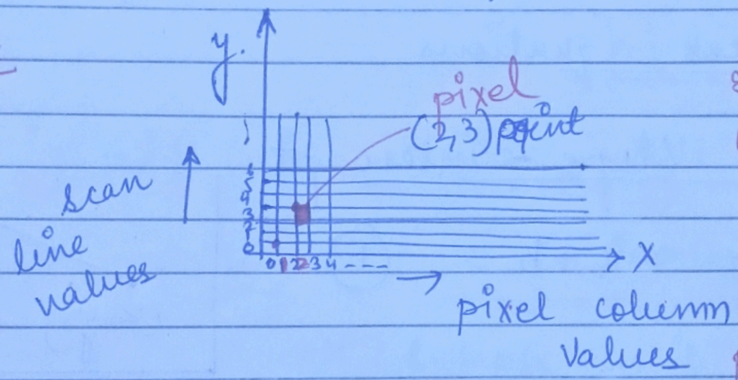
Output Primitives

** simple geometric f^n that are used to generate various computer graphics required by the user.

Point
Line
Circle
Ellipse

} Geometrical Structures (we can define a picture or a scene)

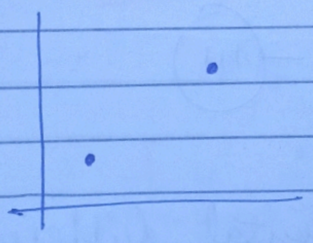
Point



* whenever you want to plot a ~~plot~~ point (known as pixel) ⇒ Intersection of pixel column values and scan line values.

Line

* To draw a line, we require 2 end points



* line plotting can be accomplished by plotting b/w these ~~two~~ end points

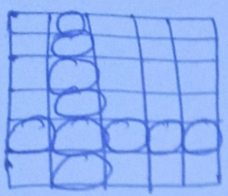
* we have different algorithms to draw a line. (The process of "turning on" the pixels for a line segmement is called line generation)

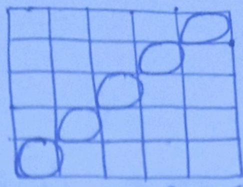
Line drawing Algorithms

There are certain characteristics to draw a line

1. Line should be terminated.
2. Density of a line should be constant
3. Density of a line should be independent of

Vertical & horizontal line





45° line

length & angle.

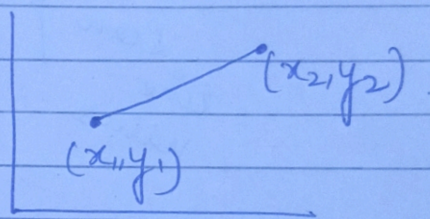
4) Line end points should be specified.

1) DDA Algorithm
2) Bresenham's Algorithm

Mathematical Equations

1) Cartesian slope - intercept

$$y = mx + b \quad \text{— (I)}$$



2) slope

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad \text{— (II)}$$

3) y- Intercept

$$b = y_1 - mx_1 \quad \text{— (III)}$$

DDA Algorithm (Digital Differential Analyzer)

→ Sample the line at unit intervals in one coordinate.

→ Determine the corresponding integer values nearest the line path in another co-ordinate.

(we have to scan over through one sampling axis & by using those sampling axes, we need to find out the other axis values)

Suppose we are sampling through x-axis (x-unit intervals) so, by using those x-unit intervals, we need to find out the y-axis values. Vice-a-versa.

Now, we have slope, m +ve value only.

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

$$m \begin{cases} \leq 1 \\ > 1 \end{cases}$$

Case 1

If $\boxed{m \leq 1}$, i.e $\underbrace{(x_2 - x_1)}_{\Delta x}$ will be $>$ $\underbrace{(y_2 - y_1)}_{\Delta y}$

$\Downarrow$

so, we can say $\boxed{x \text{ is } \uparrow \text{ more than } y}$

$\Rightarrow$ so, sample unit x & find $y = ??$

Case 2

$\boxed{m > 1}$

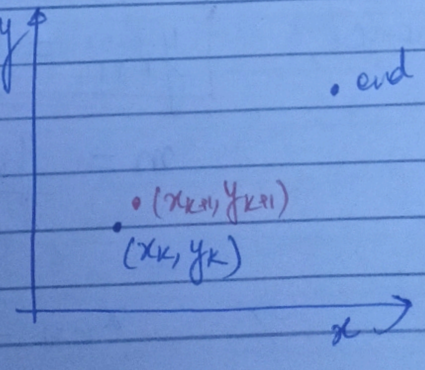
$\Rightarrow$ $\underbrace{(y_2 - y_1)}_{\Delta y} > \underbrace{(x_2 - x_1)}_{\Delta x}$

$\boxed{y \text{ is inc more than } x}$

so, sample unit y & find x.

+ve $m \leq 1$

* we want to find the next position (pixel) to be connected to pt (x_k, y_k)
* by finding all the pixel positions b/w these pts & connecting those pts we get a line.



we need to find out the next value i.e (x_{k+1}, y_{k+1})

for ~~+ve~~ $m \leq 1$

sample along x-axis & find y.

so, here ✓ $\boxed{x_{k+1} = x_k + 1}$ — need to find y_{k+1}

here

$$m = \frac{y_{k+1} - y_k}{x_{k+1} - x_k} = \frac{y_{k+1} - y_k}{\cancel{x_k} + 1 - \cancel{x_k}}$$

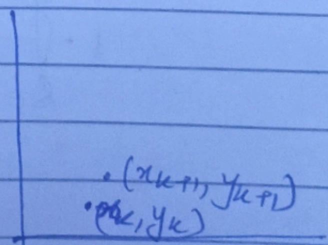
i.e $m = y_{k+1} - y_k$

or $\boxed{y_{k+1} = m + y_k}$

$x_k, y_k \Rightarrow$ int values but while calculating y_{k+1}, we may have floating values, so round off those values.

$$\boxed{(x_{k+1}, y_{k+1}) = \left(x_k + 1, \text{round off}\left(m + y_k\right)\right)}$$

+ve $m > 1$



sample along y-axis & find x.

hence, $\boxed{y_{k+1} = y_k + 1}$

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

$\Rightarrow x_{k+1} - x_k = \frac{1}{m}$ or $\boxed{x_{k+1} = x_k + \frac{1}{m}}$

So, $(x_{k+1}, y_{k+1}) = \left(\text{Round off}\left(x_k + \frac{1}{m}\right), y_k + 1\right)$

** If we are considering -ve slope, then everything would be -ve & same procedure will be followed.

Example :- Draw a line b/w $(10, 6)$ ——— $(15, 9)$
(x_1, y_1) (x_2, y_2)

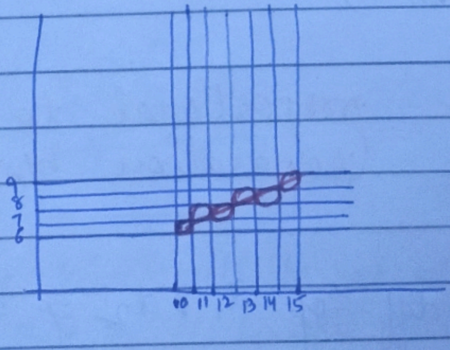
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{9-6}{15-10} = \frac{3}{5} = 0.6 < 1$$

So, $m < 1$ is the case.
then use formula $(x_k + 1, \text{Roundoff}(m + y_k))$

x_k	y_k	(x_{k+1}, y_{k+1})
10	6	(10,6)
10+1 = 11	6+0.6=6.6	(11,7)
11+1 = 12	6.6+0.6=7.2	(12,7)
12+1 = 13	7.2+0.6=7.8	(13,8)
13+1 = 14	7.8+0.6=8.4	(14,8)
14+1 = 15	8.4+0.6=9.0	(15,9)

These are the intermediate pixel values.

Repeat this process until you get x_2 (i.e 15 in this case)



These pixels will get illuminated.
(pixels are so closed, that it would be looked like a straight line)

Bresenham's Line Algorithm

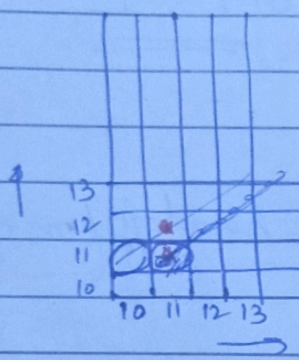
This algorithm should also posess the characteristics of a line (stated previously in DDA)

→ It is more effective algorithm as compared to DDA.

→ There are no floating values.

→ It also uses the incremental value.

$x_{k+1} = x_k + 1 \quad m \le 1$
$y_{k+1} = y_k + 1 \quad m > 1$



(10,11)

→ Let's say, we have (10,11) pt.

→ So, to avoid floating values, there is a need to decide whether to choose (11,11) or (11,12) so that we shouldn't get any floating values.

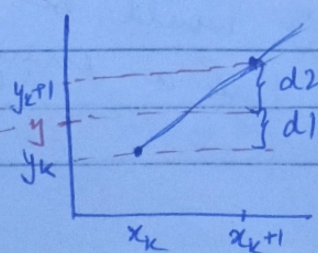
Decision Parameter ⇒ can be +ve or −ve.

depending upon sign of decision parameter, we would choose either (11,11) or (11,12)

value is directly proportional to the (difference) {distance} of the separation b/w these two pixel values.

$\boxed{m = \frac{\Delta y}{\Delta x}}$

Take some ref' pt



diff. of d_1 & d_2 ⇒ decision parameter

i.e decision parameter $\propto (d_1 - d_2)$

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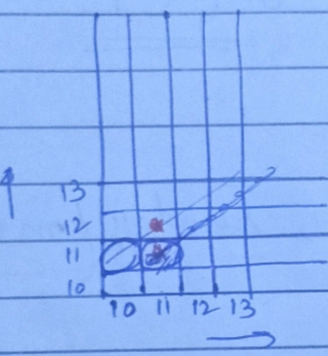

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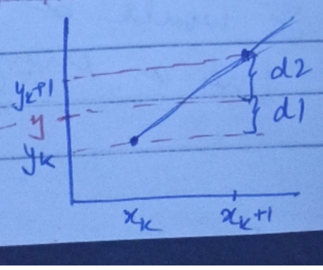


diff. of d_1 & d_2 ⇒ decision parameter

i.e decision parameter $\propto (d_1 - d_2)$

slope-intercept formula

$$y = m(x_k+1) + b \quad \text{--- (1)}$$

Now, $d_1 = y - y_k$

$= m(x_k+1) + b - y_k$

$d_2 = y_{k+1} - y = y_k+1 - m(x_k+1) - b$

Calculate $d_1 - d_2$

$= mx_k + m + b - y_k - (y_k+1) + mx_k + m + b$

$= 2m(x_k+1) + 2b - 2y_k - 1$

Decision parameter, $\boxed{P_k \propto d_1 - d_2}$

$P_k = \Delta x(d_1 - d_2)$

$= \Delta x\,(2m(x_k+1) - 2y_k + 2b - 1)$

$= \cancel{\Delta x} \cdot 2 \frac{\Delta y}{\cancel{\Delta x}} (x_k+1) - 2\Delta x\, y_k + \Delta x(2b-1)$

$$\boxed{P_k = 2\Delta y(x_k+1) - 2\Delta x\, y_k + \Delta x(2b-1)} \quad \text{--- (2)}$$

Let say $P_k < 0$

then $d_1 - d_2 < 0$

$\boxed{d_1 < d_2}$

i.e the line will be nearer to d_1, so we will select the pixel (x_k+1, y_k)

$P_k > 0$

i.e $d_1 > d_2$

means, the line will be nearer to d_2, so we will select the pixel (x_k+1, y_k+1)

Continuing with eq (2)

$$P_k = 2\Delta y\, x_k + 2\Delta y - 2\Delta x\, y_k + \Delta x(2b-1)$$

$$= 2\Delta y\, x_k - 2\Delta x\, y_k + \underbrace{2\Delta y + \Delta x(2b-1)}_{C}$$

$$\boxed{P_k = 2\Delta y\, x_k - 2\Delta x\, y_k + C} \quad \text{— (3)}$$

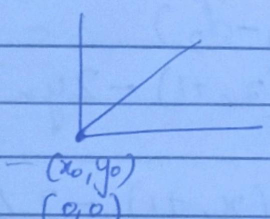
decision parameter value for next pixel value will be

$$\boxed{P_{k+1} = 2\Delta y\, x_{k+1} - 2\Delta x\, y_{k+1} + C}$$

$$= 2\Delta y(x_k + 1) - 2\Delta x\, y_{k+1} + C$$

$$\boxed{P_{k+1} = 2\Delta y\, x_k - 2\Delta x\, y_{k+1} + 2\Delta y + C} \quad \text{— (4)}$$

Suppose



we have a pixel value at the origin (0,0), so at this point also, we need to calculate decision parameter value.

so, substituting $x_k = y_k = 0$ in eq (3)

$$P_k = P_0 = 2\Delta y\, \cancel{x_0}^{\,0} - 2\Delta x\, \cancel{y_0}^{\,0} + 2\Delta y + \Delta x(2b-1)$$

$y = mx + b$

$b = y_0 - mx_0 = 0$

$$= 2\Delta y + \Delta x(2b-1)$$

$$\boxed{P_0 = 2\Delta y - \Delta x}$$

we can write P_{k+1} & P_k in single eq^n as

$$P_{k+1} - P_k = 2\Delta y\, x_{k+1} - 2\Delta x\, y_{k+1} + \cancel{c} - 2\Delta y\, x_k + 2\Delta x\, y_k - \cancel{c}$$

$$= 2\Delta y\,(x_k+1) - 2\Delta x\,(y_{k+1}) - 2\Delta y\, x_k + 2\Delta x\, y_k$$

$$= 2\Delta y\,(\cancel{x_k} + 1 - \cancel{x_k}) - 2\Delta x\,(y_{k+1} - y_k)$$

$$P_{k+1} - P_k = 2\Delta y - 2\Delta x\,(y_{k+1} - y_k)$$

OR

$$\boxed{P_{k+1} = P_k + 2\Delta y - 2\Delta x\,(y_{k+1} - y_k)} \quad (5)$$

Example end points $(\underset{x_1}{20}, \underset{y_1}{10})$ and $(\underset{x_2}{30}, \underset{y_2}{18})$

Slope, $m = \frac{\Delta y}{\Delta x} = \frac{18-10}{30-20} = \frac{8}{10} = 0.8$

$m < 1$

sample through x-axis

$P_0 = 2\Delta y - \Delta x$

$P_k < 0 \Rightarrow (x_k+1, y_k)$

Putting $y_{k+1} = y_k$: $P_{k+1} = P_k + 2\Delta y$

$P_k > 0 \Rightarrow (x_k+1, y_k+1)$

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

Now ($k=0$) ✓ $P_0 = 2\Delta y - \Delta x$

$= 2 \times 8 - 10 = 16 - 10 = 6 > 0$

$(x_k+1, y_k+1) = (20+1, 10+1) = (21, 11)$

($k=1$) ✓ $P_1 = P_0 + 2\Delta y - 2\Delta x$

$= 6 + 2 \times 8 - 2 \times 10 = 6 + 16 - 20 = 2 > 0$

$(x_k+1, y_k+1) = (21+1, 11+1)$

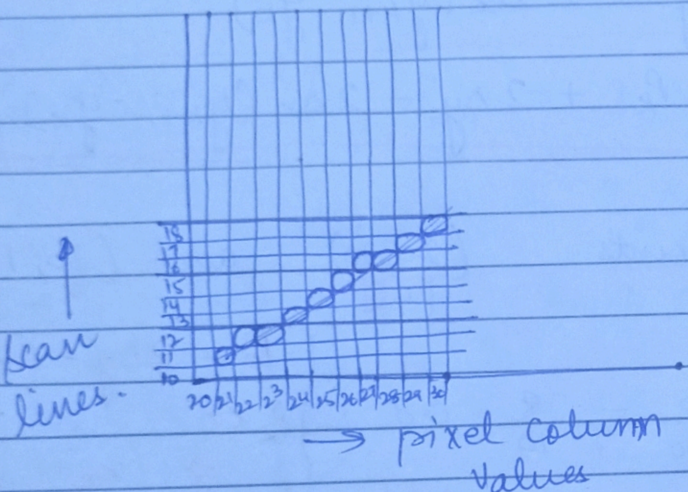
$= (22, 12)$

k	P_k	(x_{k+1}, y_{k+1})
0	6	(21, 11)
1	2	(22, 12)
2	-2	(23, 12)
3	14	(24, 13)
4	10	(25, 14)
5	6	(26, 15)
6	2	(27, 16)
7	-2	(28, 16)
8	14	(29, 17)
9	10	(30, 18)

$P_2 = P_1 + 2\Delta y - 2\Delta x$
$= 2 + 2\times 8 - 2\times 10$
$= 2 + 16 - 20 = -2 < 0$
(x_k+1, y_k)

we have to follow the same process, Δx times
Here, $\Delta x = 10$, so 10 times

Plot all the pixels



Mid-point Circle Algorithm

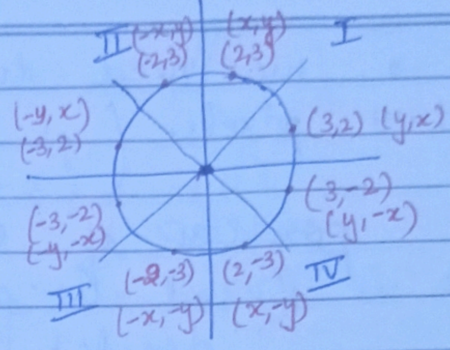
Drawing a circle on the screen is little bit complicated as compared to drawing a line.

In case of circle, we require center of the circle & radius of the circle.

Suppose, center (0,0) } may be not origin
radius – r

Circle possess 8-symmetry property.

→ we have 4 quadrants
→ divide each quadrant into 2 equal parts, then we have 8 octants

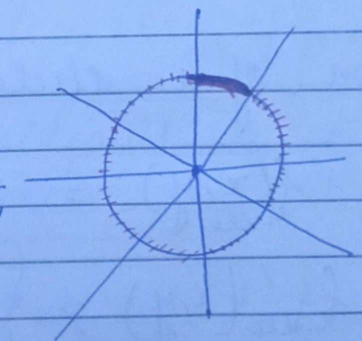


— fig ①

According to 8-way symmetry property, we can have points on the circle boundary as shown in fig ①.

So, whenever you consider one point in one-octant, you will get other values in the same position of octant using 8-way symmetry property.

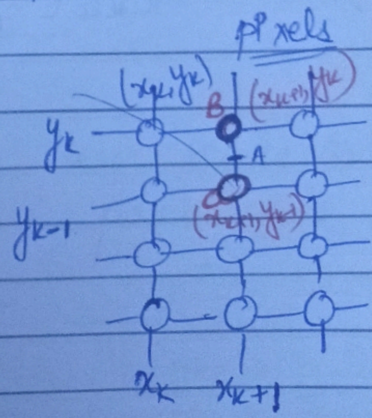
→ This algorithm uses 8-way symmetry
→ Also incremental model.



If we find all the points of an octant (highlighted), then according to 8-way symmetry, all the points of circle boundary can be found.

initial pixel (x_k, y_k)

we have to chose b/w these 2 pts i.e (x_{k+1}, y_k) or (x_{k+1}, y_{k-1}) that will be considered as pixel & illuminated — for circle boundary.



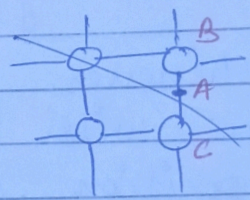
How to choose that point??

~~Draw~~ → we need to find the mid point of these two pixels. (pt A in prv. diagram)

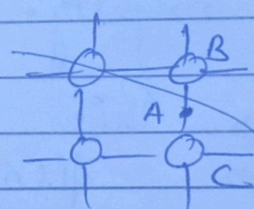
~~positions of~~

→ Based on the mid pt, it would be decided whether to choose pixel B or C.

** If mid pt. is outside the circle boundary, choose C (means C will be illuminated)



** If mid pt is inside the circle boundary, choose B. (means B will be illuminated)



Function of a circle

$$f_{circle}(x,y) = x^2+y^2-r^2 \quad \text{— (I)}$$

$$f_{circle}(x,y) \Rightarrow \begin{cases} <0, & (x,y) \text{ is inside the circle boundary} \\ =0, & (x,y) \text{ is on the circle boundary.} \\ >0, & (x,y) \text{ is outside the circle boundary.} \end{cases}$$

Mid point of (x_k+1, y_k) and (x_k+1, y_k-1)

$$\Rightarrow \left(\frac{x_k+1+x_k+1}{2}, \frac{y_k+y_k-1}{2}\right)$$

$$= \left(x_k+1, y_k-1/2\right) \quad \text{--- (II)}$$

Put the mid pt value getting in (II) in eq (I)

decision parameter

$$P_k = f_{circle}\left(x_k+1, y_k-\tfrac{1}{2}\right) = (x_k+1)^2 + \left(y_k-\tfrac{1}{2}\right)^2 - r^2 \quad \text{--- (1)}$$

if $\boxed{P_k < 0}$ $\Rightarrow f_{circle}\left(x_k+1, y_k-\tfrac{1}{2}\right) < 0$

$\Rightarrow$ midpoint is inside the circle boundary.

new pt

i.e. $\boxed{(x_{k+1}, y_{k+1}) = (x_k+1, y_k)}$

if $\boxed{P_k > 0}$ $\Rightarrow f_{circle}\left(x_k+1, y_k-\tfrac{1}{2}\right) > 0$

$\Rightarrow$ midpoint is outside the circle boundary.

new pt

i.e. $\boxed{(x_{k+1}, y_{k+1}) = (x_k+1, y_k-1)}$

Once, new pixel is finalized, then calculate the successive decision parameter.

$$P_{k+1} = (x_{k+1}+1)^2 + \left(y_{k+1}-\tfrac{1}{2}\right)^2 - r^2 \quad \text{--- (2)}$$

Subtract (2) from (1)

$$P_{k+1} - P_k = (x_{k+1}+1)^2 + (y_{k+1}-1/2)^2 - \cancel{r^2} - (x_k+1)^2 - (y_k-1/2)^2 + \cancel{r^2}$$

$$= [(x_{k+1}+1)^2 + (y_{k+1}-\tfrac{1}{2})^2 - (x_k+1)^2 - (y_k-1/2)^2$$

$$= (x_{k+1}+1)^2 + (y_{k+1}-\tfrac{1}{2})^2 - (x_k+1)^2 - (y_k-\tfrac{1}{2})^2$$

$$= x_{k+1}^2 + 1 + 2x_{k+1} + (y_{k+1}-\tfrac{1}{2})^2 - (x_k+1)^2 - (y_k-\tfrac{1}{2})^2$$

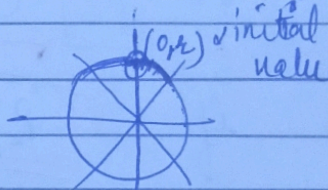
$$= \cancel{(x_k+1)^2} + 1 + 2x_{k+1} + (y_{k+1}-\tfrac{1}{2})^2 - \cancel{(x_k+1)^2} - (y_k-\tfrac{1}{2})^2$$

$$= 1 + 2x_{k+1} + y_{k+1}^2 + \cancel{\tfrac{1}{4}} - y_{k+1} - y_k^2 - \cancel{\tfrac{1}{4}} + y_k$$

$$= 1 + 2x_{k+1} + (y_{k+1}^2 - y_{k+1}) - (y_k^2 - y_k)$$

$$\boxed{P_{k+1} = P_k + 1 + 2x_{k+1} + (y_{k+1}^2 - y_{k+1}) - (y_k^2 - y_k)}$$

Initial decision Parameter



$$P_0 = f_{circle}(0, r)$$

$$= f_{circle}(x_k+1, y_k-\tfrac{1}{2}) \quad [\text{from II}]$$

initial value (0, r), Put this in the eqn

$$= (x_k+1)^2 + (y_k-\tfrac{1}{2})^2 - r^2$$

$$= (0+1)^2 + (r-1/2)^2 - r^2$$

$$= 1 + \cancel{r^2} + \tfrac{1}{4} - r - \cancel{r^2} = \boxed{\tfrac{5}{4} - r}$$

r = integer: $\boxed{P_0 = 1 - r}$

r = floating: $\boxed{\tfrac{5}{4} - r}$

formulas

Now, in P_{k+1} eq^n; we can have 2 values for y_{k+1}

$$y_{k+1} = y_k \quad \text{or} \quad = y_k - 1 \Big\} \text{ depending upon the decision parameter value}$$

$r \quad (0,0)$

$$P_0 = \frac{5}{4} - r$$

$$P_k = (x_k+1)^2 + (y_k - 1/2)^2 - r^2$$

$$P_{k+1} = P_k + 1 + 2x_{k+1} + (y_{k+1}^2 - y_{k+1}) - (y_k^2 - y_k)$$

when $P_k < 0$

$$P_{k+1} = P_k + 1 + 2(x_k+1)$$

when $P_k > 0$

$$P_{k+1} = P_k + 1 + 2(x_k+1) - 2y_{k+1}$$

So, if $\boxed{P_k < 0} \Rightarrow \boxed{y_{k+1} = y_k}$

putting in P_{k+1} eq^n.

$$P_{k+1} = P_k + 1 + 2(x_k+1) + (\cancel{y_k^2 - y_k}) - (\cancel{y_k^2 - y_k})$$

$$\boxed{P_{k+1} = P_k + 1 + 2(x_k+1)}$$

if $\boxed{P_k > 0} \Rightarrow \boxed{y_{k+1} = y_k - 1}$

$$P_{k+1} = P_k + 1 + 2(x_k+1) + ((y_k-1)^2 - (y_k-1)) - (y_k^2 - y_k)$$

$$= P_k + 1 + 2(x_k+1) + [\cancel{y_k^2} + 1 - 2y_k - \cancel{y_k} + 1 - \cancel{y_k^2} + \cancel{y_k}]$$

$$= P_k + 1 + 2(x_k+1) + 2 - 2y_k$$

$$\boxed{P_{k+1} = P_k + 1 + 2(x_k+1) - 2(y_k - 1) = P_k + 1 + 2(x_k+1) - 2y_{k+1}}$$

Example Center $(0,0)$ radius $= 10$ units

$\because r = 10$, Integer so consider $\boxed{P_0 = 1 - r}$

$P_0 = 1 - r$
$= 1 - 10 = -9$

$P_0 < 0$ then $y_{k+1} = y_k$

Initial value (x_k, y_k) $(0, r) \Rightarrow (0, 10)$

so, $(x_{k+1}, y_{k+1}) \Rightarrow (x_{k+1}, y_k)$
$= (x_k + 1, y_k)$
$(0+1, 10)$

Table 1

K	P_k	(x_{k+1}, y_{k+1})
0	-9	(1, 10)
1	-6	(2, 10)
2	-1	(3, 10)
3	6	(4, 9)
4	-3	(5, 9)
5	8	(6, 8)
6	5	(7, 7)

1st octant value

$x = y$

$P_{k+1} = P_{0+1} = P_1 = P_0 + 1 + 2(x_k + 1)$
$= -9 + 1 + 2(0+1)$
$= -9 + 1 + 2$
$= -9 + 3 = -6$

$k \Rightarrow 1$, $\boxed{P_1 \Rightarrow -6} < 0$

$(x_{k+1}, y_{k+1}) = (x_k + 1, y_k)$
$= (1+1, 10) = (2, 10)$

$P_{k+1} = P_2 = P_1 + 1 + 2(x_k + 1)$
$= -6 + 1 + 2(1+1)$
$= -6 + 1 + 4 = -6 + 5$
$\boxed{P_2 = -1} < 0$

$(x_{k+1}, y_{k+1}) = (x_k + 1, y_k)$
$= (2+1, 10)$
$= (3, 10)$

$P_{k+1} = P_3 = P_2 + 1 + 2(x_k + 1)$
$= \cancel{-1} + \cancel{1} + 2(2+1)$
$= 2(3) = 6$

$P_3 = 6 > 0$

$(x_{k+1}, y_{k+1}) = (x_k + 1, y_k - 1)$
$= (4, 9)$

$P_{k+1} = P_4 = P_k + 1 + 2(x_k + 1) - 2y_{k+1}$
$= 6 + 1 + 2(3+1) - 2(10-1)$
$= 7 + 8 - 18 = 15 - 18$
$= -3$

follow these steps until $\boxed{x \geq y}$

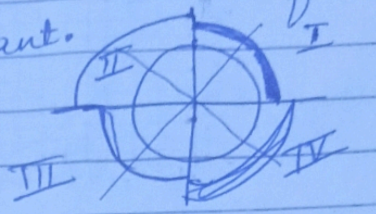
* We have got values for 1st octant, from these values, we will calculate values for other octants also (using 8-way symmetry prop.)

Continuing to table 1

Table ②

k	p_k	(x_{k+1}, y_{k+1})
6	5	(7,7)
7		(8,6)
8		(9,5)
9		(9,4)
10		(10,3)
11		(10,2)
12		(10,1)

Combing pixel values of Table ① & ②, we have calculated all the pixel values for 1st Quadrant.



for 2nd Quadrant

$\begin{pmatrix} x \to -ve \\ y \to +ve \end{pmatrix}$

Q2

Q2 pixels:

(-1,10)
(-2,10)
(-3,10)
(-4,9)
(-5,9)
(-6,8)
(-7,7)
(-8,6)
(-9,5)
(-9,4)
(-10,3)
(-10,2)
(-10,1)

for IIIrd Quadrant

$\begin{pmatrix} x \to -ve \\ y \to -ve \end{pmatrix}$

Q3 pixels:

(-1,-10)
(-2,-10)
(-3,-10)
(-4,-9)
(-5,-9)
(-6,-8)
(-7,-7)
(-8,-6)
(-9,-5)
(-9,-4)
(-10,-3)
(-10,-2)
(-10,-1)

for IVth Quadrant

$\begin{Bmatrix} x \to +ve \\ y \to -ve \end{Bmatrix}$

Q4 pixels:

(1,-10)
(2,-10)
(3,-10)
(4,-9)
(5,-9)
(6,-8)
(7,-7)
(8,-6)
(9,-5)
(9,-4)
(10,-3)
(10,-2)
(10,-1)

Numericals (Pixels, Resolution, Aspect Ratio)

Q1 How many k bytes does a frame buffer need in a 600×400 pixel?

Sol^n given Resolution $= 600 \times 400$

Size of $\boxed{\text{frame buffer} = \text{resolution} \times \text{bits/pixel}}$.

Suppose there ~~are~~ n-no. of bits

So, size $= 600 \times 400 \times n$ bits

$= 240000\,n$ bits

Now $1\ \text{Kb} = 1024$ bytes

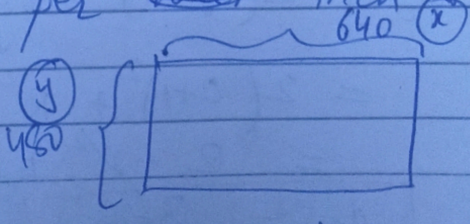
$= 1024 \times 8$ bits

So, $n\ \text{bits} = \frac{1}{1024 \times 8}$ ~~K~~b.

$\Rightarrow$ size $= \frac{240000}{1024 \times 8}$ k-byte

$= 29.30$ Kb Ans

Q2 Compute the size of 640×480 image at 240 pixels per inch.



Sol^n 240 pixels $\to$ 1 inch

1 pixel $= \frac{1}{240}$

640 pixel $= \left(\frac{640}{240}\right)$ inch

480 pixel $= \left(\frac{480}{240}\right)$ inch

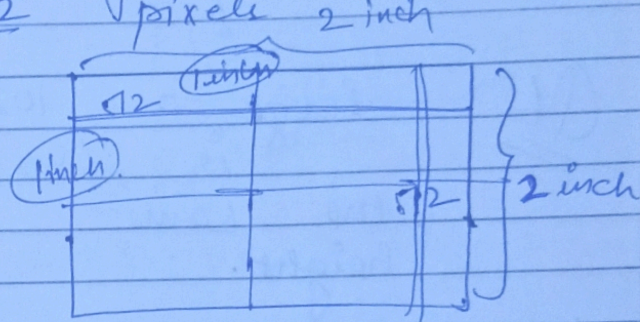
Area = $l \times b$.

$$= \left(\frac{\cancel{480}^{2}}{\cancel{240}} \times \frac{640}{240}\right)$$

$$\boxed{\text{Area} = 5.33 \text{ inch}^2}$$

Q3 Compute the resolution of $\underset{W}{2} \times \underset{H}{2}$ inch image that has $\underset{W}{512} \times \underset{H}{512}$ pixels

As Resolution is no. of pixels per unit length.

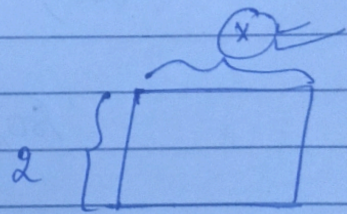


$$\frac{512}{2} = 256$$

As (256 × 256)

Q4 If an image has height of 2-inches & aspect ratio of 1.5, calculate its width.

As Aspect ratio = $\frac{\text{width}}{\text{height}}$



$$1.5 = \frac{x}{2}$$

$\boxed{x = 3}$ inches

Q5 Calculate total number of pixels for a 3x2 inch image at resolution of 300 pixels per inch.

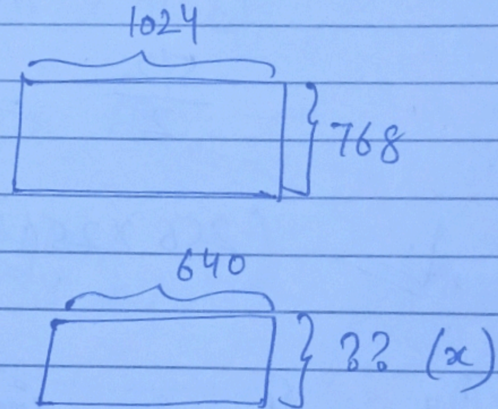
Sol^n

$(3 \times 300) \times (2 \times 300)$

$\Rightarrow (900, 600)$

Q6 Resize a 1024 X 768 image to one that is 640 pixels wide with the same aspect ratio, time its height.

Sol^n



$$\text{Aspect ratio}_1 = \frac{1024}{768}$$

$$AR_2 = \frac{640}{x}$$

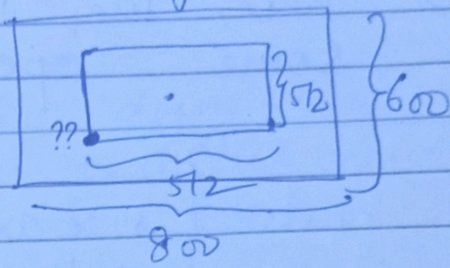
Now, $AR_1 = AR_2$

So, $$\frac{1024}{768} = \frac{640}{x}$$

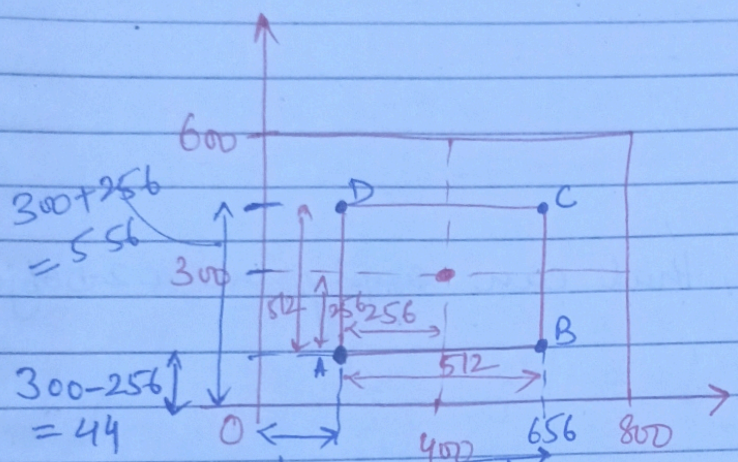
$$x = \frac{640 \times 768}{1024} = 480$$

(640×480) ✓

Q7 Cut a 512 X 512 sub image from the center of 800 X 600 image, find the coordinates of the pixel in the large image that is at the lower left corner of the small image.



Sol^n



$400 + 256 = 656$

$400 - 256 = 144$

pt $A \Rightarrow (144, 44)$

$B \Rightarrow (656, 44)$

$D \Rightarrow (144, 556)$

$C \Rightarrow (656, 556)$

$$\begin{array}{r} 556 \\ -44 \\ \hline 512 \end{array}$$