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25/04/22

Basics Of Computer Graphics And Algorithms

Basics of computer graphics

Computer graphics is an art of drawing pictures on computer screen with the help of programming. It involves computations, creations and manipulation of data. The end product of the computer graphics is a picture it may be a business graph, drawing and engineering. In computer graphics 2-D or 3-D pictures can be created that are used for research. Unit of image - pixel or pel.

Why CG is used ?

Suppose a computer manufacturing company wants to show the sale of computer for 5 years. For this vast amount of information to be stored, a lot of time and memory will be needed. This method will be tough to understand by a common man. In this situation, graphics is a better alternative. Graphics tools are charts and graphs. Using graphs, data can be represented in pictorial form. A picture can be understood easily just with a single look.

Applications of Computer graphics

1) Computer Art

Using computer graphics, we can create fine and commercial art which include animation packag paint packages. These packages provide facilities for designing object shapes and specifying object moti

2) CAD - Computer Aided Drawing

Designing of buildings, automobile air craft is done with the help of CAD. This helps in providing minute details to the drawing and producing more accurate and sharp drawings with better specifications

3) Presentation Graphics

For the preparation of reports or summarising the financial, statistical, mathematical, scientific managerial reports, moreover creation of bar graphs, pie charts can be done using the tools present in CG.

4) Entertainment

CG finds a major part of its utility in the movie industry. It is used for creating motion pictures, music, video, films etc.

5) Education

Computer generated models are extremely useful for teaching huge number of concepts and fundamentals in an easy to understand and learn manner.

6) Training

Specialised s/m for training like simulators can be used for training the candidates in a way that can be grasped in a short span of time with better understanding.

CG Types

Interactive & Passive computer graphics

* Interactive Computer Graphics — (active)

It involves a two way communication between computer and user. The observer is given some control over the image by providing him with an input device.
Eg- Observer send his request to the computer through video game controller.

* Non Interactive Computer Graphics —

It is also known as passive computer graphics. The user does not have any kind of control over the image. It involves only a one way communication. The image is merely the product of static stored program and will work according to the instructions given in the program linearly. The image is totally under the control program instructions, not under the user.
Eg- Images shown on television.

Video display devices

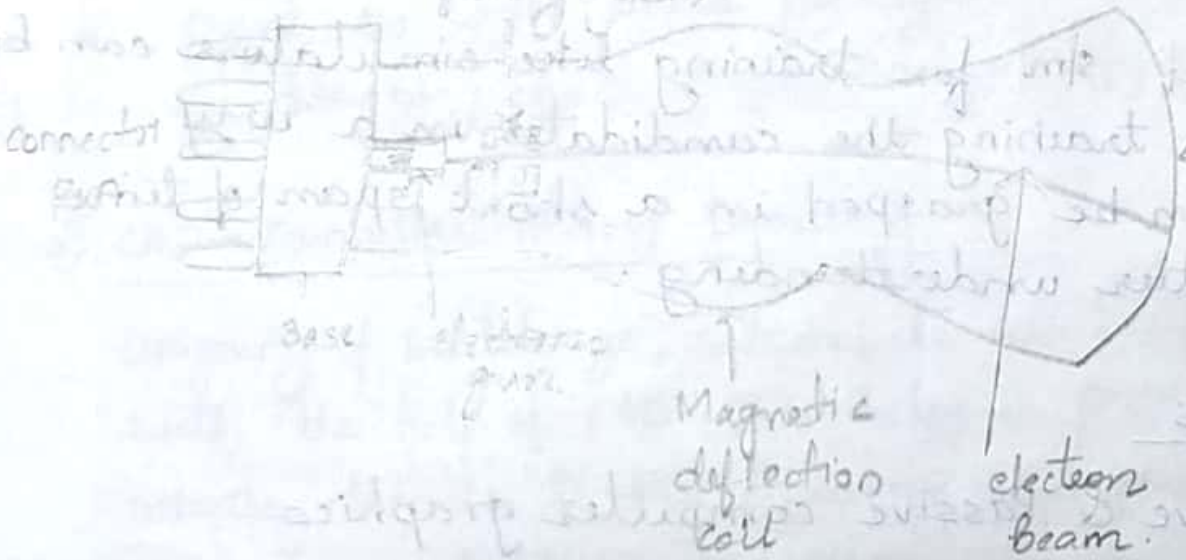
Introduction

The primary output device in a graphics system is a video monitor. The operation of most video monitors is based on the standard (CRT) cathode-ray tube but several other technologies exist and solid state monitors may eventually predominate.

Display devices :

1. CRT
2. Raster Scan Displays
3. Random Scan Displays
4. Color CRT monitors
5. Direct view storage Tubes
6. Flat panel Displays
7. Liquid Crystal displays
8. 3D viewing devices.
9. Stereoscopic & virtual reality system

① CRT - Cathode Ray Tube



Basic architecture of CRT

Working

A beam of electrons (cathode rays) emitted by an electron gun passes through the focusing and deflection systems that directs the beam towards specified position on the phosphor coated screen. The phosphor then emits a small spot of light at each position contacted by the electron beam. Because the light emitted by the phosphor fades very rapidly some method is needed for maintaining the screen picture. One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the beam back over the same points. This type of display is called refresh CRT

Components of CRT

① Electron gun :-

The electron gun is made up of several elements mainly a heating filament and a cathode. The electron gun is a source of electrons focused on a narrow beam facing the CRT

② Focusing & accelerating anode :-

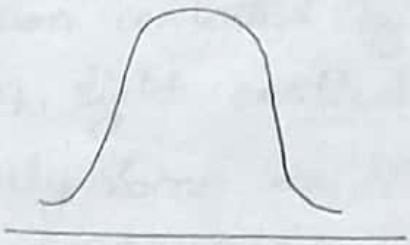
These anodes are used to produce a narrow and sharply focused beam of electrons (Otherwise the electrons will repel each other)

③ Vertical and Horizondal deflection plates :

These plates are used to guide the path of the electron beam. The plates produce an electromagnetic field that bends the electron beam through the area it travels.

④ Phosphorous - coated Screen :-

It is used to produce bright spots when the high velocity electron beam hits it.



Intensity distribution of an illuminated phosphor spot on a CRT screen

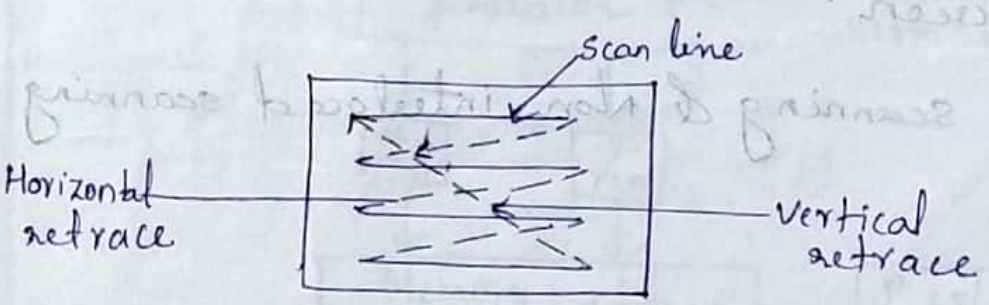
The figure shows the intensity distribution of spot on the screen. The intensity is greatest at the centre of the spot and decreases with a gaussian distribution out to the edges of the spot.

The maximum no. of points that can be displayed without overlap on a CRT is referred to as the resolution or it can be defined as the no. of points per centimeter that can be plotted horizontally and vertically. Typical resolution on high quality system is 1280 by 1204. The high resolution systems are often referred to as high definition system.

Aspect ratio of a video monitor

The number gives the ratio of vertical points to horizontal points necessary to produce equal length lines.

(2) RASTER SCAN DISPLAYS

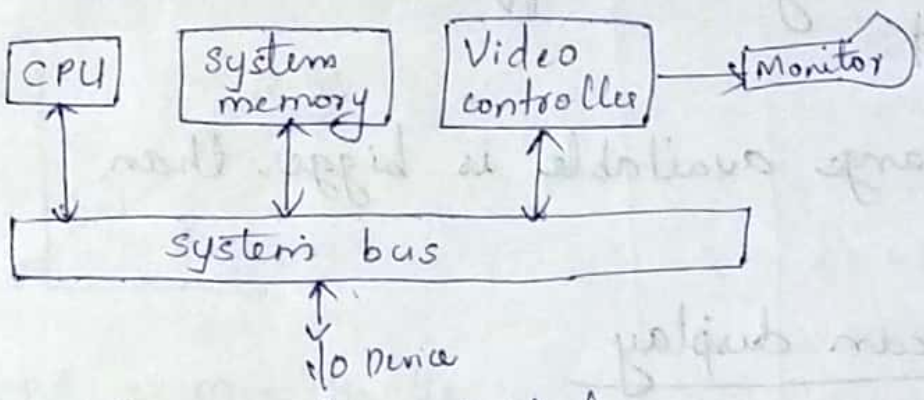


The most common type of graphics monitor employing a CRT is the raster scan display. In this system, a beam of electrons is moved across the screen. It moves from top to bottom considering one row at a time. As the beam of electron moves through each row, its intensity is alternatively turned on and off which helps to create a pattern of spots that are illuminated when each scan of the line is refreshed, it returns to the left side of the screen. This motion is known as horizontal retrace. As a particular frame ends, the beam of electrons moves to the left top corner of the screen, to move to another frame. This motion is referred to as vertical retrace. The picture is then stored in an area of memory known as frame buffer or refresh buffer. The buffer in a raster scan is that area that is responsible for containing intensity of the various points on the screen. The values stored in the buffer are then fetched and traced over scan lines one by one on the screen.

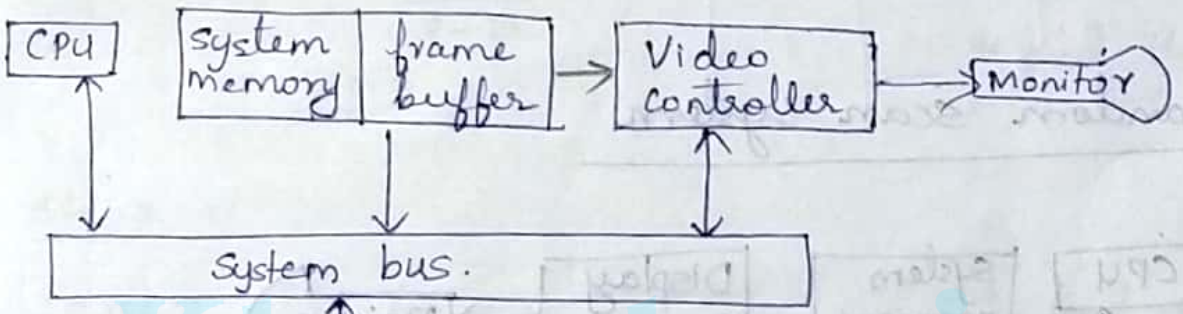
Interlaced scanning & Non interlaced scanning.

Raster Scan System

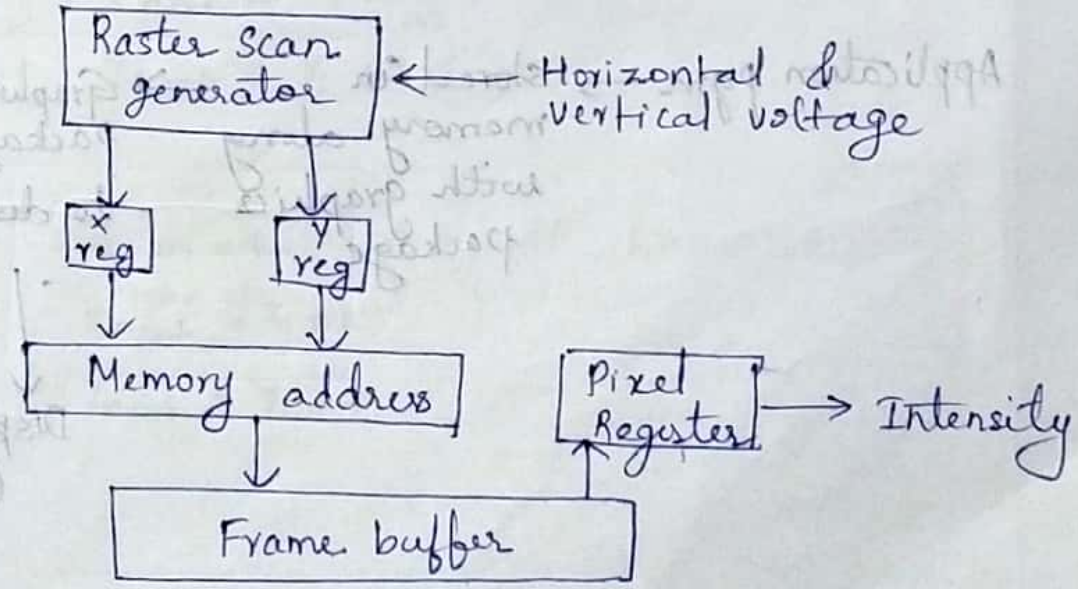
Simple architecture



Commonly used architecture



Basic video controller



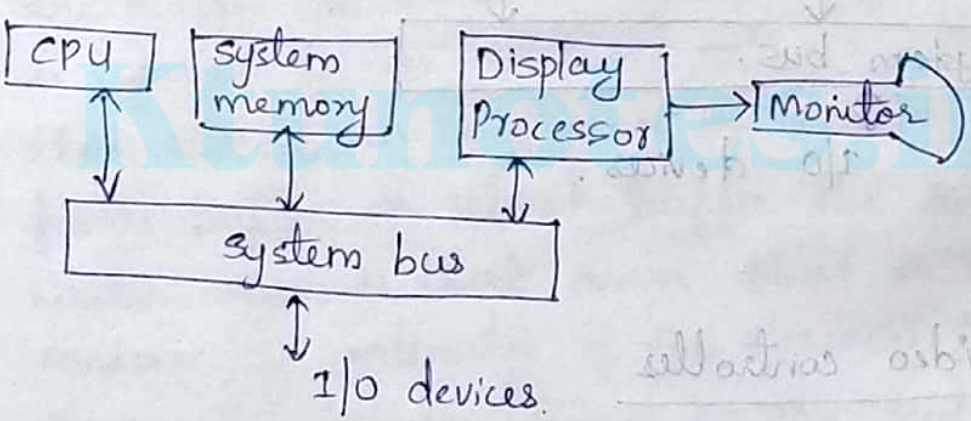
Advantages

1. Real life images in different shade can be displayed
2. Colour range available is bigger than

Random Scan display

Vector scan / calligraphic scan

Random scan system



Application pgm → stored in memory along with graphics package → Graphics package translated to display file.

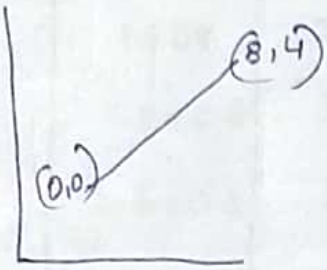
Display processor (refresh)

↓

Monitor

DDA - Digital Differential Analyzer

Eg:



Step 1 : $m = \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{4-0}{8-0} = 0.5$

to find the slope.

$m = 0.5$

Step 2 :

case 1 if $m < 1$ — to find the intermediate points

$x_{next} = x + 1$

$y_{next} = y_1 + m$

case 2 if $m > 1$

$x_{next} = x_1 + \frac{1}{m}$

$y_{next} = y_1 + 1$

case 3 if $m = 1$

$x_{next} = x_1 + 1$

$y_{next} = y_1 + 1$

Step 3 : $m = 0.5$

x_1	y_1	x_{next}	y_{next}
0	0		
0+1	0+0.5	1	0.5
1+1	0.5+0.5	2	1
2+1	1+0.5	3	1.5
3+1	1.5+0.5	4	2
4+1	2+0.5	5	2.5
5+1	2.5+0.5	6	3
6+1	3+0.5	7	3.5
7+1	3.5+0.5	8	4

Q1) Draw a line from (1,1) to (8,7) using DDA algorithm

Step 1

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

$$= \frac{7-1}{8-1} = \frac{6}{7}$$

$$= 0.8$$

Step 2

As $m < 1$, then $x_{next} = x + 1$

$y_{next} = y_1 + m$

Step 3

x_1	x	x_{next}	y_{next}
1	1		
1+1	1+0.8	2	1.8
2+1	1.8+0.8	3	2.6
3+1	2.6+0.8	4	3.4
4+1	3.4+0.8	5	4.2
5+1	4.2+0.8	6	5
6+1	5+0.8	7	5.8
7+1	5.8+0.8	8	6.6

Q2) Draw a line using DDA algorithm for point (0,0) (4,6).

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

$$= \frac{6-0}{4-0} = \frac{3}{2}$$

$$= 1.5$$

Step 2

As $m > 1$, then $x_{next} = x_1 + \frac{1}{m}$

$$y_{next} = y_1 + 1$$

x_1	y_1	x_{next}	y_{next}
0	0		
$0+\frac{1}{1.5}$	0+1	0.6	1
$0.6+\frac{1}{1.5}$	1+1	1.2	2
$1.2+\frac{1}{1.5}$	2+1	1.8	3
$1.8+\frac{1}{1.5}$	3+1	2.4	4
$2.4+\frac{1}{1.5}$	4+1	3.0	5
$3+\frac{1}{1.5}$	5+1	3.6	6

Bresenham's line drawing algorithm

① $A(x_1, y_1)$ $B(x_2, y_2)$

$\Delta x = x_2 - x_1$

$\Delta y = y_2 - y_1$

$x_1 = 20$ $y_1 = 10$

$x_2 = 30$ $y_2 = 18$

$\Delta x = 30 - 20 = 10$

$\Delta y = 18 - 10 = 8$

② find decision parameter, P_K

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

$P_K = 2 \times 8 - 10$

$= 16 - 10$

$= \underline{6}$

③ **Case 1**: if $P_k > 0$

$$P_{k+1} = P_k + 2\Delta Y - 2\Delta X$$

$$X_{next} = X_1 + 1$$

$$Y_{next} = Y_1 + 1$$

Case 2: if $P_k < 0$

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

$$X_{next} = X_1 + 1$$

$$Y_{next} = Y_1$$

P_K	X_n	Y_n
$6 > 0$	21	11
$P_{K+1} = 6 + 2\times8 - 2\times10$ $= 6 + 16 - 20$ $= 2 > 0$	22	12
$P_{K+1} = 2 + 2\times8 - 2\times10$ $= 2 + 16 - 20$ $= -2 < 0$	23	12
~~$P_{K+1} = -2 + 2\times8 - 2\times10$~~ ~~$= -2 + 16 - 20$~~ $P_{K+1} = -2 + 2\times8$ $= -2 + 16$ $= 14 > 0$	24	13
$P_{K+1} = 14 + 2\times8 - 2\times10$ $= 14 + 16 - 20$ $= 10 > 0$	25	14
$P_{K+1} = 10 + 2\times8 - 2\times10$ $= 10 + 16 - 20$ $= 6 > 0$	26	15
$P_{K+1} = 6 + 2\times8 - 2\times10$ $= 6 + 16 - 20$ $= 22 - 20 = 2 > 0$	27	16

$P_{k+1} = P_k + 2\times8 - 2\times10$ $= 2 + 16 - 20$ $= +2 > 0$	28	16
$P_{k+1} = +2 - 4$ $= -2 < 0$	29	17
$P_{k+1} = -2 + 16$ $= +14 > 0$	30	18

Q Draw a line using Bresenham's line drawing algorithm for the point (9, 18) (14, 22)

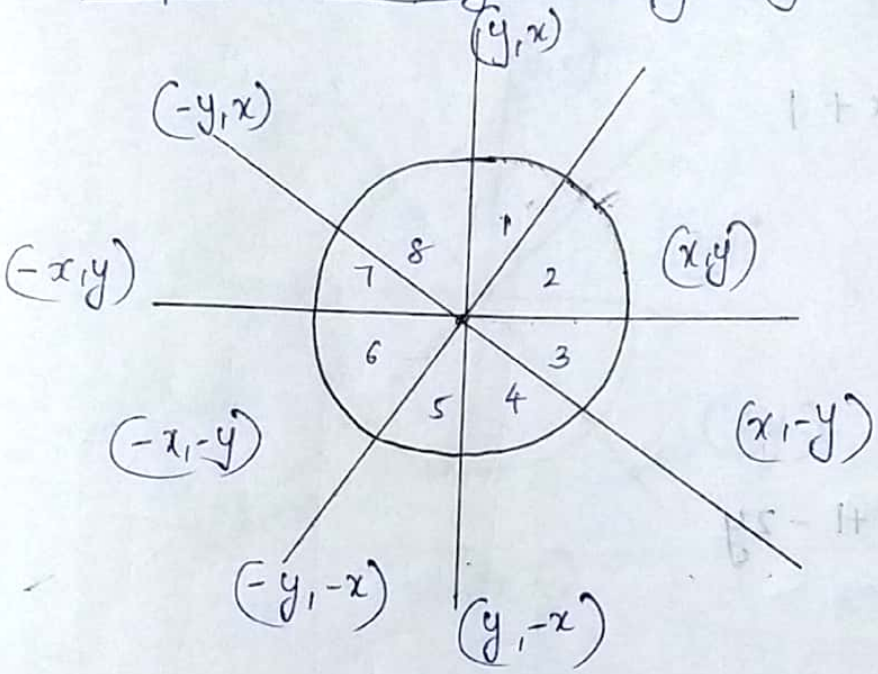
$\Delta x = x_2 - x_1$
$= 14 - 9 = 5$

$\Delta y = y_2 - y_1$
$= 22 - 18 = 4$

$P_k = 2\times4 - 5$
$= 3$

P_k	x_n	y_n
$3 > 0$	10	19
$P_{k+1} = 3 + 2\times4 - 2\times5$ $= 3 + -2 = 1 > 0$	11	20
$P_{k+1} = 1 - 2$ $= -1 < 0$	12	20
$P_{k+1} = -1 + 8$ $= +7 > 0$	13	21
$P_{k+1} = +7 - 2$ $= +5 > 0$	14	22

Midpoint Circle generating algorithm

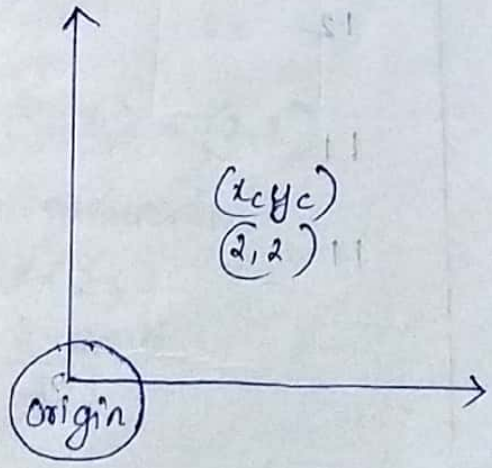


① Given $Y = 10$

$$\boxed{Y = R}$$

R is the radius

② Given $(x_c\ y_c)$



③ Decision parameter

$$P_K = 1 - R$$
$$= 1 - 10$$

$$\boxed{P_K = -9}$$

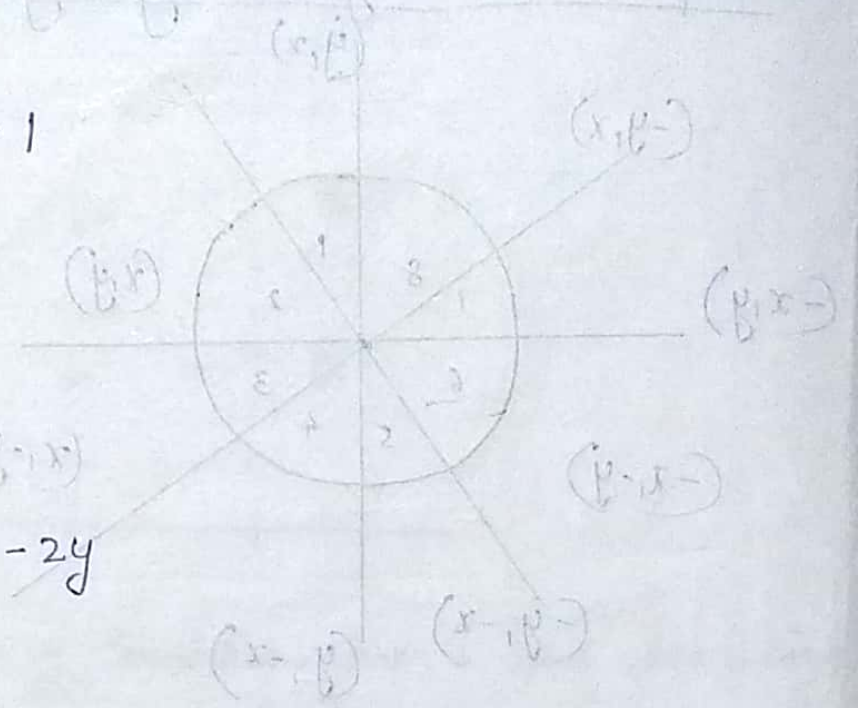
④ Case 1

$P_k < 0$

$P_{k+1} = P_k + 2x + 1$

$x_n = x + 1$

$y_n = y$



Case 2

$P_k > 0$

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

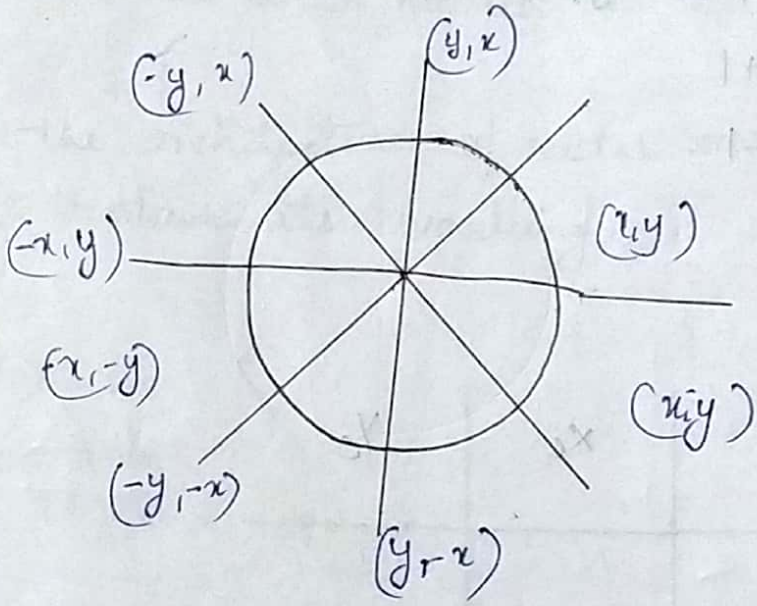
$x_n = x + 1$

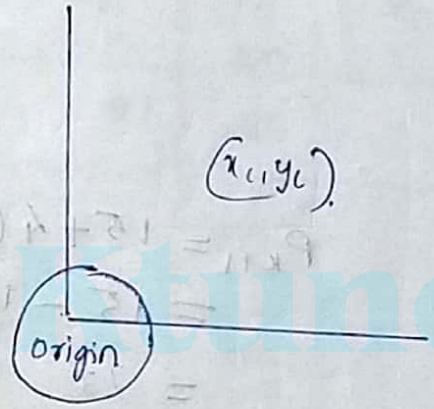
$y_n = y - 1$

⑤ stop when $x = y$.

P_k	x_n	y_n	x_c	y_c
$-9 < 0$	0	10	$x + x_c$	$y + y_c$
$-9 + 2\times1 + 1 = -6 < 0$	1	10	2	12
$-6 + 2\times2 + 1 = -4 < 0$	2	10	4	12
$-1 + 2\times3 + 1 = 6 > 0$	3	10	5	11
$6 + 2\times4 + 1 - 2\times9 = -3 < 0$	4	9	6	11
$-3 + 2\times5 + 1 = 8 > 0$	5	9		
$8 + 2\times6 + 1 - 2\times8 = 5 > 0$	6	8		
$5 + 2\times7 + 1 - 14 = 6$	7	7		

Bresenham's Circle generating algorithm





① Given $R = 10$

$$\boxed{Y = R}$$

② Given $(x_c, y_c) = (2, 2)$

③ Decision parameter

$$P_K = 3 - 2r$$
$$= 3 - 2 \times 10$$
$$\boxed{P_K = -17}$$

④ Case 1 $\quad P_K < 0$

$$P_{K+1} = P_K + 4x + 6$$
$$x_n = x + 1$$
$$y_n = y$$

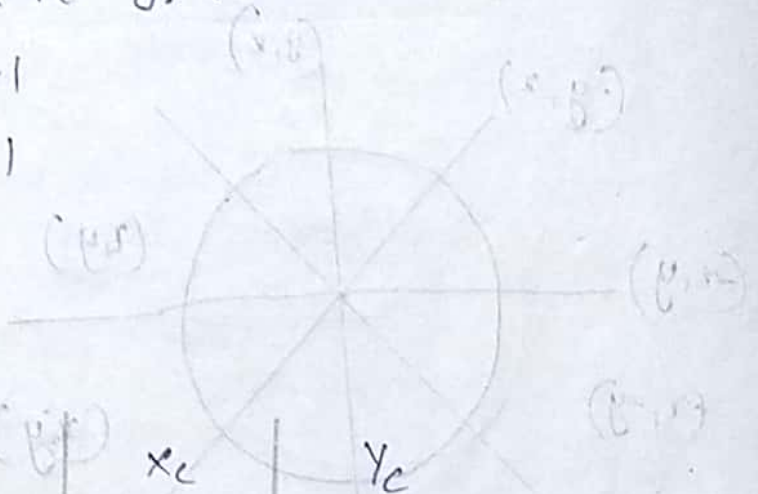
Case 2 $P_k > 0$

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

$$x_n = x+1$$

$$y_n = y-1$$

(5) Stop when $x=y$



P_k	x	y	x_c	y_c
	0	10		
$-17<0$	1	10		
$-17+4\times1+6$ $-17+10=-7<0$	2	10		
$-7+8+6$ $7>0$	3	9		
$7+4(-6)+10$ $7-24+10$ $-7<0$	4	9		
$-7+16+6$ $15>0$	5	8		
$15+4(-3)+10$ $15-12+10$ $13>0$	6	7		
$13+4(-1)+10$ $13-4+10$ $19>0$	7	6		

$$P_{k+1} = 15 + 4(-3) + 10$$
$$= 15 - 12 + 10$$
$$= 13$$

Q1) Write midpoint circle algorithm and use it to plot a circle with radius 20 and centre (50, 30)

Q2) Draw the architecture of raster scan display system and explain its working.

Ans: 1). $Y = R = 20$

$P_k = 1 - R$

$= 1 - 20 = -19$

P_k	x_n	y_n	x_c	y_c
	0	20		
$-19 < 0$	1	20		
$-19+2+1$ $-16<0$	2	20		
$-16+4+1$ $-11<0$	3	20		
$-11+6+1$ $-4<0$	4	20		
$-4+8+1$ $5>0$	5	19		
$5+10+1-38$ -22				