CGA Unit 1

What is Computer Graphics?

Computer graphics is a field of computer science that is concerned with digitally synthesizing and manipulating visual contents. It is also sometimes called the science and technology of creating, storing, displaying, and manipulating images and objects.

Application of Computer Graphics -

- Digital art
- Video games
- Visual and Special effects
- Medical imaging
- Printing Technology
- Computer Graphics Education and Training
- Presentation Graphics
    - Financial Reports
    - Statistical Reports
    - Mathematical Reports
    - Scientific Reports

Input Devices for Operator Interaction -

Following are some of the important input devices which are used in a computer -

- Keyboard
- Mouse

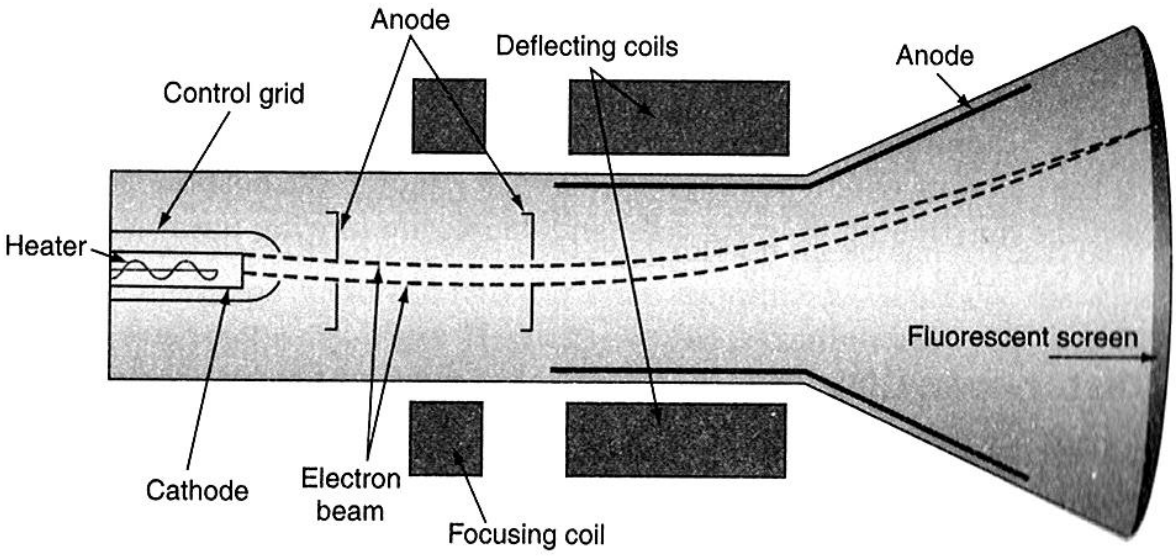
- Joystick
- Light pen
- Track Ball
- Scanner
- Graphic Tablet
- Data Glove
- Touch panels
- Voice systems

Bitmap v/s Vector Image -

Bitmap	Vector
• Composed of pixels • Created and edited in photo or paint program • Images are mapped to a grid or an array of pixels. • Not easily scalable • Used in photorealistic images involves complex variation • The larger we display a bitmap, the jagged it appears	• Composed of paths • Created and edited in software like Coral draw & Adobe Illustrator • Images have smooth edges and create curves or shapes • Good for precise illustrator but not as good as bitmap • Easily scalable due to the use of mathematical formula • A vector image remains smooth in any size

Cathode Ray Tube -

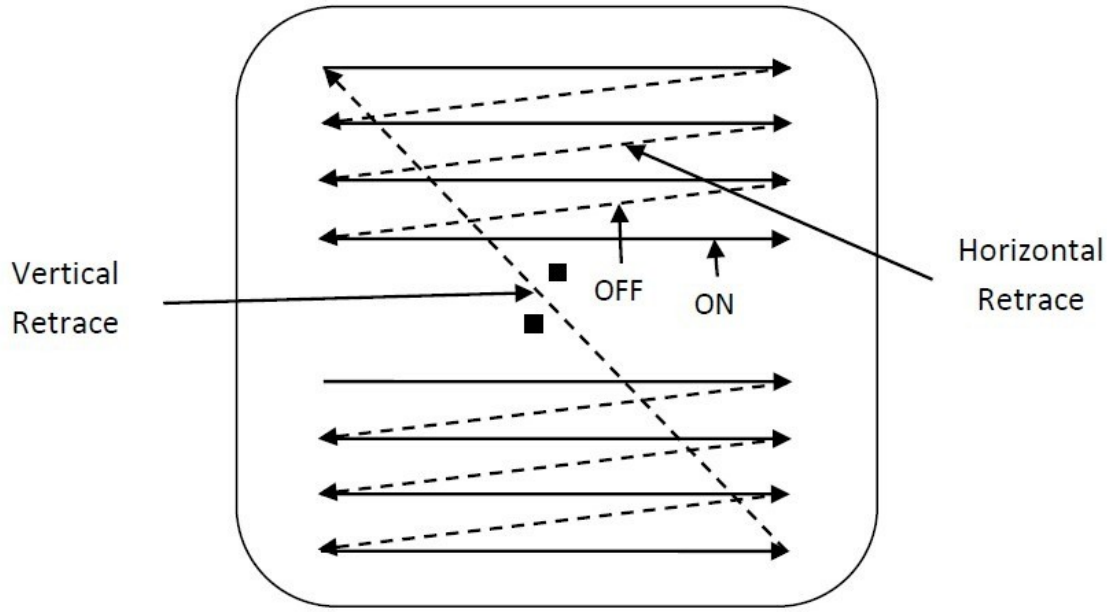
- A specialized vacuum tube in which images are produced when an electron beam strikes a phosphorescent surface.
- Heat is supplied to the cathode by passing current through a heater element.
- The cathode is a cylindrical metallic structure.
- That is rich in electrons On heating, electrons are released from cathode surface The control grid is the next element that follows the cathode.



- Focusing and deflecting coils are needed to force the electron beam to converge into a small spot as it strikes the screen.
- Deflecting coils produce an extremely low frequency electromagnetic that allows for the constant adjustment of the direction of the electron beam.
- When the electrons in the beam collide with phosphor coating, they are stopped and their kinetic energy is absorbed by the phosphor, resulting in the screen display.

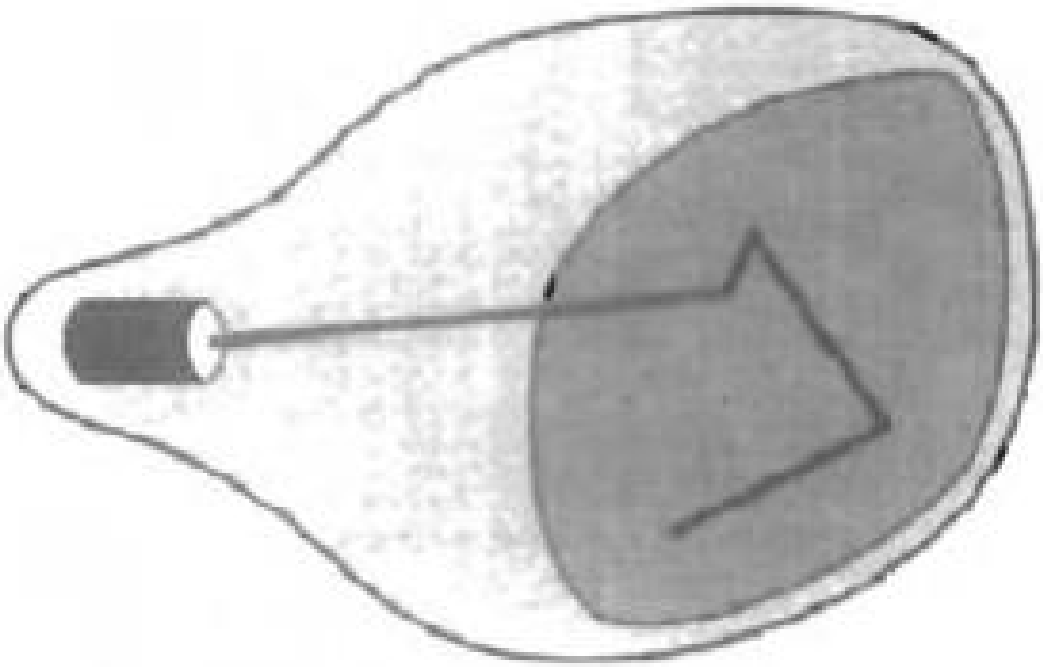
Raster-scan Display -

- Electron beam is swept across the screen one row at a time from top to bottom
- The beam is ON, while it moves from left to right it is OFF when moves back right to left
- This is called horizontal retrace
- When the beam reaches the bottom of the screen it is turned OFF and is rapidly retraced back to the top to start again This is called vertical retrace
- Repeated scanning of the same image is known as refreshing of screen



Random-scan Display -

- A CRT, as a random scan display unit has an electron beam directed only to the parts of the screen where a picture is to be drawn
- Draws a picture one line at a time
- Also referred to as vector display
- The components of picture can be drawn and refreshed by random scan display
- Also called as Calligraphic display



Difference Between a Raster-scan and a Random-scan Display -

Raster-scan display	Random-scan display
It draws the image by scanning one row at a time	It draws the image by directing the electron beam directly to the part of the screen, where the image is to be drawn.
They generally have resolution limited to pixel size.	They have higher resolution than the raster scan system.
Lines are jiggered, and curves are less smooth.	Lines plots are straight, and curves are smooth.
They are more suited to geometric area drawing applications, e. g. monitors, TV.	They are more suited to line drawing application, e.g. CRO and pen plotter.

Color CRT Monitors -

- A CRT displays color pictures by using a combination of phosphors that emit different colored light.
- There are 2 basic techniques for producing color displays.
- Beam Penetration method (Used in Random Scan display)

- Shadow mask method (Used in Raster Scan display)

Direct View Storage Tubes (DVST) -

- A method for maintaining a screen image is to store picture information inside the CRT instead of Refreshing the screen.
- It stores the picture information as a charge distribution.
- Two electron guns are used in DVST, the primary gun and flood gun.
- Primary helps is storing picture patterns and flood gun maintain picture.

Flat Panel Display -

- Video display that are much lighter & thinner than traditional television.
- Examples: cellular phones, digital camera, LCD (Liquid Crystal display), TV and computer displays etc.
- Two categories Emissive & Non emissive
- Emissive: It converts electric energy into light.
    - Eg. Plasma Panel
- Non-emissive: It uses optical effects to convert sunlight or light from some other resources into graphics pattern.
    - Eg. LCD

LCD Displays -

- The term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, flow like a fluid.
- Flat panel display use nematic liquid - crystal compounds.
- The intersection of row and column conductor defines the pixel position.
- Two glass plates, each containing a light polarizer at right angles to each other plate sandwich the liquid –crystal material.

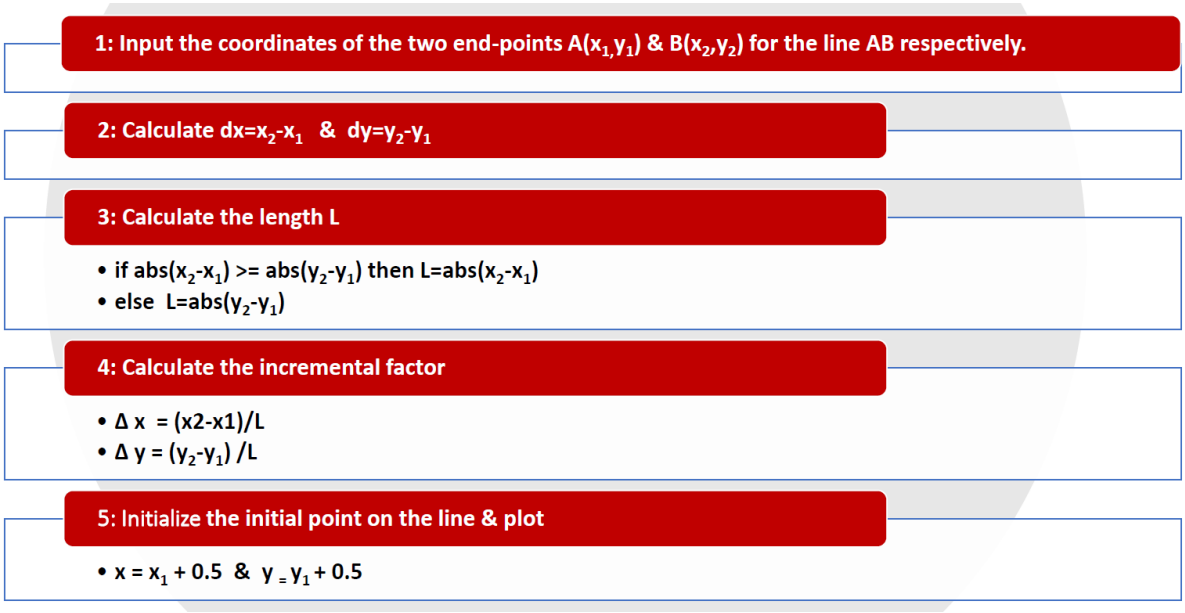
- In ON State, polarized light passing through material is twisted material is twisted so that it will pass through the opposite polarizer. It is reflected back to the viewer.
- To turn OFF the pixel, we apply voltage to the intersecting conductors to align the molecules so that the light is not twisted.
- It is also referred as passive matrix LCD

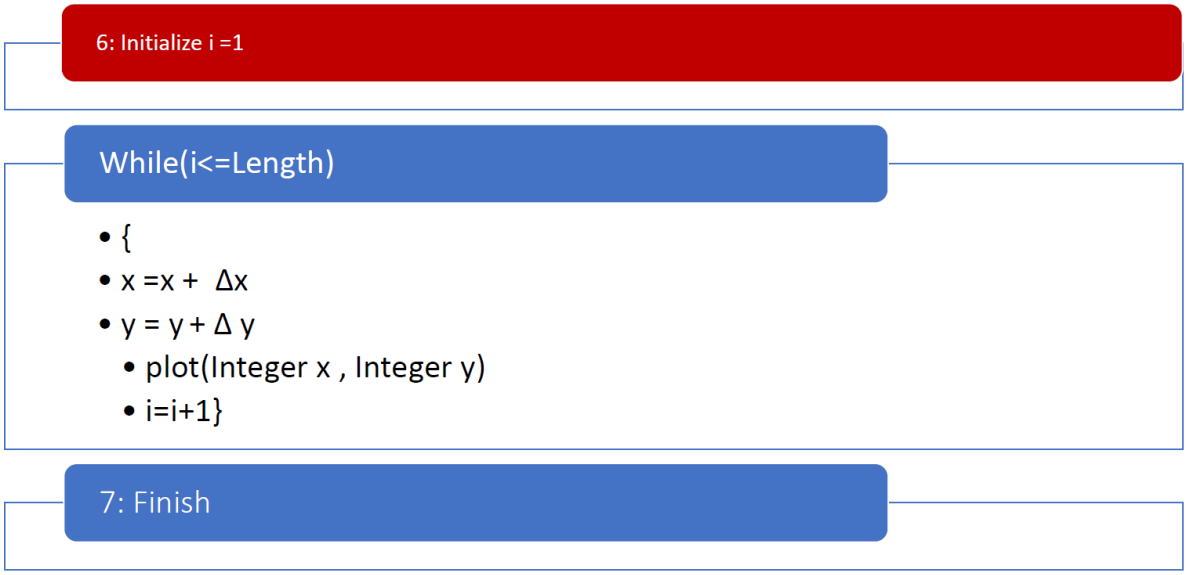
Scan Conversion -

- Scan Conversion It is a general form for drawing methods, which create raster images according to picture primitives.
- 2D picture elements.
- The process to determine which pixel provides the best approximation to shape the object is called as rasterization.
- when rasterization is combined with picture generation using scan line is called as Scan Conversion.

Digital Differential Analyzer Algorithm (DDA) -

Steps -





1	Consider the line from (0,0) to (4,6). Use the simple DDA algorithm to rasterize this line.
2	Consider the line from (2,3) to (6,15). Use the simple DDA algorithm to rasterize this line.
3	Calculate the points between the starting point (5, 6) and ending point (8, 12).
4	Calculate the points between the starting point (5, 6) and ending point (13, 10).
5	Calculate the points between the starting point (1, 7) and ending point (11, 17).

Advantages -

- Simple & fast
- Does not require special skills for implementing it in any programming language

Disadvantages -

- Rounding off errors may drift the pixel away from the actual pixels.

Bresenham's Line Drawing Algorithm -

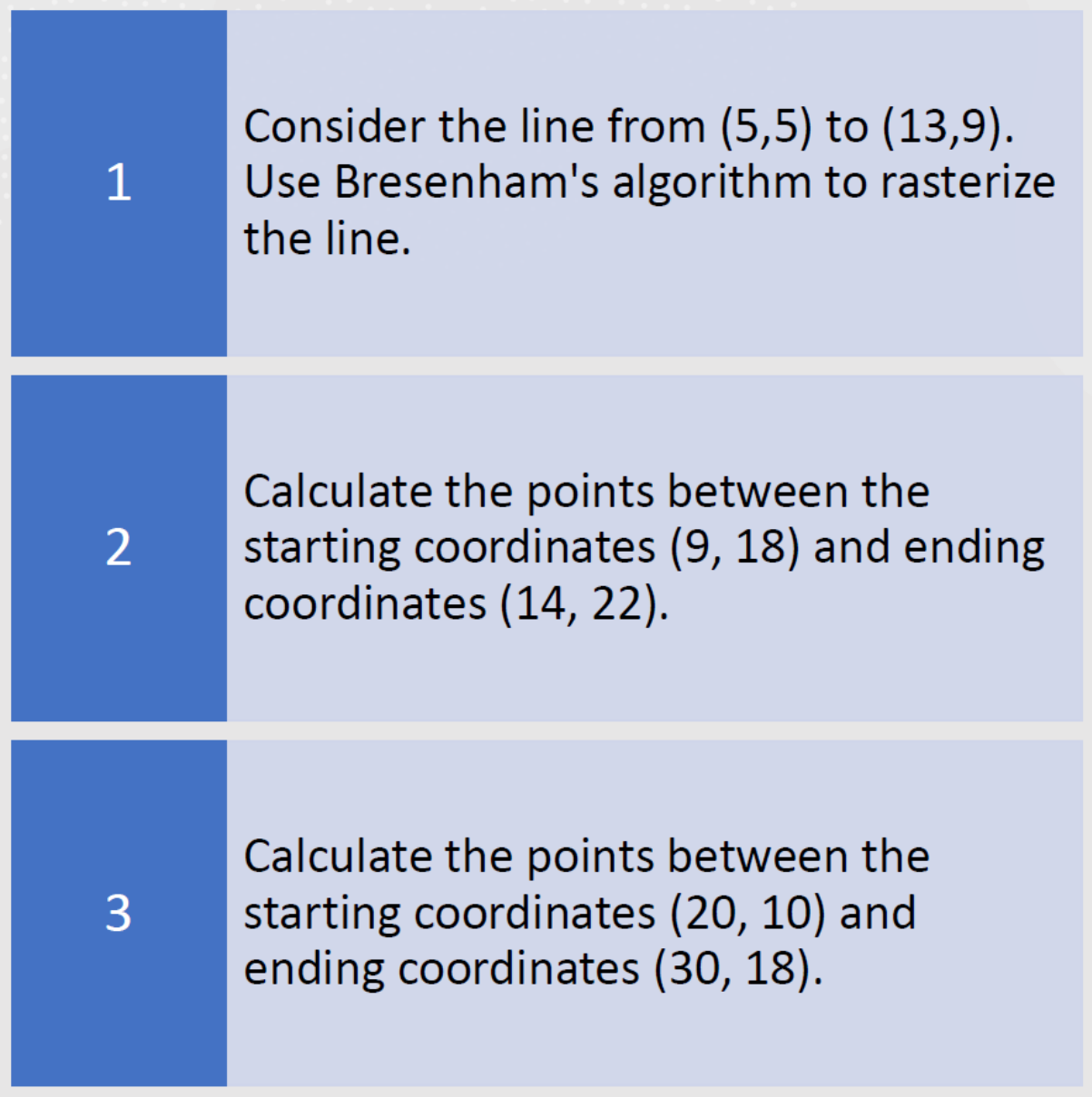
- The Bresenham's algorithm uses only integer addition, subtraction and multiplication by 2

- And we know that computer can perform integer addition and subtraction very rapidly.
- The computer is also time efficient when performing integer multiplication by 2.
- The basic principle of Bresenham's algorithm is to select the optimum raster locations to represent a straight line.
- To accomplish this the algorithm always increments either x or y by one unit depending upon the slope of the line.
- The increment in other variable is determined by examining the distance between the actual line location and the nearest pixel.
- This distance is called decision variable or error.
- The error term is initially set as e=2*Δy --Δx.
- Let us study the algorithm now:

Algorithm -

Read the coordinates of the two end points (x_1,y_1) & (x_2,y_2) such that they are not equal.(if equal then plot that point and exit)
Δx=|x2-x1| and Δy=|y2-y1|.
Initialize the starting point i.e x=x1 and y=y1.
Calculate e= 2Δy-Δx
Initialize i=1.
Plot(x,y)

While(e≥0)
{
y=y+1
e=e-2*Δx
}
x=x+1
e=e+2*Δy
i=i+1
if(i≤Δx) then go to step 6.
Stop.



Bresenham’s Circle Drawing Algorithm -

- The Bresenham’s circle drawing algorithm considers the eight way of the symmetry of the circle to generate it.
- It plots 1/8th part of the circle i.e. from 90^o to 45^o.
- As circle is drawn from 90^o to 45^o, the x moves in positive direction and y moves in the negative direction.

Algorithm to plot 1/8 of the circle -

1. Read the radius (r) of the circle.
2. Initialize the decision variable. d=3-2r
3. Initialize the starting point x=0 and y=r.
4. do

```
{
 plot(x, y)
 if(d<0)then
    {d=d+4x+6}
 else
     {d=d+4(x-y)+10
      y=y-1
     }
     x=x+1
}while(x<y)
```

5. Stop.

Midpoint circle drawing algorithm -

- It also uses the eight way symmetry of the circle to generate it.
- It plots 1/8th part of the circle i.e. from 90^o to 45^o.

- As circle is drawn from 90^o to 45^o,the x moves in positive direction and y moves in the negative direction.
- To draw a 1/8 part of the circle we take unit steps in the positive x direction and make use of decision parameter to determine which of the two possible y positions is closer to the circle.

Midpoint circle drawing algorithm -

1. Read the radius (r) of the circle.
2. Initialize the starting point x=0 and y=r.
3. Calculate the initial value of the decision parameter as p=1.25-r
4. do

```
{
 plot(x,y)
 if(d<0)then
    {
     x=x+1
    y=y
    d=d+2x+1
 }
```

```
else
        {
          x=x+1
         y=y-1
          d=d+2x+2y+1
       }while(x<y)
```

5.Determine the symmetry points.

6. Stop.

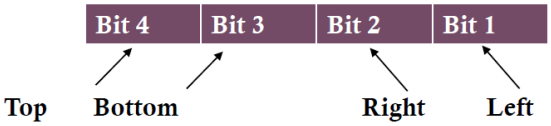
Line Clipping -

- Any procedure that eliminates those portions of a picture that are either inside or outside a specified region of space is referred to as a Clipping Algorithm or Clipping.
- A line clipping algorithm processes each line in a scene through a series of tests and intersection calculations to determine whether the entire line or any part of it is to be saved.
- Difficulty: Calculating the intersection points.

- Goal: Minimize the intersection calculations.

COHEN SUTHERLAND LINE CLIPPING ALGORITHM

- Step 1: Read the two end points of the line say $P_1(x_1, y_1)$ and $P_2(x_2, y_2)$.
- Step 2: Read the corners of the window i.e left, top, right and bottom.(say W_{x1}, W_{y1}, W_{x2}, W_{y2}).
- Step 3: Assign the region codes of two end points P1 and P2 using following steps.



- Step 4: Check for visibility of line P1P2

ASSIGNING OPCODE OR OUTCODE

1 0 0 1	1 0 0 0	1 0 1 0
0 0 0 1	Clipping Window 0 0 0 0	0 0 1 0
0 1 0 1	0 1 0 0	0 1 1 0