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Computer Graphics
Tutorial 2

Ans 1.
- Assume pixel $P_1(x_1', y_1')$, then select subsequent pixel as we move two a particular direction.
- If $x_1' > x_2'$, then swap (x_1', y_1') & (x_2', y_2').
- If $abs(x_2 - x_1) > abs(y_2 - y_1)$, then use y_1' in below steps and use the algorithm considering y axis as the primary axis.
- Now for any point (x_k, y_k) the next point is either (x_{k+1}, y_k) or (x_{k+1}, y_k+1) where $x_{k+1} = x_k+1$
- The next point is decided with the help of a decision parameter
- Let us now derive the decision parameter.

Let the line be $y = mx_i + b$

Now $S = (x_i+1, y_i)$

$T = (x_i+1, y_i+1)$

If S is chosen,

$$s_{diff} = y - y_i$$

If T is chosen,

$$t_{diff} = (y_i+1) - y$$

Now, $s_{diff} - t_{diff} = 2y - 2y_i - 1$

$= \cancel{2(m(x_i+1)+b) - 2y_i - 1}$

$= 2((m(x_i+1)) + 2b - 2y_i + 1$

Let decision variable,

$$d_i = \Delta x(s - t) \quad \& \quad m = \frac{\Delta y}{\Delta x}$$

$$d_i = 2\Delta y\, x_i - 2\Delta x y_i + 2\Delta y + \Delta x(2b - 1)$$

- If $d_i < 0$,
  then choose S, else choose T.
- Calculate new d_i and iterate these steps till $x_i = x_2'$.

Remember,

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

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

Also, $d_0 = 2\Delta y - \Delta x$

Now, given (0,0) & (5,4)
the points to be plotted are :-

x_i	y_i	d_i	d_{i+1}
0	0	3	1
1	1	1	-1
2	1	7	5
3	2	5	3
4	3	3	1
5	4	-1	-

Ans 2. Given,
Centre of circle as origin (0,0)
Radius = 10.
The points to be plotted are as follows:-

-9	10	0	-6	(10,0)	(0,10)	(-10,0)	(0,-10)
-6	10	1	-1	(10,1)	(1,10)	(-10,1)	(1,-10)
				(10,-1)	(-1,10)	(-10,-1)	(-1,-10)
-1	10	2	6	(10,2)	(2,10)	(-10,2)	(2,-10)
				(10,-2)	(-2,10)	(-10,-2)	(-2,-10)
6	9	3	-1	(9,3)	(3,9)	(-3,9)	(-9,3)
				(9,-3)	(3 -9)	(-3,-9)	(-9,-3)

Date
Page

-1	9	4	10	(9,4) (9,-4)	(4,9) (4,-9)	(-9,4) (-9,-4)	(-4,9) (-4,-9)
10	8	5	9	(8,5) (8,-5)	(5,8) (5,-8)	(-8,5) (-8,-5)	(-5,8) (-5,-8)
9	7	6	12	(7,6) (-7,6)	(7,-6) (-7,-6)	(6,7) (-6,-7)	(6,-7) (-6,7)
12	6	7		break loop.			

Ans 3: Given - P = (1,1)
Q = (5,9)

Here, abs$(y_2 - y_1)$ > abs$(x_2 - x_1)$.

Hence, ~~ystep~~ step = 8
~~xstep~~ x_{inc} = dx/step = 0.5
y_{inc} = dy/step = 1

x	y	plot x	plot y
1	1	1	1
1.5	2	2	2
2	3	2	3
2.5	4	3	4
3	5	3	5
3.5	6	4	6
4	7	4	7
4.5	8	5	8
~~4~~5	9	5	9.

Ans 4: Here,

$P_1 = (0,0)$

$P_2 (-8,-4)$

Now, $abs(x_1 - x_2) > abs(y_2 - y_1)$, so major axis is x axis

Now, $x_1 > x_2$, so swap P_1 & P_2. Hence,

$P_1 = (-8,-4)$ $\quad 2\Delta y = -8 \quad 2\Delta y - 2\Delta x = -8+16 =$

$P_2 (0,0)$. $\quad \Delta x = -8$

Now,

x_i	y_i	d_i	d_{i+1}
-8	-4	0	-8
-7	-3	-8	0
-6	-3	0	-8
-5	-2	-8	0
-4	-2	0	-8
-3	-1	-8	0
-2	-1	0	-8
-1	0	-8	0
0	0	0	-

Ans 5: Given,

$P_1 = (1,1)$

$P_2 = (5,3)$

Here, $x_2 > x_1$ & $abs(x_1 - x_2) > abs(y_2 - y_1)$.

Now, $2\Delta y = 4 \quad d_0 = 2\Delta y - \Delta x = 0$

$2\Delta x = 8$

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

x_i	y_i	d_i	d_{i+1}
1	1	0	-4
2	2	-4	0
3	2	0	-4
4	3	-4	0
5	3	0	-

Ans 6. Given,
Centre (100,100)
And radius 10.

Similar to question 2, the pixels are similar with an x shift of +100 & y shift of +100.

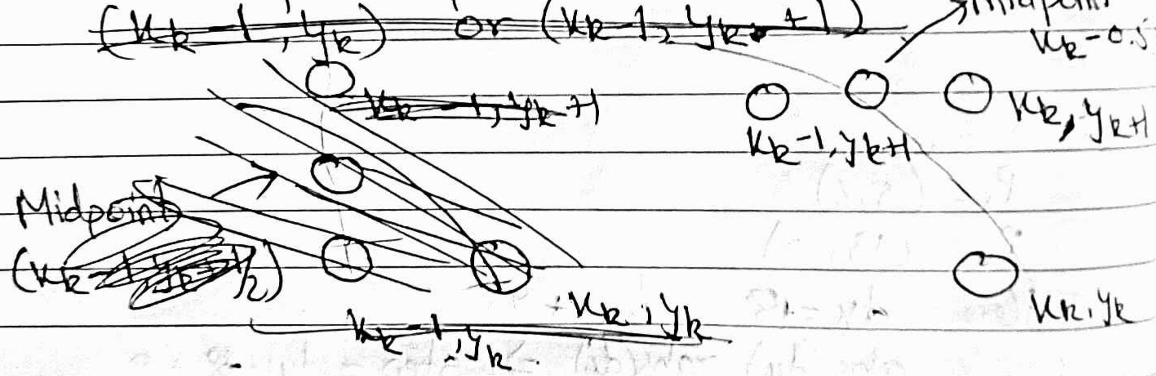
Ans 7. Given,
$P_1 = (5,6)$
$P_2 = (13,10)$
Here $dx = +8$ $dy = +4$.
abs(dx) > abs(dy) ⇒ step = abs(dx) = +8
$x_{inc} = dx/step = +1$
$y_{inc} = dy/step = +0.5$

x_1	y_1	Plotx	Ploty
5	6	5	6
6	6.5	6	7
7	7	7	7
8	7.5	8	8
9	8	9	8
10	8.5	10	9
11	9	11	9
12	9.5	12	10
13	10	13	10

Ans 8:- For midpoint circle theorem,
we need to understand the fact that a circle is similar to the axes which are perpendicular or at an angle 45° to each other.
Hence, an eight way Symmetry is followed.

Hence, we only need to iterate for any one octant.
let the origin be (0,0) & radius be r.
Then, we shall start plotting from (r,0) ~~a~~ till that octant is completed, that is when,
~~$x_k <= y_k$~~ $x_k <= y_k$, we stop.

Now, we reduce ~~x_k~~ y_k by 1 in each loop,
so the next possible point is either:-
~~$(x_k - 1, y_k)$ or $(x_k - 1, y_k + 1)$~~



Now, if the midpoint lies inside or on circle, we will use $(x_k - 1, y_k)$, otherwise $(x_k - 1, y_k + 1)$.

How do we check whether it lies inside or not?
Thats where the decision parameter comes in.
let the circle be:-
$$x^2 + y^2 = r^2$$
then, $P_k = x_k^2 + y_k^2 - r^2$.
If $P_k > 0$, point lies outside, else inside or on.

Now, $P_{mid} = (x_k - 1)^2 + (y_k + \cancel{0.5}\,1)^2 - r^2$

Here, $x_{k+1} = x_k$ or $x_k - 1$

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

Hence, $P_{k+1} = (x_{k+1} - 0.5)^2 + (y_{k+1} + 1)^2 - r^2$

$$P_{k+1} = P_k + (x_{k+1} - 0.5)^2 + (x_k - 0.5)^2 + 2(y_k+1) + 1$$

Hence, $P_{k+1} = P_k + 2(y_k + 1) + 1$ when $P_k <= 0$

$P_{k+1} = P_k + 2(y_k + 1) - 2(x_k - 1) + 1$ when $P_k > 0$.

The first point is $(r, 0)$.

Hence,

$$P_0 = (r - 0.5)^2 + (0+1)^2 - r^2$$
$$= r^2 - r + 1/4 + 1 - r^2$$
$$= 1.25 - r$$
$$\simeq \underline{\underline{1 - r}}$$

Calculate P_k for each iteration and plot required points (x_k, y_k) (y_k, x_k) $(x_k, -y_k)$ $(-x_k, y_k)$ $(y_k, -x_k)$ $(-y_k, x_k)$ $(-x_k, -y_k)$ $(-y_k, -x_k)$.