Syllabus

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Unit – I

INTRODUCTION- Computer graphics is an art of drawing pictures, lines, charts, etc. using computers with the help of programming. Computer graphics is made up of number of pixels. Pixel is the smallest graphical picture or unit represented on the computer screen. Basically there are two types of computer graphics namely, Interactive Computer graphics and Non-Interactive Computer Graphics.

Interactive Computer Graphics: Whenever the user has control over the image by providing him with an input device .For example the video game controller of the ping pong game. This helps him to signal his request to the computer.The computer on receiving signals from the input device can modify the displayed picture appropriately. To the user it appears that the picture is changing instantaneously in response to his commands. He can give a series of commands, each one generating a graphical response from the computer. In this way he maintains a conversation, or dialogue, with the computer.

In real life interactive computer graphics may be used to train an airplane pilot by providing him a simulator in place of the real airplane so that he may protect himself from any type of accident. The flight simulator is a mockup of an aircraft flight deck, containing all the usual controls and surrounded by screens on which we have the projected computer generated views of the terrain visible on take-off and landing.

Non-Interactive Computer Graphics: In non-interactive computer graphics otherwise known as passive computer graphics. It is the computer graphics in which user does not have any kind of control over the image. 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 of program instructions not under the user. Example: screen savers.

APPLICATION OF COMPUTER GRAPHICS –

1. **Cartography:** Computer graphics is used to produce both accurate and schematic representations of geographical and other natural phenomena from measurement data. Examples include geographic maps, relief maps, exploration maps for drilling and mining, oceanographic charts, weather maps, contour maps, and population density maps.

2. **User interfaces:** Most applications that run on personal computers and workstations, and even those that run on terminals attached to timeshared computers and network computer servers, have user interfaces that rely on desktop window systems to manage multiple simultaneous activities, and on point and click facilities to allow users to select menu items, icons, and objects on the screen. Word processing, spreadsheet, and desktop-publishing programs are typical applications of user interface facility.
3. **Plotting in business, science and technology:** The next most common use of graphics today is probably to create 2D and 3D graphs of mathematical, physical, and economic functions; histograms, bar and pie charts; task-scheduling charts; inventory and production charts, and the like . All these are used to present meaningfully and concisely the trends and patterns gleaned from data, so as to clarify complex phenomena and to facilitate informed decision making.
4. **Office automation and electronic publishing:** The use of graphics for the creation and dissemination of information has increased enormously since the advent of desktop publishing on personal computers. Many organizations whose publications used to be printed by outside specialists can now produce printed materials in house.
5. **Computer-aided drafting and design:** In computer-aided design (CAD), interactive graphics is used to design components and systems of mechanical , electrical,electromechanical, and electronic devices, including structure such as buildings, automobile bodies, airplane and ship hulls, very large scale-integrated (VLSI) chips, optical systems, and telephone and computer networks. Sometimes, the use; merely wants to produce the precise drawings of components and assemblies, as for online drafting or architectural blueprints Color Plate 1.8 shows an example of such a 3Ddesign program, intended for nonprofessionals also a customize your own patiodeck" program used in lumber yards. More frequently however the emphasis is on interacting with a computer based model of the component or system being designed in order to test, for example, its structural, electrical, or thermal properties. Often,the model is interpreted by a simulator that feeds back the behavior of the system tothe user for further interactive design and test cycles. After objects have been designed, utility programs can post process the design

database to make parts lists, to process 'bills of materials', to define numerical control tapes for cutting or drilling parts, and so on.

6. **Simulation and animation for scientific visualization and entertainment:** Computer produced animated movies and displays or the time-varying behavior of real and simulated objects are becoming increasingly popular for scientific and engineering visualization. We can use them to study abstract mathematical entries as well as mathematical models of such phenomena as fluid flow, relativity, nuclear and chemical reactions, physiological system and organ function, and deformation of mechanical structures under various kinds of loads. Another advanced-technology area is interactive cartooning. The simpler kinds of systems for producing 'Flat" cartons are becoming cost-effective in creating routine 'in-between" frames that interpolate between two explicitly specified 'key frames". Cartoon characters will increasingly be modeled in the computer as 3D shape descriptions whose movements are controlled by computer commands, rather than by the figures being drawn manually by cartoonists. Television commercials featuring flying logos and more exotic visual trickery have become common, as have elegant special effects in movies. Sophisticated mechanisms are available to model the objects and to represent light and shadows.
7. **Art and commerce:** Overlapping the previous categories the use of computer graphics in art and advertising here, computer graphics is used to produce pictures that express a message and attract attention. Personal computers and Tele text and Video texts terminals in public places such as in private homes, offer much simpler but still informative pictures that let users orient themselves, make choices, or even "teleshop" and conduct other business transactions. Finally, slide production for commercial, scientific, or educational presentations is another cost-effective use of graphics, given the steeply rising labor costs of the traditional means of creating such material.
8. **Process control:** Whereas flight simulators or arcade games let users interact with a simulation of a real or artificial world, many other applications enable people or interact with some aspect of the real world itself. Status displays in refineries, power plants, and computer networks show data values from sensors attached to critical system components, so that operators can respond to problematic conditions. For example,

military commanders view field data – number and position of vehicles, weapons launched, troop movements, causalities – on command and control displays to revise their tactics as needed; flight controller airports see computer-generated identification and status information for the aircraft blips on their radar scopes, and can thus control traffic more quickly and accurately than they could with the uninitiated radar data alone; spacecraft controllers monitor telemetry data and take corrective action as needed.

Raster Graphics Fundamentals:

Raster graphics are digital images created or captured (for example, by scanning in a photo) as a set of samples of a given space. A *raster* is a grid of x and y coordinates on a display space. (And for three-dimensional images, a z coordinate.) A raster image file identifies which of these coordinates to illuminate in monochrome or color values. The raster file is sometimes referred to as a bitmap because it contains information that is directly mapped to the display grid.

A raster file is usually larger than a vector graphics image file. A raster file is usually difficult to modify without loss of information, although there are software tools that can convert a raster file into a vector file for refinement and changes. Examples of raster image file types are: BMP, TIFF, GIF, and JPEG files.

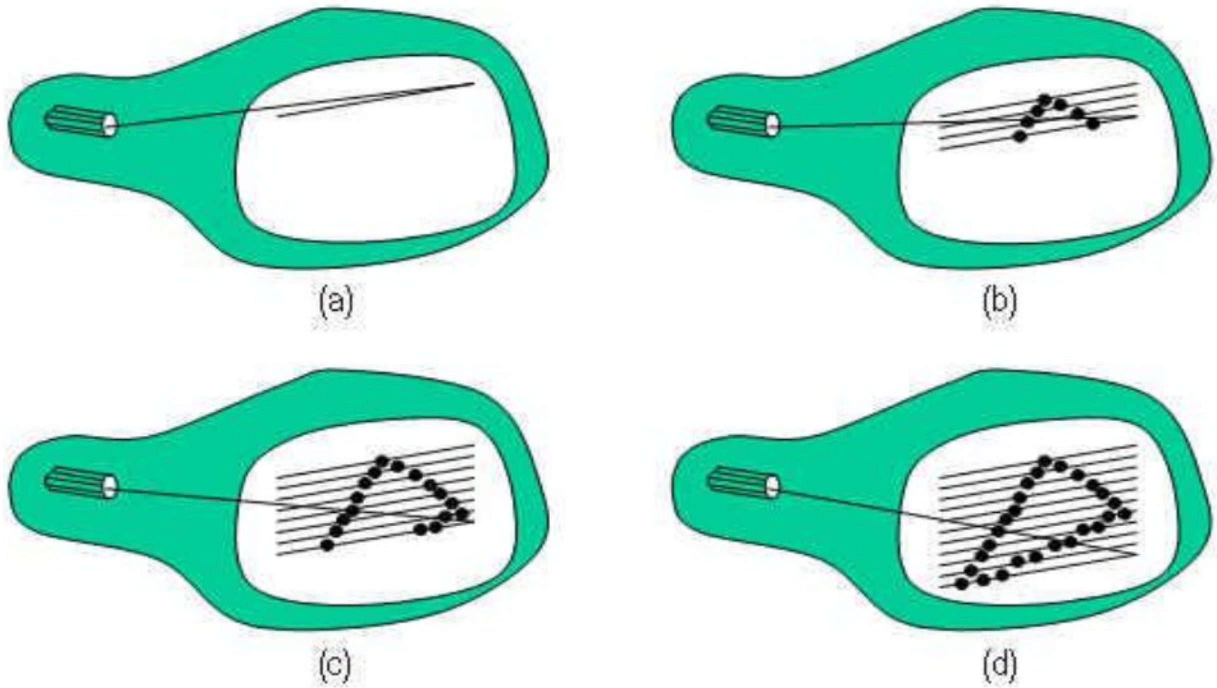
Raster-scan display

In a raster- scan system, the electron beam is swept across the screen, one row at a time from top to bottom. As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots. Picture definition is stored in memory area called the refresh buffer or frame buffer. This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and "painted" on the screen one row (scan line) at a time (Fig). Each screen point is referred to as a pixel or pel (shortened forms of picture element).The raster scan system is well suited for the realistic display of scenes.

Intensity range for pixel position in a simple black and white system is one bit per pixel, as each screen point is either ON or OFF. A bit value of 1 indicates that the beam intensity is to be ON, while 0 indicates OFF. But if color and intensity variations can be displayed, then additional bits are needed up to 24 bit per pixel are there in high quality system. the storage for the frame buffer require 3 megabytes of memory, if the frame buffer is to define a system with 24 bit per pixel and a screen resolution of 1024 by 1024.

The frame buffer is referred to as a bitmap in a black and white system. While, it is called as a pixmap for a system with multiple bit per pixel.

Refreshing on raster-scan displays is carried out at the rate of 60 to 80 frames per second, although some systems are designed for higher refresh rates. Sometimes, refresh rates are described in units of cycles per second, or Hertz (Hz), where a cycle corresponds to one frame. At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line. The return to the left of the screen, after refreshing each scan line, is called the horizontal retrace of the electron beam. And at the end of each frame, the electron beam returns (vertical retrace) to the top left corner of the screen to begin the next frame.

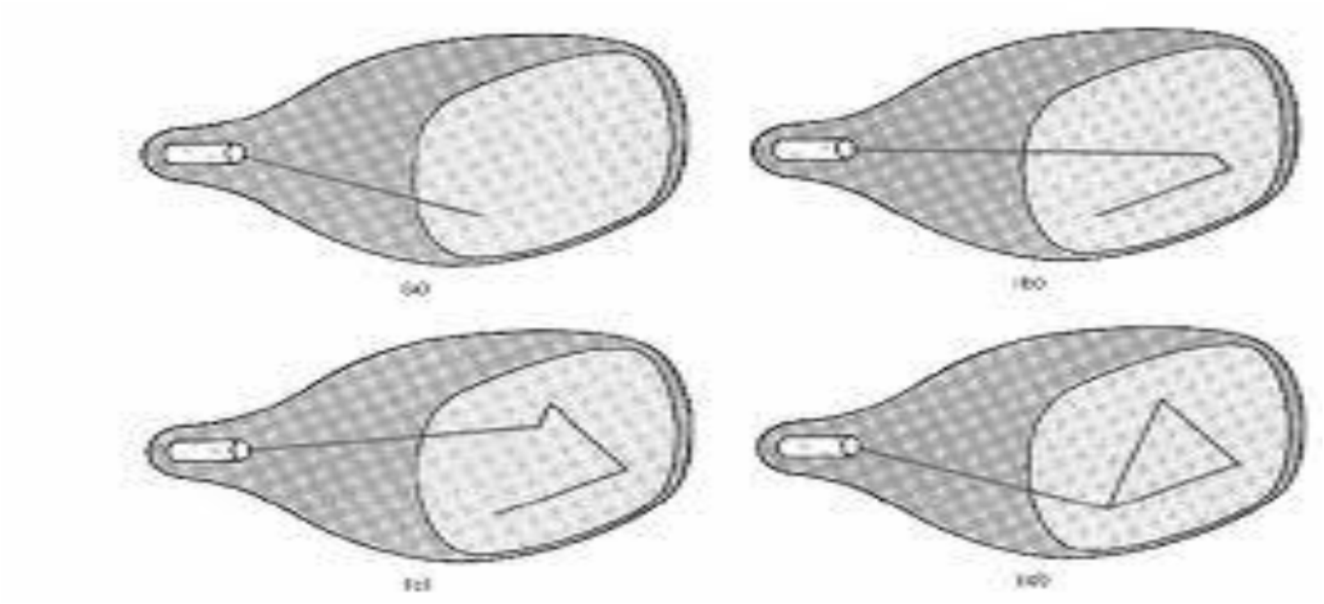


Random-scan display

Random scan monitors draw a picture one line at a time and for this reason are also referred to as vector displays (or stroke-writing or calligraphic displays). The component lines of a picture can be drawn (Figure) and refreshed by a random-scan system in any specified order.Example of random scan system includes pen plotter etc.

Refresh rate on a random-scan system depends on the number of lines to be displayed. Picture definition is now stored as a set of line-drawing commands in an area of memory referred to as the refresh display file. Sometimes the refresh display file is called the display list, display program, or simply the refresh buffer. To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn.

After all line- drawing commands have been processed, the system cycles back to the first line command in the list. Random-scan displays are designed to draw al the component lines of a picture 30 to 60times each second.



Difference between Raster Scan Display and Random Scan Display:

Base of Difference	Raster Scan System	Random Scan System
Electron Beam	The electron beam is swept across the screen, one row at a time, from top to bottom.	The electron beam is directed only to the parts of screen where a picture is to be drawn.
Resolution	Its resolution is poor because raster system in contrast produces zig-zag lines that are plotted as discrete point sets.	Its resolution is good because this system produces smooth lines drawings because CRT beam directly follows the line path.
Picture Definition	Picture definition is stored as a set of intensity values for all screen points, called pixels in a refresh buffer area.	Picture definition is stored as a set of line drawing instructions in a display file.
Realistic Display	The capability of this system to store intensity values for pixel makes it well suited for the realistic display of scenes contain shadow and color pattern.	These systems are designed for line-drawing and can’t display realistic shaded scenes.
Draw an mage	Screen points/pixels are used to draw an image.	Mathematical functions are used to draw an image.

Color CRT Monitor:

This was one of the earlier CRTs to produce color displays. Coating phosphors of different compounds can produce different colored pictures. But the basic problem of graphics is not to produce a picture of a predetermined color, but to produce color pictures, with the color characteristics chosen at run time.

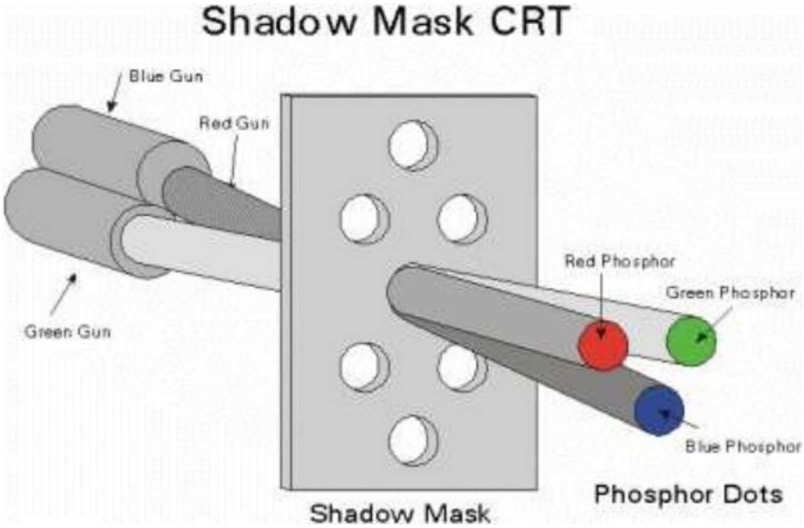
The basic principle behind colored displays is that combining the 3 basic colors –Red, Blue and Green, which can produce every color. By choosing different ratios of these three colors we can produce different colors – millions of them in-fact. We also have basic phosphors, which can produce these basic colors. So, one should have a technology to combine them in different combinations.

There are two popular techniques for producing color displays with a CRT are:

1. Beam-penetration method2. Shadow-mask method

1. ***Beam Penetration method:*** This CRT is similar to the simple CRT, but it makes use of multi coloured phosphorus of number of layers. Each phosphorus layer is responsible for one colour. All other arrangements are similar to simple CRT. It can produce a maximum of 4 to 5 colours. The organization is something like this - The red, green and blue phosphorus are coated in layers - one behind the other. If a low speed beam strikes the CRT, only the red colored phosphorus is activated, a slightly accelerated beam would activate both red and green (because it can penetrate deeper) and a much more activated one would add the blue component also.
But the basic problem is a reliable technology to accelerate the electronic beam to precise levels to get the exact colors - it is easier said than done. However, a limited range of colors can be conveniently produced using the concept.

2. *The Shadow - Mask method.*



This works, again, on the principle of combining the basic colors - Red, green and Blue - in suitable proportions to get a combination of colors, but it's principle is much more sophisticated and stable.

The shadow mask CRT, instead of using one electron gun, uses 3 different guns placed one by the side of the other to form a triangle or a "Delta" as shown. Each pixel point on the screen is also made up of 3 types of phosphors to produce red, blue and green colors. Just before the phosphor screen is a metal screen, called a "shadow mask".

This plate has holes placed strategically, so that when the beams from the three electron guns are focused on a particular pixel, they get focused on particular color producing pixel only i.e. If for convenience sake we can call the electronic beams as red, blue and green beams (though in practice the colors are produced by the phosphors, and until the beams hit the phosphor dots, they produce no colors), the metal holes focus the red beam onto the red color producing phosphor, blue beam on the blue producing one etc. When focused on to a different pixel, the red beam again focuses on to the red phosphor and so on.

Now, unlike the beam penetration CRTs where the acceleration of the electron beam was being monitored, we now manipulate the intensity of the 3 beams simultaneously. If the red beam is made more intense, we get more of red color in the final combination etc. Since fine-tuning of the beam intensities is comparatively simple, we can get much more combination of colors than the beam penetration case. In fact, one can have a matrix of combinations to produce a wide variety of colors.

The shadow mask CRT, though better than the beam penetration CRT in performance, is not without it's disadvantages. Since three beams are to be focused, the role of the "Shadow mask" becomes critical. If the focusing is not achieved properly, the results tend to be poor. Also, since instead of one pixel point in a monochrome CRT now each pixel is made up of 3 points (for 3 colors), the resolution of the CRT (no. of pixels) for a given screen size reduces.

Another problem is that since the shadow mask blocks a portion of the beams (while focusing them through the holes) their intensities get reduced, thus reducing the overall brightness of the picture. To overcome this effect, the beams will have to be produced at very high intensities to begin with. Also, since the 3 color points, though close to each other, are still not at the same point, the pictures tend to look like 3 colored pictures placed close by, rather than a single picture. Of course, this effect can be reduced by placing the dots as close to one another as possible.

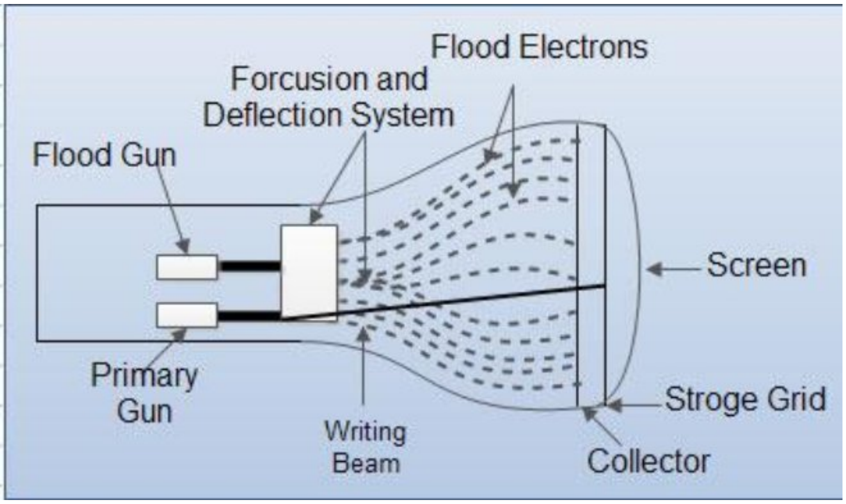
The above displays are called refresh line drawing displays, because the picture vanishes (typically in about 100 Milliseconds) and the pictures have to be continuously refreshed so that the human persistence of vision makes them see as static pictures. They are costly on one hand

and also tend to flicker when complex pictures are displayed (Because refreshing because complex).

These problems are partly overcome by devices with inherent storage devices - i.e. they continue to display the pictures, till they are changed or at least for several minutes without the need of being refreshed. We see one such device called the Direct View Storage Tube (DVST) below.

Direct View Storage Tube DVST:

Conceptually the Direct View Storage Tube (DVST) behaves like a CRT with highly persistent phosphor. Pictures drawn on there will be seen for several minutes (40-50 minutes) before fading. It is similar to CRT as far as the electronic gun and phosphor-coated mechanisms are concerned. But instead of the electron beam directly writing the pictures on the phosphor coated CRT screen, the writing is done with the help of a fine-mesh wire grid.



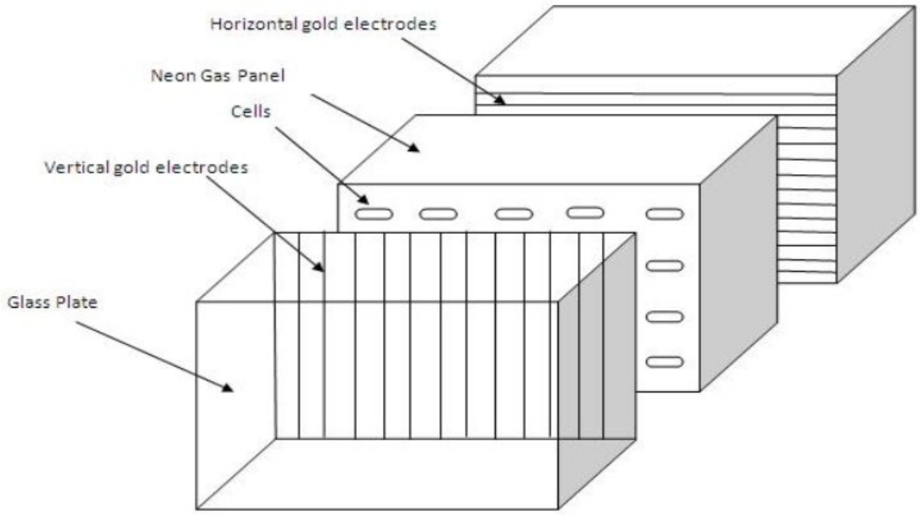
The grid made of very thin, high quality wire, is located with a dielectric and is mounted just before the screen on the path of the electron beam from the gun. A pattern of positive charges is deposited on the grid and this pattern is transferred to the phosphor coated CRT by a continuous flood of electrons. This flood of electrons is produced by a "flood gun" (This is separate frame the electron gun that produces the main electron beam).

Just behind the storage mesh is a second grid called the collector. The function of the collector is to smooth out the flow of flood electrons. Since a large number of electrons are produced at high velocity by the flood gun, the collector grid, which is also negatively charged reduces, the acceleration on these electrons and the resulting low velocity flood pass through the collector and get attracted by the positively charged portions of the storage mesh (Since the electrons are negatively charged), but are repelled by the other portions of the mesh which are negatively charged (Note that the pattern of positive charges residing on the storage mesh actually defines the picture to be displayed).

Thus, the electrons attracted by the positive charges pass through the mesh, travel on to the phosphor coated screen and display the picture. Since the collector has slowed the electrons down, they may not be able to produce sharp and bright images. To over come this problem, the screen itself is maintained at a high positive potential by means of a voltage applied to a thin aluminum coating between the tube face and the phosphor. The dotted circle on the mesh is created by positive charges the flood of electrons hit the mesh at all points. But only those electrons that hit the dotted circle pass through and hit the CRT screen. The negatively charged mesh repels others. Since the phosphor is of a very high persistence quality, the picture created on the CRT screen will be visible for several minutes without the need for being refreshed. Now the problem arises as to how do we remove the picture, when the time for it's erasure or modification comes up. The simple method is to apply a positive charge to the negatively charged mesh so that it gets neutralized. This removes all charges and clears the screen. But this technique also produces a momentary flash, which may be unpleasant to the viewer. This is mainly so when only portions of the picture are to be modified in an interactive manner. Also, since the electrons hit the CRT screen at very low speeds (though they are slightly accelerated in the last part of their journey to the CRT by a positively charged aluminum coating), the contrasts are not sharp. Also, even though the pictures stay for almost an hour, there will be a gradual degradation because of the accumulation of the background glow.

The other popular display device is the plasma panel device, which is partly similar to the DVST in principle, but over comes some of the undesirable features of the DVST.

Plasma Panel: In a plasma panel display, two glass plates having horizontal and vertical gold electrodes are kept. These gold electrodes are covered with dielectric material. In between these two glass plates there is another glass plate filled with neon gas. When voltage is applied through the gold electrodes the neon gas is split in to independent cells and they start to glow. By applying voltages through the gold electrodes this glow can be controlled, thus, creating a display. No refresh is required in a Plasma panel display.



Advantage and Disadvantages of Plasma Panel:

Advantages

- Capable of producing deeper blacks allowing for superior contrast ratio
- Wider viewing angles than those of LCD; images do not suffer from degradation at less than straight ahead angles like LCDs. LCDs using IPS technology have the widest angles, but they do not equal the range of plasma primarily due to "IPS glow", a generally whitish haze that appears due to the nature of the IPS pixel design.
- Less visible motion blur, thanks in large part to very high refresh rates and a faster response time, contributing to superior performance when displaying content with significant amounts of rapid motion
- Superior uniformity. LCD panel backlights nearly always produce uneven brightness levels, although this is not always noticeable. High-end computer monitors have technologies to try to compensate for the uniformity problem
- Unaffected by clouding from the polishing process. Some LCD panel types, like IPS, require a polishing process that can introduce a haze usually referred to as "clouding".
- Less expensive for the buyer per square inch than LCD, particularly when equivalent performance is considered.

Disadvantages

- Earlier generation displays were more susceptible to screen burn-in and image retention. Recent models have a pixel orbiter that moves the entire picture slower than is noticeable to the human eye, which reduces the effect of burn-in but does not prevent it.[14]
- Due to the bistable nature of the colour and intensity generating method, some people will notice that plasma displays have a shimmering or flickering effect with a number of hues, intensities and dither patterns.
- Earlier generation displays (circa 2006 and prior) had phosphors that lost luminosity over time, resulting in gradual decline of absolute image brightness. Newer models have advertised life spans exceeding 100 000 hours, far longer than older CRTs.
- Uses more electrical power, on average, than an LCD TV using an LED backlight. Older CCFL backlights for LCD panels used quite a bit more power, and older plasma TVs used quite a bit more power than recent models.
- Does not work as well at high altitudes above 6,500 feet (2,000 metres) due to pressure differential between the gases inside the screen and the air pressure at altitude. It may cause a buzzing noise. Manufacturers rate their screens to indicate the altitude parameters.
- For those who wish to listen to AM radio, or are amateur radio operators (hams) or shortwave listeners (SWL), the radio frequency interference (RFI) from these devices can be irritating or disabling.
- Plasma displays are generally heavier than LCD, and may require more careful handling such as being kept upright.

Unit – II

Algorithm for line Generation: There is basically two line generating algorithm:

1) DDA (Digital Differential Algorithm)

2) Bresenham's line drawing algorithm

1) DDA: DDA algorithm is an incremental scan conversion method. Here we perform calculations at each step using the results from the preceding step. The characteristic of the DDA algorithm is to take unit steps along one coordinate and compute the corresponding values along the other coordinate. The unit steps are always along the coordinate of greatest change, e.g. if dx = 10 and dy = 5, then we would take unit steps along x and compute the steps along y.

DDA algorithm:

Step 1: Input to the function is two endpoints (x1,y1) and (x2,y2)

Step 2: length ← abs(x2-x1);
if (abs(y2-y1) > length) then length ←abs(y2-y1);

Step 3: xincrement ← (x2-x1) / length;
yincrement ← (y2-y1) / length;

Step 4: x ←x + 0.5; y ← Y + 0.5;

Step 5 : [illegible]

Step 6 : [illegible]

Step 7: [illegible]
[illegible]

Step 8: [illegible]

[illegible]

Advantages of DDA Algorithm

[illegible]

Disadvantages of DDA Algorithm

[illegible]

Consider the line from (0,0) to (4,6). Use the simple DDA algorithm to rasterize this line.

Sol. b □□□□□□□□=□□□□□=N=□=R=□=□□=a a □=□□□□□□□=□ =□□□□

u □ □=M= v N □=M

u O □=□= v O □S

i □□□□=□=v OJv N□=□S

Δu =□=u OJ u □=Li □□□□

□ □LS□MSSSST

Δv =□=v OJ v □=Li □□□□

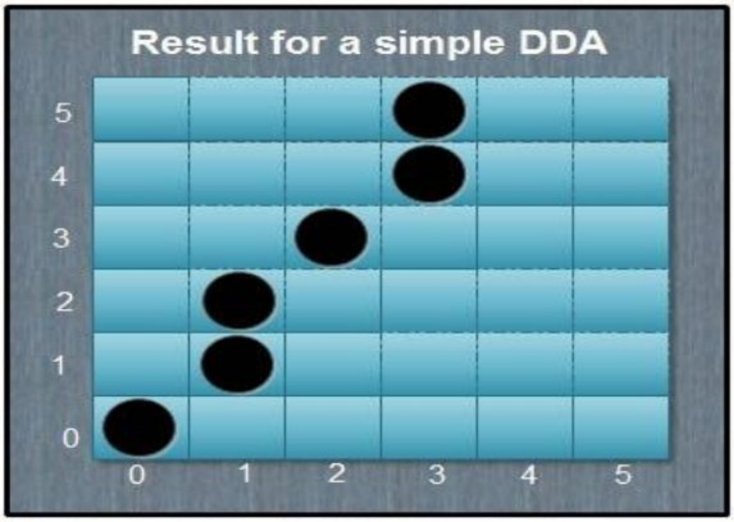
□=SLS□N

f□□□□=□□□□=□□

u =□=MH=MR=G=p □□□=EMSSSSTF=□=MR

v =□=MH=MR=G=p □□□=ENF=□=MR

i	Plot	x	y
		0.5	0.5
1	(0, 0)		
		1.167	1.5
2	(1,1)		
		1.833	2.5
3	(1,2)		
		2.5	3.5
4	(2,3)		
		3.167	4.5
5	(3,4)		
		3.833	5.5
6	(3,5)		
		4.5	6.5



[illegible]

***Example 2** Consider the line from (0, **0**) to **(-6, -6)**. Use the simple **DDA** algorithm line.*

[illegible]

$x_1 = 0$ $\quad y_1 = 0$

$x_2 = -6$ $\quad y_2 = -6$

Length $= \max(|x_2 - x_1|, |y_2 - y_1|) = 6$

$\Delta x = \Delta y = -1$

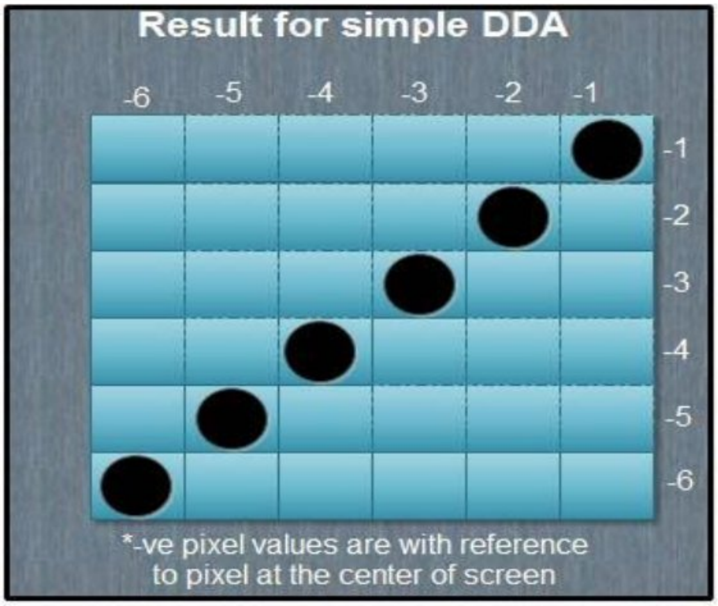
Initial values are

$x = 0 + 0.5 * \text{Sign}(-1) = -0.5$

$y = 0 + 0.5 * \text{Sign}(-1) = -0.5$

i	Plot	x	y
		–0.5	–0.5
1	(–1, –1)		
		–1.5	–1.5

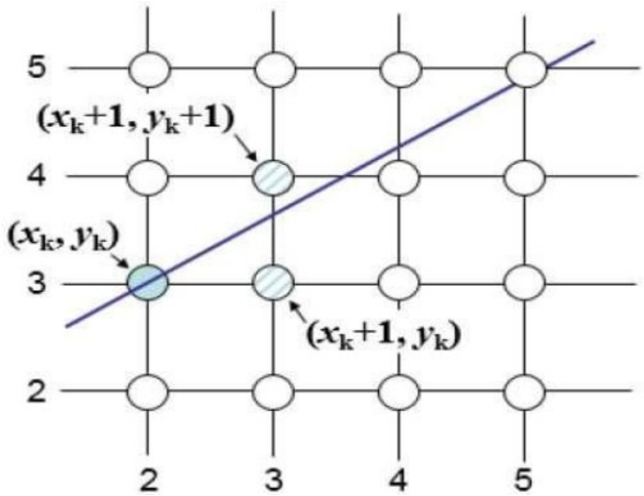
2	(−2, −2)		
		−2.5	−2.5
3	(−3, −3)		
		−3.5	−3.5
4	(−4, −4)		
		−4.5	−4.5
5	(−5, −5)		
		−5.5	−5.5
6	(−6, −6)		
		−6.5	−6.5



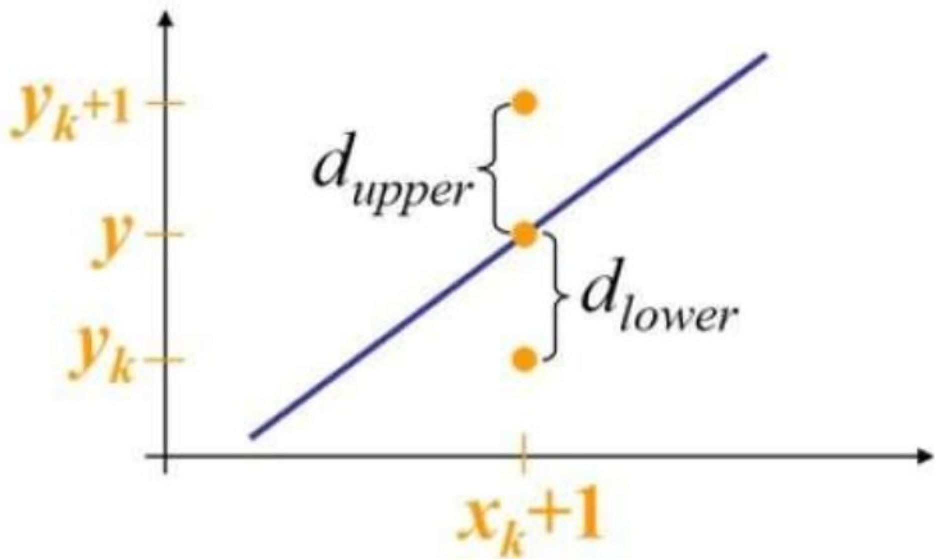
[illegible]

2) Bresenham 's line drawing algorithm: [illegible]

[illegible]



[illegible] *Xk*+1 [illegible] *dupper* [illegible] *dlower* [illegible]



Algorithm:(here m<1)

Step 1: [illegible]

Step 2: [illegible]

Step 3: [illegible] Δ [illegible] Δ [illegible] Δ [illegible] Δ [illegible] Δ [illegible]

$$p_0 = 2\,\Delta y - \Delta x$$

Step 4 : [illegible]

[illegible]

$$p_k+1 = p_k + 2\,\Delta y$$

[illegible]

$$pk+1 = p_k + 2\,\Delta y - 2\,\Delta x$$

Step 5: [illegible] Δ [illegible]

Example:

[illegible]

[illegible]

[illegible]

$$p_0 = 2\,\Delta y - \Delta x$$
$$= 6$$

[illegible]

$$2\Delta y = 16 \qquad 2\,\Delta y - 2\Delta x = -4$$

[illegible]

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

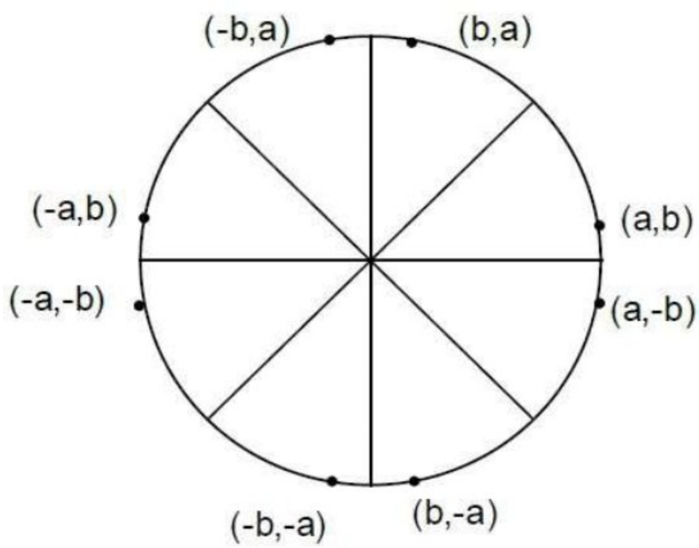
Difference Between DDA Line and Bresenham's Line Drawing Algorithm.

	Digital Differential Analyzer [illegible]	[illegible]
Arithmetic	[illegible] **floating points** [illegible] **Real Arithmetic** [illegible]	[illegible] **fixed points** [illegible] **Integer Arithmetic** [illegible]
Operations	[illegible] **multiplication** [illegible] **division** [illegible]	[illegible] **subtraction** [illegible] **addition** [illegible]
Speed	[illegible] **slow** [illegible]	[illegible] **faster** [illegible]
Accuracy & Efficiency	[illegible]	[illegible]
Drawing	[illegible]	[illegible]

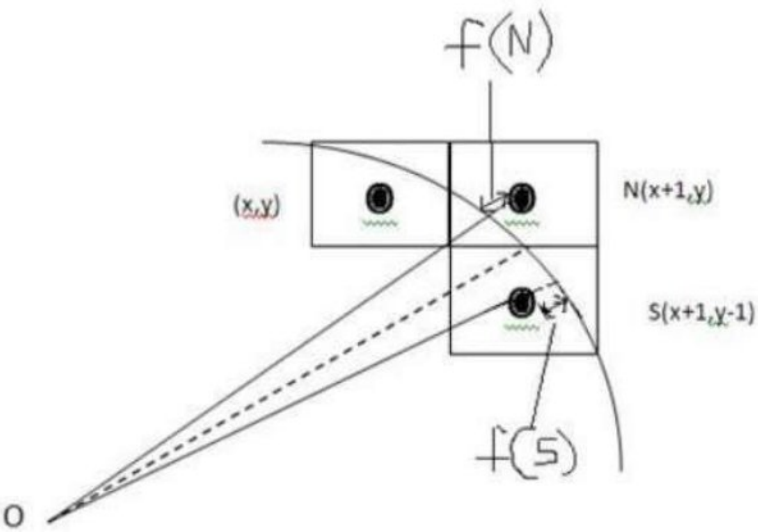
	[illegible]	[illegible]
Round Off	[illegible]	[illegible] **round off** [illegible]
Expensive	[illegible]	[illegible]

Circle Generation Algorithm: [illegible] **Bresenham's Algorithm** [illegible] **Midpoint Circle Algorithm** [illegible]

[illegible]



1) Bresenham Circle Drawing Algorithm: [illegible]



[illegible]

- [illegible]
- [illegible]

[illegible]

Step 1: [illegible]
Step 2: [illegible]
Step 3: [illegible]
Step 4: [illegible]
Step 5: [illegible]
Step 6: [illegible]
Step 7: [illegible]
Step 8: [illegible]
Step 9: [illegible]
Step 10: [illegible]
[illegible]
Step 11: [illegible]
[illegible]
Step 12: [illegible]

Draw Circle (Xc, Yc, X, Y):

Step 1 : [illegible]
Step 2: [illegible]
Step 3: [illegible]
Step 4: [illegible]
Step 5: [illegible]
Step 6: [illegible]
Step 7: [illegible]
Step 8: [illegible]

Step 9: [illegible]

2) Mid-Point Circle (Xc, Yc, R):

[illegible]

Step 1: [illegible]

Step 2: [illegible]

Step 3: [illegible]

Step 4: [illegible]

Step 5: [illegible]

Step 6: [illegible]

Step 7: [illegible]

Step 8: [illegible]

Step 9: [illegible]

Step 10: [illegible]

[illegible]

Step 11: [illegible]

[illegible]

Step 12: [illegible]

Draw Circle (Xc, Yc, X, Y):

Step 1: [illegible]

Step 2: [illegible]

Step 3: [illegible]

Step 4: [illegible]

Step 5: [illegible]

Step 6: [illegible]

Step 7: [illegible]

Step 8: [illegible]

Step 9: [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

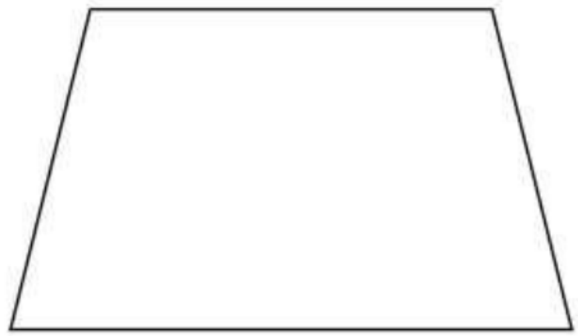
[illegible]

K	P_k	(x_{k+1},y_{k+1})	$2x_{k+1}$	$2y_{k+1}$
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

S	R	EITIF	N	N

Polygon Generation and Filling Algorithm:

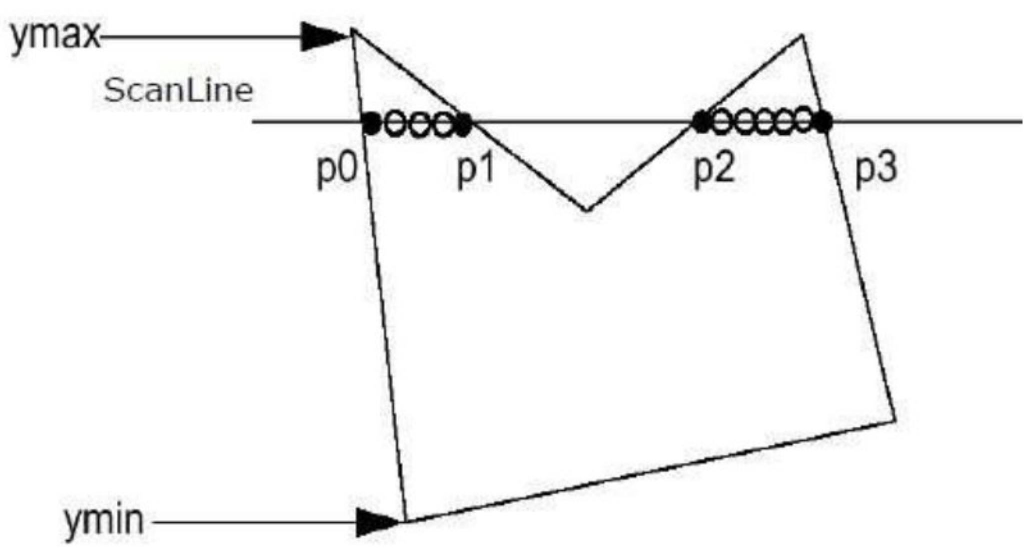
[illegible]



Scan Line Algorithm

[illegible]

Step 1 − [illegible]



Step 2 − [illegible]

Step 3 − [illegible]

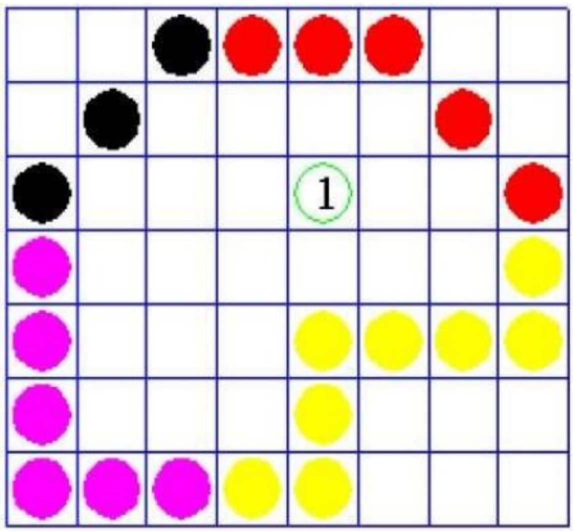
Step 4 − [illegible]

Flood Fill Algorithm

[illegible]

[illegible]

[illegible]



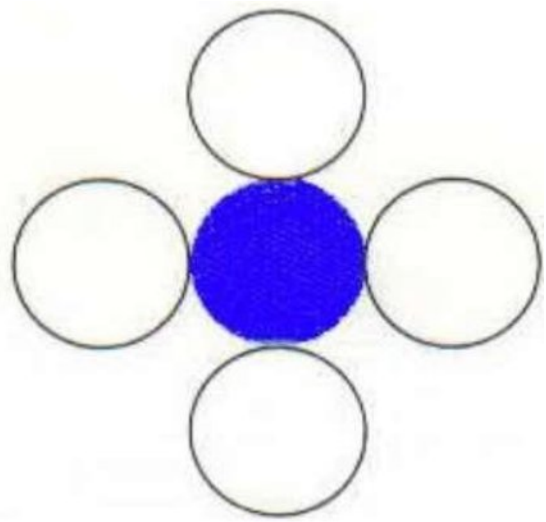
Boundary Fill Algorithm

[illegible]

[illegible]

4-Connected Polygon

[illegible]



Algorithm

Step 1 − [illegible]

Step 2 − [illegible]

Step 3 − [illegible]

[illegible]

Step 4 − [illegible]

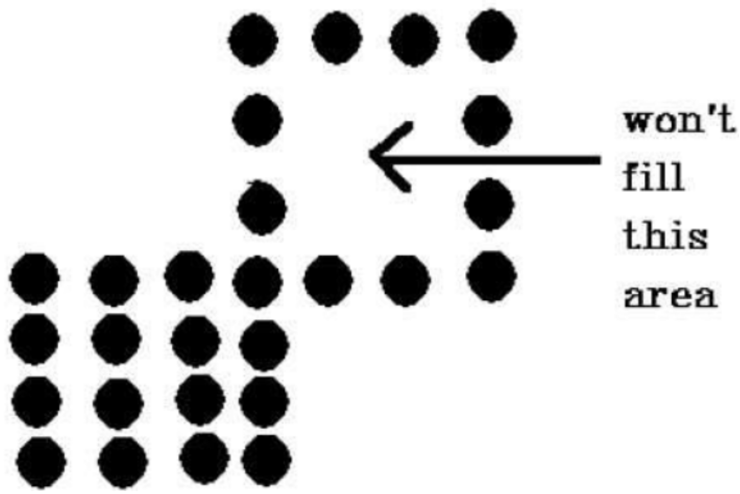
[illegible]

Step 5 − [illegible]

[illegible]

Step 6 − [illegible]

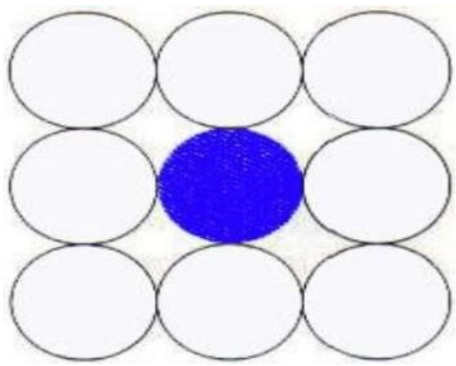
[illegible]



8-Connected Polygon

[illegible]

[illegible]



Algorithm

Step 1 − [illegible]

Step 2 − [illegible]

Step 3 − [illegible]

[illegible]

Step 4 − [illegible]

[illegible]

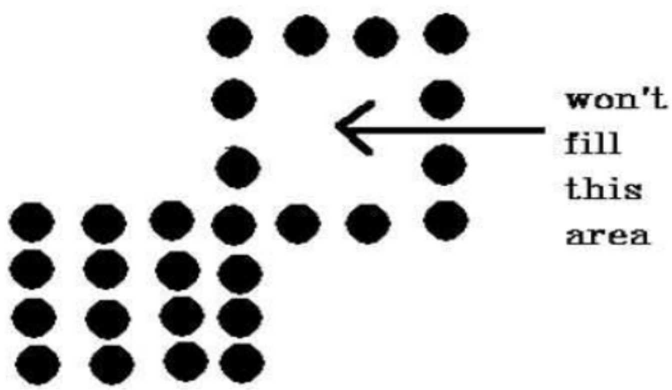
Step 5 − [illegible]

[illegible]

```
[illegible]
```

Step 6 – [illegible]

[illegible]



Anti Aliasing: [illegible] *antialiasing* [illegible] *jaggies* [illegible] *smoothing* [illegible] *oversampling.*

Transformations [illegible]

(i) Geometric transformation: [illegible]

(ii) Coordinate transformation: [illegible]

[illegible]

[illegible]

Homogenous Coordinates

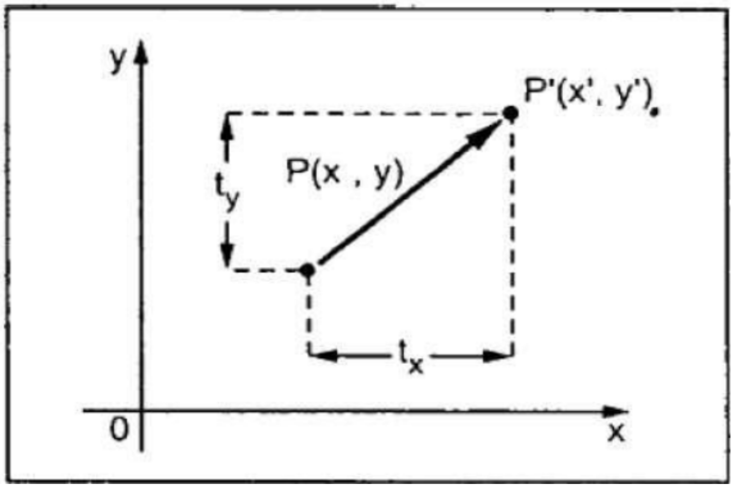
[illegible]

- [illegible]
- [illegible]
- [illegible]

[illegible] **Homogenous Coordinate** [illegible]

Translation

[illegible]



[illegible]

$$X' = X + t_x$$

$$Y' = Y + t_y$$

[illegible]

[illegible]

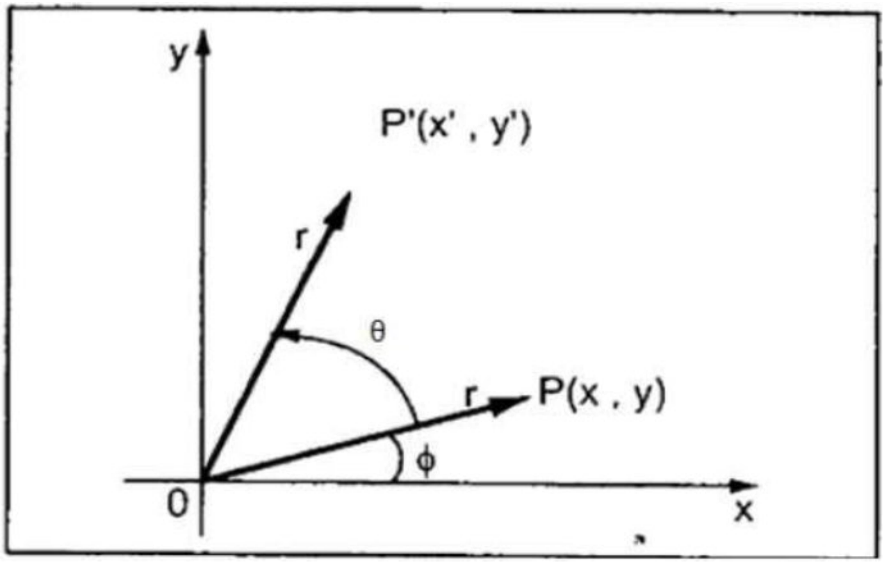
[illegible]

$$P' = P + T$$

Rotation

[illegible]

[illegible]



$$X = r\cos\phi \quad (1)$$

$$Y = r\sin\phi \quad (2)$$

$$x' = r\cos(\phi+\theta) = r\cos\phi\cos\theta - r\sin\phi\sin\theta \quad (3)$$

$$y' = r\sin(\phi+\theta) = r\cos\phi\sin\theta + r\sin\phi\cos\theta \quad (4)$$

$$x' = x\cos\theta - y\sin\theta$$

$$y' = x\sin\theta + y\cos\theta$$

$$[X' \; Y'] = [X \; Y]\begin{bmatrix}\cos\theta & \sin\theta \\ -\sin\theta & \cos\theta\end{bmatrix} \text{ OR } P' = P \cdot R$$

$$R = \begin{bmatrix}\cos\theta & \sin\theta \\ -\sin\theta & \cos\theta\end{bmatrix}$$

$$R = \begin{bmatrix}\cos(-\theta) & \sin(-\theta) \\ -\sin(-\theta) & \cos(-\theta)\end{bmatrix} = \begin{bmatrix}\cos\theta & -\sin\theta \\ \sin\theta & \cos\theta\end{bmatrix} \quad (\because \cos(-\theta) = \cos\theta \text{ and } \sin(-\theta) = -\sin\theta)$$

Scaling

[illegible]

[illegible]

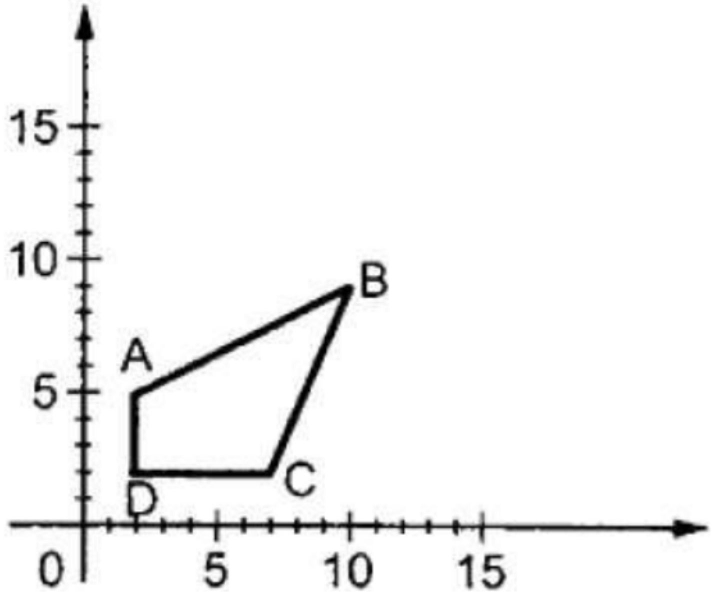
$$X' = X . S_X \text{ and } Y' = Y . S_Y$$

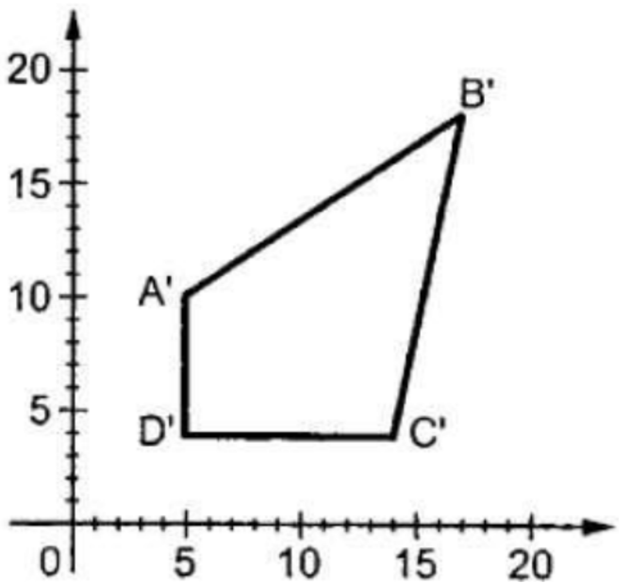
[illegible]

[illegible]

$$P' = P . S$$

[illegible]

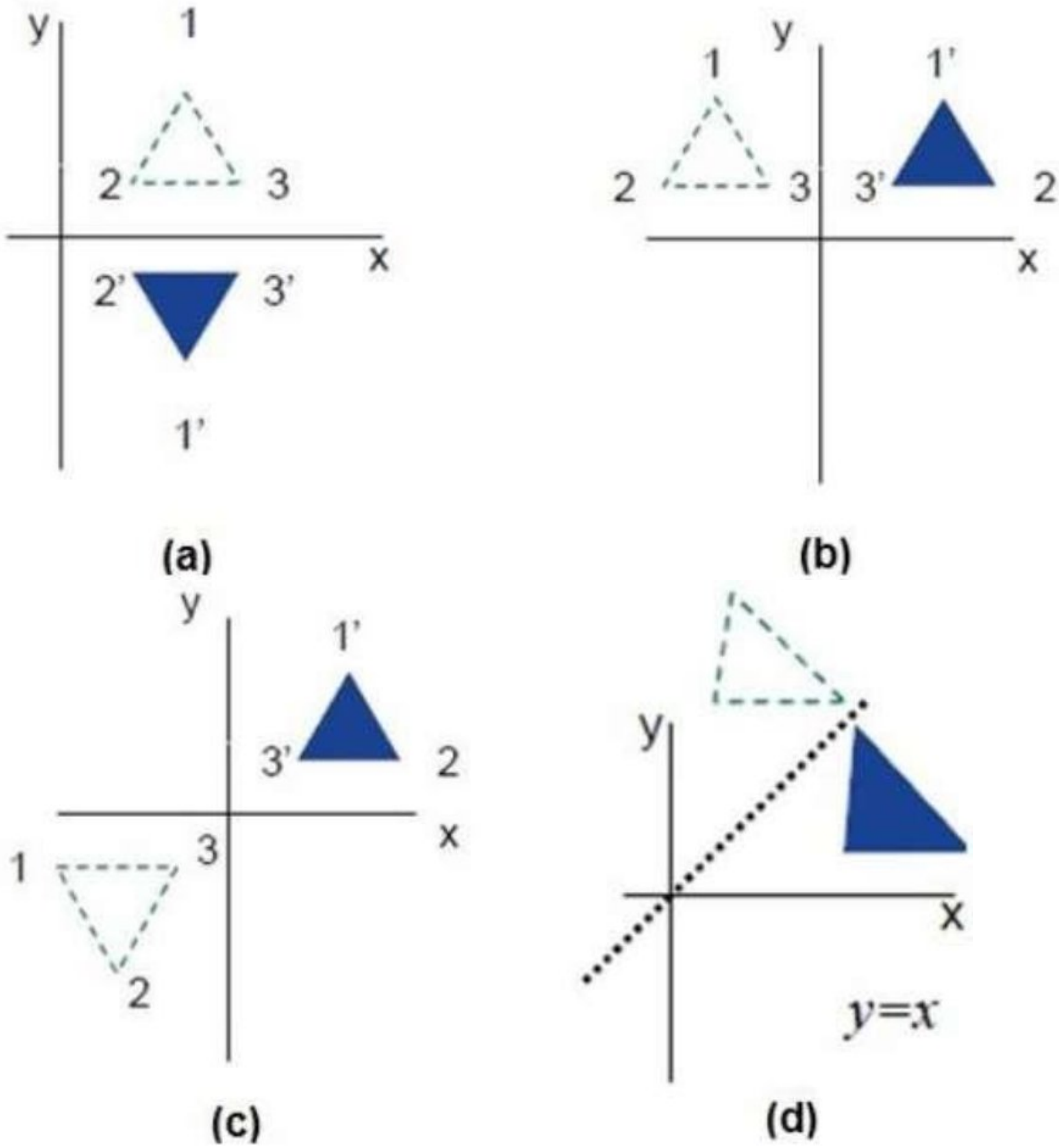




[illegible]

Reflection

[illegible]

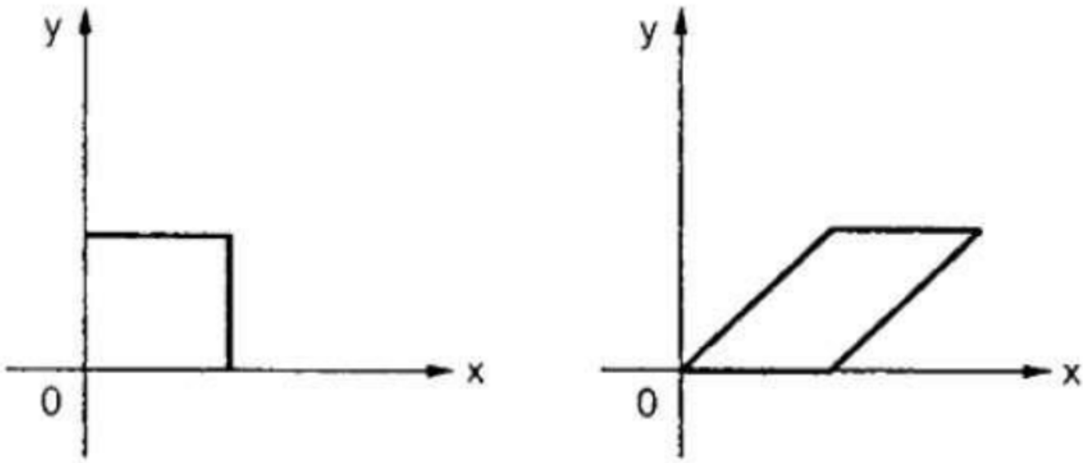


Shear

q u X-Shear Y-Shear l u v e X p Skewing

u Jp

q u Jp v u l



(a) Original object (b) Object after x shear

[illegible]

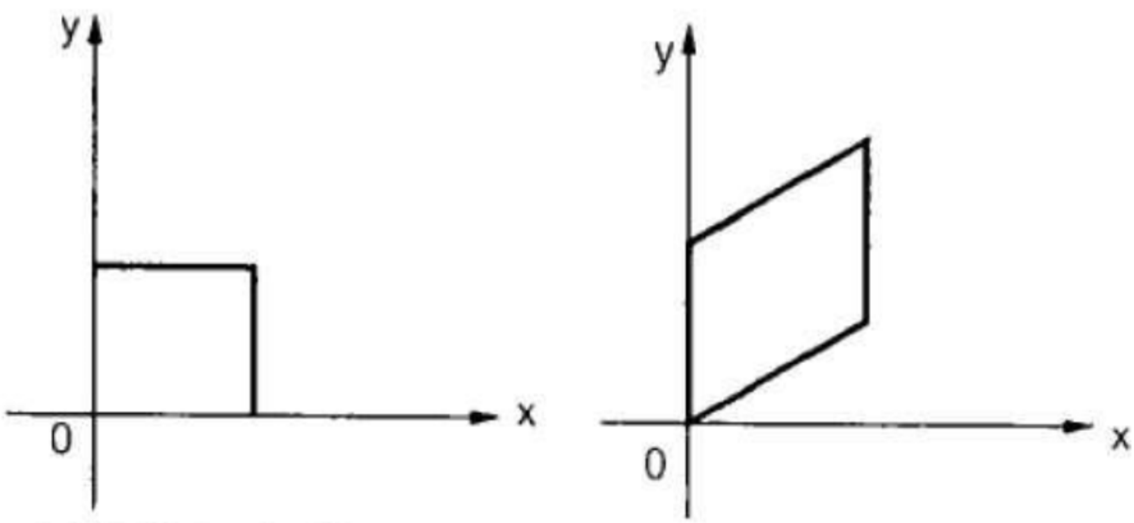
Xsh [illegible] shx [illegible]

[illegible]

[illegible]

Y-Shear

[illegible]



(a) Original object (b) Object after y shear

[illegible]

Ysh [illegible] shy [illegible]

[illegible]

[illegible]

Composite Transformation

[illegible]

[illegible]

[illegible]

[T][X] = [X] [T1] [T2] [T3] [T4] …. [Tn]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]