FRANKLIN'S LECTURES

S6 First Series MARATHON

COMPUTER GRAPHICS & IMAGE PROCESSING

Module 1

CST304

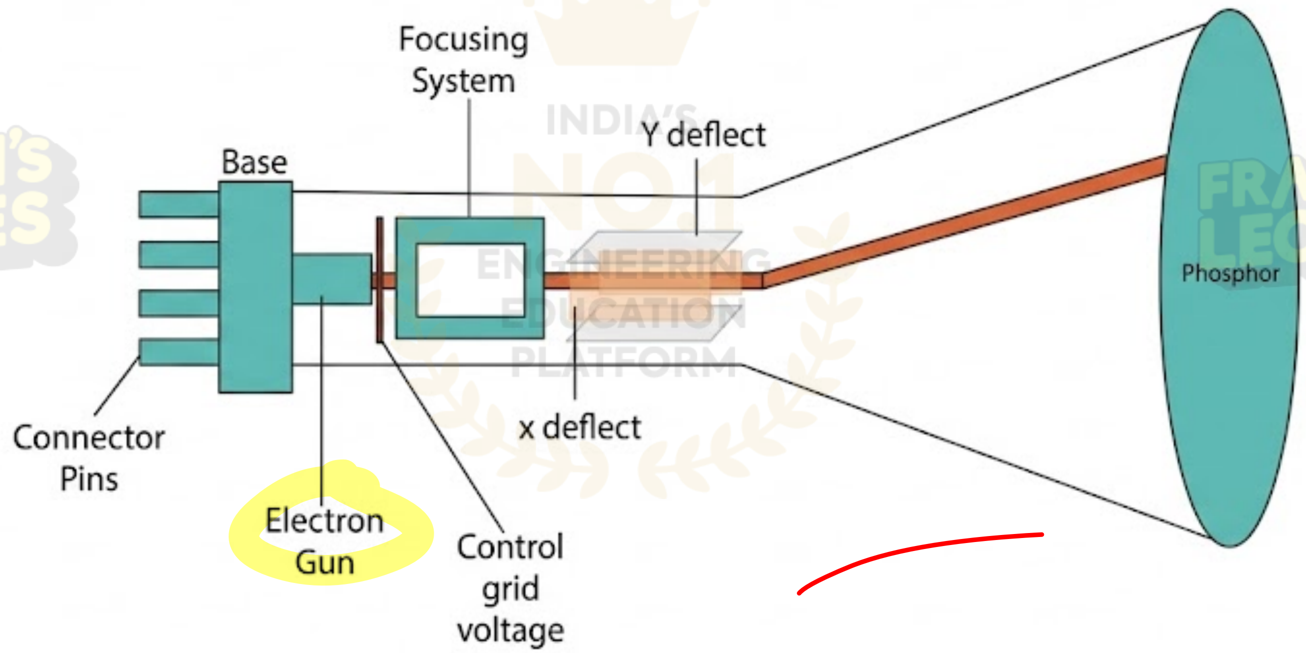
Q. Write any three applications of computer graphics

1. Graphical User Interface
2. Computer Art
3. Computer-Aided Design
4. Education and Training
5. Presentation Graphics
6. Entertainment
7. Image Processing

Q. Compare DDA and Bresenham's line drawing algorithm

DDA	Bresenham line Algorithm
DDA stands for Digital Differential Analyzer.	While it has no full form.
DDA algorithm is less efficient than Bresenham line algorithm.	While it is more efficient than DDA algorithm.
DDA algorithm has less precision or accuracy.	While it has more precision or accuracy.
DDA algorithm round off the coordinates to integer that is nearest to the line	Bresenhams algorithm does not round off but takes the incremental value in its operation.

Q. Describe the working principle of a Refresh CRT monitor with suitable diagram



Cathode Ray Tube

The basic CRT consists of 4 major components

- Electron gun
- Focusing and accelerating anode
- Horizontal and vertical deflection plates
- Evacuated glass envelop

- It is an evacuated glass tube.
- An electron gun at the rear of the tube produce a beam of electrons which is directed towards the screen of the tube by a high voltage typically 15000 to 20000 volts
- Inner side screen is coated with phosphor substance which gives light when it is stroked bye electrons.
- 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. The negative the control voltage is the fewer the electrons that pass through the grid.

- Thus control grid controls Intensity of the spot where beam strikes the screen.
- The focusing system concentrates the electron beam so it converges to small point when hits the phosphor coating.
- Deflection system directs beam which decides the point where beam strikes the screen.
- Deflection system of the CRT consists of two pairs of parallel plates which are vertical and horizontal deflection plates.
- Voltage applied to vertical and horizontal deflection plates is control vertical and horizontal deflection respectively.

Q. Calculate the points between the starting point (9, 18) and ending point (14,22) Bresenham's line drawing algorithm.

$(9, 18)$ — $x_0 \; y_0$

$(14, 22)$ — $x_n \; y_n$

$\Delta x = x_n - x_0$
$= 14 - 9$
$= \underline{\underline{5}}$

$\Delta y = y_n - y_0$
$= 22 - 18$
$= \underline{\underline{4}}$

Calculate decision parameter

$$P_k = 2\Delta y - \Delta x$$

$$= 2 \times 4 - 5$$

$$\boxed{P_k = 3}$$

$P_k \geq 0$

$$P_{k+1} = P_k + 2\Delta y - 2\Delta x$$

$$x_{k+1} = x_k + 1$$

$$y_{k+1} = y_k + 1$$

$P_k < 0$

$$P_{k+1} = P_k + 2\Delta y$$

$$x_{k+1} = x_k + 1$$

$$y_{k+1} = y_k$$

P_k	P_{k+1}	x_{k+1}	y_{k+1}
		9	18
3	$P_k + 2\Delta y - 2\Delta x$ $= 3 + 2\times 4 - 2\times 5$ $= \underline{\underline{1}}$	$9+1=10$	$18+1=\underline{\underline{19}}$
1	$=1+2\times 4-2\times 5$ $= \underline{\underline{-1}}$	$10+1=\underline{\underline{11}}$	$19+1=\underline{\underline{20}}$
-1	$P_k + 2\Delta y$ $= -1 + 2\times 4$ $= \underline{\underline{7}}$	$11+1=\underline{12}$	$\underline{20}$

7	$7+2\times4-2\times5$ $=5$	$12+1=13$	$20+1$ $=21$
5	$5+2\times4-2\times5$ $=3$	$13+1=14$	$21+1$ $=22$

(9,18), (10,19),
(11,20), (12,20),
(13,21)
(14,22)

Q. Explain the beam penetration & shadow mask method for displaying colour pictures.

- **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.

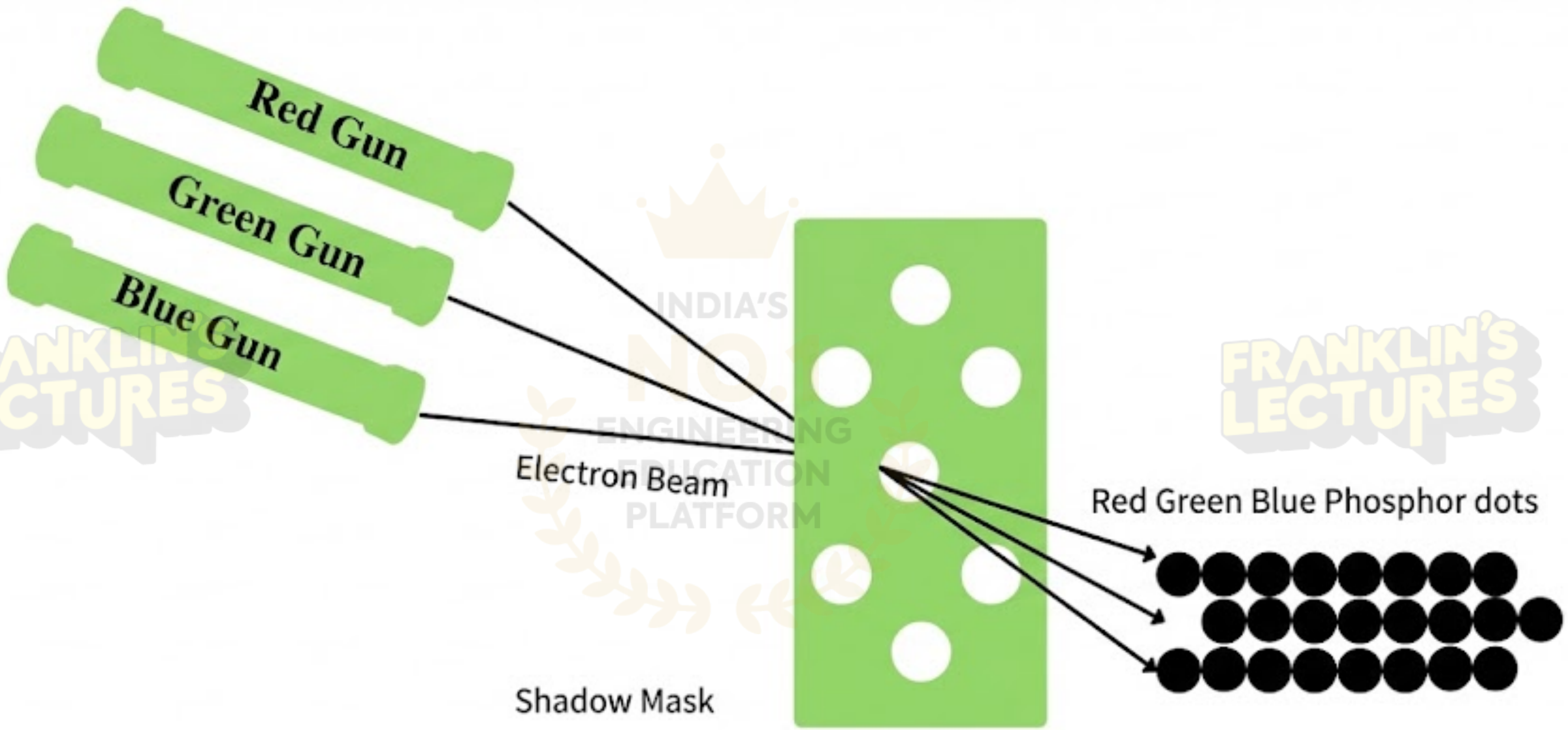
- A beam of fast electron penetrates more and excites inner green layer while slow electron excites outer red layer.
- At intermediate beam speed we can produce combination of red & green lights which emit additional two colors orange & yellow.
- The beam acceleration voltage controls the speed of the 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.

• Shadow-mask technique

- Shadow Mask Technique in Computer Graphics is commonly used in raster-scan systems (including color TV) because they produce a much wider range of colors than the Beam Penetration Method.
- It has three phosphor color dots at each pixel position. The first phosphor dot emits a red light, the second one emits a green light and the third emits a blue light.
- The phosphor transforms the Kinetic Energy of the electrons into Light Energy

- The Shadow Mask Technique involves the usage of three electron guns, one for each color dot, & a shadow-mask grid just behind the phosphor-coated screen.


Red Gun
Green Gun
Blue Gun
Electron Beam
Red Green Blue Phosphor dots
Shadow Mask

Q. Plot the circle with centre (5,3) & radius 5 using Bresenham's circle drawing algorithm. Show the steps in detail.

Centre (5, 3)

Radius = 5

x y

Initial point (0, 5)

Decision Parameter

$P = 3 - 2r$

$= 3 - 2 \times 5$

$\boxed{P = -7}$

Case 1

$P_k < 0$

$P_{k+1} = P_k + 4x + 6$

$x_n = x + 1$

$y_n = y$

Case 2

$P_k > 0$

$P_{k+1} = P_k + 4(x-y) + 10$

$x_n = x + 1$

$y_n = y - 1$

P	$x = 0$	$y = 5$	(x_{plot}, y_{plot})
$3 - 2x$ $= 3 - 2 \times 5$ $= -7$	$x + 1$ $= 0 + 1 = 1$	5	$(1, 5)$
$-7 + 4 \times 0 + 6$ $= -1$	$1 + 1 = 2$	5	$(2, 5)$
$-1 + 4 \times 1 + 6$ $= 9$	$2 + 1 = 3$	$5 - 1$ $= 4$	$(3, 4)$

$= 9 + 4(2-5) + 10$

$= \underline{\underline{7}}$

$3 + 1$

$= 4$

$4 - 1$

$= 3$

$(4, 3)$

$\downarrow$

(x, y)

stop

$(0, 5)\ (1, 5)\ (2, 5)\ (3, 4)$

Q. Explain the pixel, resolution and aspect ratio of a display screen.

- ~~Beam penetration technique~~ Pixel

  A pixel, short for "picture element," is the smallest point or dot that can be displayed on a screen.

  - Function: Each pixel is assigned a specific color and brightness, and the combination of all pixels forms the complete image.

- **Resolution**
  - Definition: Resolution is the number of pixels in both the horizontal and vertical dimensions of the screen.
  - Expression: It is expressed as a pair of numbers, such as (Full HD), where the first number is the width in pixels & the second is the height.

1920 x 1080

↓ Horizontal

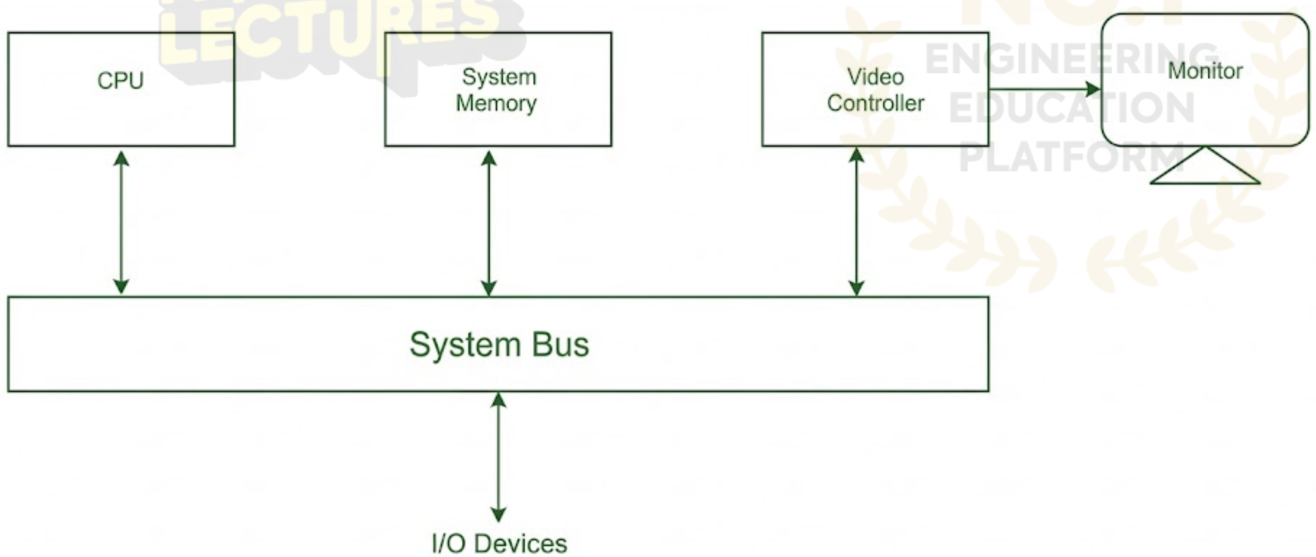
↓ vertical

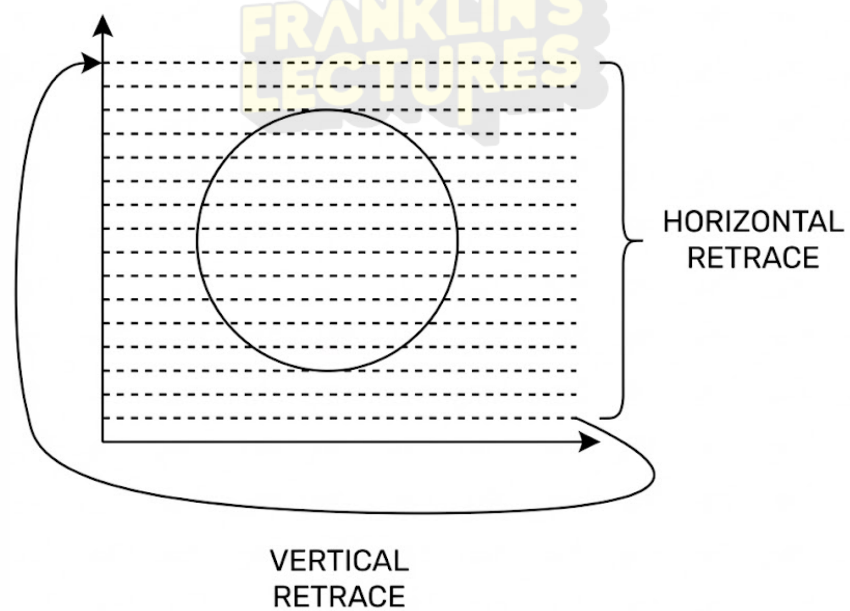
- **Aspect Ratio**
  - Definition: The aspect ratio is the ratio of an image's width to its height.
  - Expression: It is expressed as a ratio, such as 16:9 (widescreen) or 4:3 (older standard).

Q. Explain the working of the raster scan system with suitable figure

Raster scan display

Simple architecture





- Raster Scan Displays are most common type of graphics monitor which employs CRT.
- It is based on television technology. In raster scan system electron beam sweeps across the screen, from top to bottom covering one row at a time.
- A pattern of illuminated pattern of spots is created by turning beam intensity on and off as it moves across each row. A memory area called refresh buffer or frame buffer stores picture definition.

- This memory area holds intensity values for all screen points.
- Stored intensity values are restored from frame buffer and painted on screen taking one row at a time.Each screen point is referred to as pixels.

Q. Apply the Digital Differential Analyzer (DDA) Algorithm to draw a line between the points (2, 4) & (7, 8). Show step-by-step calculations & determine the intermediate pixel positions plotted.Find out and discuss the advantages and disadvantages of this method.

$(2, 4) \quad (7, 8)$

$x_1 \quad y_1 \quad x_2 \quad y_2$

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

$$= \frac{8 - 4}{7 - 2} = 0.8$$

$$\boxed{m = 0.8}$$

Case 1

If $m < 1$

$y_{k+1} = y_k + m$

$x_{k+1} = x_k + 1$

Case 2

If $m > 1$

$x_{k+1} = x_k + \frac{1}{m}$

$y_{k+1} = y_k + 1$

Case 3

If $m = 1$

$x_{k+1} = x_k + 1$

$y_{k+1} = y_k + 1$

$m = 0.8$

$x_k = 2$

$y_k = 4$

No	x_{k+1}	y_{k+1}	Round (x_k, y_k)
0	2	4	(2, 4)
1	2+1=3	4 + 0.8 = 4.8	(3, 5) ✓
2	3+1=4	4.8+0.8 = 5.6	(4, 6) ✓
3	4+1=5	5.6+0.8 = 6.4	(5, 6) ✓
4	5+1=6	6.4+0.8 = 7.2	(6, 7) ✓
5	6+1=7	7.2+0.8=8	(7, 8)

(2, 4), (3, 5), (4, 6), (5, 6), (6, 7)

(7, 8).

Q. How many bits are required for 1024 x 1024 raster with each pixel being represented by 24 bits ?

Total no of pixels $= 1024 \times 1024$

$= 1,048,576$ pixels

Bits required for 1 pixel

Bits per pixel $= 24$ bits

Total bits $= 1048,576 \times 24$

$= 25,165,824$ bits

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Module 2

CST304

Q. Differentiate between boundary filling and flood filling algorithms.

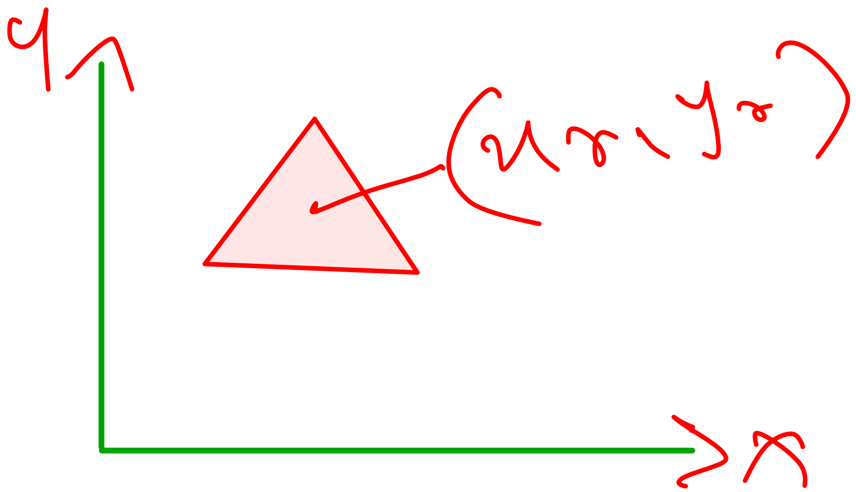
Boundary Fill Algorithm	Flood Fill Algorithm
Fills an area until a specified boundary color is encountered	Fills an area by replacing a target (interior) color
Stops when boundary color is reached	Stops when pixel color is not the target color
Yes (boundary must be defined)	No boundary color required
Interior color can be anything	Interior region must have the same color
Uses boundary color and fill color	Uses target color and replacement color
Closed shapes with clearly defined boundaries	Areas with uniform color regions

Q. List the steps for general pivot point rotation.

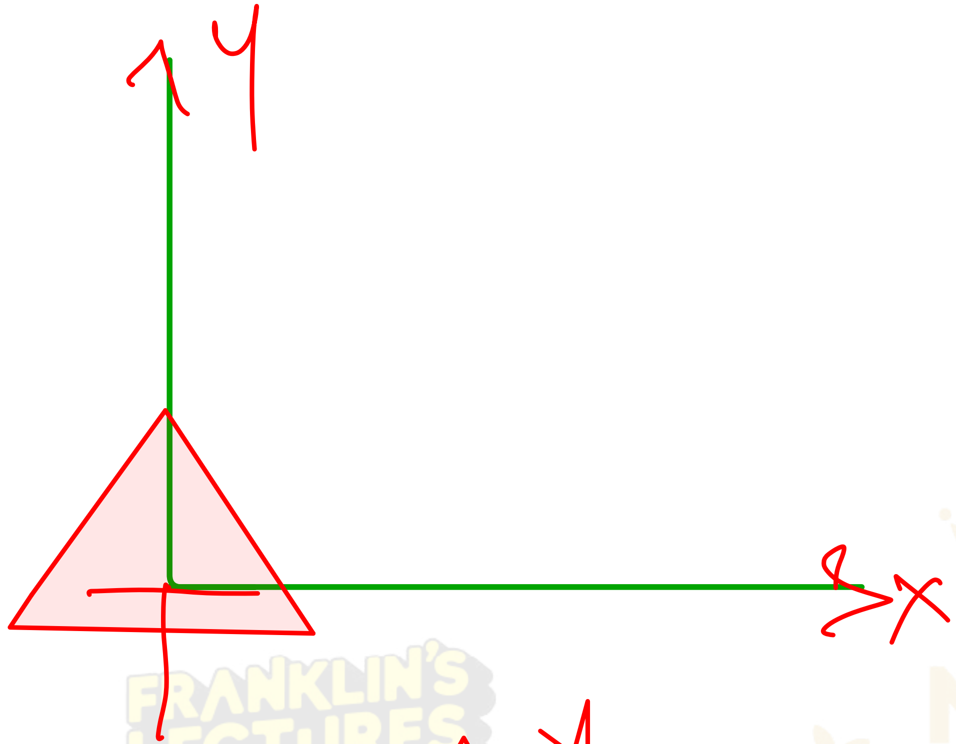
STEP 1:Translate the object so that pivot point position is moved to the coordinate origin.

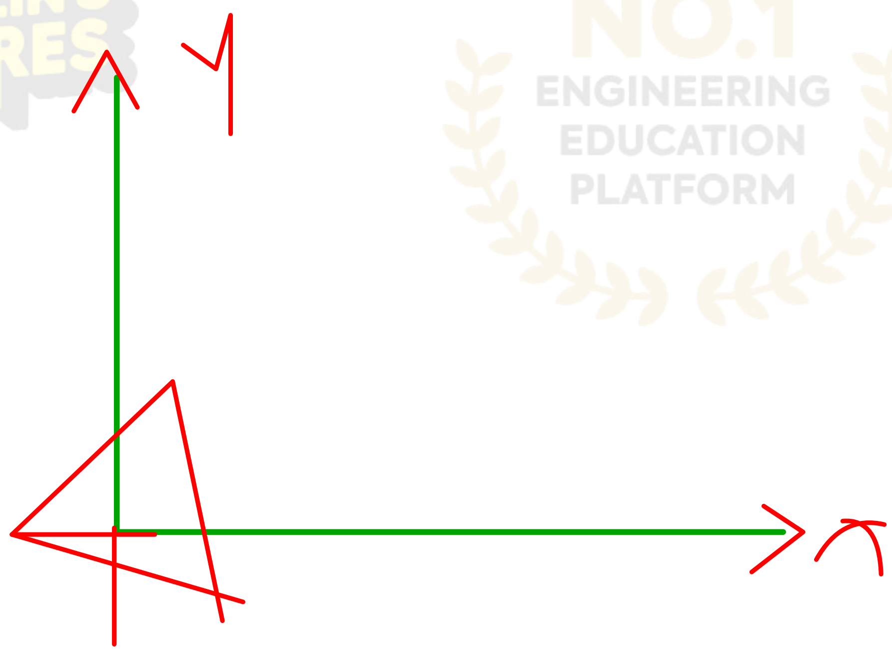
STEP 2:Rotate the object about the coordinate origin

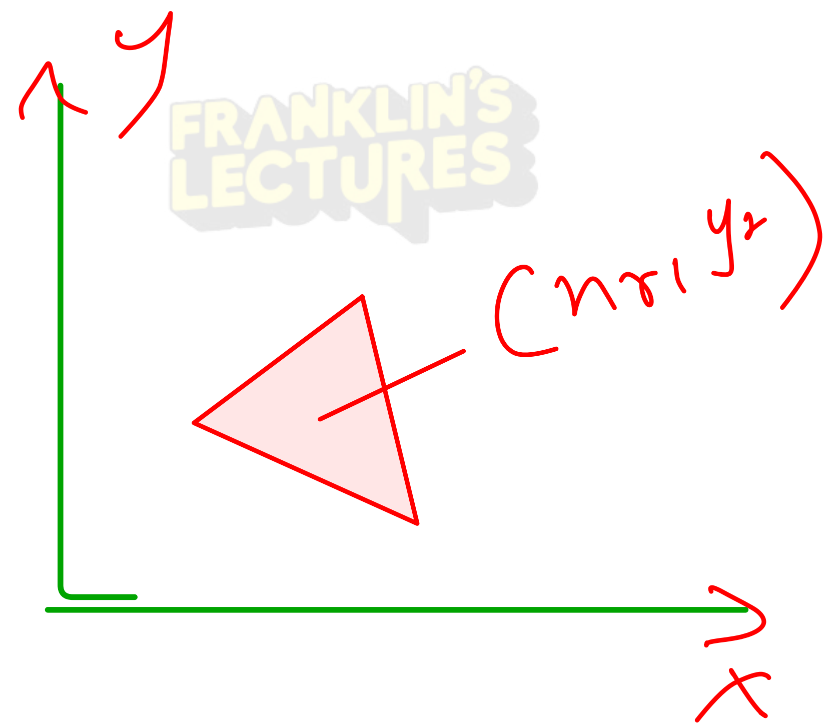
STEP 3:Translate the object so that pivot point is returned to original position



→ Original position


y
x


y
x


y
(x_r, y_r)
x

Q. List the fundamental types of 3D transformations in computer graphics.

- Translation: Moves an object by adding constant offsets to its x, y, and z coordinates.
- Rotation: Rotates an object around a specific axis (x, y, or z) by applying rotation matrices.
- Scaling: Enlarges or shrinks an object by multiplying its coordinates by scaling factors, either uniformly or non-uniformly.

- Reflection: Mirrors an object across a plane, effectively flipping its coordinates on one or more axes.
- Shearing: Skews an object by shifting coordinates in proportion to their distance from a reference plane, altering its shape.

Q. A triangle with vertices A(2, 3), B(5, 4), and C(4, 1) is rotated counter clockwise by 45° about the origin. Determine the new coordinates of the triangle after rotation.

$A(\underset{x}{2}, \underset{y}{3})$

$x' = x\cos\theta - y\sin\theta$

$= 2 \times \frac{1}{\sqrt{2}} - 3 \times \frac{1}{\sqrt{2}}$

$= \frac{2}{\sqrt{2}} - \frac{3}{\sqrt{2}} = \frac{-1}{\sqrt{2}}$ //

$y' = x\sin\theta + y\cos\theta$

$= 2 \times \frac{1}{\sqrt{2}} + 3 \times \frac{1}{\sqrt{2}}$

$= \frac{5}{\sqrt{2}}$

$A'\left(-\frac{1}{\sqrt{2}}, \frac{5}{\sqrt{2}}\right)$

$B(\underset{x}{5}, \underset{y}{4})$

$$x' = 5 \times \frac{1}{\sqrt{2}} - 4 \times \frac{1}{\sqrt{2}}$$

$$= \frac{1}{\sqrt{2}}$$

$$y' = 5 \times \frac{1}{\sqrt{2}} + 4 \times \frac{1}{\sqrt{2}}$$

$$= \frac{9}{\sqrt{2}}$$

$$B'\left(\frac{1}{\sqrt{2}}, \frac{9}{\sqrt{2}}\right)$$

$C(4, 1)$
$\quad\; x \;\; y$

$x' = 4 \times \frac{1}{\sqrt{2}} - 1 \times \frac{1}{\sqrt{2}}$

$= \frac{4}{\sqrt{2}} - \frac{1}{\sqrt{2}} = \frac{3}{\sqrt{2}}$

$y' = 4 \times \frac{1}{\sqrt{2}} + 1 \times \frac{1}{\sqrt{2}}$

$= \frac{5}{\sqrt{2}}$

$C' \left(\frac{3}{\sqrt{2}}, \frac{5}{\sqrt{2}} \right)$

Q. Explain the Boundary Fill Algorithm, its working principle, and the step-by-step process. Compare the 4-connected and 8-connected approaches, & explain how the 8-connected approach improves over the 4-connected approach.

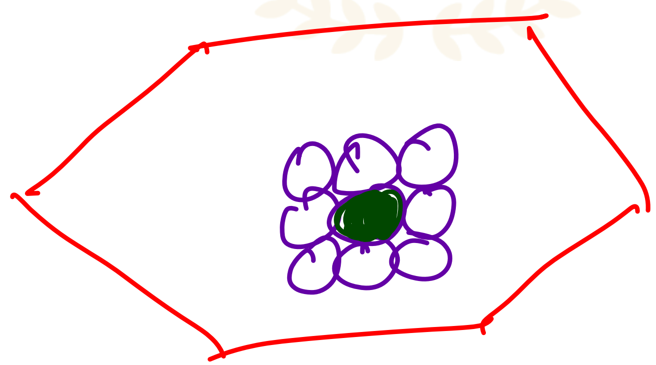
In Boundary fill Algorithm the basic concept is filling the color in closed area by starting at a point inside a region and paint the interior outward towards the boundary.

One requirement for Boundary Fill algorithm is that the boundary has to have a single color.

Working

In Boundary fill algorithm, you start from a point inside the region & fill the color interior outward towards the boundary pixel by pixel.

So the process is that you check the default color of the pixel before filling, if the color is not boundary color, then you fill it with the fill color, and move to the next pixel and check for the same criteria till you encounter the boundary colored pixel or the boundary.



Aspect	4-Connected Approach	8-Connected Approach
Connected neighbors	Only up, down, left, right	Up, down, left, right + 4 diagonals
Number of neighbors	4	8
Diagonal connectivity	Not considered	Considered
Connectivity detection	May treat diagonally touching pixels as disconnected	Correctly treats diagonally touching pixels as connected
Filling accuracy	Less accurate	More accurate
Leakage in fill	Higher chance	Lower chance
Computational cost	Lower	Slightly higher

How 8-Connected Improves Over 4-Connected

- Handles diagonal connections
- Reduces unfilled gaps
- Improves boundary detection
- Produces smoother and more accurate regions

Q. Compare the Scan Line Algorithm and the Flood Fill Algorithm used for polygon filling in computer graphics.

Scan Line Algorithm	Flood Fill Algorithm
Fills polygon row by row	Fills region from a seed point
No seed point needed	Seed point required
Fast and efficient	Slower for large areas
No leakage problem	Leakage possible
Used for polygon filling	Used in paint bucket tools

Q. Given a triangle with vertices at coordinates (10,20), (10,10), (20,10). Find the coordinates of vertices after Scaling with parameters Sx:2, Sy:1.5, with respect to the origin

$A(10,20)$

$S_x = 2$

$S_y = 1.5$

$x_{new} = x_{old} \times S_x$

$= 10 \times 2$

$= 20$

$y_{new} = y_{old} \times S_y$

$= 20 \times 1.5$

$= 30$

$A'(20,30)$

$B(10, 10)$
$\quad x \quad y$

$x_{new} = 10 \times 2$
$= 20$

$y_{new} = 10 \times 1.5$
$= 15$

$B'(20, 15)$

$C(20, 10)$

$x_{new} = 20 \times 2$
$= 40$

$y_{new} = 10 \times 1.5$
$= 15$

$C'(40, 15)$

Q. Consider a triangle at (2,2), (10,2), (2,10). Perform the following 2D transformations in succession & find the resultant vertices

- (i)Scale with respect to (2,2) by scaling factors (2,2) respectively along x and y directions.
- (ii) Rotate by ~~900~~ counter clockwise direction

90°

1) $S_x = 2$.

$S_y = 2$

Scaling about fixed point $(2, 2)$
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad x_f \; y_f$

$$x = x_f + S_x (x - x_f)$$

$$y = y_f + S_y (y - y_f)$$

$A(2, 2)$
$\quad\;\; x \;\; y$

$$x_A = 2 + 2(2 - 2) = 2$$

$$y_A = 2 + 2(2-2)$$
$$= 2$$

$$A_1 = (2, 2)$$

$$B\,(\underset{x}{10}, \underset{y}{2})$$

$$x_B = 2 + 2(10 - 2)$$
$$= 18$$

$$y_B = 2 + 2(2-2)$$
$$= 2$$

$$B_1 = (18, 2)$$

$$C(\overset{x}{2}, \overset{y}{10})$$

$$x_c = 2 + 2(2 - 2)$$
$$= 2$$

$$y_c = 2 + 2(10 - 2)$$
$$= 18$$

$$C_1(2, 18)$$

ii) $(x, y) \rightarrow (-y, x)$

$A(\overset{x}{2}, \overset{y}{2}) \rightarrow (-2, 2)$

$B(\overset{x}{18}, \overset{y}{2}) \rightarrow (-2, 18)$

$C(\underset{x}{2}, \underset{y}{18}) \rightarrow (-18, 2)$

$x' = x\cos\theta - y\sin\theta$

$= x \times 0 - y \times 1$

$\boxed{x = -y}$

$y' = x\sin 90^\circ + y\cos 90^\circ$

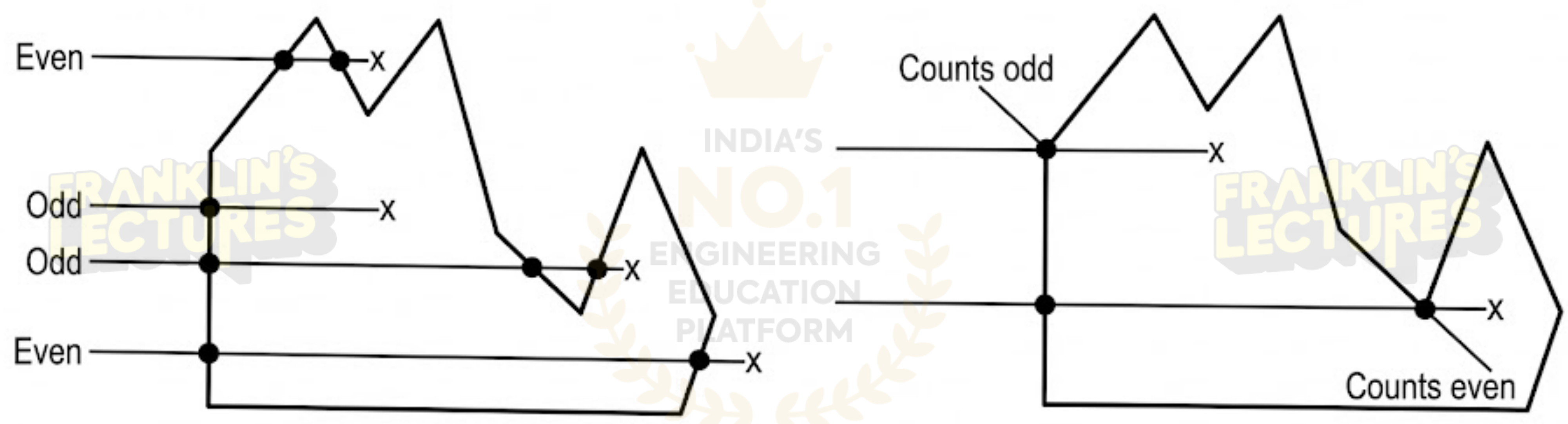
$y' = x \times 1 + 0$

$= x$

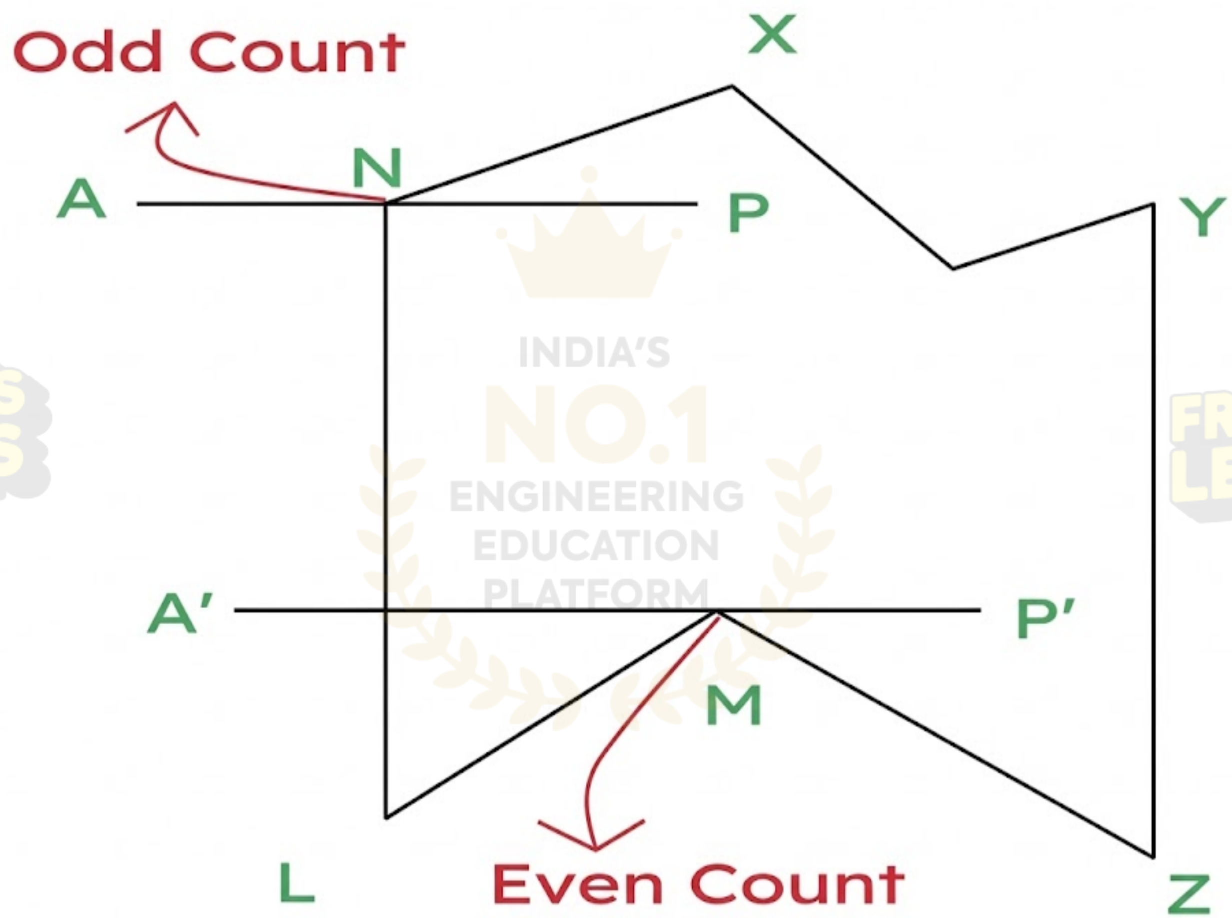
Q. Discuss the techniques used to identify the inside and outside points of a polygon.

Odd Even Rule (Odd Parity Rule)

1. Construct a line segment from point to be examined to point outside of a polygon.
2. Count the number of intersections of line segment with polygon boundaries.
3. If Odd number of intersection, then Point lies inside of Polygon.
4. Else, Point lies outside of polygon.

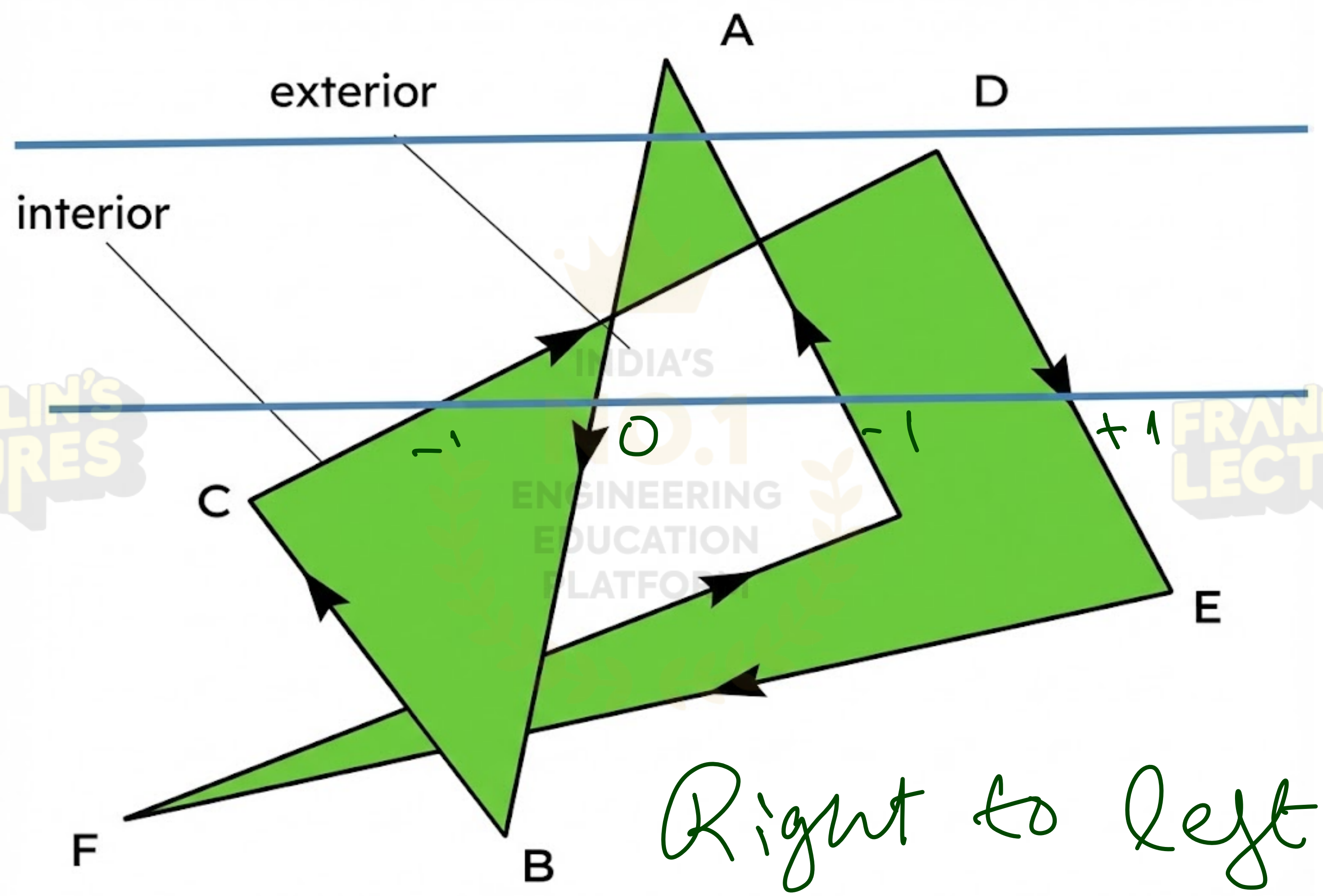

Even
x
Odd
x
Odd
x
Even
x
Counts odd
x
x
Counts even

- Scan line cut a vertex is a special case;
- Consider edges intersect at a vertex, if their other endpoints are on the same side of the scan line count number of intersections as 2(or even).
- Consider edges intersect at a vertex, if their other endpoints are on the opposite sides of the scan line count number of intersections as 1(or odd)-


Odd Count
X
N
A
P
Y
A′
P′
M
L
Even Count
Z

Non Zero winding number Rule

- Initial value of winding number=0.
- Then draw a line from point (p-point to test) to outside the polygon which does not pass through any vertex.
- Add 1 to the winding number every time we intersect a polygon edge that crosses the line from right to left and subtract 1 every time we intersect an edge that crosses from left to right.
- The interior points are that have a non zero value for the winding number.
- Exterior points are those whose value of the winding number is zero.



Right to left = +1

Left to Right = -1


FRANKLIN'S LECTURES
Step ahead with the
right guidance
Live + recorded classes
Expert faculty pool
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S6 SINDOOR BATCH
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