→ Pixel :- 1920 x 1080 pixels

→ Resolution = W x H

→ PPI > Pixel per Inch

→ Aspect ratio > $\frac{W}{H}$ W:H

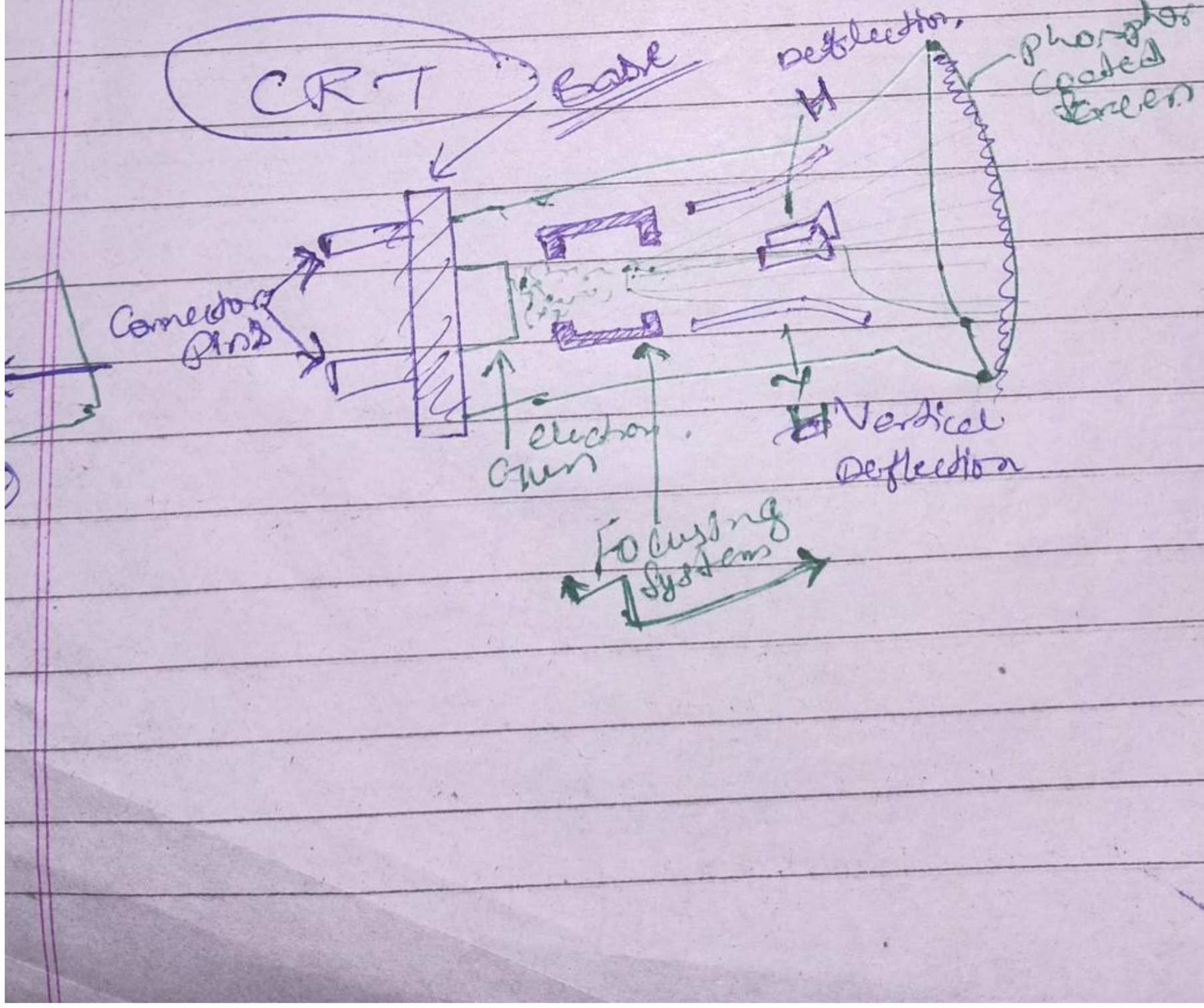
→ Frame buffer :- (Memory storing inform to

Q): 5inch, H = 1080, W = 1920

$$x = \sqrt{(1920)^2 + (1080)^2}$$

$$= \sqrt{3686400 + 1166400}$$

$$= \frac{2205}{5} = 441 \text{ PPI}$$



Raster

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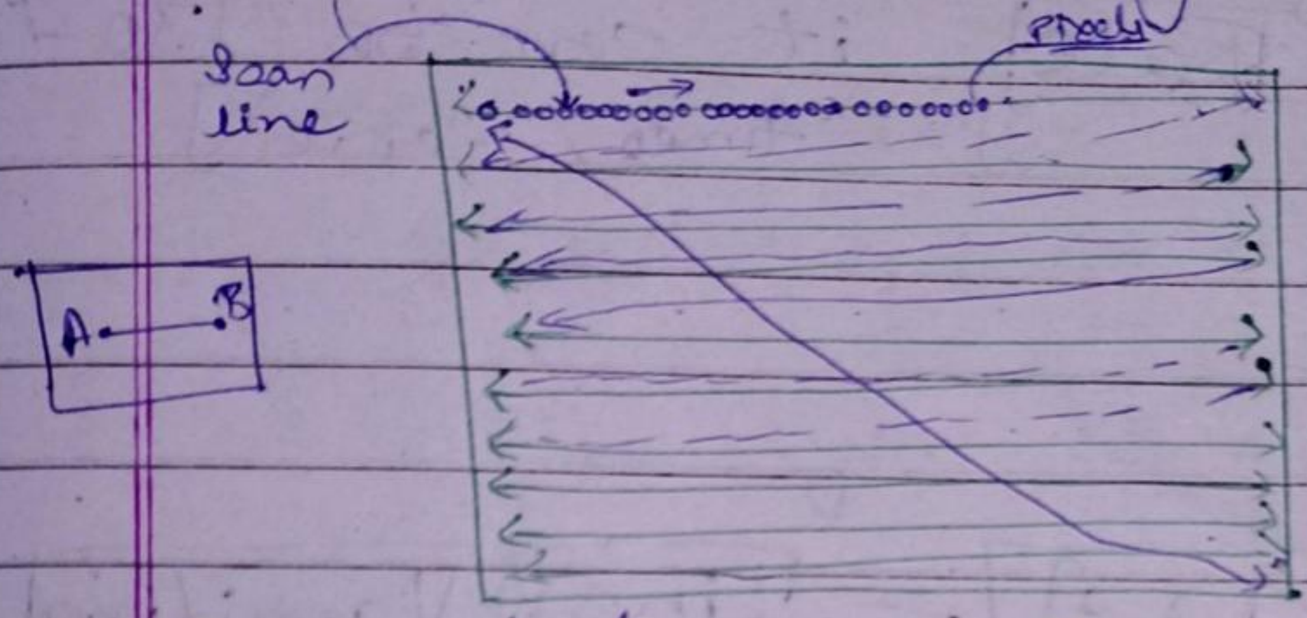
* Vector / Raster Scan Display



* In this Display we start from (Top-left pixel & move to the Right (Horizot.) & have to display every pixels according to their Intensity level/value of pixels.

(1) Moving electron beam from left to Right In [ON] mode :-

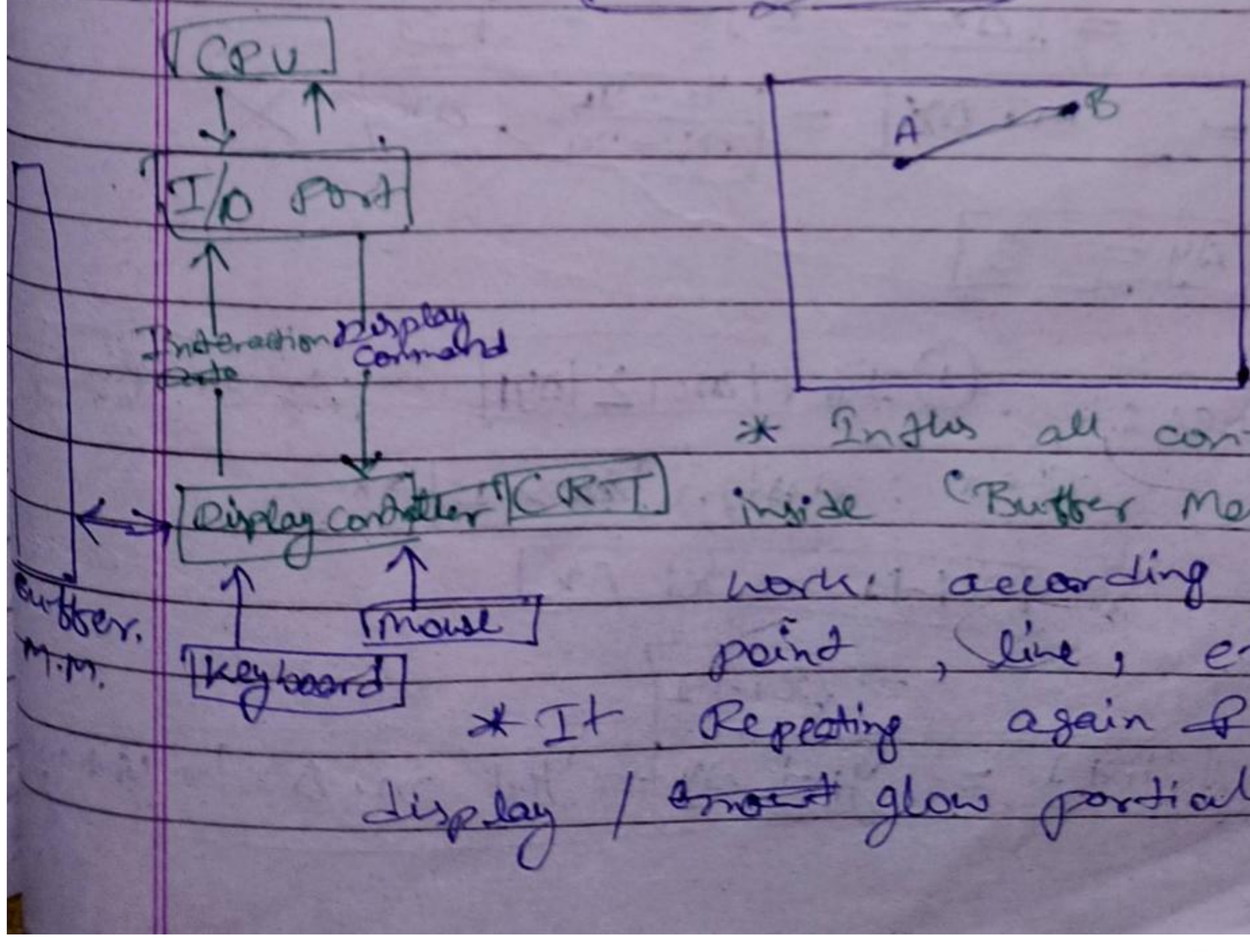
(2) But while changing one line to another line of pixels (that time electron beam is in 'OFF' mode. &

* Moving Right to left called [Horizontal Retrace]

* In last line, it follows vertical [Retrace]

Stored IN [Frame buffer]

Vector



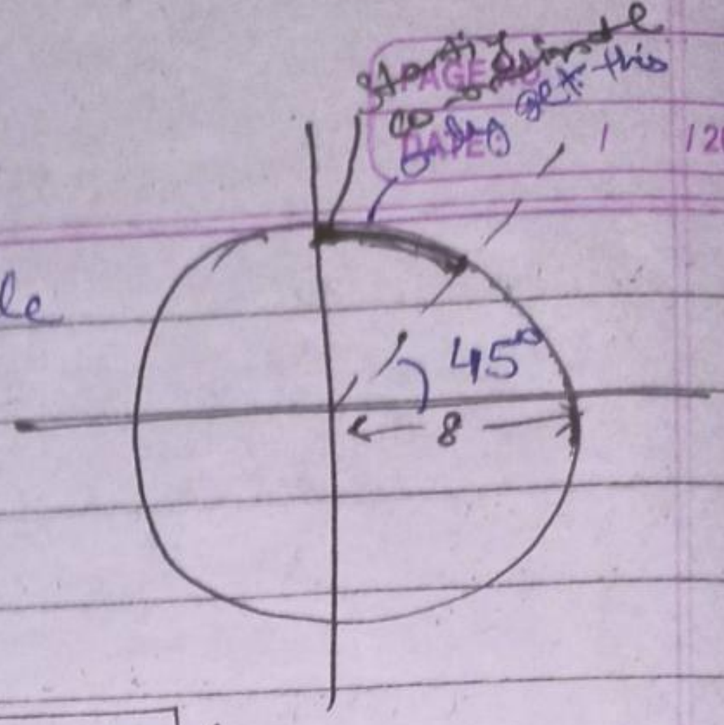
* It have to display A point so,

* In this all commands are given inside 'Buffer Memory' so it work: according to that. ie it point, line, etc.

* It Repeating again & again to display / glow particular pixels off. Screen

**Important

Bresenham Circle Drawing



Sues Given (0,0) — center of circle
& r = 8 Given

Algo (1st step) Start point → $x_0 = 0$;
$y_0 = r = 8$;

(2nd step) Decision Parameter (P).
It used to check y_{i+1} will constant or decrement.;

$P = 3 - 2r$ (3 fixed)

$P = 3 - 2(8) = -13$

	x_i	y_i	x_{i+1}	y_{i+1}
1st	0	8	1	8
2nd	1	8	2	8
	2	8	3	7
	3	7	4	6
	4	6	5	5.

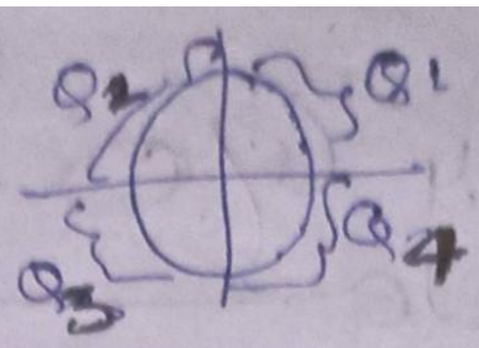
case 1: (P < 0)
{
$x_{i+1} = x_i + 1$ ←
$y_{i+1} = y_i$ ←
$P_{i+1} = P_i + 4 \times x_{i+1} + 6$
}

case 2: if (P ≥ 0)
{
$x_{i+1} = x_i + 1$ ←
$y_{i+1} = y_i - 1$ ←
$P_{i+1} = P_i + 4(x_{i+1} - y_{i+1}) + 10$
}

1st (P < 0)
$x_{i+1} = 0 + 1 = 1$
$y_{i+1} = 8$
$P_{i+1} = -13 + 4 \times 1 + 6$
$= -3$
P < 0 ✓

2nd

Table ** Both cases will Run while ($x_{i+1} \geq y_{i+1}$) looping ✓



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* If draw the $\frac{1}{8}$ part NOW have to complete all circle . SO, :-

(8,1)	Q2	Q3	Q4
(x, y)	(-x, y)	(-x, -y)	(x, -y)
(0, 8)	(0, 8)	(0, -8)	(0, -8)
(1, 8)	(-1, 8)	(-1, -8)	(1, -8)
(2, 8)	(-2, 8)	(-2, -8)	(2, -8)
(3, 7)	(-3, 7)	(-3, -7)	(3, -7)
(4, 6)	(-4, 6)	(-4, -6)	(4, -6)
(5, 5)	(-5, 5)	(-5, -5)	(5, -5)
(6, 4)	(-6, 4)	(-6, -4)	(6, -4)
(7, 3)	(-7, 3)	(-7, -3)	(7, -3)
(8, 2)	(-8, 2)	(-8, -2)	(8, -2)
(8, 1)	(-8, 1)	(-8, -1)	(8, -1)
(8, 0)	(-8, 0)	(-8, 0)	(8, 0

Range (θ^{-1})

Copy & apply -ve In (x)

Polygon

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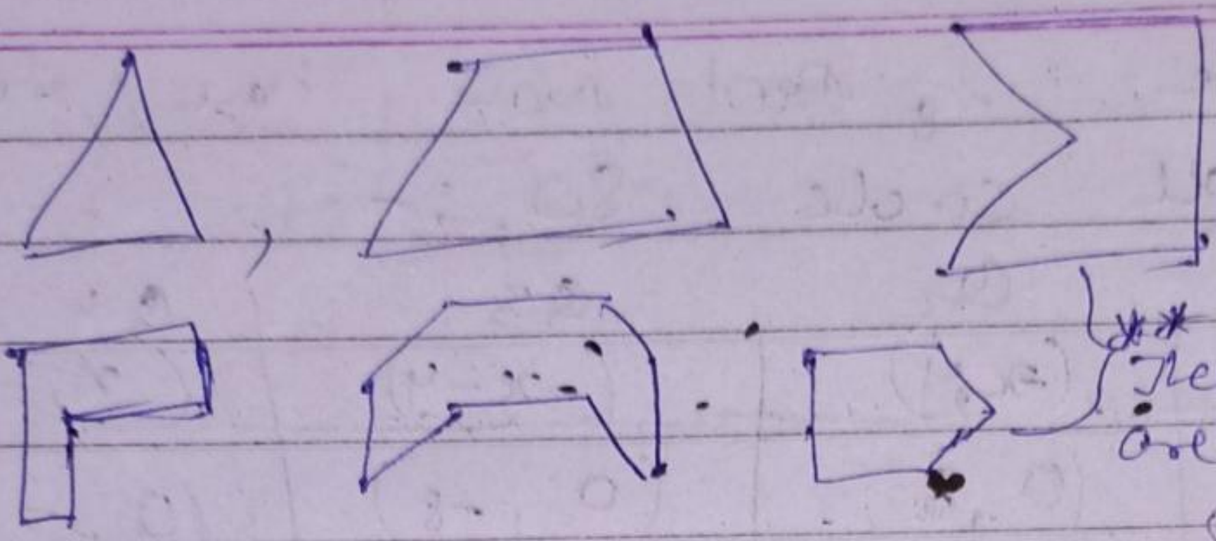


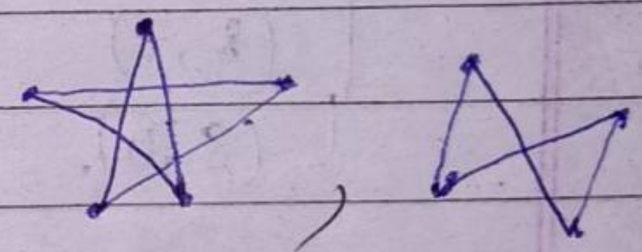
* No. of lines
* Must be clos
Circuit / cyclic

** These all are Simple Polygon

* :- Types of Polygon :-

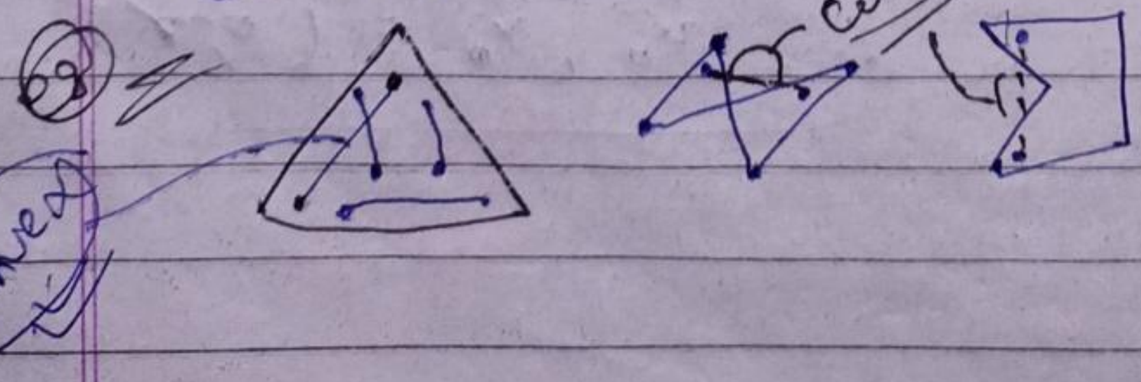
(1) Simple pol
(2) complex "
(3) Convex "
(4) Concave "

(2) Complex :-
The polygon when
meeting lines Inter-sec
to each other is kno
as complex polygon:- Eg:-



(3) Convex :- (1) Take two points in-side the polygon than connect both dots' if line is looking outside of polygon than non convex, (2nd) if line is inside the polygon i.e = Convex polygon

(4) Concave :- Just connecting the two dots of their connection looking / comes out-side of polygon at areal than its concave.



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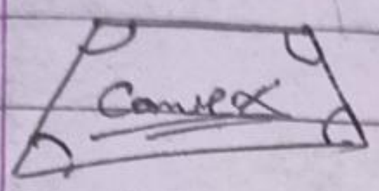
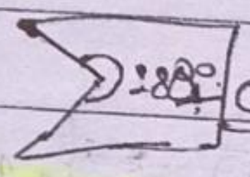
Imp Point :- Convex → polygon's All possible angle are under 180°
i.e $\boxed{P(\angle) < 180°}$



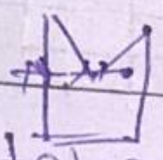
** Imp :- Concave polygons must contain 0-n No. of angles is greater than 180°
can be [Concave Angles > 180°]

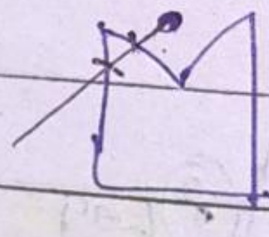


Polygon Inside Test

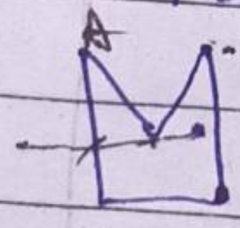
* Odd - Inside
* even - Out side

Both rule used to detect the point drawn are Inside or outside.

Eg:-  here • Dot is under the polygon - 2nd take one with Dot in any direction if No. of intersect by this line it odd then it drawn in-side else outside the polygon

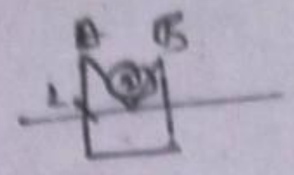
Eg:-  Two intersection is done by this dot means. it [even → outside]

Note:- Problem in this method when following of error happen:-



In this case count is (2) or (3) is Problem

To Solve :- If the point (intersected by line) & the point which make this point A,B are



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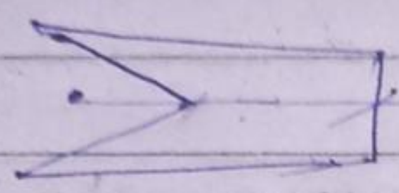
Some side than count of intersect is (2)
else (1).
So, := 2+1 = 3 - odd

* Then not on - same side

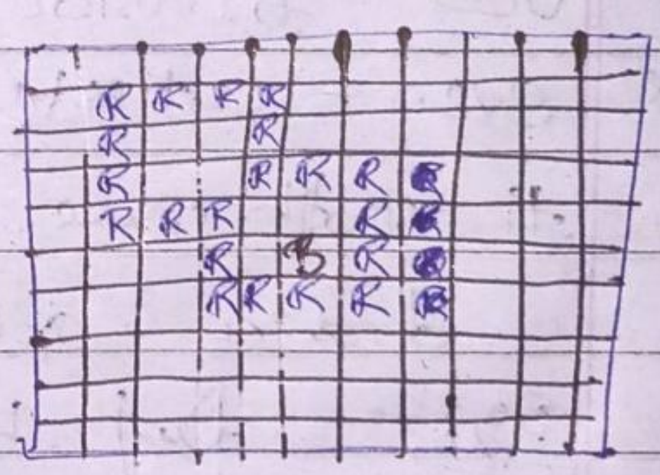


even - outside.

* Boundary-fill algorithm

** It used to fill color in ~~set~~ boundary inside the polygon only. Whor Boundary color must same every where

It always ** [boundary color ≠ Inside polygon color]
[R ≠ R]
[B = R]

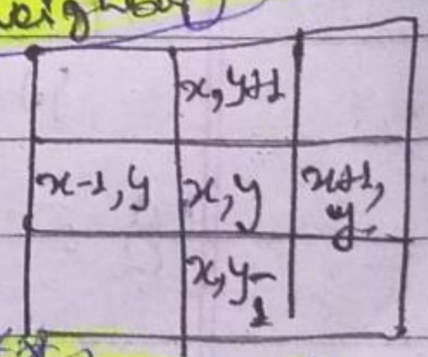


```
Boundary(x, y, F, b)
{
if( getpixel(x,y) != b)        // boundary color.
getpixel(x,y) != F)            // Fill color.
{
putpixel(x, y, f)
boundary(x+1, y, F, b)
boundary(x, y+1, F, b)
(x-1, y, F, b)
(x, y-1, F, b)
(x-1, y-1, F, b)
(x-1, y+1, F, b)
(x+1, y-1, F, b)
(x+1, y+1, F, b)
}
}
```

Fill color
= boundary color.

(4) way

** 4-way neighbour



(8) way ** only.
Convex (plus Area)

* Boundary filling Algo used when boundary color is only contain single color i.e All boundary pixel = (R) or (G) or (Black) (etc) But must be one color.

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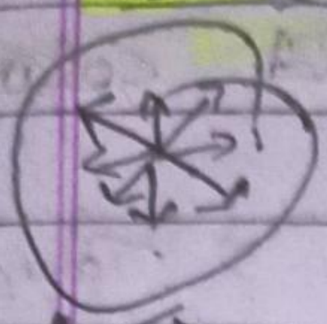
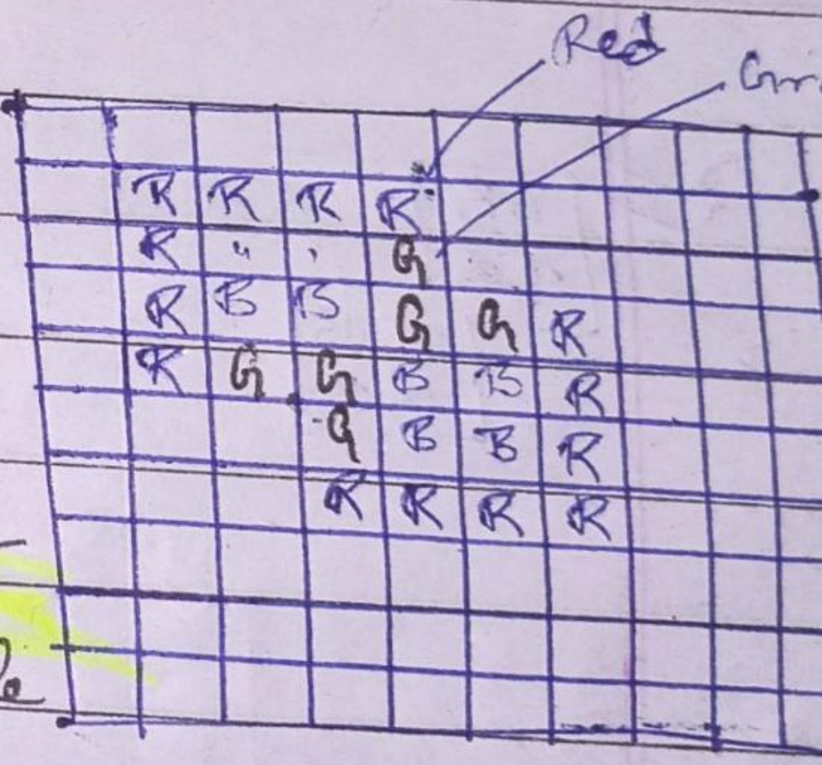
* 8-neighbour Lay:- It covers all diagonal neighbours.



x-1, y+1	x, y+1	x+1, y+1
x-1, y	x, y	x+1, y
x-1, y-1	x, y-1	x+1, y-1

Why needed Flood Fill

* Because In this Flood fill also we can fill polygon. Where Boundary Contains More than one Color like Red + Green taken in this example



Flood fill

Algo:-

```
flood (x, y, n, 0)
{
  if (getpixel(x,y) == 0)
  {
    putpixel(x, y, n)
    flood (x+1, y, n, 0)
    flood (x, y+1, n, 0)
    flood (x-1, y, n, 0)
    flood (x, y-1, n, 0)
    flood (x-1, y-1, n, 0)
    flood (x-1, y+1, n, 0)
    flood (x+1, y-1, n, 0)
    flood (x+1, y+1, n, 0)
  }
}
```

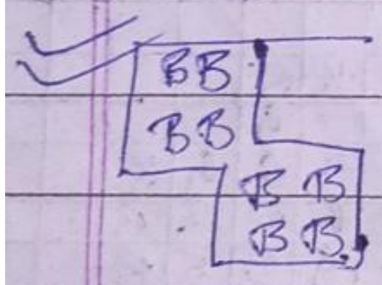
(n:- New color
(0):- Old color
Blue color
Taken (white) for example in this Algo.

4-Adj.

8-way connected

x & - x Adjacent

x-1, y+1	x, y+1	x+1, y+1
x-1, y	(x, y)	x+1, y
x-1, y-1	x, y-1	x+1, y-1



P

Computer Graphics

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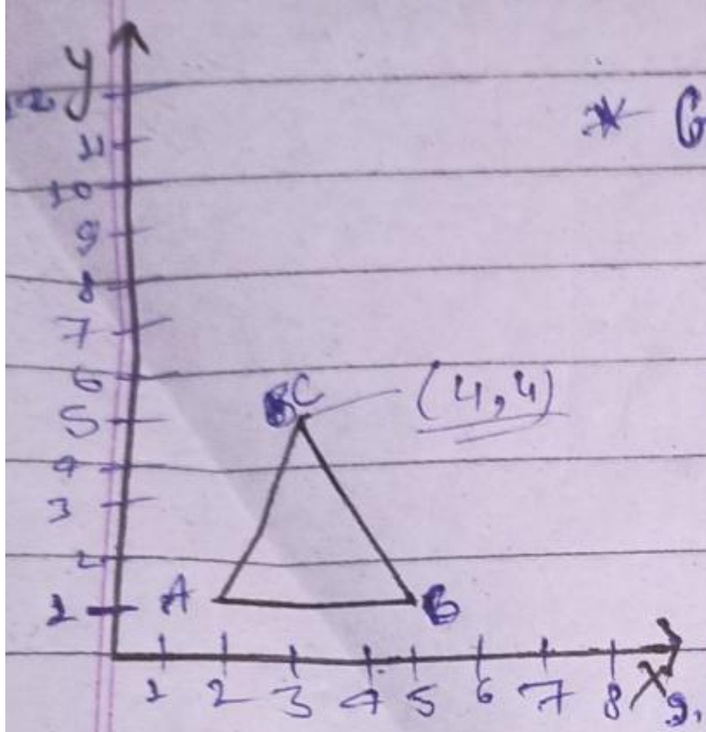
* **Numerical :-** Translate the give polygon. According to ~~start~~ Start values

* Distance :- (x) 4 Unit in 'x' coordinate
(y) 2 Unit in 'y' coordinate

* Given, $A = (2,1)$; $B = (5,1)$; $C = (4,4)$



[Sol^n] we have,

$$[A' = A + T]$$

$$[A'] = \begin{bmatrix} 2 \\ 1 \end{bmatrix} + \begin{bmatrix} 4 \\ 2 \end{bmatrix} = \begin{bmatrix} 6 \\ 3 \end{bmatrix}$$

$$[B' = B + T]$$

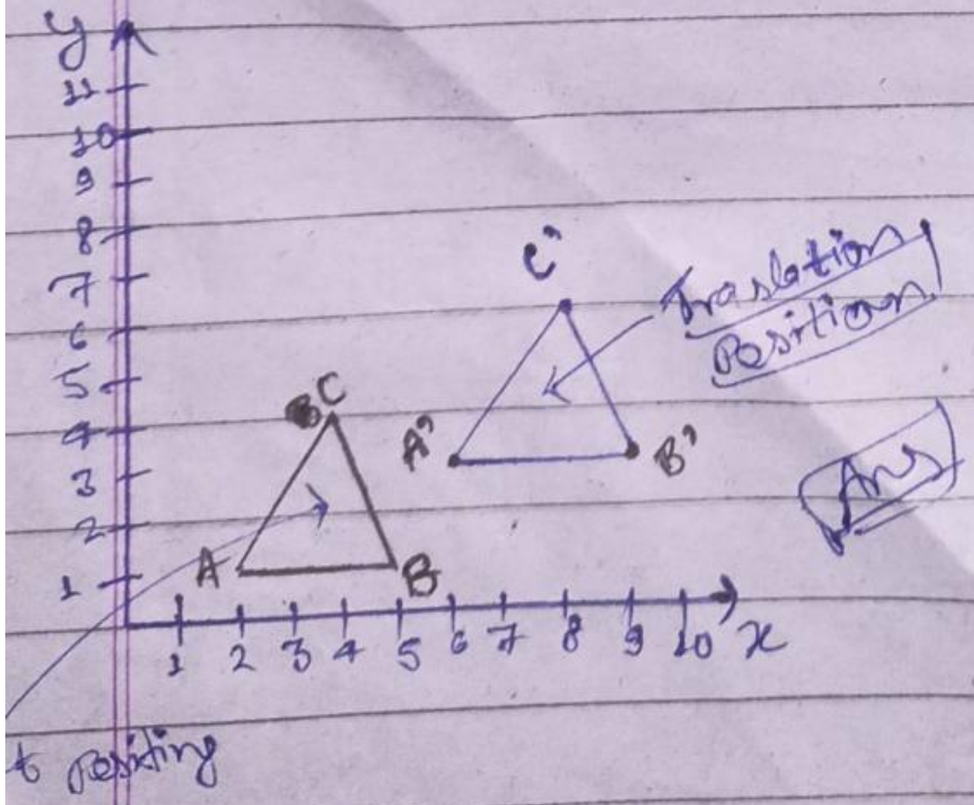
$$[B'] = \begin{bmatrix} 5 \\ 1 \end{bmatrix} + \begin{bmatrix} 4 \\ 2 \end{bmatrix} = \begin{bmatrix} 9 \\ 3 \end{bmatrix}$$

$$[C' = C + T]$$

$$[C'] = \begin{bmatrix} 4 \\ 4 \end{bmatrix} + \begin{bmatrix} 4 \\ 2 \end{bmatrix} = \begin{bmatrix} 8 \\ 6 \end{bmatrix}$$

[Now] we got All the Three cordinates for Translation :-

$$[A' = (6,3) \quad B' = (9,3) \quad C = (8,6)]$$ Ans



Ans

to Positing

Numerical — Scaling

PART = 2

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Question. Find the Scaling position after apply & plot on graph paper.

A = (3, 2) B = (5, 9) C = (9, 5).

① 'x' unit (3) co-ordinate.
② 'y' unit (4) co-ordinate.

Solution;

Formula :- $[A' = A \cdot S]$

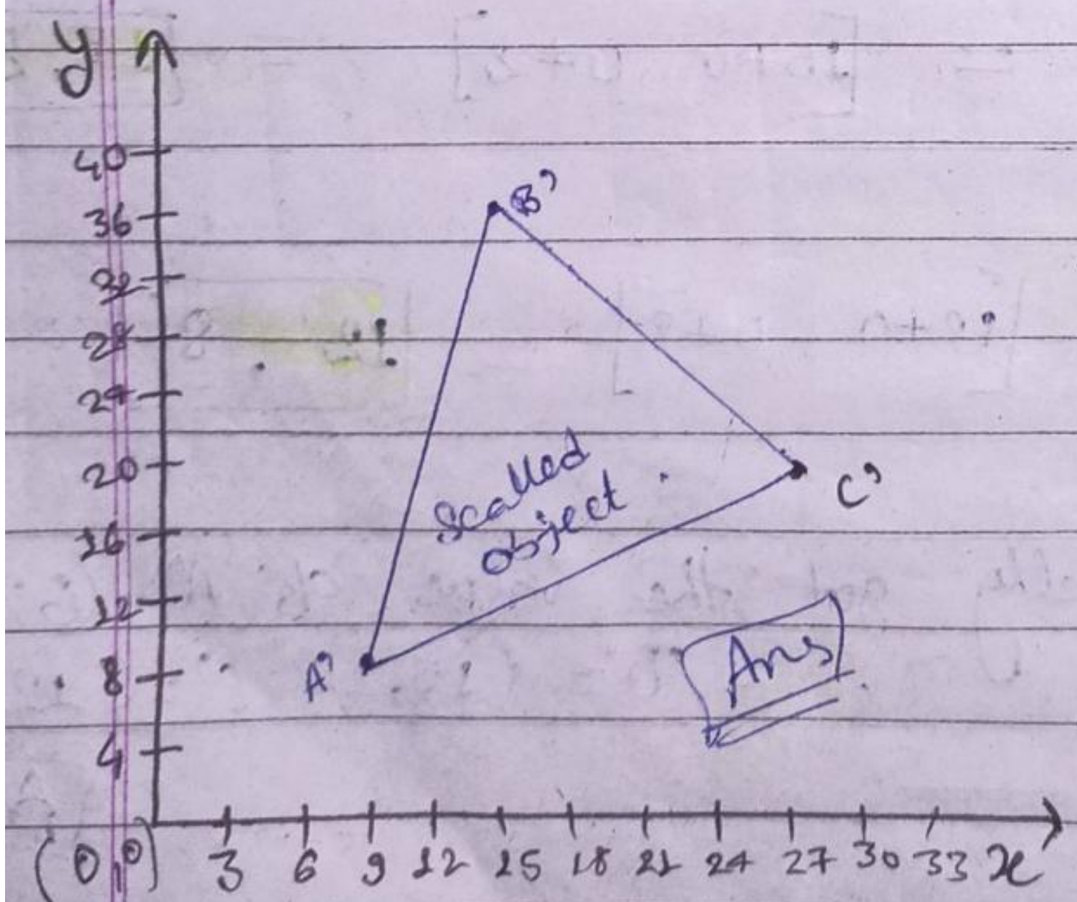
*Given, $S = \begin{bmatrix} 3 & 0 \\ 0 & 4 \end{bmatrix}$

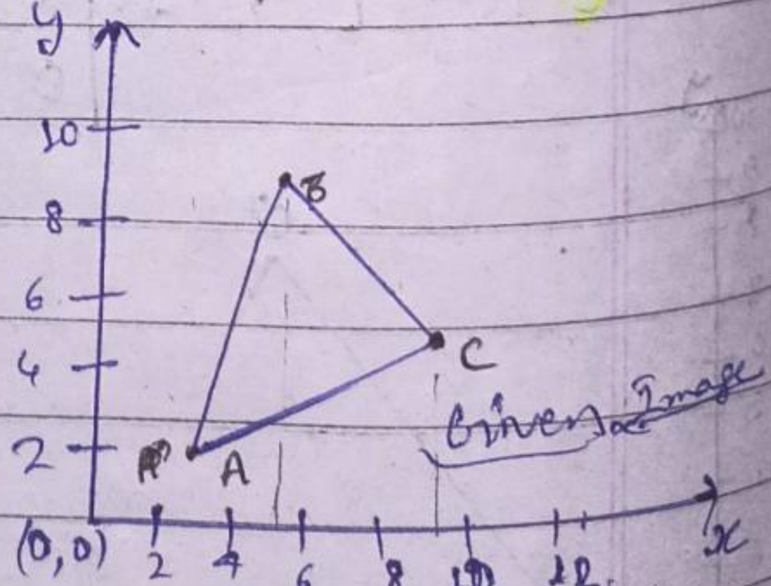
* $A' = [3, 2] \begin{bmatrix} 3 & 0 \\ 0 & 4 \end{bmatrix} = [9, 8]$

* $B' = [5, 9] \begin{bmatrix} 3 & 0 \\ 0 & 4 \end{bmatrix} = [15, 36]$

* $C' = [9, 5] \begin{bmatrix} 3 & 0 \\ 0 & 4 \end{bmatrix} = [27, 20]$

⇒ we got all : A' = (9, 8) B' = (15, 36) C' = (27, 20)





Rotation:- Numerical

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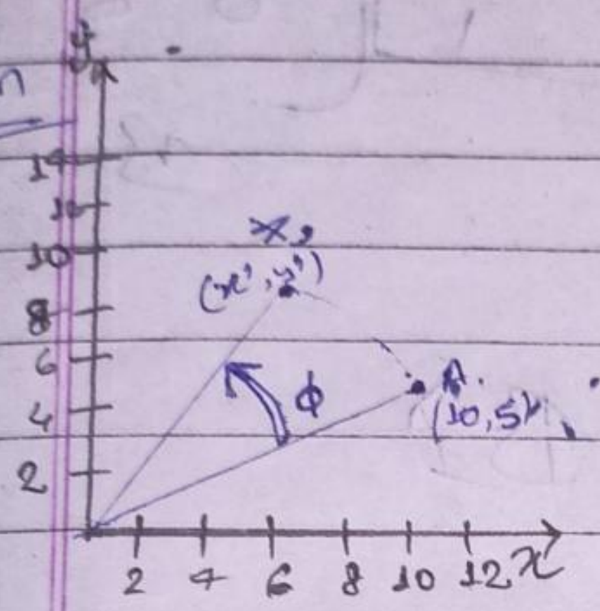
Ques Perform 2-D Rotation according to give value - co-ordinate :-

A (10, 5) ; ϕ 45° - [Anti-Cl.wise]



Given;

A (10, 5) ; $\phi = 45°$

We Know:-

$$[A' = A \cdot R]$$

$$[x'\ y'] = [x, y] \begin{bmatrix} \cos\phi & \sin\phi \\ -\sin\phi & \cos\phi \end{bmatrix}$$ — (45° given)

$$= [10\ 5] \times \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}_{2\times 2}$$

$$= \left[\frac{10}{\sqrt{2}} - \frac{5}{\sqrt{2}} \quad \frac{10}{\sqrt{2}} + \frac{5}{\sqrt{2}}\right]$$

$$= \left[\frac{5}{\sqrt{2}} \quad \frac{15}{\sqrt{2}}\right]$$ Answer

$$(x', y') = [3.5, 10.6]$$

For clock-wise :-

$$= [10,5] \begin{bmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}$$

$$= \left[\frac{10}{\sqrt{2}} + \frac{5}{\sqrt{2}} \quad -\frac{10}{\sqrt{2}} + \frac{5}{\sqrt{2}}\right]$$

$$= \left[\frac{15}{\sqrt{2}} \quad \left(-\frac{5}{\sqrt{2}}\right)\right]$$ Answer

	(0)	(30)	(45)
Sin θ	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$
Cos θ	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$

HOMOGeneous Co-Ordinate

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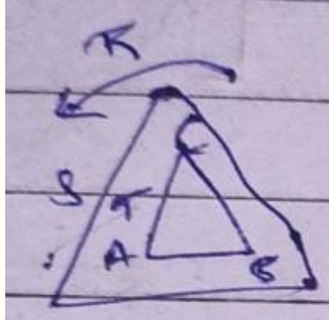
Method used for multiple operations on on object.

Translation

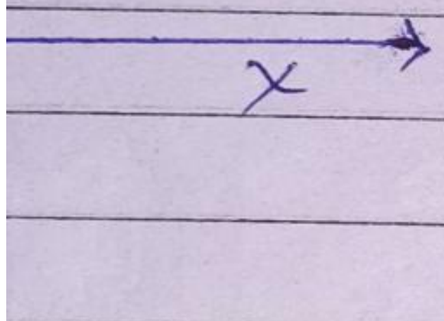
$$T_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ t_x & t_y & 1 \end{bmatrix}$$



$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & T_x \\ 0 & 1 & T_y \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

(1) Can be no negative value

Scaling



$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Rotation

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

(1) Xaxis (1) or (-

Xaxis -
(-1) or

* Composite Transformation :-

* 2-D comb. of Translation, rotation & Sc

Shear

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & Sh_y & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Reflection Numerical

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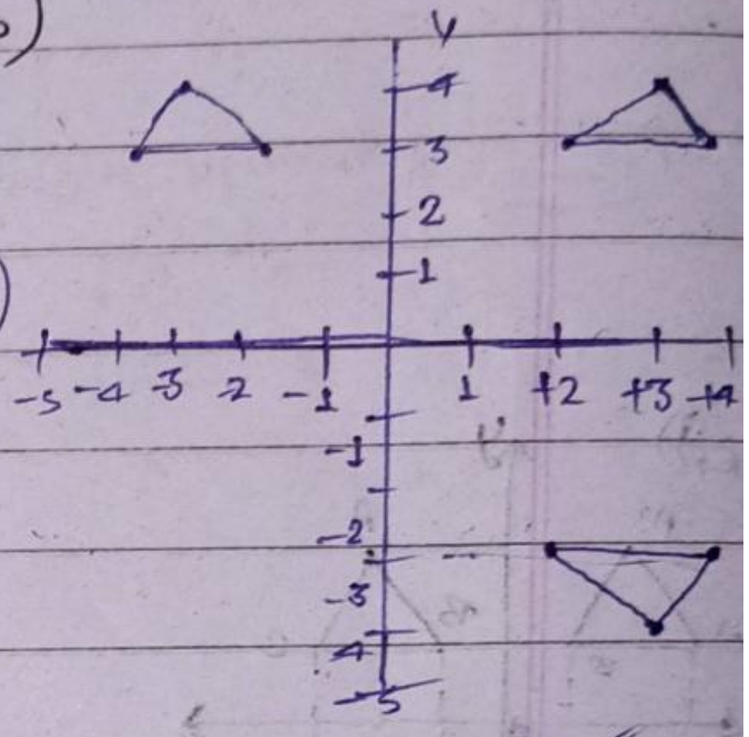
*Question :- 1st

1

Q① Find the reflected image of given co-ordinates on the X-axis plane. ② Y-axis.

A(3,4) B(2,3) C(4,3)



① Ans

Given :-

A(3,4), B(2,3), C(4,3)

$$A' = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} [3,4] = [3, -4]$$

$$B' = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} [2,3] = [2 \quad -3]$$

$$C' = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} [4,3] = [4 \quad -3]$$

△ Reflection co-ordinate on the X axis :-

A' = (3, -4) B' = (2, -3) C' = (4, -3) Answer

△ on y-axis

② Sol^m

Given, & we know :- $A' = R * A$,

A(3,4) ; B(2,3) C(4,3)

$$A' = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} * [3 \quad 4] = [-3 \quad 4]$$

$$B' = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} * [2 \quad 3] = [-2 \quad 3]$$

$$C' = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} * [4 \quad 3] = [-4 \quad 3]$$

△ Reflection co-ordinate on the Y-axis :-

A' = (-3, 4), B' = (-2, 3), C' = (-4, 3)

Answer

Numerical ON Shearing

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Question Apply shearing methode on given co-ordinate A(2,2) ; B(1,1) , C(3,1). X-axis & Y-axis.

Sol^n Given;

A(2,2), B(1,1), C(3,1)

* $Sh_x = 1$; $Sh_y = 1$

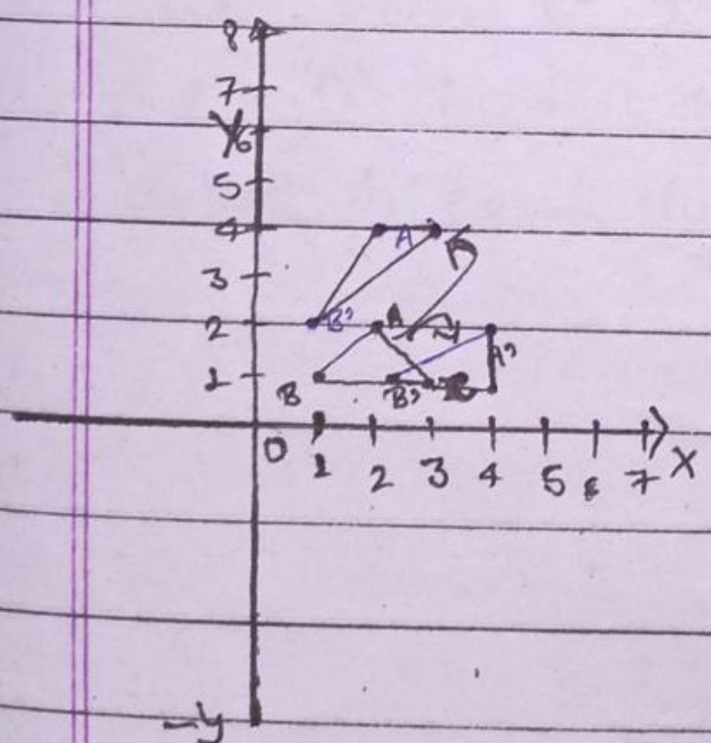
[X-axis]

$$A' = \begin{bmatrix} 1 & Sh_x \\ 0 & 1 \end{bmatrix} * \begin{bmatrix} 2 \\ 2 \end{bmatrix} = [2+2 \quad 0+2]$$

$$B' = \begin{bmatrix} 1 & Sh_x(1) \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} = [2 \quad 1]$$

$$C' = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 3 \\ 1 \end{bmatrix} = [4 \quad 1]$$

▷ Final Shearing co-ordinates :- A' = (4, 2) B' = (2, 1) C' = (4, 1)



[Y-Axis] Given $Sh_y = 1$ $Sh_x = 1$

$$A' = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} * \begin{bmatrix} 2 \\ 2 \end{bmatrix} = [2 \quad 4]$$

$$B' = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} * \begin{bmatrix} 1 \\ 1 \end{bmatrix} = [1 \quad 2]$$

$$C' = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} * \begin{bmatrix} 3 \\ 1 \end{bmatrix} = [3 \quad 4]$$

* 3-D Translation

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▸ Example Question

Question:- Translate the given object in 3-D

Translation :-

A(0, 3, 6) B(4, 5, 9) C(3, 4, 8)

* Tx = 3unit Ty = 2unit Tz = 4 unit

Sol^n Give,

A(0, 3, 6) B(4, 5, 9) C(3, 4, 8).

* Tx = 3unit , Ty = 2unit * Tz = 4unit.

* We have :-

$$A' = \begin{bmatrix} 0 \\ 3 \\ 6 \end{bmatrix} + \begin{bmatrix} 3 \\ 2 \\ 4 \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \\ 10 \end{bmatrix}$$

$$B' = \begin{bmatrix} 4 \\ 5 \\ 9 \end{bmatrix} + \begin{bmatrix} 3 \\ 2 \\ 4 \end{bmatrix} = \begin{bmatrix} 7 \\ 7 \\ 13 \end{bmatrix}$$

$$C' = \begin{bmatrix} 3 \\ 4 \\ 8 \end{bmatrix} + \begin{bmatrix} 3 \\ 2 \\ 4 \end{bmatrix} = \begin{bmatrix} 6 \\ 6 \\ 12 \end{bmatrix}$$

▸ we got the Translation value of co-ordinate :-

A' = (3, 5, 10) B' = (7, 7, 13) C' = (6, 6, 12)

3-D Scaling

Example:- Numerical

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Ques Perform 3-D Scaling on given co-ordinate.

n Given;

A(3, 1, 2) B(1, 2, 1) C(0, 1, 1)

* S_x = 2 unit S_y = 1 unit S_z = 3 unit.

Sol

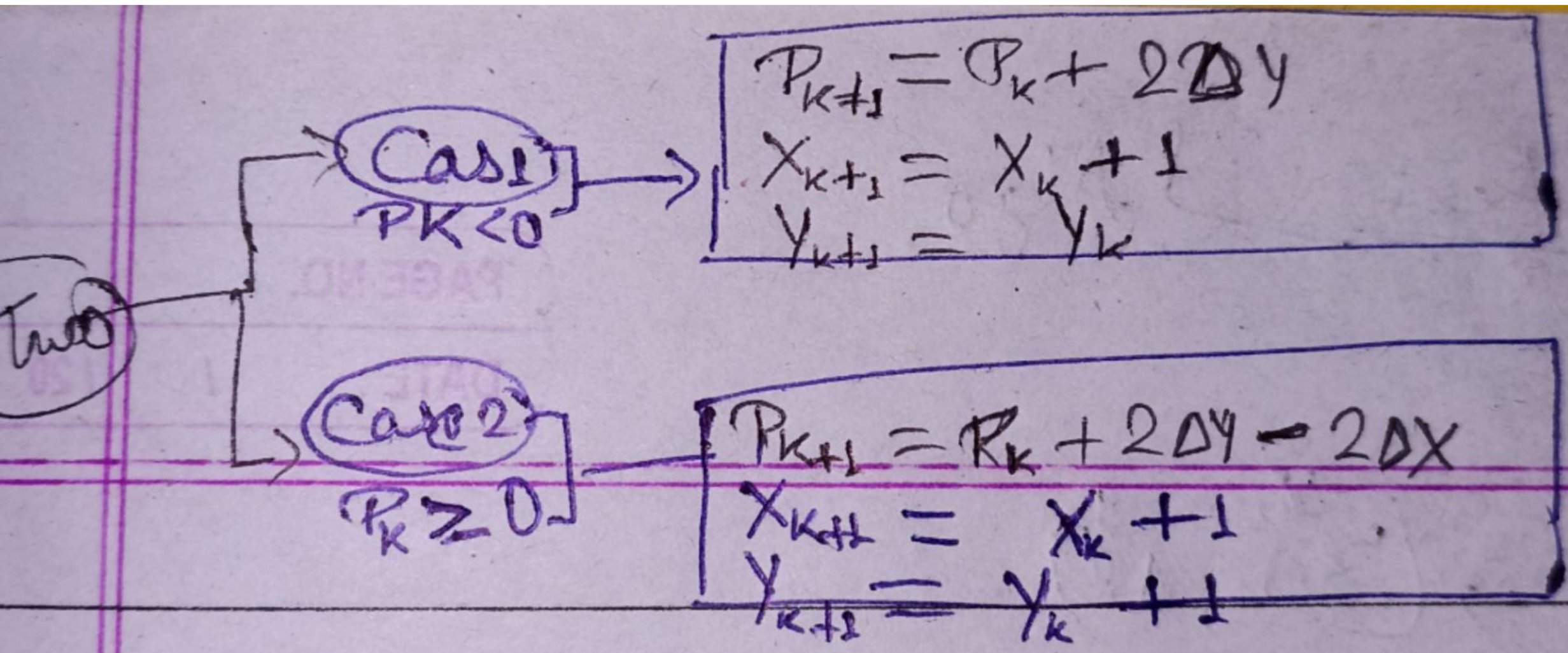
$$A' = \begin{bmatrix} x' = x \cdot S_x = 3 \times 2 = 6 \\ y' = y \cdot S_y = 1 \times 1 = 1 \\ z' = z \cdot S_z = 2 \times 3 = 6 \end{bmatrix} \quad A' = (6,1,6)$$

$$B' = \begin{bmatrix} x' = x \cdot S_x = 1 \times 2 = 2 \\ y' = y \cdot S_y = 2 \times 1 = 2 \\ z' = z \cdot S_z = 1 \times 3 = 3 \end{bmatrix} \quad B' = (2,2,3)$$

$$C' = \begin{bmatrix} = 0 \times 2 = 0 \\ = 1 \times 1 = 1 \\ = 1 \times 3 = 3 \end{bmatrix} \quad C' = (0,1,3),$$

▷ Final Scaling co-ordinates is :-

$A' = (6,1,6)$ $B' = (2,2,3)$ $C' = (0,1,3)$



BRESENHAM Line Algo

Circle Drawing (mid point)

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* Step 1:- $X_1 = 0$ (Given) $Y_1 = R$ ∴ Given $(X_1 = 0, Y_1 = 0)$

* Step 2:- $P_1 = 3 - 2 \times R$

* Step 3:- Suppose the current point is (X_k, Y_k) & the Next point is (X_{k+1}, Y_{k+1}).
  * Find (P_k)

Two case

Case 1: $P_k < 0$

$X_{k+1} = X_k + 1$; $Y_{k+1} = Y_k$

$P_{k+1} = P_k + 4 * X_{k+1} + 6$

Case 2: $P_k >= 0$

$X_{k+1} = X_k + 1$; $Y_{k+1} - 1$

$P_{k+1} = P_k + 4 * (X_{k+1} - Y_{k+1}) + 10$

* Step (4) Additional → If centre point is No (0,0) then Do the given:-
  - $X_{plot} = X_c + X_0$ (Current X, given mid point X)
  - $Y_{plot} = Y_c + Y_1$ (Current Y, given mid point Y)

(P=1) Given the centre $(X_0, Y_0) = (0, 0)$ radius = 8

Sol^n

(1) $X_1 = 0$
$Y_1 = R = 8$ $(x_1, y_1) = (0, 8)$

(2nd) $P_1 = 3 - 2 \times R = 3 - 2 \times 8 = -13$

(3rd) $P_1 = -13 < 0$ ✓

$X_{k+1} = X_k + 1 = 0 + 1 = 1$

$Y_{k+1} = Y_k = 8$

$P_{k+1} = P_k + 4 * X_{k+1} + 6 = -13 + (4 * 1) + 6 = -3$

G 1

video display devices, Physical & logical i/p devices, simple color models

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COMPUTER GRAPHICS

help

→ Computer graphics deals with generating images with the aid of computers. It is core Technology in digital photography, film, video games, cell phone & computer displays, & many specialized applications.

* Application:- Used in UI design, rendering, geometric object animation, etc. (<Graphic.h> Header file)

Δ C.G refers to several things:-

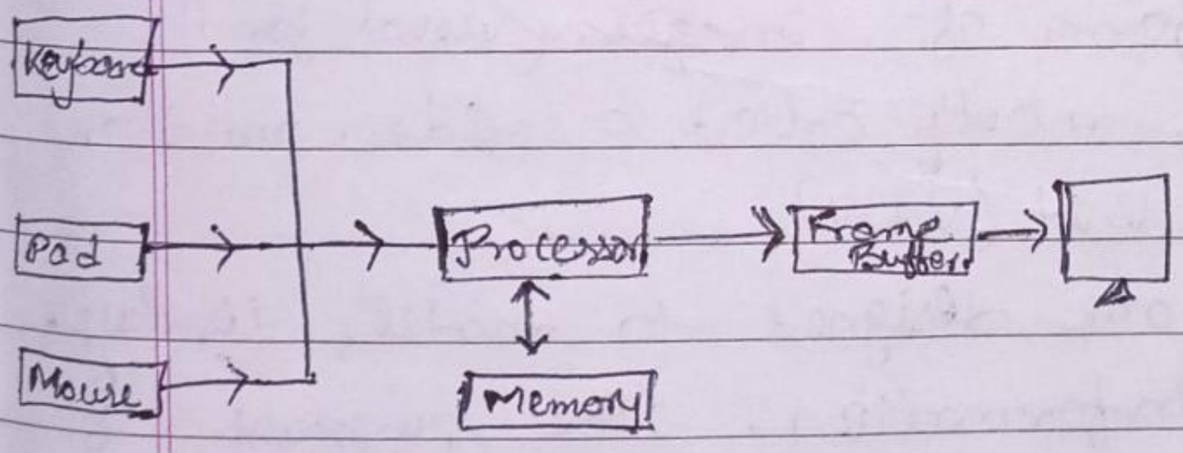
- The manipulation of the representation of the image or the data in a graphical manner.
- Various technology is required for the creation & manipulation.
- Digital Synthesis and its Manipulation.

संश्लेषण / संयोजन

↳ हेरफेर / बनावटी

* Graphics System *

1. processor 2. Memory 3. Frame Buffer
4. Output device 5. Input device.



Raster & Vector

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* Two types of C.G. :- 1) Raster 2) Vector.

- **Raster** :, Graphics pixels are used for an image to be drawn. It is also known as a bitmap image in which a sequence of images is into smaller pixels. Basically, a Bit map indicates a large number of pixels together

- **Vector** :- In this, Mathematical formulae are used to draw different types of shapes, lines, objects, & so on.

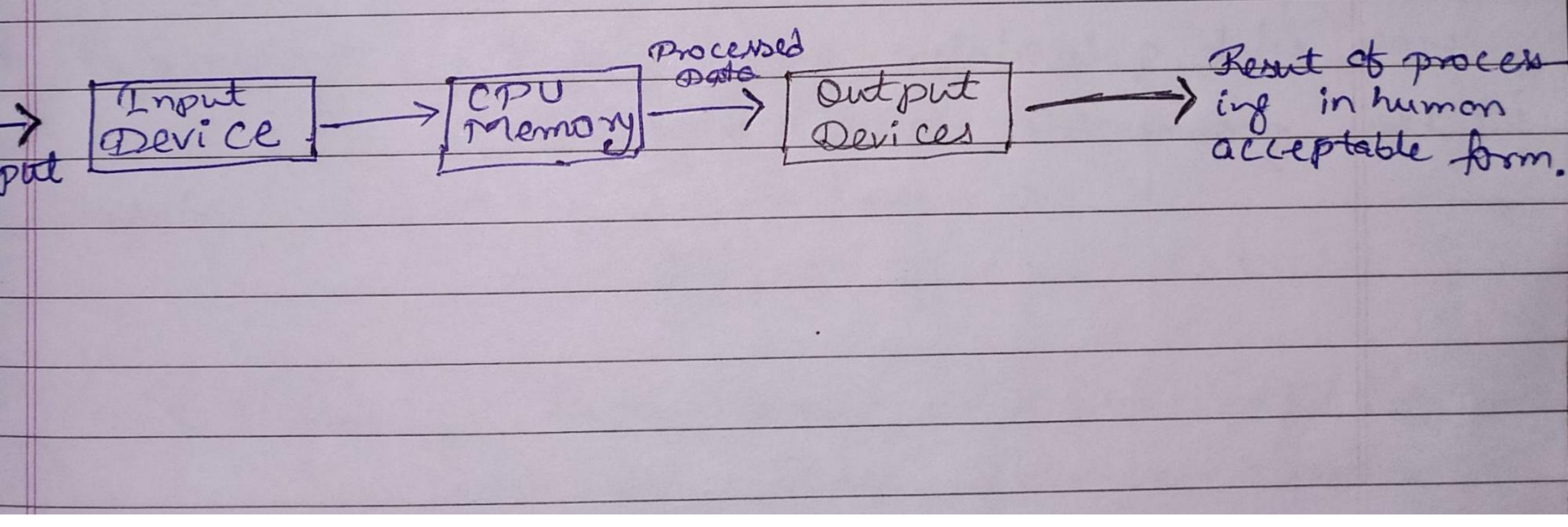
Note:- C.G **Application** :- • Computer Art • Entertainment
• used in engineering & Architectural System.
• Presentation Graphics • Visualization • Edu. & Train

* **Display Devices in C.G.** :- The display device is an output device used to represent the information in the form of images. (visual form).
Display systems are mostly called a video monitor or display Unit (VDU).
⇒ Displays devices are designed to model, display, view, or display information. The purpose of Display technology is to simplify information sharing.

* There are some Devices below :- • Cathode-Ray-Tube
• Color CRT monitor • 3D display
• plasma Display • Liquid crystal display
• Light Emitting Diode (LED) • Direct view (DVST)

* Physical & logical Devices in C.G:-

▷ Input Devices :- * Keyboard * Mouse * Joystick
* Trackball * Data Glove * Digitizers
* Image Scanners * Light pen * Touch panal.



* **Pixel** :- Smallest part of a particular screen, can further divide, it.
Broken

* **Resolution** :- It is the Number of pixels contained on a display monitor. (Width X Height)

* **PPI** :- (Pixels per Inch) refers display resolution, or how many individual pixels are displayed in one inch of a digital image

FORM

* Aspect Ratio :- refers to the relationship b/w something's WIDTH and HEIGHT, and commonly used to describe computer and TV screens etc.

W
H

W : H

* Frame Buffer :- is a large contiguous piece of memory where the image is stored as a pattern of bits
→ Amount of frame buffer memory required depends on the resolution of the screen.