COMPUTER GRAPHICS & IMAGE PROCESSING

Module 1 **Part 2**

CST 304

COLOR CRT MONITORS

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

BEAM-PENETRATION TECHNIQUE
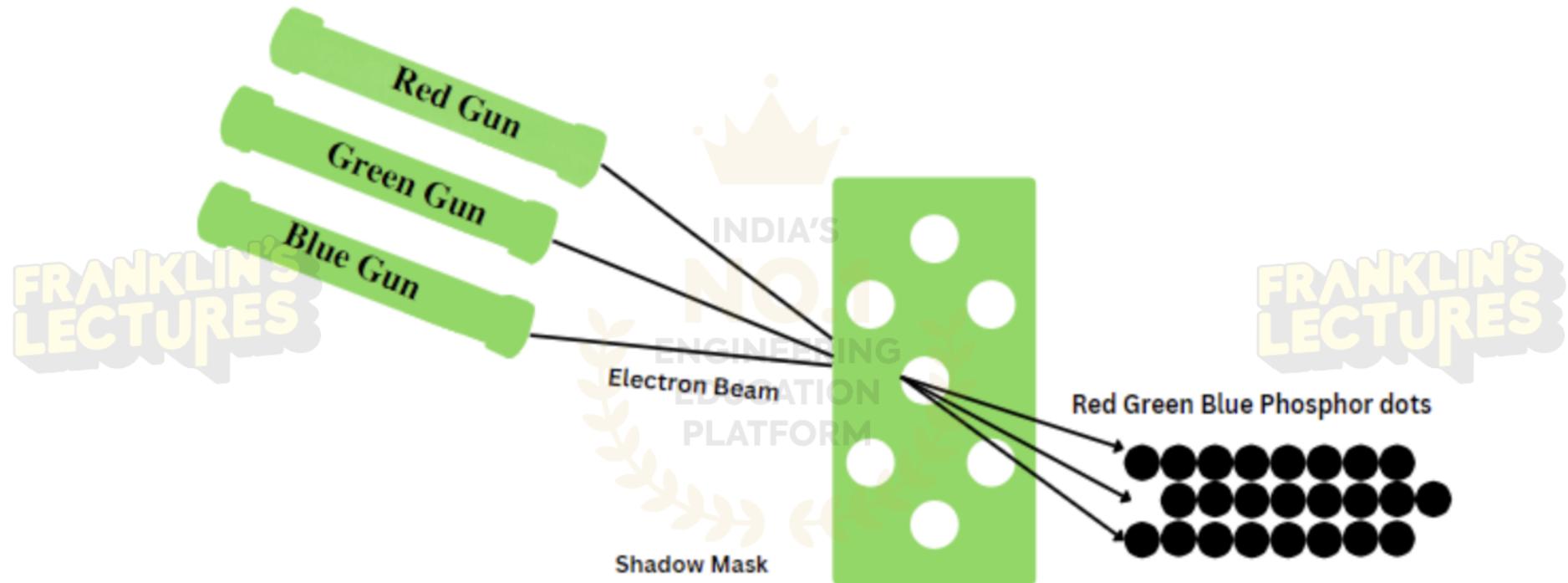
This technique is used with random scan monitors.

- In this technique inside of CRT coated with two phosphor layers usually red and green. The outer layer of red and inner layer of green phosphor.

- The color depends on how far the electron beam penetrates into the phosphor layer.

- A beam of fast electron penetrates more and excites inner green layer while slow electron excites outer red layer.

- At intermediate beam speed we can produce combination of red and green lights which emit additional two colors orange and yellow.

- The beam acceleration voltage controls the speed of the electrons and hence color of pixel.
- It is a low cost technique to produce color in random scan monitors.
- It can display only four colors.
- Quality of picture is not good compared to other techniques.

↓ Drawback

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, and a shadow-mask grid just behind the phosphor-coated screen.

Q, Describe the beam-penetration technique in CRT displays. How does it contribute to color generation?

(3,April 2025)

**Q,** Describe the raster scan display system.

(8 ,April 2025)
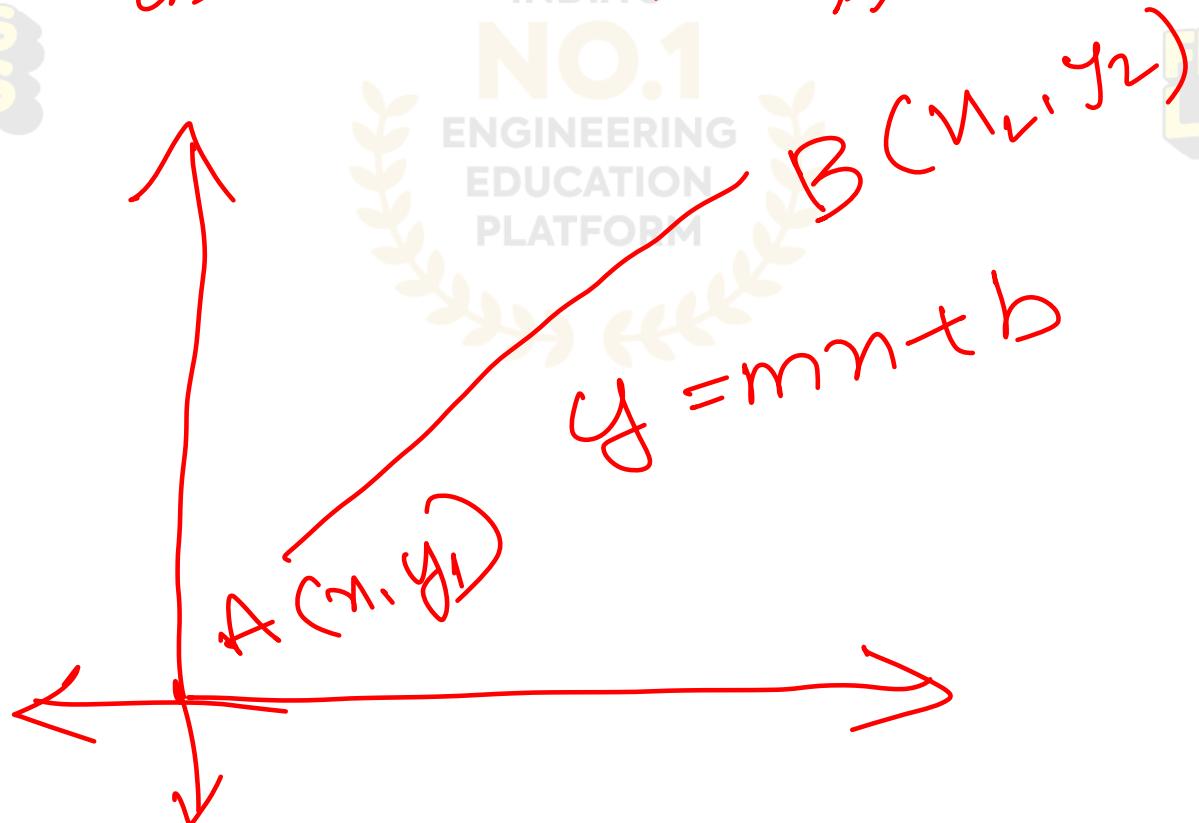
DIGITAL DIFFERENTIAL ANALYZER (DDA)

- Scan conversion method for drawing lines

- It uses incremental approaches

$$y = mx + b$$

$A(x_1, y_1)$

$B(x_2, y_2)$

Straight line equation is

$$y = mx + b$$

$$m = \text{Slope}$$

If the line has 2 end points

A (x_1, y_1) & B (x_2, y_2)

Slope of the line, $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{dy}{dx}$

$$\boxed{m = \dfrac{dy}{dx}}$$

To find the value of

$y \div$

$$dy = m \times dx$$

$$dx = \dfrac{dy}{m}$$

Case I

If $m < 1$

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

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

Case II

If $m > 1$

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

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

Case III

If $m = 1$

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

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

Advantages of the DDA Algorithm:
- Simplicity and Ease of Implementation
- Faster than Direct Line Equation

Disadvantages of the DDA Algorithm:
- Reliance on Floating-Point Arithmetic
- Rounding Errors

Q, Apply the Digital Differential Analyzer (DDA) Algorithm to draw a line between the points (2,4) and (7,8). Show step-by-step calculations and determine the intermediate pixel positions plotted.(6,April 2025)

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

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

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

$$= \frac{8-4}{7-2} = \frac{4}{5} = \underline{0.8}$$

$$\boxed{m = 0.8}$$
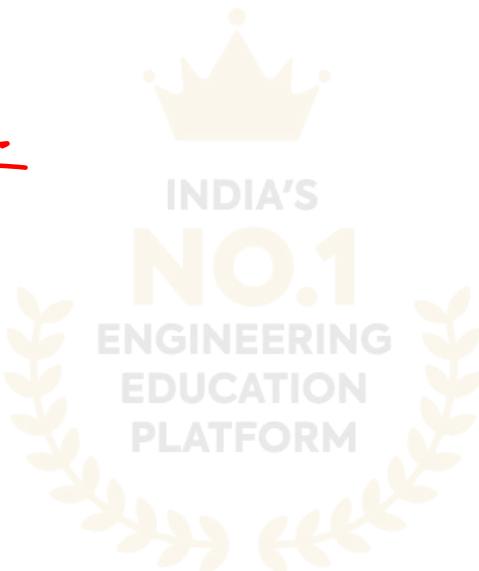
$m < 1, \text{ then}$

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

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

$$x_k = 2$$

$$y_k = 4$$

No.	x_{k+1}	y_{k+1}	$Round(x_k, y_k)$
0	2	4	(2, 4)
1	$x_k + 1 = 2 + 1$ $= 3$	$y_k + m = 4 + 0.8$ $= 4.8$	(3, 5)
2	$x_{k+1} = 3 + 1$ $= 4$	$y_k + m = 4.8 + 0.8$ $= 5.6$	(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, Scan convert the line segment with end points (0,0) and (10,5) using DDA line drawing algorithm. Find out and discuss the advantages and disadvantages of this method.

(10,JUNE 2023)

$$(0,0) \quad (10,5)$$
$$x_1 \; y_1 \qquad x_2 \quad y_2$$

$$m = \frac{5-0}{10-0} = \frac{5}{10} = 0.5$$

$$m \angle 1$$

$$\eta_{k+1} = \eta_k + 1$$

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

Q, Find the points in the line from (5, 6) to (8, 12) using the DDA line drawing algorithm.

(3, May 2024)

$(5,6) \quad (8,12)$ ✓
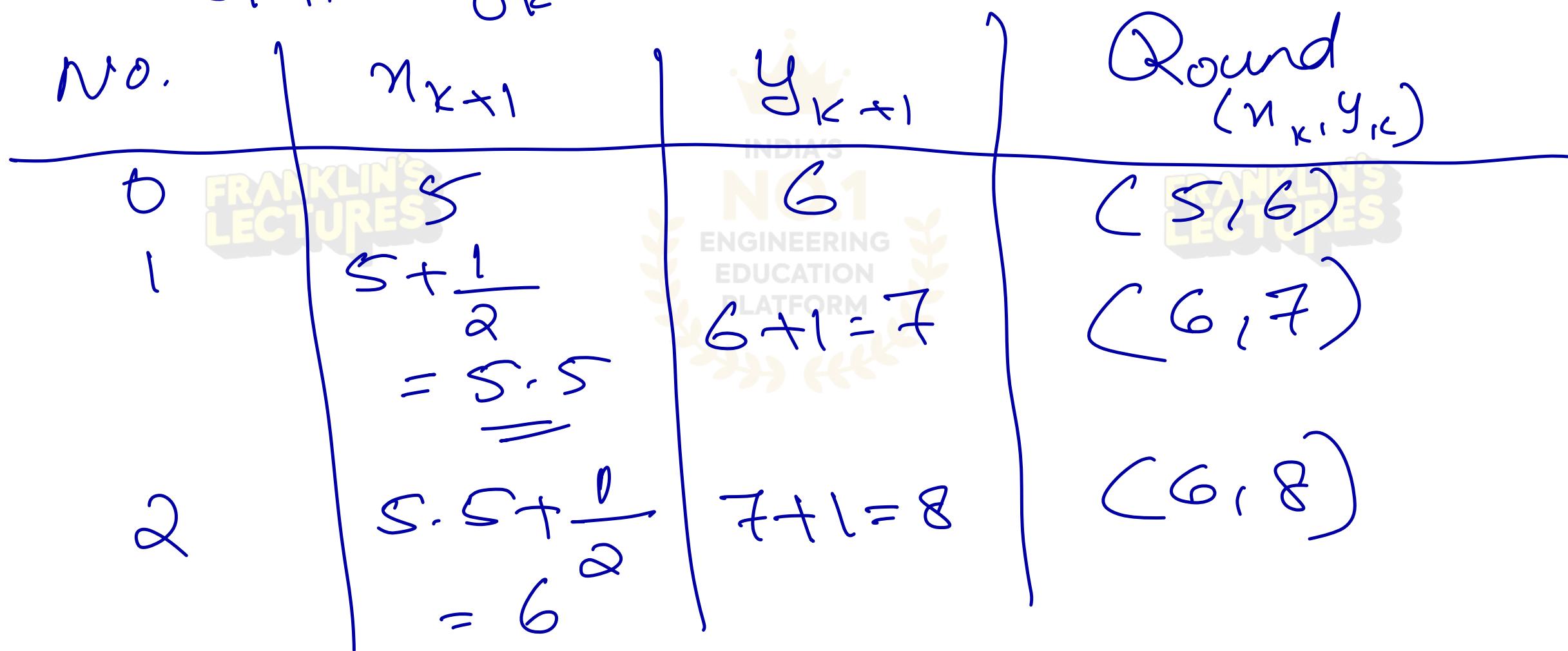
$x_1 \quad y_1 \qquad x_2 \quad y_2$

$$m = \frac{12-6}{8-5} = \frac{6}{3} = 2$$

$$\boxed{m = 2}$$

$m > 1$

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

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

No.	x_{k+1}	y_{k+1}	Round (x_k, y_k)
0	5	6	$(5, 6)$
1	$5 + \frac{1}{2}$ = 5.5	$6 + 1 = 7$	$(6, 7)$
2	$5.5 + \frac{1}{2}$ = 6	$7 + 1 = 8$	$(6, 8)$

$$3 \quad \left| \begin{array}{l} 6 + \dfrac{1}{2} \\ = 6 \cdot 5 \end{array} \right. \quad \left| \begin{array}{l} 8+1=9 \end{array} \right. \quad \left| (7,9) \right.$$

$$4 \quad \left| \begin{array}{l} 6 \cdot 5 + \dfrac{1}{2} \\ = 7 \end{array} \right. \quad \left| \begin{array}{l} 9+1=10 \end{array} \right. \quad \left| (7,10) \right.$$

$$5 \quad \left| \begin{array}{l} 7 + \dfrac{1}{2} \\ = 7 \cdot 5 \end{array} \right. \quad \left| \begin{array}{l} 10+1=11 \end{array} \right. \quad \left| (8,11) \right.$$

$$6 \quad \left| \begin{array}{l} 7 \cdot 5 + \dfrac{1}{2} \\ = 8 \end{array} \right. \quad \left| \begin{array}{l} 11+1=12 \end{array} \right. \quad \left| (8,12) \right.$$
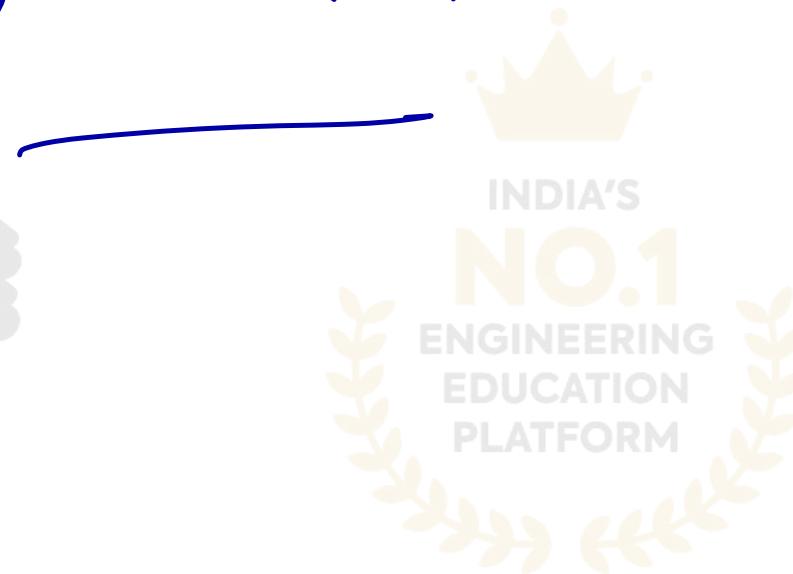
Points Generated are :-
(5,6), (6,7), (6,8), (7,9),
(7,10), (8,11), (8,12)

BRESENHAM'S LINE DRAWING ALGORITHM

. It determines the point of n-dimensional raster that should be selected in order to form a close approximation to a straight line b/w 2 points.

Start coordinates = (x_0, y_0)

End coordinates = (x_n, y_n)

Step 1 → Calculate Δx and Δy

$$\Delta x = x_n - x_0$$

$$\Delta y = y_n - y_0$$

Step 2 → Calculate decision parameter

$$\boxed{P_K = 2\Delta y - \Delta x}$$

Step 3 → Suppose current point (x_k, y_k) then next point (x_{k+1}, y_{k+1})

Case 1

if $P_k < 0$

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

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

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

Case 11

if $P_k \geq 0$

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

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

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

Q.₁ Plot a line using Bresenham's Line Drawing Algorithm for the coordinates (2, 3) to (10, 8). Show the step-by-step calculations and determine the sequence of pixel positions.

(6,April 2025)

Q.₂ Rasterize the line segment from pixel coordinate (1, 1) to (8,5) using Bresenham's line drawing algorithm

(8,june 2023)

1) $(2,3)$ $\quad$ $(10,8)$

$\quad\quad$ x_0 y_0 $\quad\quad\quad$ x_n $\quad$ y_n

Step 1 $\Rightarrow$ $\Delta x = x_n - x_0$

$\quad\quad\quad\quad\quad\quad\quad = 10 - 2 = \underline{\underline{8}}$

$\quad\quad\quad\quad\quad \Delta y = y_n - y_0$

$\quad\quad\quad\quad\quad\quad\quad = 8 - 3 = \underline{\underline{5}}$

Step 2 $\Rightarrow$ Calculate decision parameter

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

$\quad\quad\quad\quad\quad\quad = 2 \times 5 - 8$

$\quad\quad\quad\quad\quad\quad = 10 - 8 = \underline{\underline{2}}$

$$\boxed{P_K = 2}$$

Step 3 $\rightarrow$

if $\quad P_k \geq 0$

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

$n_{k+1} = n_k + 1$

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

$P_k < 0$
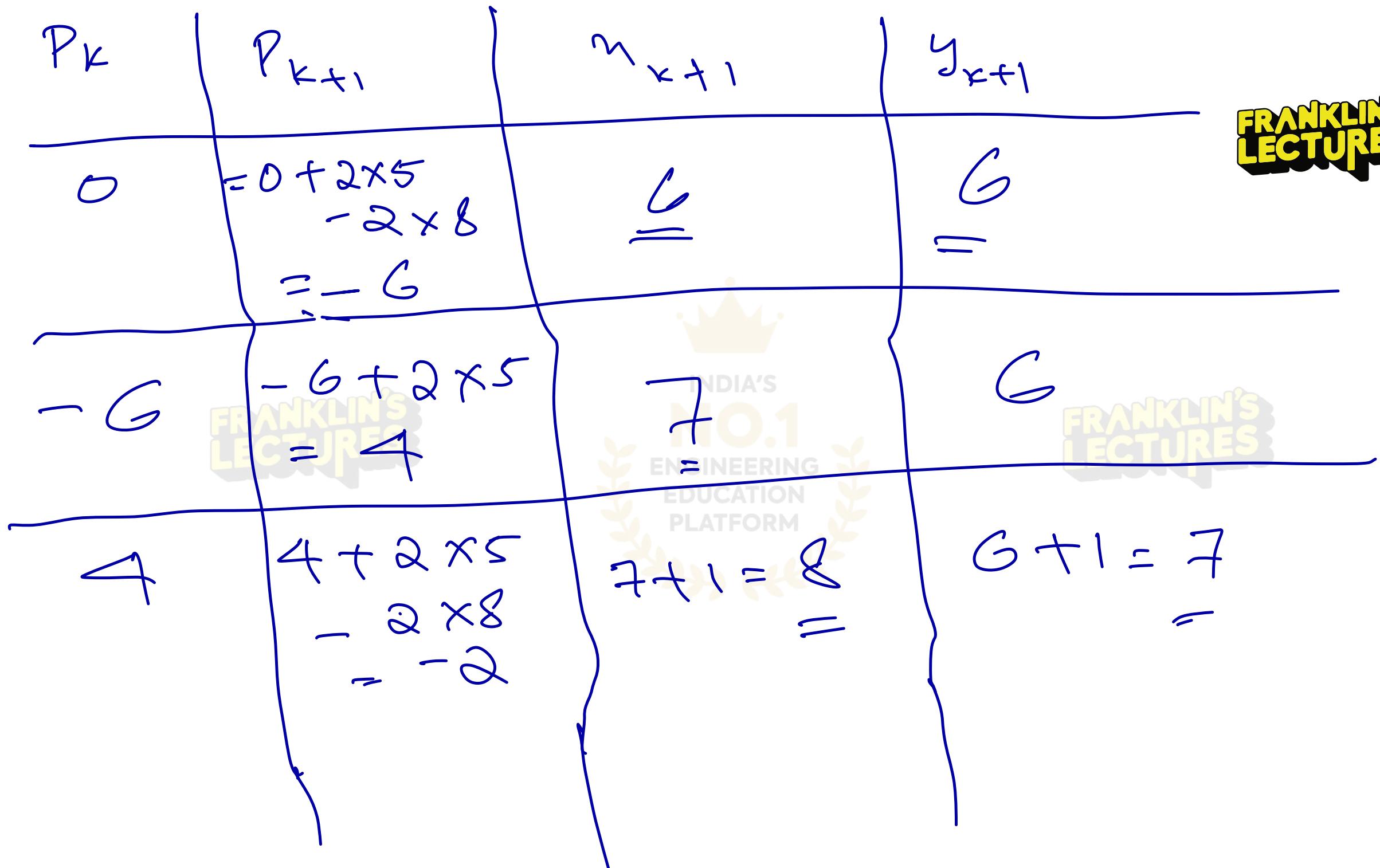
$P_{k+1} = P_k + 2\Delta y$
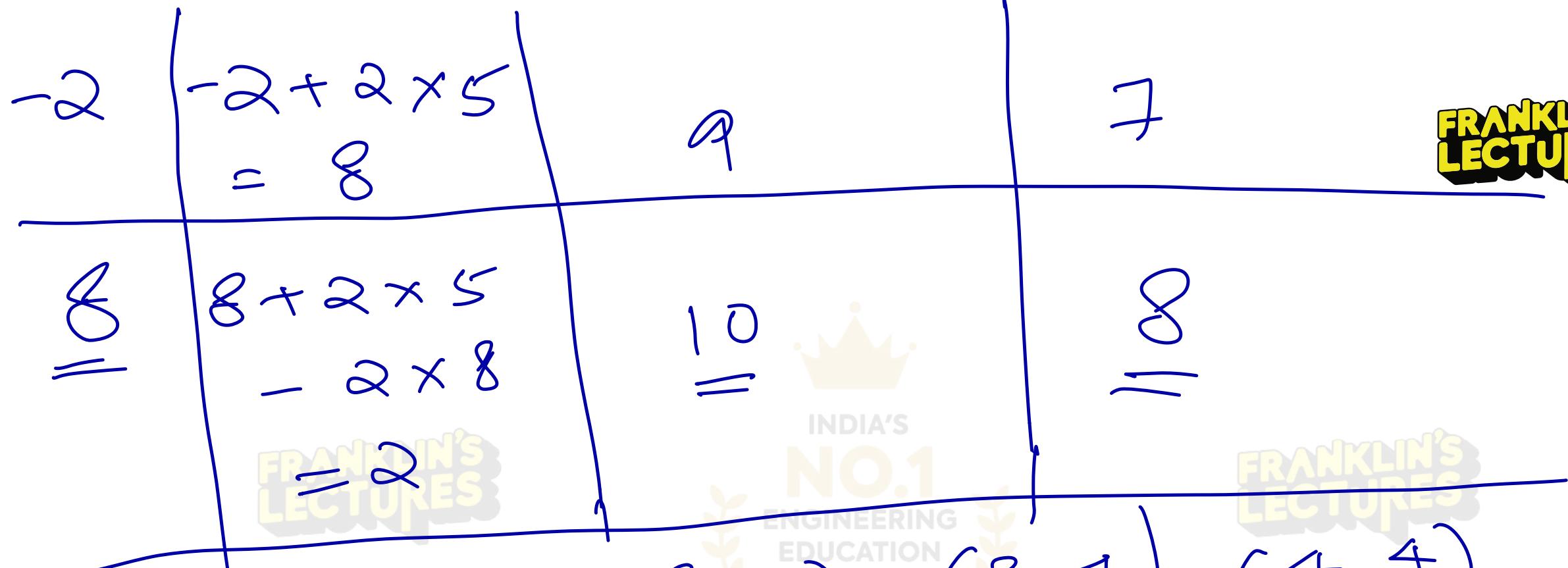
$u_{k+1} = u_k + 1$

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

P_k	P_{k+1}	n_{k+1}	y_{k+1}
		2	3
2	$P_k + 2\Delta y - 2\Delta n$ $= 2 + 2 \times 5 - 2 \times 8$ $= \underline{-4}$	$n_k + 1$ $= 2 + 1 = 3$	$y_k + 1$ $= 3 + 1 = 4$
-4	$P_k + 2\Delta y$ $= -4 + 2 \times 5$ $= \underline{6}$	$n_k + 1$ $= 3 + 1 = \underline{4}$	4
6	$= 6 + 2 \times 5 - 2 \times 8$ $= \underline{0}$	$n_k + 1$ $= 4 + 1 = 5$	$y_k + 1$ $= 4 + 1 = 5$

P_k	P_{k+1}	x_{k+1}	y_{k+1}
0	$= 0 + 2 \times 5$ $- 2 \times 8$ $= -6$	$\underline{\underline{6}}$	$\underline{6}$
-6	$-6 + 2 \times 5$ $= 4$	7	6
4	$4 + 2 \times 5$ $- 2 \times 8$ $= -2$	$7 + 1 = 8$	$6 + 1 = 7$

-2	$-2 + 2 \times 5$ $= 8$	9	7
8	$8 + 2 \times 5$ $- 2 \times 8$	10	8
$= 8$	$= 2$	$= 10$	$= 8$

Points are:- $(2,3), (3,4), (4,4),$
$(5,5), (6,6), (7,6),$
$(8,7), (9,7), (10,8)$

Ans2) $(1,1)$ $(8,5)$
x_0 y_0 x_n y_n

$\Delta x = 8-1 = 7$

$\Delta y = 5-1 = 4$

$P_k = 2\Delta y - \Delta x$
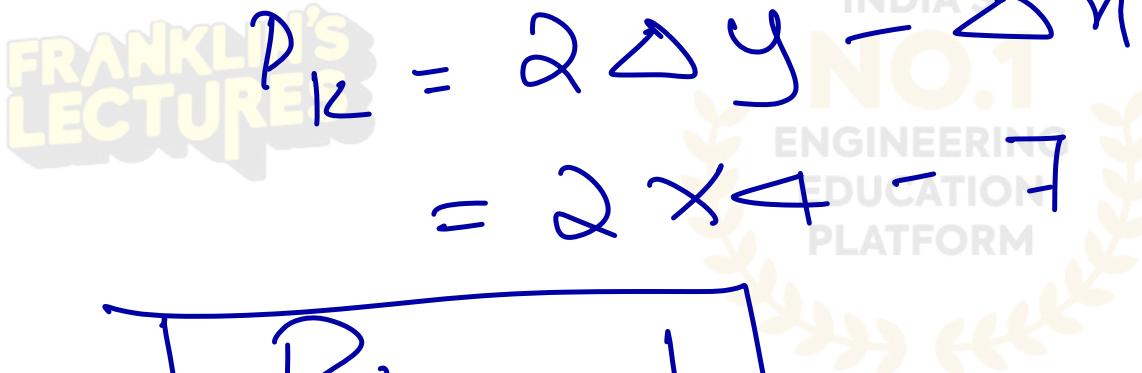
$\quad = 2 \times 4 - 7$

$$\boxed{P_k = 1}$$
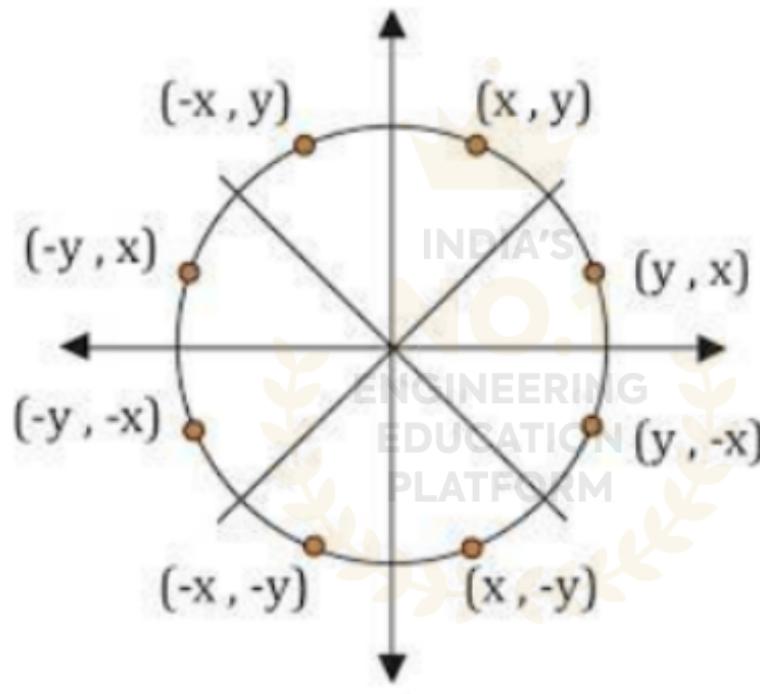
MID-POINT CIRCLE GENERATION ALGORITHM

- The main idea of the Mid-point Circle Generation Algorithm is to determine whether a pixel lies inside, on, or outside the boundary of a circle. We plot the points for one-eighth of the circle (the first octant) and use the symmetry of the circle to replicate those points in the other octants.

Step1 → initial point (x, y)
$$= (0, r)$$

Decision Parameter

$$\boxed{P = 1 - r}$$

Case 1

1) $P < 0$

$(x_k, y_k) = (x+1, \underline{y})$

$P_k = P + 2x + 3$

Case 11

1) $P \geq 0$

$(x_k, y_k) = (x+1, y-1)$

$P_k = P + 2(x-y) + 5$

Q₁ Draw a circle where center is $(5,7)$ and diameter is 12 using Mid-point theorem.

Center $(x, y) = (5, 7)$

$$r = \frac{12}{2}$$

$$\boxed{r = 6}$$

Initial point $(x, y) = (0, 6)$

$$\boxed{P = 1 - r}$$

| P	$x=0$	$y=6$	(x_{plot}, y_{plot})
$1-\gamma$ $=1-6$ $=-5$	$x+1$ $=0+1=1$	6	$(5+1, 7+6)$ $=(6,13)$
$P+2x+3$ $=-5+2\times0$ $+3$ $=-2$	$x+1$ $=2$	6	$(5+2, 7+6)$ $(7,13)$
$=-2+2\times1$ $+3$ $=3$	$x+1$ $=3$	$y-1$ $=6-1=5$	$(5+3, 7+5)$ $(8,12)$

P	n	y	$(x_{plot}+1, y_{plot}+1)$
$P+2(n-y)+5$ $=3+2(2-6)+5$ $=0$	4	4	$(5+4, 7+4)$ $(9, 11)$
$0+2(3-5)$ $+5$ $=1$	5	3	$(5+5, 7+3)$ $=(10, 10)$
$1+2(7-4)$ $+5$ $=6$	6	2	$(11, 9)$

$6+2(5-3)$ $+5$ $=15$	7 $=$	1 $=$	$(12,8)$
28	8	0	$(13,7)$
$28+2(7)$ $+5$ $=45$	9	-1	$(14,6)$ $\downarrow$ $x>y$
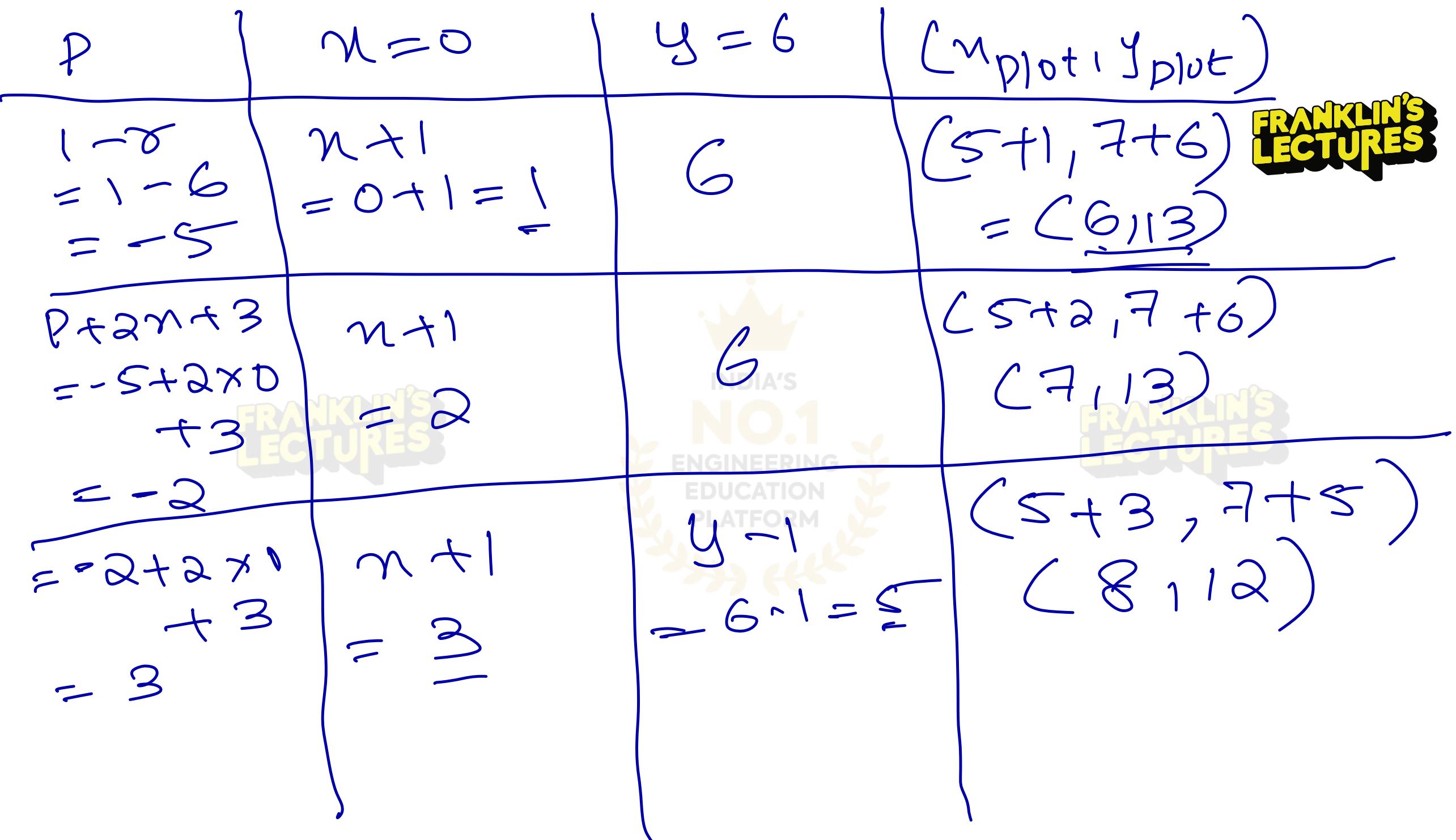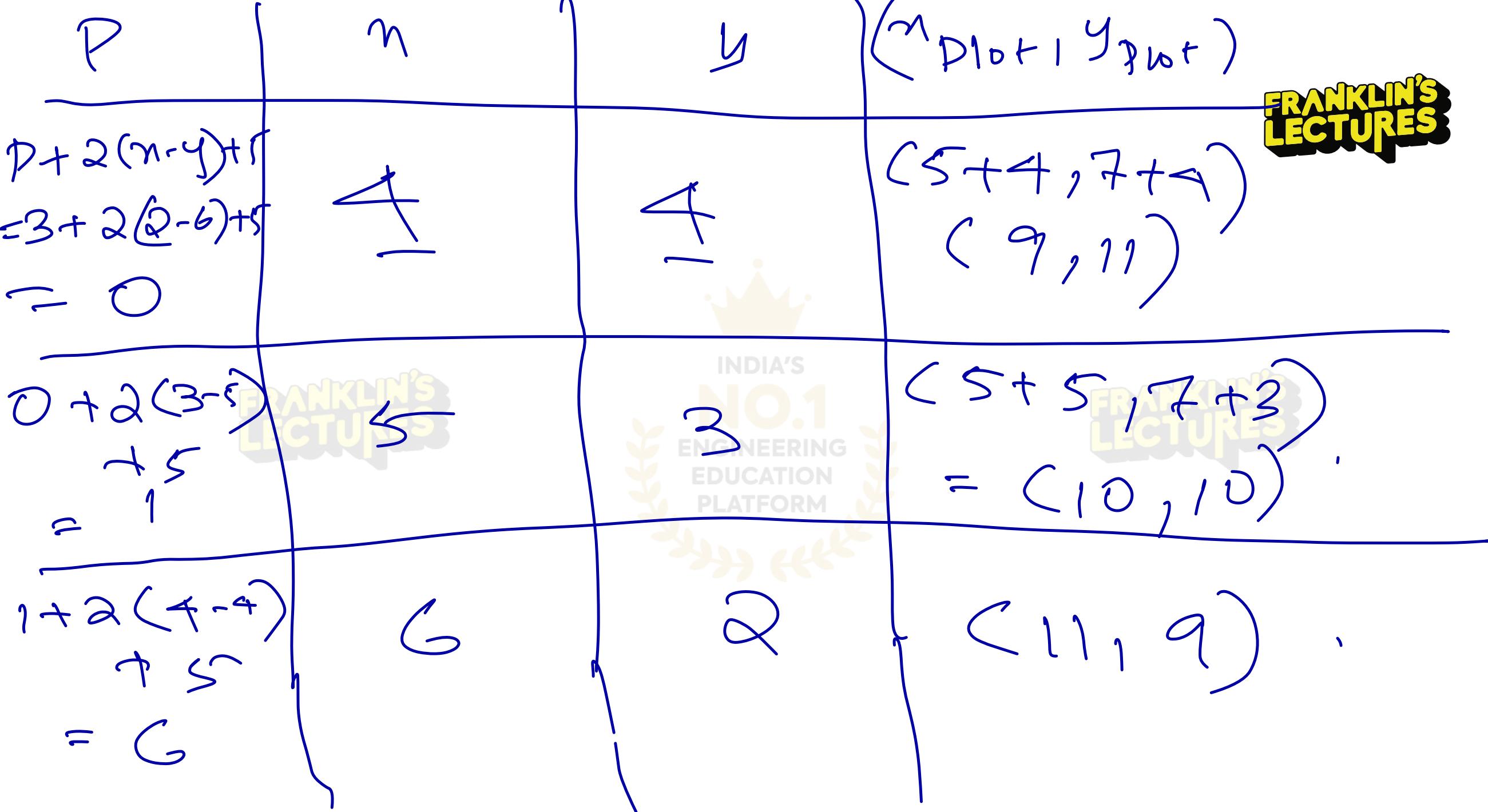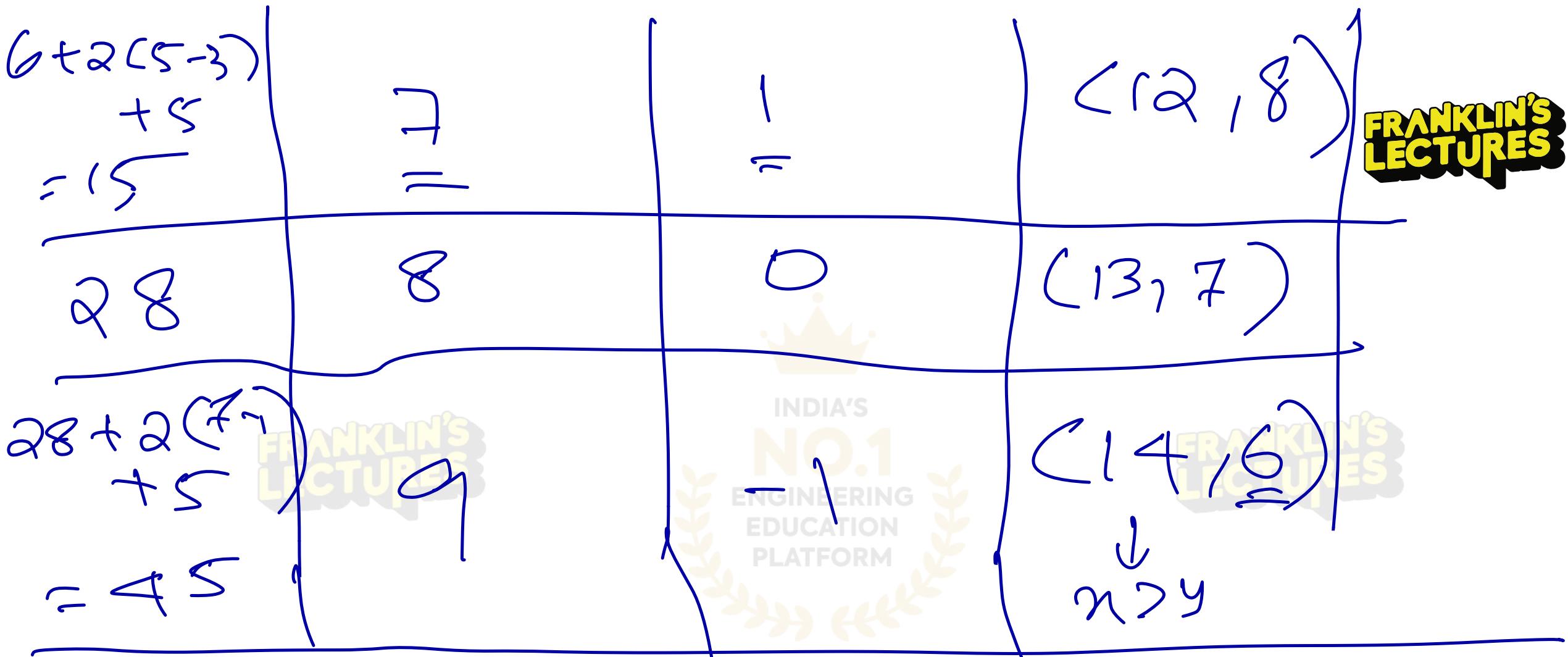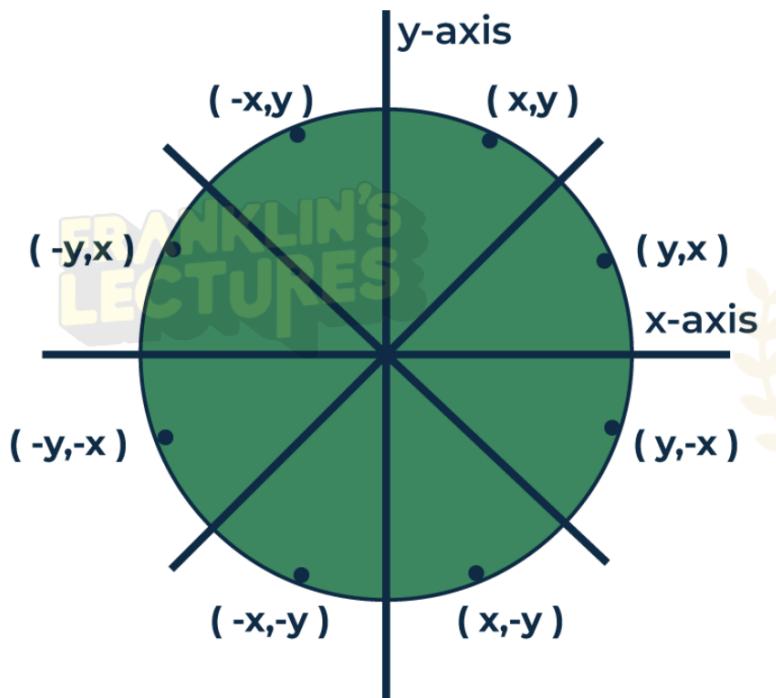
Q, Write Bresenham's circle drawing algorithm. Find the points in a circle octant in the first quadrant with the centre point coordinates (0, 0) and radius as 8.

(7,May 2024)

Centre $(0, 0)$

Radius $= 8$

$y = 8$

Initial point $(0, 8)$

Decision parameter

$$P = 3 - 2r$$

$$P = 3 - 2 \times 8$$
$$= -13$$

$$\boxed{P = -13}$$

Case 1

$P_k < 0$

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

$x_n = x + 1$

$y_n = y$

Case 11

$P_k > 0$

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

$x_n = x + 1$ ✓

$y_n = y - 1$ ✓

P	$x = 0$	$y = 8$	(x_{Dplot}, y_{plot})
$3 - 2r$ $= 3 - 2 \times 8$ $= -13$	$0 + 1$ $= \underline{1}$	8 $= \underline{8}$	$(0+1, 0+8)$ $(1, 8)$
$P_k + 4x + 6$ $= -13 + 4 \times 0 + 6$ $= \underline{-7}$	2	8	$(0+2, 0+8)$ $(2, 8)$
$-7 + 4 \times 1 + 6$ $= \underline{3}$	3	$8 - 1$ $= 7$	$(0+3, 0+7)$ $(3, 7)$

$P_k + 4(n-y) + 10$
$= 3 + 4(0-8)$
$\quad + 10$

$= -11$

$-11 + 4 \times 3$
$\quad + 6$

$= 7$

$= 7 + 4(4-7)$
$\quad + 10$

$= 5$

1	7	$(4,7)$
5	6	$(5,6)$
6	5	$(6,5)$ $(n>y)$

Q write all $\rightarrow$ $(0,8)$, $(1,8)$, $(2,8)$, $(3,7)$
$(4,7)$, $(5,6)$, $(6,5)$,