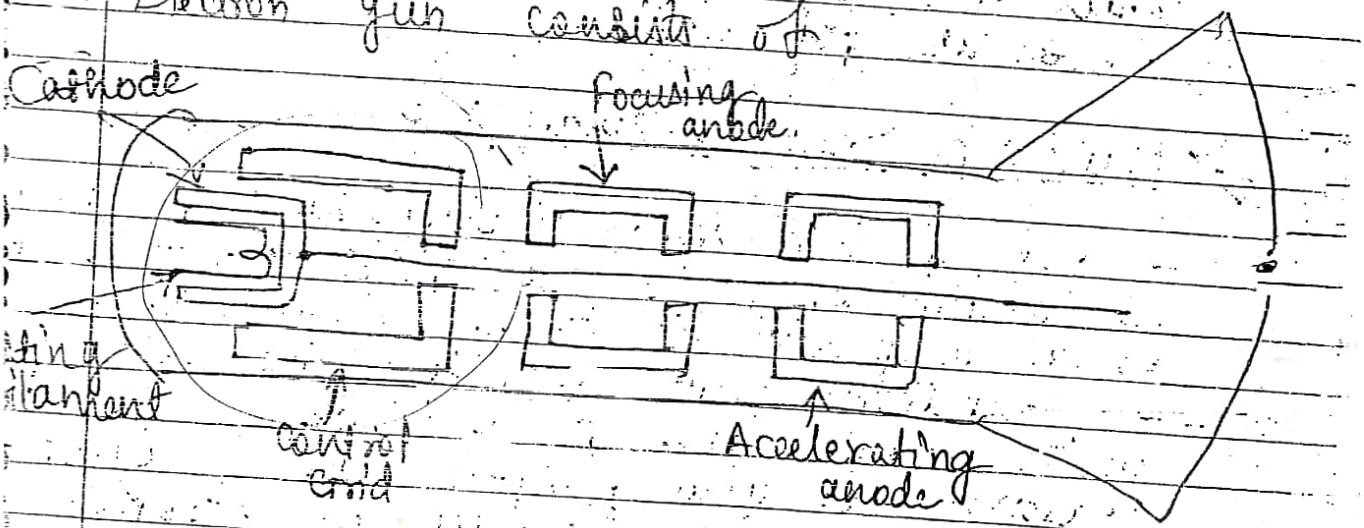
1) Cathode Ray Tube :— (CRT)



— Cathode Ray Tube is a major part of any display ie. screen / monitor / visual display unit. This component functions to display pixels on the screen. Pixels are also known as pels.

- CRT has two ends. At one end, electron gun is fixed and at the other end phosphor coated screen is fixed. Heat is supplied to the electron gun by supplying a current. When electron gun gets heated, it throws heated electrons on the phosphor screen. This results into excitement of that pixel & light gets emit.

- Electron gun consists of;



- Electron guns major component is cathode. The current is supplied to the cathode. This current is supplied through the wire called filament which is a coil of wire.
- Due to heat, electrons from the cathode gets boiled off.
- These electrons are then directed to the phosphorous screen through the electron beam path. There are three different components which come in the path are control grid, focusing anode & accelerating anode.
- An intensity of electron can be controlled by the control grid. It allows to set the different voltages.
- A high negative voltage applied to control grid will shut off beam by repelling electrons & stopping them from passing through the small hole at end of control grid structure.

— The focusing system is used to focus electrons on phosphor screen. Focusing is needed because without it, the electrons may repel each other.
— Accelerating System is used to maintain the speed of electrons in electron beam.
— The deflection plates pair are mounted on the top & bottom of the neck. One coil does vertical deflection & other does horizontal deflection.

2) Random Scan Display :—

— In random scan display, electron beam is directed only to the part of the screen where a picture is to be drawn.
— Random Scan monitor draws a picture one line at a time & for this reason, it is also referred as Calligraphic display or vector display or stroke writing display.
— Refresh rate on a random scan system depends on the no. of lines to be displayed.
— Vector display generally have higher resolution than raster scan display.
— Random Scan system are designed for line-drawing applications and cannot display realistic shaded pictures.
eg. Pen Plotter

3) Raster Scan Display :—

The most common method of implementing Raster CRT Graphics device utilizes a frame buffer.
— Picture built up in frame buffer one at time is referred to as single bit plane.

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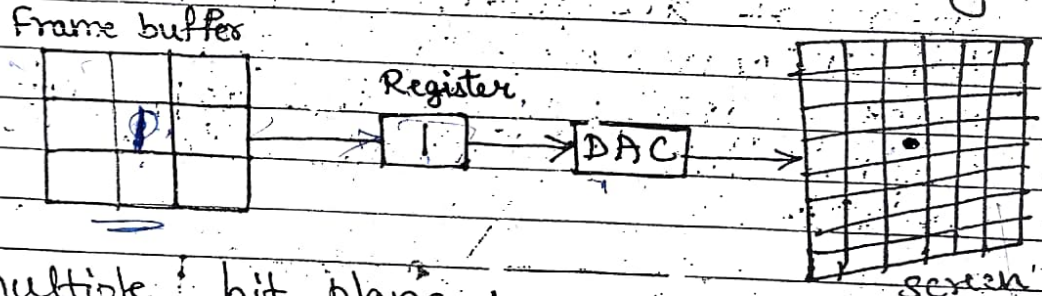
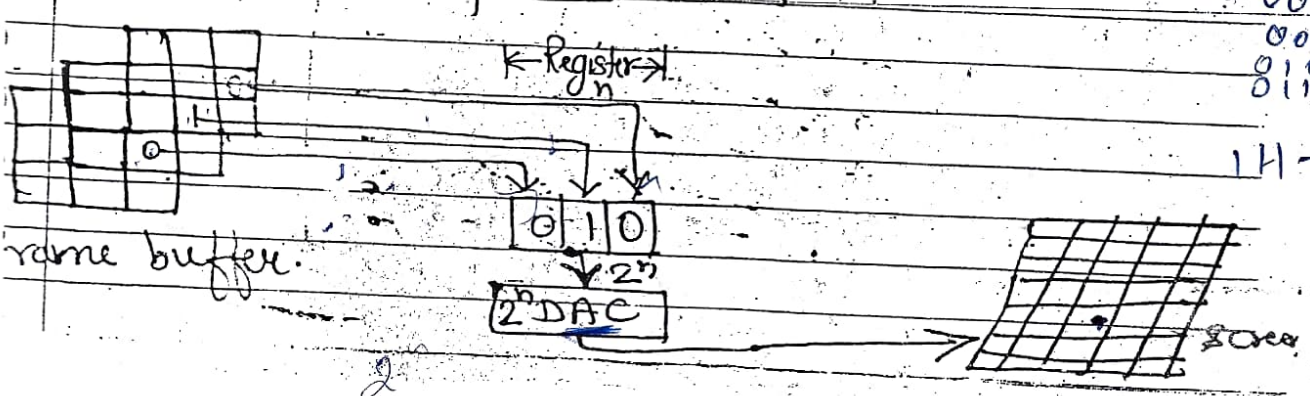
- Single bit plane is a black & white display.
- Since, bit plane is a digital device while CRT is an analog device which requires an electrical voltage; conversion from digital representation to an analog signal must take place when information is read from the frame buffer and display on the CRT device. This is done by digital to analog convertor.
- Schematic diagram of single bit plane Raster CRT device is shown in fig.



0 - Black
1 - White
$2^1 = 2$
$2^3 = 8$.
000 - Black
001 -
010 -
011 -
111 - white

- Multiple bit plane :-



rame buffer.

The intensity of each pixel on the CRT is controlled by the corresponding pixel location. Binary value from each of N bit plane is loaded into corresponding positions in a register. The resulting binary number is interpreted as an intensity level between 0 and $2^N - 1$. This is converted into voltage between 0 (dark) and $2^N - 1$ (full intensity) by DAC.

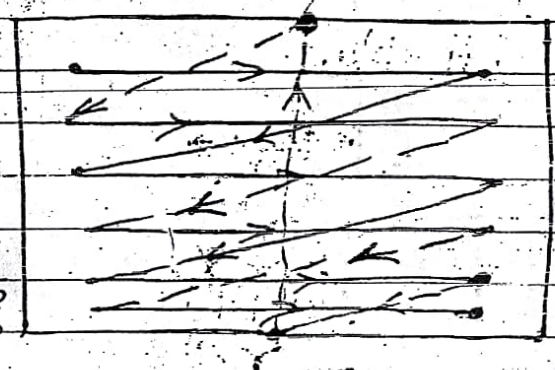
Raster Scan Display uses two technique to reduce the flickering effect.

a) Interlacing technique :-

In this technique, each frame is divided into two fields, each containing one half of the picture. The two fields are interlaced.

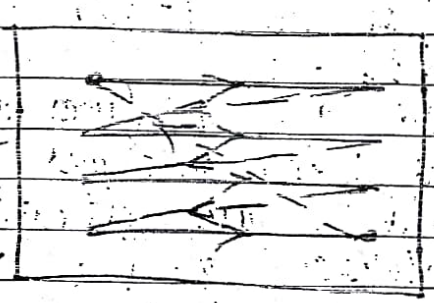
One field contains odd number lines & other even number lines. Scanning pattern begins at the upper left corner of the screen with the odd fields.

When the beam will be at the bottom center of the screen then odd scan-line field is complete. The beam is then quickly returned to the top center of the screen. This is the odd field vertical retrace.



b) Non-Interlacing Technique :-

This technique is required while presenting a video picture. When such a non-interlaced picture is represented, the frame repeatation rate must be increased to 60 frames per second to avoid the flicker.



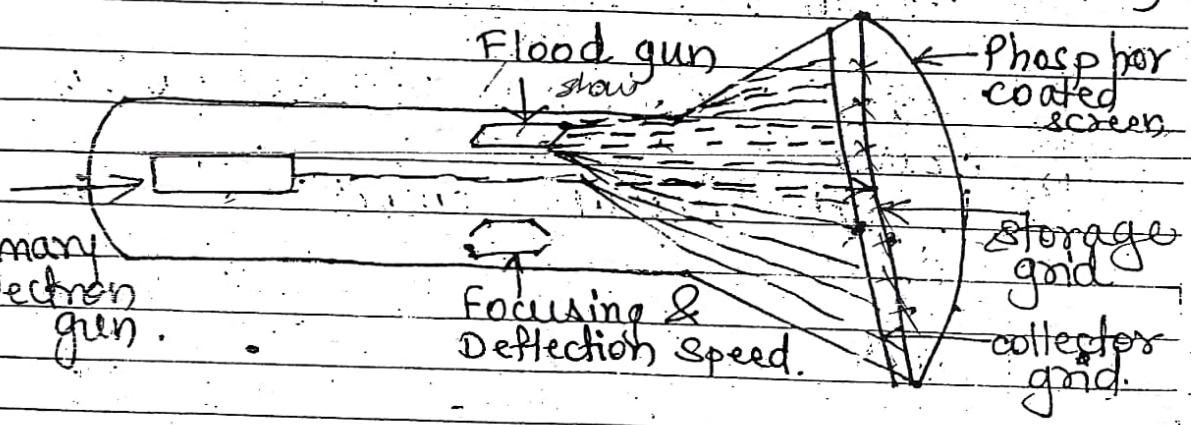
4) Direct View Storage Tube (DVST) :

It is used for maintaining a screen image to store the picture information inside CRT instead of refreshing the CRT.

It stores the picture information as a charge distribution just behind the phosphor coated screen.

DVST uses two electron guns :-

1) Primary electron gun is used to store the picture pattern.
2) Flood gun maintain the picture display.



Primary electron gun is used to draw picture definition on storage grid, a non-conductive material. High speed electrons from primary gun strike the storage grid, knocking out electrons are attracted to the collector grid. Since, the storage grid is a non-conducting, the areas where electrons have been removed will keep the net positive charge. This stores the picture positive charge pattern on the storage grid is the picture definition.

The flood gun produces a continuous stream of low speed electrons that pass through the collector grid & are attracted to positive areas of the storage grid.

These low speed electrons penetrate the storage grid to the phosphor coating without appreciably affecting the charge pattern on the storage grid.

Advantages of DVST :-

1) No Refreshing is needed.
2) Very Complex pictures can be displayed clearly without flicker.
3) Very high resolution is possible.
4) Cost of DVST is less.

Disadvantages of DVST :-

1) Selected part of a picture cannot be erased.
2) Do not display colors.

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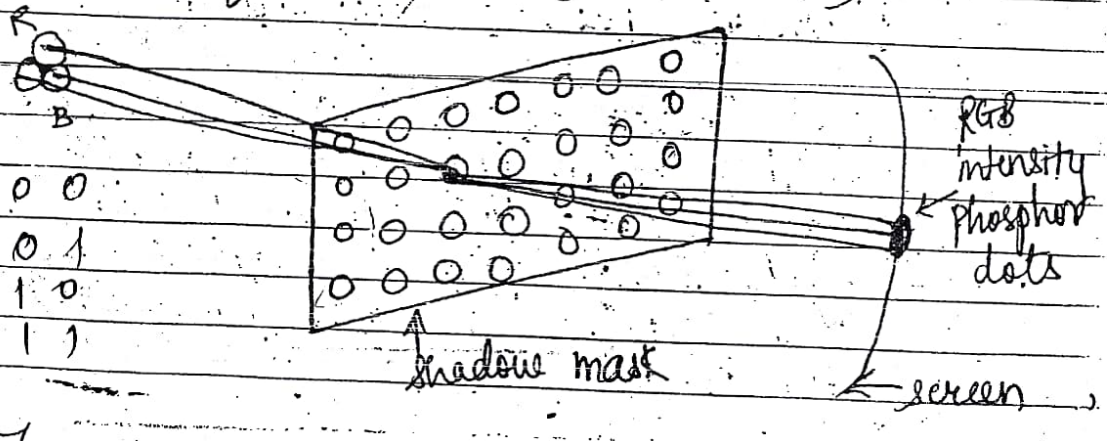
Q) Color Monitors :-

- In color CRT, instead of single electron gun three electron guns are used. The colors are red, green & blue.
- In color CRT, the guns are placed close to each other. There are different ways of placing electron gun together.

(1) R, G, B — Traid

(2) R G B — Inline

- Shadow Mask is used which is a thin metal plate which has small holes on it. These holes are used to focus exactly phosphor dot through it. Shadow mask is placed in front of the CRT (inside CRT).



P 0 0 0
0 0 1
0 1 0
0 1 1
to 1

— Shadow mask technique is commonly used in Raster Scan Display including color T.V. because they produce wider range of colors.

Another Technique used in Color CRT Monitor is Beam Penetration Method.

This method is used with random Scan Display.

— Two layers of phosphor usually red & green are coated inside the CRT screen and display color depending on how far electron beam penetrate into phosphor layer.

— Beam of slow electrons excite only outer layer ie. Red layer.

— Beam of fast electrons penetrate to red layer & excites inner green layer.

— At intermediate beam speed combination of red & green light are emitted to show two additional colors orange & yellow.

— Therefore, only four colors are possible and quality of picture is not good as other method.

its of Beam Penetration:-
ited range of colors are
used.

to change beam
erating voltage which is
difficult.

FLAT Panel Display :- (Flat)

The classes of devices where light weight, and reduction in power requirements of its are called Flat panel displays.

— Flat panel displays are much thinner than CRT. They are only 4 inches thick.

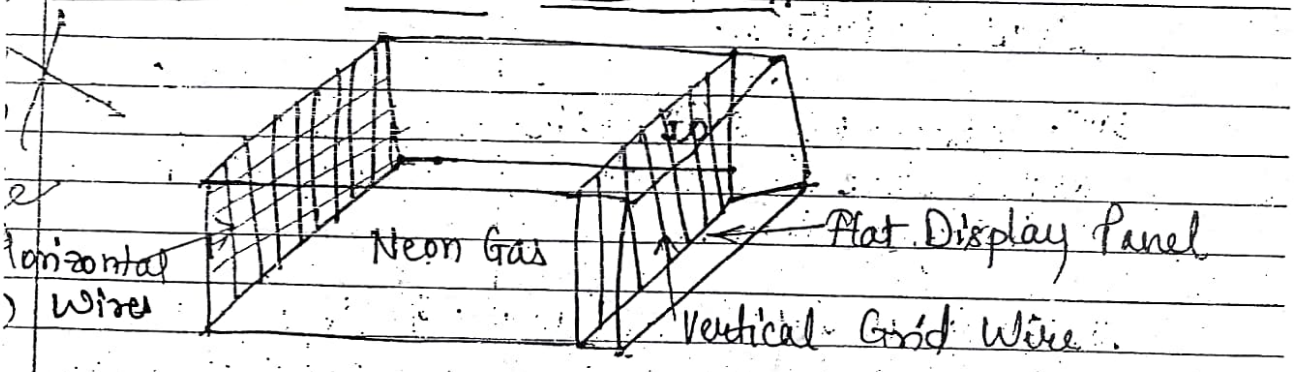
- Applications of Flat Panel Display :-
1) Small TV monitor
2) Calculator
3) Pocket Video Game
4) Laptop
5) Digital Camera
6) Cell Phones.

- There are two categories in this type of display :-

1) Emissive Display :-
Emissive Displays convert the electrical energy into light energy.
Examples :- LED (Light Emitting Diodes) & Plasma Panels.

2) Non-Emissive Display :-
Non-emissive display uses the sunlight or light from other source & uses it using optical effects to display the image.
examples :- LCD i.e. Liquid Crystal Display.

PLASMA PANEL DISPLAY :-



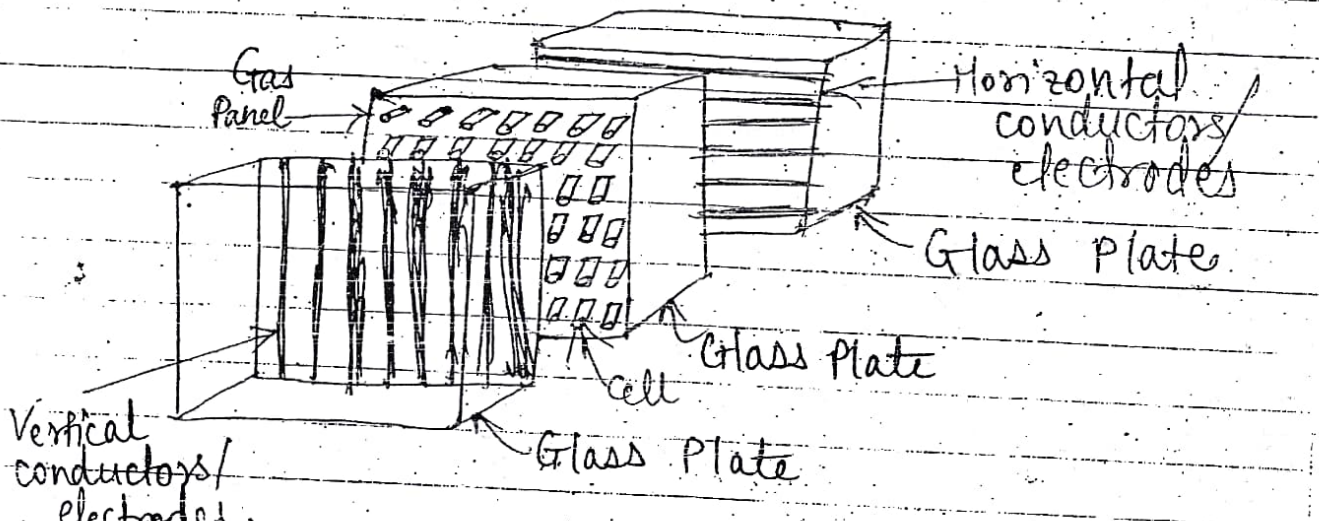
- In Plasma Panel Systems, the mixture of gases that includes neon and xenon fills the gap between two glass plates.
- A series of vertical conducting ribbons is placed on one glass panel & a set of horizontal ribbons (wire) is built into the other glass panel.

- Due to the firing of voltage across horizontal and vertical conductors, the gas at the intersection of the two conductors gets break down into glowing plasma of electrons & ions. (each independent of one another)
- Separation of pixels is achieved by electric field of conductors.
- Plasma Displays are monochrome i.e. grayscale as well as colored displays.

Differentiate between Raster Scan Display and Random Scan Display.

Raster Scan Display	Random Scan Display
1) It draws picture frame by frame.	1) It draws picture one line at a time.
2) Refresh rate is 60 frames/sec. to maintain steady picture.	2) Refresh rate depends on no. of lines displayed
3) It generates stair-step appearance in a straight line.	3) It is used for smooth line drawing
4) It is useful to display realistic shaded pictures.	4) It does not display realistic shaded pictures.
5) It has low resolution.	5) It has high resolution.
6) In this, the screen is pointed by a frame.	6) By directing CRT electron beam to the part of screen & draws a line.
7) Slow speed of scan conversion.	7) High speed of scan conversion.

* Plasma Panel Display :- (Gas Discharge Display)



It consists of two sheets of glass with thin closed spaced gold electrodes attached and covered with dielectric material. These are attached as series of vertical conductors on one glass plate & horizontal conductors on other glass place. The space between two glass plate, is filled with neon based gas and is sealed. By applying voltage between electrodes the gas within panel is divided into tiny cells & each cell is independent of its neighbours firing voltage applied to horizontal & vertical conductors cause the gas at intersection cell to break down into glowing plasma. This glow can be sustained by maintaining high alternating voltages across cell.

Merits :-

1) Light weight, less bulky device.
2) Produces flicker free image
3) Refreshing is not required
4) It allows selecting erasing & writing

Demerits :-

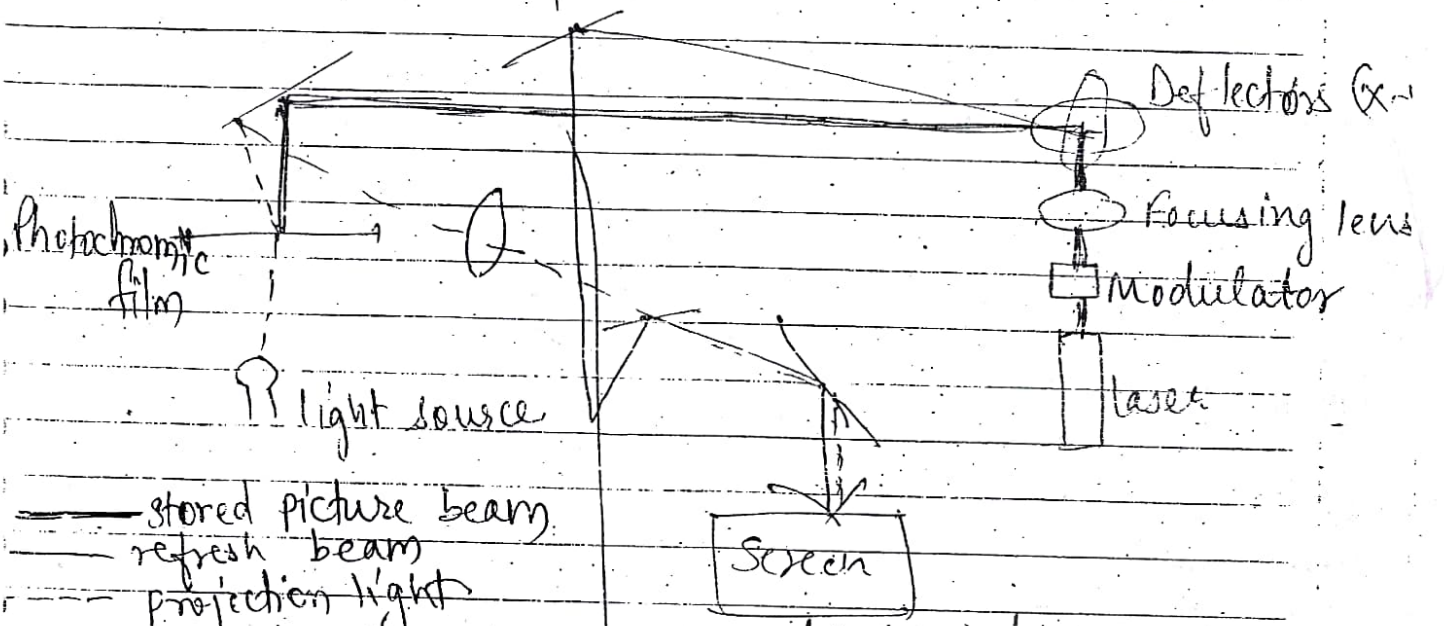
1) Poor Resolution
2) It needs complex addressing & wiring
3) Costly.

Liquid Crystal Display (LCD) :-

- This display use nematic (thread like) liquid crystal compounds that tend to keep long axes of rod shaped molecules aligned.
- These nematic compounds have crystalline arrangement of molecules, they flow like a liquid. & hence called as LCD.
- LCD is filled between two glass plates. One glass plate have horizontal transparent conductors are built into same glass plate & other end glass plate have vertical light polarizer & vertical conductors are built into it.
The intersection of 2 conductors difines pixel position.
- Polarized light passing through material is twisted so that it will pass through ~~original~~ opposite polarizer. The light is reflected back to viewer. To turn OFF, we apply voltage to two intersecting conductors to align molecules so.

that light is not twisted.
— Picture definitions are stored in refresh buffer & screen is refreshed at the rate of 60 frames per sec.

* Laser Scan Display :-



——— stored picture beam
—— refresh beam
--- projection light

— High resolution, large screen display device.
— Used for displaying maps, high quality text & ckt diag
— Principle :-
① Laser is deflected by pair of mirrors so that it trac out desired image on sheet of photochromic film.
② Film is usually transparent but laser leaves dark trace on it.
③ Light projection sys. is used to project film on large screen
— Mirrors are extremely small & are controlled by electrical signals recieved from display controller.
— To produce fresh image, the display simply wind the roll of film to bring blank region under the laser.

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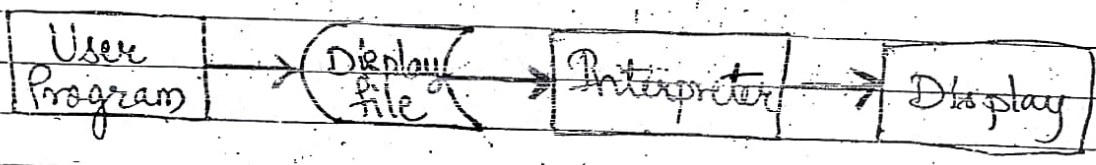
Display File Interpreter :-



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- The program which converts these commands into actual picture is called display file interpreter.
- It is an interface between graphics representation in the display file & display device.
- Display Process is divided into steps.

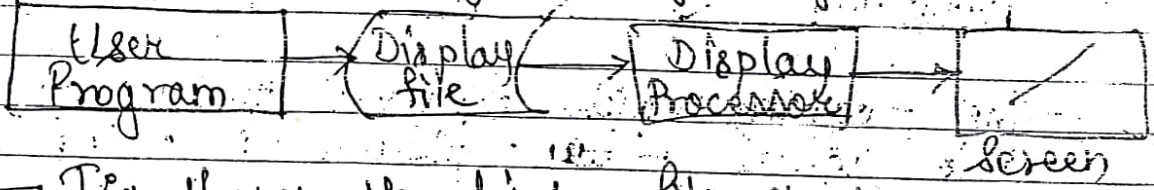
(1) The image is stored in the display file structure.

(2) It is interpreted by an appropriate interpreter to get the actual image.

- If we store actual image for particular display device, it may not run on other displays. To achieve device independence the image is stored in raw format i.e. in the display file.
- Another advantage of using interpreter is that saving raw image takes much less storage than saving the picture itself.

* Display File Structure :-

- In raster scan displays, image information is stored in the frame buffer. It includes the information of all pixels.
- The vector refresh displays store only the commands necessary for drawing the line segments. Here, input to the vector generator is stored instead of the output.
- The file used to store the commands necessary of drawing the line segments is called display file.
- In vector refresh display system, the display processor uses the information in the display file to draw lines with the help of vector generating algorithms.



- Fig shows the display file structure.
- Display file consists of commands.
- Each command contains two fields.
  - an operation code (opcode) and
  - operands.
- Opcode identifies the command such as draw line, move cursor, etc. and operands provide the co-ordinates ~~of point~~ to process the command.
- One way to store opcode & operands of series of commands is to use three seperate arrays.
  One for operation code
  One for operand 1 i.e. x coordinate.
  One for operand 2 i.e. y co-ordinate.

It is necessary to assign meaning to the possible operation codes before proceeding to interpret them.

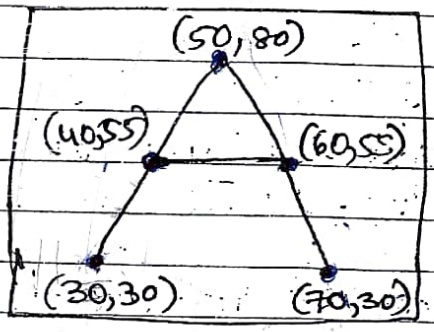
let us consider two commands & assign opcode to them.

command	opcode
MOVE	1
LINE	2

eg

opcode	operand1 (X)	operand2 (Y)
1	30	30
2	50	80
2	70	30
1	40	55
2	60	55

Output :-



* Primitive Operations :-

1) lines :-

line (int x1, int y1, int x2, int y2)

The procedure above draws line from the point (x_1, y_1) to (x_2, y_2) on the standard co-ordinate system of screen.

1. moveto (x, y);
2. lineto (x, y);

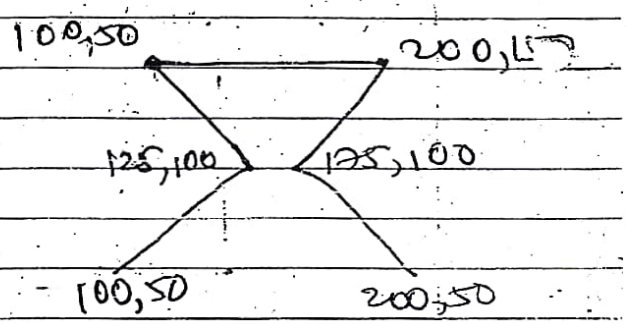
Polylines :-

The sequence of the lines drawn from the vertices of lines one by one is known as polyline.

polyline (int vertexcount, point * vertices)

eg. polyline (6, varray)

X	Y
100	50
125	100
100	150
200	150
175	100
200	50



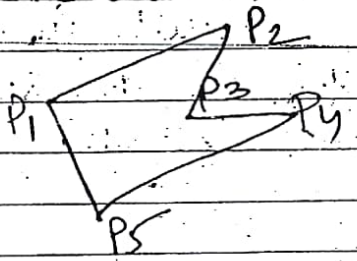
3) Polymarkers :-

Markers are the dots or circles which are placed at the vertices for the user convenience.

polymarker (vertex count, varray)

4) Polygons :-

Polygon is the chain where lines are connected to each other. When we draw polyline & close them, it is known as polygon.



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Applications of Computer Graphics :-

1) CAD, CAM :

Major application of computer graphics which is used in design process specially for civil engineering & architecture crystal use in design of building, automobile, aircrafts, watercraft, computers, etc.

eg. Floor plan drawing using CAD.

2) Computer Art :

Computer Graphics Methods are used in fine arts & commercial arts applications.

eg Symbolic mathematical package, desktop publication software, Animation Packages, etc.

3) Presentation Graphics :

It is used to produce illustration for report or to generate 35 mm slides or transparency for used with projector. It is commonly used to summarize financial, statistical, mathematical, scientific, managemental report, consumers information

bulletin, etc.
eg- Bar Chart, Pie Chart

4) Entertainment :

The computer graphics methods are commonly used for making motion pictures, music videos, TV shows, video-games, etc.

5) Education and Training :-

Computer generated models of physical, financial or economical systems are often used as educational aid.

For some training applications special systems are design.
eg. simulations of practice sessions, training of shift captain, aircraft pilots, Air Traffic Control personnel.

6) Visualisation :

Scientists, engineers, medical personnels, business analyst, others needs to analysed a large amount of information or to study behaviour of certain process.

Producing graphical representation of scientific, engineering & medical data sets & processes is referred as scientific visualisation.

Business visualisation is used in connection with data sets related to commerce, industries & other non-scientific areas.

7) Image Processing :-

In computer Graphics, computer is used to create a picture. Image processing is a technique to modify or interpret existing pictures such as photographs or TV scans. Two principle applications of image processing are
- Improve picture quality
- Machine perception of visual information.

8) Graphical User Interface (GUI) :

(9) Engg / Scientific software, Business s/w
(10) TV channels, Space simulation training
(11) PCB designing, map preparation
(12) UI, Animation
(13) making charts, image processing
(14) commerse

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PROGRESSIVE THEORY TEST I / II / 2.....

4 Pages

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Graphics File Formats :- (BMP, GIF, JPEG, PCX, TIFF)

Information of an image is stored in memory. This inf^n. is stored in some standard formats so that it can be interpreted by different devices. These file formats are called as graphics file formats. These file formats stores inf^n. of pixels of image as well as incorporate some methods of data compression.

1) BMP (Bitmap) file format :-

→ Earliest & most commonly used file format.
→ Default format used by Ms-windows.
→ Storing & manipulation of pixels is done with their location & attributes by bit coding method.
→ Inf^n. is stored in device-independent-Bitmap format (DIB).
→ Inf^n. of this bitmap can be displayed on any display device.
→ .bmp is the extension.

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Bitmap File Structure :-

Each bitmap file contains a bitmap - file header, a bitmap information header, color table and an array of bytes that defines bitmap bits.

Merits :-
1) Simple to use.
2) It is display device independent.

Demerits :-
1) Large file size.
2) Though display device independent they are limited to windows platform.
3) Cannot store multiple images in one file.

2) GIF (Graphic Interchange format) :-

→ It is simple, memory efficient and back bitmap format.
→ Designed by Compuserve.
→ Compresses BMP files to smaller size.
→ GIF stores images & other relevant inf. in sequence of blocks and sub-blocks.
→ Each sub-block has different functions regarding image inf. ; color, brightness & data compression.
→ GIF is CompuServes standard for defining generalized color raster images.
→ GIF allows high-quality, high-resolution graphics to be displayed on variety of graphics hardware.
→ It is intended as an exchange & display mechanism for graphics images.

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GIF File Structure :-
GIF Signature
Screen Descriptor
Global Color Map
Image Descriptor
local Color Map → Repeated n times
Raster data
GIF Terminator.

Merits :-
1) It gives compact file format.
2) Provides option to specify how many colors should be saved.
3) Allows multiple images to be stored in single file.
4) Suitable and are popular in internet & intranet
5) Device independent.
6) O.S. independent.

Demerits :-
1) Decompression of GIF data is slow.
2) It uses only palette colors.
3) It do not provide other RGB color & gray scale.

3) JPEG (Joint Photographic Expert Group) :-

→ Special bitmap image format used to reduce file size.
→ Especially used with photographic images
→ Compression method used in this format reduces file size by removing some detail information & image which is generally not noticeable.
→ It is a lossy compression techniques for color images.

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→ lossy compression refers to data compression techniques in which some amount of data is lost.

→ JPEG standard specifies
a) codec which defines how image is compressed into stream of bytes & decompressed back into image. &
b) File format used to contain that stream.

→ JPEG's are better suited for natural, complex images.

→ Most image editing software programs that write to a "JPEG file" actually creates a file in ~~GIFF~~ "JFIF" formats.

→ Extensions are .jpg → .jpeg, .jpe → .jfif, .jif.

→ Most used for storing & transmitting photographs on world wide web.

→ JPEG are not well suited for line drawings & other textual graphics. for this GIF or PNG is used.

Merits :-
1) Suitable for photographic images.
2) Reduces file size.

Demerits :-
1) Some info. of image is lost.

4) PCX Format :-

→ Developed by ZSOFT for its PC Paintbrush program.

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PROGRESSIVE ~~THEORY TEST I / II / 2.....~~ (2)

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→ It is a graphics file format for graphics programs running on PC's.

→ It is supported by optical scanners, fax programs and desktop publishing systems.

→ .pcx extension.

→ PCX is raster image format which is device independent.

→ File header stores info about display hardware (screen resolution, color depth and palette info., bit planes & so on) seperately from image info.

→ PCX image data is compressed using run-length encoding (RLE) which requires very little processor power or memory to apply.

Merits :-

1) most widely used bitmap image format.

De-merits :-
1) It has no provision for gray-scale images.
2) No provision for any color mode other than RGB.
3) Does not support other platform.

5) TIFF (Tagged Image file format) :-
→ Developed by Aldus Corporation.
→ TIFF, a tags based file format that is designed to produce the interchange of digital image data.
→ Stores image data in tagged (indexed) fields.
→ Very flexible & versatile & can be used on variety of computer systems.
→ Consists of three fields.
a) Image file header
b) image file directory &
c) tag fields where each one is identified by unique tag.

Merits :-
1) Platform independent.
2) Independent of computer system also.
3) Versatile & flexible.
4) Supports many compression schemes.
5) It supports additional information about images.

Demerits :-
1) Does not support multiple images in one file.
2) Complex file format.
3) Open ended format, hence, programmer can make changes.

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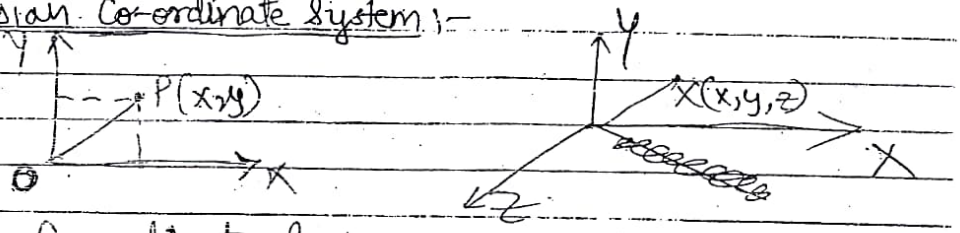
* Co-ordinate Systems :-

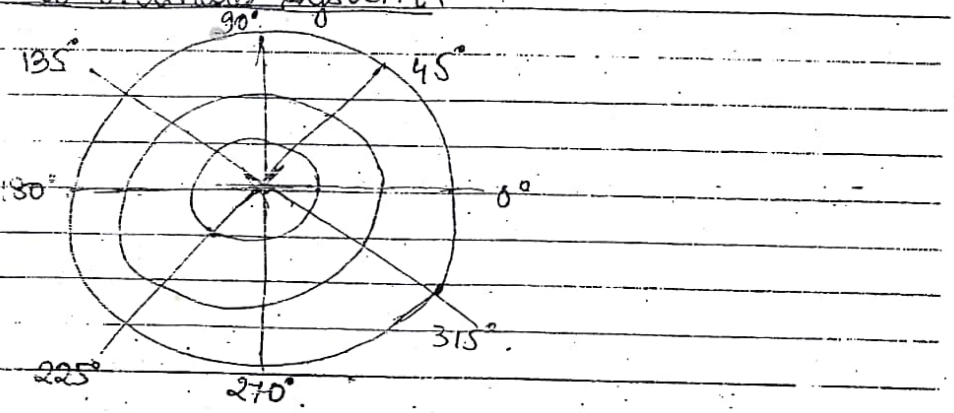
Two-dimensional :-
cartesian (x, y)
polar (r, θ).

Three dimensional :-
Cartesian (x, y, z)
Cylindrical (r, θ, z)
Spherical (r, θ, ϕ).

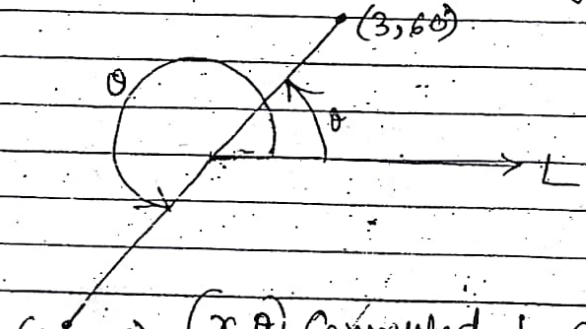
1) Cartesian Co-ordinate System :-



2) Polar Co-ordinate System :-



→ 2D co-ordinate system in which each point on a plane is determined by an angle & a distance.



(r, θ) Converted to Cartesian

$x = r \cos\theta$

$y = r \sin\theta$

3) Cylindrical Co-ordinate System :-

→ 3D Co-ordinate system which essentially extends circular polar co-ordinates by adding

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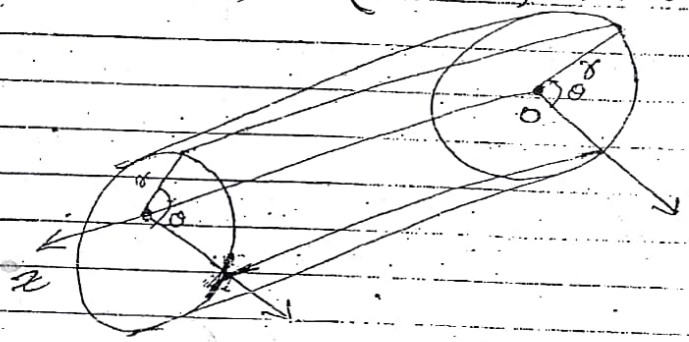
third co-ordinate which is height (h).

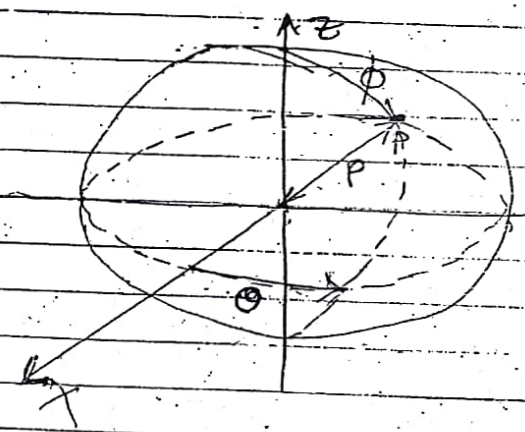
r → distance
θ → angle
h → height same as z in Cartesian CS.

$\therefore f(x,y,z) = (r\cos\theta, r\sin\theta, h)$



4) Spherical CS :-

→ Co-ordinate System (CS) for representing geometric figures in 3D.



P (ρ, φ, θ)
- ρ: distance from fixed origin
- φ: angle from z axis
- θ: angle from positive x axis

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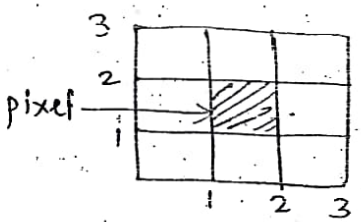
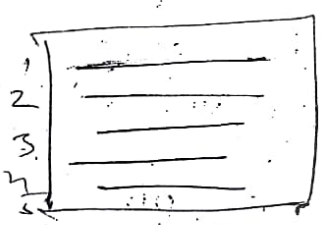
Ch. 2 Line, Circle and Polygon.

* **Pixel** :- Smallest screen addressable element.
Computer screen is divided into rows and columns Intersection area of this row & column is known as pixel.





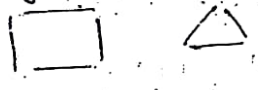
* **Scan Conversion** :-
The process of representing continous graphics object as a collection of discrete pixels is called as scan conversion.

* **Rasterisation** :-
The process of determining which combination of pixels provide best approximation to the desired line is known as rasterisation.

* Criteria for drawing a straight line :-

1) Line should appear straight.
   There are three straight lines possible with point-plotting technique.
   a) 45° angle line
   b) Parallel to x-axis line.
   c) Parallel to y-axis line.
   Other lines have the stair-step appearance (disturbance) in it.

2) Line should terminate accurately.
   If line is not terminated accurately, the gaps will be seen between end points

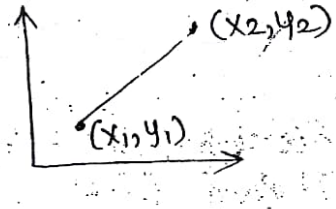


3) Line should have constant density.
   Line density is observed as brightness. Line density is proportional to the number of dots displayed divided by length of the line. To maintain constant density, the dots (pixels) should be equally spaced.

4) Line should be independent on the line length and angle.

5) Line should be drawn rapidly.

* Line-drawing algorithms :-



$y = mx + c$ — equation of line.

$$\frac{y-y_1}{x-x_1} = m = \frac{y_2-y_1}{x_2-x_1}$$

$\therefore y-y_1 = m(x-x_1)$

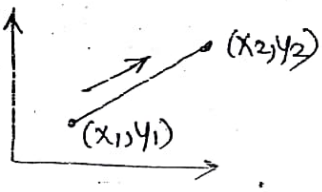
$\therefore y = mx - mx_1 + y_1$

$\therefore y = mx + c$ where $c = y_1 - mx_1$

We are using incremental & search procedure for drawing a line.

1) DDA (Digital Differential Analyzer) Algorithm:-

$$m = \frac{\Delta y}{\Delta x} = \frac{y_2-y_1}{x_2-x_1}$$



if $m \leq 1$,

then increment the value of x by unit step. and search the value for y by eqn.

$$y_i + 1 = y_i + m \quad \text{---} (1)$$

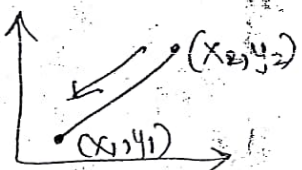
else if $m > 1$

then increment the value of y by unit step and search the value for x by equation.

$$x_i + 1 = x_i + 1/m \quad \text{---} (2)$$

From both equations (1) & (2), the line is moving from left to right or lower end to upper end.

$$m = \frac{\Delta y}{\Delta x} = \frac{y_2-y_1}{x_2-x_1}$$



If $m \leq 1$,

then decrement the value of x by unit step. and search for value of y by eqn.

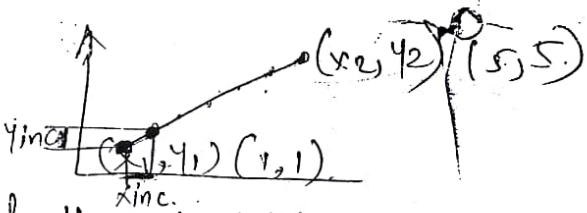
$$y_{i+1} = y_i + m \quad \text{—— (3)}$$

else if $m > 1$,
decrement the value of y by unit step and search for value of x by eqn.

$$x_{i+1} = x_i - 1/m \quad \text{—— (4)}$$

From both equations (3) & (4), the line is moving from right to left or upper end to lower end.

DDA Algorithm :-



Step 1 :
Accept the inputs of the straight line (x_1, y_1) and (x_2, y_2).

Step 2 :
To calculate the value of Δx & Δy.

$\Delta x = x_2 - x_1 = 4$

Difference $\Delta y = y_2 - y_1 = 4$

Step 3:
To check the magnitude between Δx and Δy & set a parameter length which will specify on which axis, the line is moving and how many pixels are plotted between end points of the line.

if (abs (Δx) $\geq$ abs (Δy))
then length = abs (Δx)
else
length = abs (Δy)
$= 4$

Step 4 :

To calculate x increment & y - increments.

$$Xinc = \frac{\Delta x}{length} = \frac{4}{4} = 1.$$

$$Yinc = \frac{\Delta y}{length} = \frac{4}{4} = 1$$

Step 5 :

To setup a starting pixel where $x = x_1$ and $y = y_1$ and display it.

putpixel (x, y, color).

Step 6 : Continue to increment the value of i by unit step till length times.

for (i = 0; i ≤ length; i++).

Step 7 :

Calculate next x & y co-ordinates.

$x_{new} = x_{old} + Xinc$

$y_{new} = y_{old} + Yinc$

and display all the pixels.

Step 8 : Repeat the procedure through Step. 6.

Step 9 : End.

length	x	y
0	1	1
1	2	2
2	3	3
3	4	4
4	5	5

C Program for DDA Algorithm :-

```
#include <stdio.h>
#include <conio.h>
#include <graphics.h>
#include <math.h>
void main ()
{
```

```
int gd, gm;
clrscr();
initgraph (& gd, & gm, "C:\TC\BGI");
int x, y, x1, y1, x2, y2, dx, dy, xinc, yinc, length, i;
printf ("Enter the values of x1, y1 and x2 y2");
scanf ("%d %d %d %d", &x1, &y1, &x2, &y2);
dx = x2 - x1;
dy = y2 - y1;
if (abs (dx) >= abs (dy))
  {
   length = abs (dx);
  else
    length = abs (dy);
xinc = dx / length;
yinc = dy / length;
 x = x1;
 y = y1;
for (i = 1; i <= length ; i++)
  {
   putpixel (x, y, 15);
   x = x + xinc;
   y = y + yinc;
  }
closegraph ();
getch ();
}
```

Adv :-
1) Faster method & simple.

Disadv :-
1) Time consuming due to FPA.
2) Round-off error.

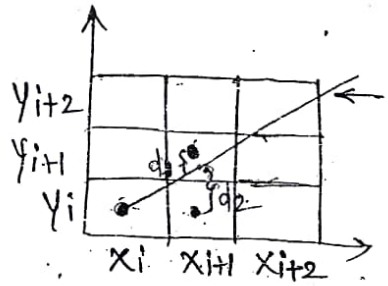
(1,1) & (5,3)

2) Bresenhams line drawing algorithm :-

This is an accurate and efficient line generating algorithm. This algorithm uses only integer calculation, multiplication by 2 and avoids division.

To illustrate Bresenham's approach, consider a line with positive slope ≤ 1.

$\frac{y_2 - y_1}{x_2 - x_1} = 1$



$m \leq 1$.

From the fig., assume that starting pixel at (x_i, y_i) is displayed and need to determine which pixel is closer to the actual line path whether lower pixel (x_{i+1}, y_i) or upper pixel (x_{i+1}, y_{i+1}).

It is decided based upon decision parameter d_i which is calculated by following eqn.

$$d_i = 2\Delta y - \Delta x.$$

Based on d_i, the next x and y co-ordinates values of next pixel is calculated.

if $d_i \leq 0$,

select lower pixel at position (x_{i+1}, y_i)

$d_{i+1} = d_i + 2\Delta y$.

else

select upper pixel at position (x_{i+1}, y_{i+1})

$d_{i+1} = d_i + 2\Delta y - 2\Delta x$.

$y = y + 1$.

Bresenham's line drawing algorithm :-

Step 1 :

Accept the co-ordinates (x_1, y_1) & (x_2, y_2) as an input.

Step 2:

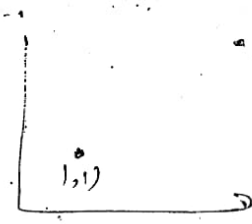
Calculate initial parameters.

$\Delta x = x_2 - x_1 = 4$

$\Delta y = y_2 - y_1 = 4$

$di = 2\Delta y - \Delta x = 4$

Decision parameter



Step 3:

To setup starting pixel for a line.

if $(x_1 < x_2)$

then $x = x_1$

$y = y_1$

$x_{end} = x_2$

else

$x = x_2$

$y = y_2$

$x_{end} = x_1$

Step 4: Move the value of x from $x = x_1$ to $x = x_{end}$ by unit step.

Step 5:

Plot starting pixel

putpixel (x, y, color).

Step 6:

if $(di \leq 0)$

then select lower pixel at (x_{i+1}, y_i)

$di+1 = di + 2\Delta y$. $x = x+1, y = y$.

otherwise

select upper pixel at (x_{i+1}, y_{i+1})

$di+1 = di + 2\Delta y - 2\Delta x$ 4+8-8

$x = x+1, y = y+1$.

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Step 7 : Repeat a procedure through step 4.

Step 8 : End.

* C Program for Bresenham's Algorithm :-

```
#include <stdio.h>
#include <conio.h>
#include <graphics.h>
void main()
{
int gd=DETECT, gm;
clrscr();
initgraph (&gd, &gm, "C:/TC/BGI");
int x, y, x1, y1, x2, y2, xend, dx, dy, di;
printf ("Enter values of x1, y1 & x2, y2");
scanf ("%d %d %d %d", &x1, &y1, &x2, &y2);
dx = x2 - x1;
dy = y2 - y1;
di = 2 * dy - dx;
```

di	x	y
1	1	1
4	2	2
4	3	3
4	4	4
5	5	5

(1,1) (5,5)

```
if (x1<x2)
 {
  x=x1;
  y=y1;
  xend=x2;
 }
else
 {
  x=x2;
  y=y2;
  xend=x1;
 }
for (x=x1; x<=xend ; x++)
 {
  putpixel (x,y,15);
  if (di<0)
   {
    di=di+2*dy;
   }
  else
   {
    di=di+2*dy-2*dx;
    y=y+1;
   }
 }
closegraph();
getch();
}
```

This algorithm is efficient when slope is smaller than or equal to 1. ($m \leq 1$) that is angle smaller than or equal to 45° ($\Delta x \geq \Delta y$).

If the slope is greater than 1 that is greater than 45° and less than 90° then interchange co-ordinates of x & y. ($\Delta x < \Delta y$).

Algorithm for angle between 45° & 90°

Step 1: Accept inputs x_1, y_1, x_2, y_2 as an integer.

Step 2: Calculate $\Delta x = y_2 - y_1$;
$\Delta y = x_2 - x_1$
$di = 2 * \Delta y - \Delta x$;

Step 3: Setup a starting pixel.
if ($y_1 < y_2$)
then,
$x = y_1$
$y = x_1$
$xend = y_2$
else
$x = y_2$
$y = x_2$
$xend = y_1$

Step 4: Continue to increment value of x till xend times by unit step. Plot starting pixel.

Step 5: if ($di \leq 0$)
select lower pixel $(xi+1, yi)$
$di+1 = di + 2\Delta y$
else
select upper pixel $(xi+1, yi+1)$
$di+1 = di + 2\Delta y - 2\Delta x$
$y = y+1$

Step 6: Repeat the procedure through step 4.

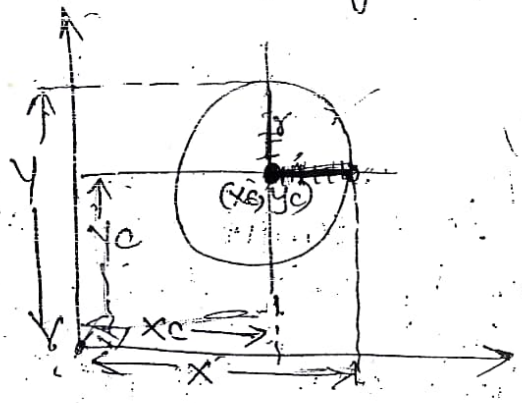
Step 7: End.

$x_{inc} = \Delta x / length$

DDA Algorithm	Bresenham's Algorithm
1) It uses division.	1) It uses addition, subtraction & multiplication
2) It uses floating-point arithmetic.	2) It uses integer calculations.
3) It takes more time to process.	3) It takes less time to process.
4) DDA is more accurate.	4) It is less accurate.

* Circle :-

Circle is frequently used component in a picture and graph.
Consider circle center (x_c, y_c) and radius r as shown in fig.



$x^2 + y^2 = r^2$

Equation of circle is,

$$(y-y_c)^2 + (x-x_c)^2 = r^2$$

If circle center is at origin, above equation becomes,

$x = 0$ to r

$$y^2 + x^2 = r^2$$

$$y = \sqrt{r^2 - x^2}$$

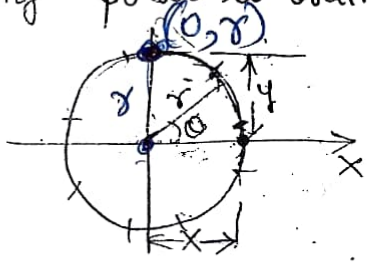
Move the value of x from $x=0$ to $x=r$ and calculate value of y at every step.

D-2, C-4+, D-7, D-6, D-12, D-9, C-41, 44, 46, D-10, D-11, D-9.

This refers to as polynomial method.

With this method, spaces between pixels are not same.

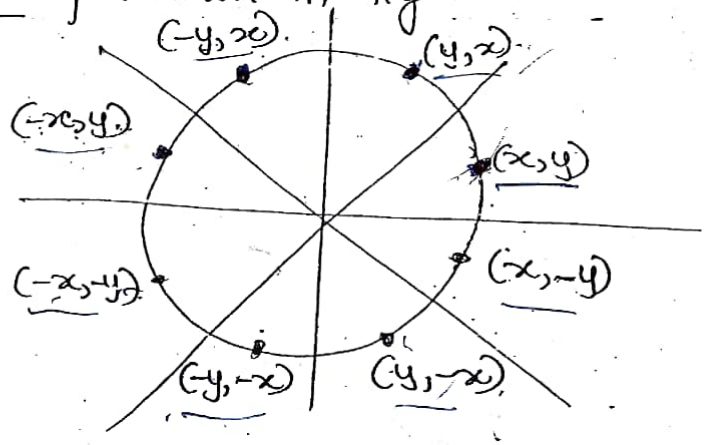
To avoid unequal spacing, circle is ~~drawing~~ drawn using polar co-ordinates..



$x = r \cos\theta$
$y = r \sin\theta$ — Trigonometric

Move the value of θ from 0° to 90° & calculate x and y.

The circle is generated using 8-way symmetry shown in fig..



pp(x+xc, y+yc, 15)

1)* Circle generation algorithm using polynomial method :-

Step 1 : Accept the circle center (xc, yc) and radius r as input.

Step 2 : Set initial parameters.
$x = 0, y = r$

Step 3 : move value of x from x=0 to x=r by unit step.

Step 4 : Calculate value of y
$y = \sqrt{r^2 - x^2}$

17, 51, 58, 02, 14, 08

Step 5: Generate circle using 8-way symmetry.

```
putpixel (x+xc, y+yc, 15);
putpixel (y+xc, x+yc, 15);
putpixel (-x+xc, y+yc, 15);
putpixel (-y+xc, x+yc, 15);
putpixel (-x+xc, -y+yc, 15);
putpixel (-y+xc, -x+yc, 15);
putpixel (y+xc, -x+yc, 15);
putpixel (x+xc, -y+yc, 15);
```

Step 6: Repeat procedure through step 3.
Step 7: End.

2) Circle generation algorithm using trigonometric method:-

Step 1: Accept circle center (x_c, y_c) & radius r as an input.
Step 2: ~~Set initial parameters~~
~~$x = 0, y = r$~~
Step 3: Move value of θ from $\theta = 0°$ to $90°$ by unit step.
Step 4: Calculate values of x & y.

$$x = r \cos\theta$$
$$y = r \sin\theta$$

Step 5: Generate circle using 8 way symmetry.
(Write above 8 putpixel commands here).
Step 6: Repeat procedure through Step 2.
Step 7: End.