MAA OMWATI DEGREE COLLEGE HASSANPUR (PALWAL)

Notes

BCA 5th Sem

Computer Graphics

BCA-302: **Computer Graphics**

External Marks: 80
Internal Marks: 20

Time: 3 hours

Note: Examiner will be required to set NINE questions in all. Question Number 1 will consist of total 8 parts (short-answer type questions) covering the entire syllabus and will carry 16 marks. In addition to the compulsory question there will be four units i.e. Unit-I to Unit-IV. Examiner will set two questions from each Unit of the syllabus and each question will carry 16 marks. Student will be required to attempt FIVE questions in all. Question Number 1 will be compulsory. In addition to compulsory question, student will have to attempt four more questions selecting one question from each Unit.

UNIT-I

Graphics Primitives: Introduction to computer graphics, Basics of Graphics systems, Application areas of Computer Graphics, overview of graphics systems, video-display devices, and raster-scan systems, random scan systems, graphics monitors and workstations and input devices.

Output Primitives: Points and lines, line drawing algorithms, mid-point circle and ellipse algorithms. Filled area primitives: Scan line polygon fill algorithm, boundary fill and flood-fill algorithms .

UNIT-II

2-D Geometrical Transforms: Translation, scaling, rotation, reflection and shear transformations, matrix representations and homogeneous coordinates, composite transforms, transformations between coordinate systems.

2-D Viewing: The viewing pipeline, viewing coordinate reference frame, window to view-port coordinate transformation, viewing functions, Cohen-Sutherland and Cyrus-beck line clipping algorithms, Sutherland –Hodgeman polygon clipping algorithm.

UNIT-III

3-D Object Representation: Polygon surfaces, quadric surfaces, spline representation, Hermite curve, Bezier curve and B-Spline curves, Bezier and B-Spline surfaces. Basic illumination models, polygon-rendering methods.

UNIT-IV

3-D Geometric Transformations: Translation, rotation, scaling, reflection and shear transformations, composite transformations.

3-D Viewing: Viewing pipeline, viewing coordinates, view volume and general projection transforms and clipping.

SUGGESTED READINGS

1. Donald Hearn and M. Pauline Baker : Computer Graphics, PHI Publications.
2. Plastock : Theory & Problem of Computer Gaphics, Schaum Series.
3. Foley & Van Dam : Fundamentals of Interactive Computer Graphics, Addison-Wesley.
4. Newman : Principles of Interactive Computer Graphics, McGraw Hill.
5. Tosijasu, L.K. : Computer Graphics, Springer-Verleg.

Note : Latest and additional good books may be suggested and added from time to time.

⇒ **Computer Graphics →**

It is a field which deal representation of graphics using computers.

Computer graphics is a branch of computer graphics that deal with Generation, Manipulation, Evaluation & representation of graphics objects with aid of a computer. It is one of most effective & commonly used way to communicate the processed information to the user. Thus, computer graphics make it possible to express data in pictorial form.

Concept & principles →

Images are typically produced by optical device; such as camera, mirror, Lenses, telescope etc & natural object and phenomenon such as human eye or water surfaces.

The study of CG is a sub-field of computer science which studies methods for digital image & mani-pul-ating visual content. CG is often differentiated from the field of visualiz-

-ation.

Classification of application of CG are→

- Data display or data presentation graphics
- Design & image graphics.

Data display graphics → This provide symbolic representation of numerical data. The data can be from scientific investigation, industrial monitoring and testing or Management statistics. It has the common forms as bar chart, line, graphs and pie chart etc. Such graphics are designed for human appeal & clarity.

Design graphics → Represent actual physical or Geographical data. It include Computer-aided-design (CAD), Computer-Aided-manufacturing (CAM), image processing & mapping, Image processing or picture processing deals with the following

→ Pictorial synthesis of real or imaginary object

→ The analysis of sc[stain] the [stain] struc[stain] of model of 2D or 3D objects from their pictures.

Design graphics require higher resolution devices than data display graphics & have a higher degree of interaction.

Origin of CG → In 1950, the first Computer display was used to generate simple picture by the use of cathode ray tube.

Various types of Computer Graphics →

① Noninteractive or passive CG

② interactive CG.

① **Noninteractive CG →** In this CG, the user is passive. The user does not have any control over the graphics image. This is a traditional kind of computer graphics. e.g. → advertisements on TV, billboards, movies etc.

It also involve only one-way Communication b/w the computer & the user i.e. user can only see, read or take a print out of produced image [stain] any changes in the image

② **Interactive computer graphics →**

In ICG user has some control over the picture i.e user can make some change in the produced image. The user can interact with it. e.g. → video game. The user cannot only see the image of the game but also control it & alter it using any i/p device.

ICG involve two way communi-cation b/w the computer & the user. User can see the image & make any change by sending his command with any i/p device. ICG enable a user to customize the graphics in his own way. It increases user's ability to understand & analyze the data to achieve more precise results.

⇒ **Component of CG →**

ICG consists of 3 component such as

ⓐ **Digital memory Buffer →** This is the place where image or pictures are stored as an array (matrix of 0 & 1, 0 rep. darkness & 1 rep. image/picture)

Using these components, we are able to see the o/p on the screen in the form of pixels.

CPU —(Update process)→ Frame buffer —(Refresh process)→ Display Controller —(Pixel information)→ Video monitor

Pixel // A pixel is a single point in a raster image. Pixels are normally arranged in a regular 2-D grid and are often rep. using dots or squares. Each pixel is a sample of an original image where more samples typically provide a more accurate rep. of the original. Each pixel has 3 component such as red, green & blue (R, G & B)

Frame buffer is the video RAM (V-RAM) that is used to hold or map the image displayed on the screen. The amount of memory required to hold the image depends on the resolution of the screen image & also the color depth used per pixel. Formula to calculate how much video memory is required at a given resolution is

$$\text{Memory in MB} = \frac{\text{X resolution} \times \text{Y-resolu.} \times \text{Bits per pixel}}{8 \times 1024 \times 1024}$$

ⓑ **TV monitor →** Monitor help us to view the display & they make use of CRT

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(c) Display Controller → It is an interface b/w digital memory buffer & TV monitor. The main fn. of this is to pass the Content of frame-buffer to the monitor. The display Controller reads each successive byte of data from the frame buffer memory & Converts 0's & 1's into Correspon-ding video signal. This signal is then fed to the TV monitor to produce a black & white picture on the screen.

⇒ Use of Computer graphics →
CG is the branch of science & technology which is concerned with the methods and techniques to convert the data to visual presentation or from visual presentation to data by the use of computers. The application/use of cg are

(1) Computer aided design/drafting (CAD/CAD)

A major use of cg is in design process particularity for engineering application such as building & other structural design, mechanical & industrial design as well as design of manufacturing process, including ... es

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and aircraft. It is used to enhance the products in industry.

(2) Entertainment → CG is used to make Cartoons, animations, advertisement, animated videos etc. CG plays a vital role in making the animated games like cricket, packman, spiderman, racer etc. CG is used in making motion pictures, music videos & television shows special effect in movies also show the vast impact of CG. e.g → chhoto chetan, Jurassic park, Bal-Ganesha the animation in Bhootnath etc

(3) Education and presentation → CG is used to educate people in an efficient way. One may use animations, present-ation pointers to stress the important points. Every Colourful visual education is much efficient as compared to the other method.

(4) Bussiness → Graphics are commonly used in bussiness & economics to create the financial chart & tables. The term Bussiness graphics came into use in the 1970. It enable drawing graph & chart instead using a tabular format. BG can be used to highlight change ... period of time

(5) Advertising → is one of most profitable uses of graphics; artists often do advertising work or take advertising potential into account when creating art to increase the change of selling the artwork. Graphics is an important way of advertising the sale of goods or services.

(6) Political → The use of graphics for political purpose like cartoons graffiti, poster art, flag design etc is a famous pratice today in every part of world.

(7) Education & Text books → The graphics visuals are used to supplement text & help readers in understanding a particular concepts.

(8) Image processing → is the manipulation of image with the help of computer. Image processing is the technique to modify or interpret the existing picture such as photograph etc. IP has a very important role in medical field. e.g. Image processing technique can be used to ~~modify~~ monitor any internal problem of the body.

(9) Electronic Industry → CG is used in electronic industry. All electronic equipments use Printed circuit Board (PCB) & IC technology. These PCB can

be drawn very efficiently and in shorter time using CG. Using CG, the engineer can drawn the circuit as well as check the design & modify it just in minutes.

(10) Visualization → is used to analyse the large amount of data in the visual form i.e large amount of data is converted into visual form to analyse it. Data related to any bussiness can be presented using bargraph, pie-chart etc for more attractive presentation.

⇒ Describe Interactive CG → ICG involve two way communication b/w computer & user. The user can control the image with the help of an i/p device. The computer on receiving signals from the i/p device, can modify the display picture appropriately. It appears that the picture is changing immediately in response to user's commands i.e user's each command generate a graphical response from the computer.

The contents, structure & apperance of objects and of their displayed image are controlled by the user by using i/p device. Thus in interactive com. Graphics, there is a close

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relationship b/w input devices & the display.

Advantages of IG →

(1) Training Pilots → It helps to train the pilots of airplanes. A pilot spends his time at the control of a flight simulator on the ground instead of real aircraft. It is surrounded by screen that provide computer generated views and give an accurate impression of the plane's motion. Flight simulator help in - Fuel saving, safety & familiarize the trainee with world's airports.

(2) Plotting in Bussiness, Science & techn →
IG are used to create 2D & 3D graphs of (1) mathematical, physical & economic fun, histogram, bar & pie chart (2) Task-scheduling charts, (3) Inventory & production charts & the like.

Barchart, linegraph & pie graph show the relationship b/w multiple parameters.

Three dimensional graphs are used to make an effective & attractive presentation.

(3) Process Control → The data values obtain through sensors attached to critical system components in refineries, power plants & computer n/w etc. display their status. Such status display help the operators to view the condition & control the process accordingly. e.g. → Spacecraft controllers monitor telemetry data & take corrective action accordingly. Military commanders view field data as no. & position of vehicle, weapons installed, troop position & movement.

(4) Computer Art → Another application of CG is in area of fine arts & commercial art. In the arts, sculptures may become more productive with aid of computer. A variety of computer technology may be used to produce images. The computer activate a robot like sclupting tool that rough out the general shape of the figure.

(5) Fast & effective means → The ICG is very effective in all its application. With the ability to interact with the computer an engineer can quickly correct a design error & see a revised picture of the c...

Conclusion → IG thus significantly enhance the ability

(1) To understand data.

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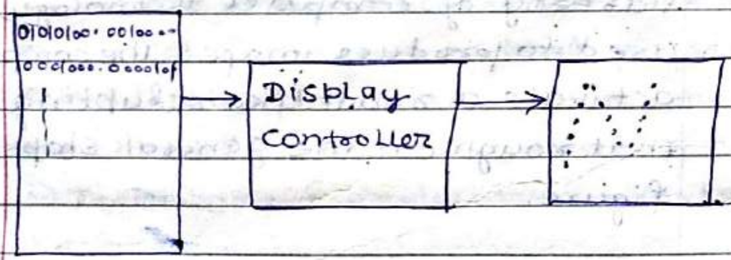
2. To visualize real or imaginary object
3. To increase productivity
4. To lower analysis & design Costs etc.

In the end, IG improve the bandwidth of communication b/w the user & computer in both directions.

⇒ **Component of Interactive graphics →** Three major component of IG syst. are

(i) **Digital memory or frame buffer →** This Component store the intensity value of the displayed image as a matrix.

(ii) **A Television monitor →** It enables to view the image and plan further action.



(iii) **An interface or display Controller →** This Component serve to pass the contents of frame buffer to the monitor. The image is passed repeatedly to the monitor 30 or more times a second in order to maintain a steady picture on the screen. This provide an interface b/w above two

Components. The frame buffer has the storage as a pattern of binary numbers which rep. a 2-D array of picture element of pixels. To store black & white images, black pixels are rep. by ones in the frame buffer & white pixels by zeros. Thus a 16X16 array of black & white pixels could be rep. by 32 bytes, stored in frame buffer.

The display Controller read each successive byte of data from framebuffer & convert its 0s & 1s into corresponding video signal. The signal is then fed into the TV monitor which produces a black & white screen. The display Controller repeats this operation 30 times per sec. & thus maintains a steady picture on the TV screen. Speed is must in displaying picture. Any CRT based display must be refreshing at least 30 times a second. The image must be transimitted to display point by point. Speed enables transmission of more & more elements.

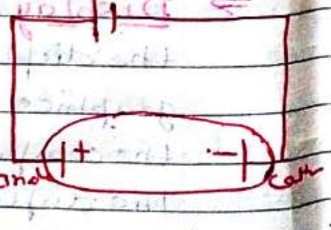
⇒ **Display Device →** The most imp. part of PC is the display system. The D system where the graphics are rendered in console screen of the computer. It is responsible of graphics display. The display system may be attached with a port to display character, picture & video o/p.

Some of common types of display systems are
① Raster scan display. ② Random Scan display
③ Directed view storage tube ④ Flat panel "

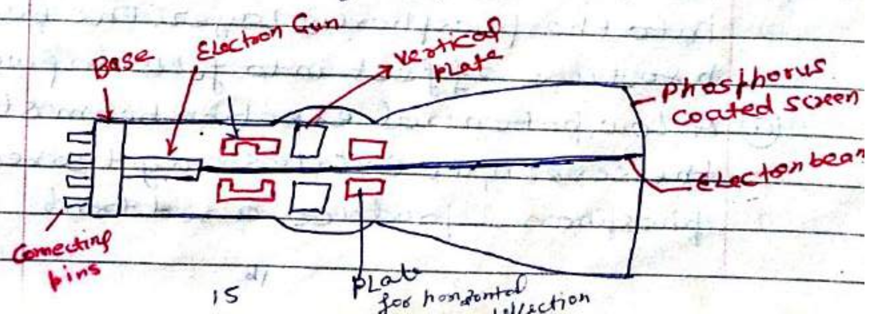
The display system are referred to as Video monitor or video display unit. The most Common Video monitor that normally Comes with a PC is the Raster Scan type.

Every display system has three part
ⓐ Display adapter, that creates & hold the image information.
ⓑ Monitor which display that information.
ⓒ Cable that carries the image data b/w display adapter & monitor. The monitor is based on CRT.

CRT → The simplest Version of a CRT Consist of a gas-filled glass tube in which two metal plates one negative charge (cathode) & another positive charged have been placed. when a very Large Voltage is placed across the electrodes, the neutral gas inside the tube will ionize into conducting plasma & a current will flow as electrons travel from the cathode to other side. A CRT is a type of anode display device. CRT are special electronic Vaccum tube that use focused electron beam to display image. CRT are most famous for their



use in such things as T.V, computer & radar display & automated teller machine (A.T.M). CRT are also used in Videogame equipment. In CRT, The negative charge terminal is a heated filament. This filament is contained inside a vaccum with a glass tube. Inside the tube, a beam of electrons is allowed to flow from the filament into the vaccum. The electron's beams are Concentrated by anode. Anode are used to accelerated the speed of electrons. These fast moving electrons fly through the tube's vaccum hitting the phosphor-coated screen & making it glow. The beam of electrons passes b/w two pair of deflection plates. An electric field b/w the first pair of plates deflects the electron horizontally & an electric field b/w the second pair of them vertically. If no deflection field are present the electrons travel in a st. Line from the hole in the accelerating anode to the center of the screen where they produce a bright spot.



⇒ Colors obtained in a CRT display device

A crt color monitor display picture by using a combination of phosphors that emit different colored light. By combining the emitted light from different phosphors, a range of colors can be generated. Two basic technique for producing colors display with a CRT are –

① **Beam penetration Methods** → The normal CRT can generate image of only a single color due to limitations of its phosphor. A color CRT device use a multi-layer phosphor & acheive color control by modulating a normally constant parameter namely beam penetration accelerating potential. The screen is coated with a layer of green phosphor over which a layer of red phosphor is desposited. Outer layer is red & inner is green. The displayed color depends on how far the electrons beam penetrates into the phosphorus layer. The beam produce effect into following ways

ⓐ A low potential electron beam strike the screen, it excites only the red color phosphor & produce a red trace

ⓑ A higher velocity beam will penetrate into the green phosphor increasing the green component of light o/p.

ⓒ At intermediate beam speeds, combin-ation of red & green lights are emitted & show two more colors orange & yellow.

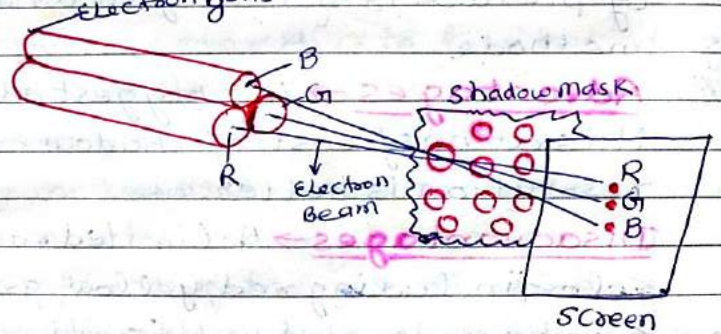
Beam penetration has been an inexpensive way to produce color in random-scan monitors, but only four colors are possible & quality of picture is not as good as with other methods.

Advantages → The biggest adv. is that it is at half cost of shadow mask & its resolution is better.

Disadvantages → A limited range of color, including red, yellow, green & orange can be generated in this m/d.

- quality of picture generated is not as good as with other m/ds.

② **Shadow Mask Method** → This m/d is commonly used in raster scan system bcz they produce a much wider range of color than beam penetration m/d. A shadow mask CRT has three phosphorus color dots at each pixel position. One phosphor dot emits a red light, another emits a a green light & third emits a blue light. This type of CRT has three electrons guns, one for each color dot & a showdow mask grid just behind phosphor coated screen. The three electron beam are focused as a gp. onto shadow mask which contains a series of holes in the window. when the three beams pass through a hole in the shadow mask, they activate a dot triangle, which appears as a small color spot on the screen.



Color variation in a shadow mask are obtained combining different intensity levels of the three electrons beam as

* By turning off the red & green gun, the light emitted will be only through blue gun.
* A white aera is the result of activating all three dots with equal intensity.

* Yellow is produced with the green & red dots only.
* magneta is produced with the blue and red dots.
* Cyna is produced when blue and green are activated equality.

Some low cost shadow masks can produce eight colors only. Good quality masks can produce millions of colors.

Advantages→ 1) It is used with inexp--ensive home computers.
2) Realistic image can be drawn.
3) Several million different colors can be generated.

Disadvantages→ 1) It is relatively expensive.
2) Relatively poor performance.
3) The mask blocks a large proportion of the available beam energy and thus reduces the brightness.
4). Convergence is another problem that occur in shadow-mask. It is difficult to adjust the three guns and deflection system in such a way that all three beams are deflected together.

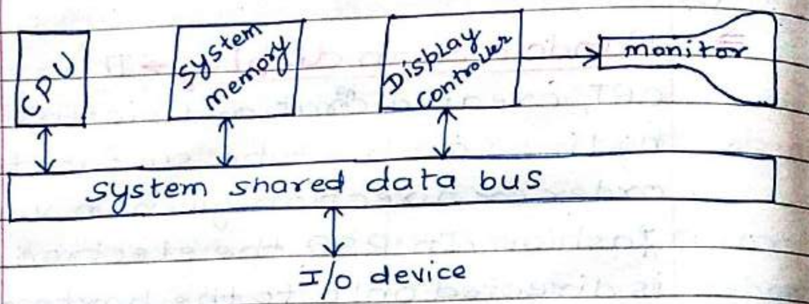
⇒ Difference b/w beam penetration m/d and shadow mask m/d.

Beampenetration	shadow mask m/d
1) In this m/d, color displayed will depend on penetr-ation level of beam into the phosphors layers.	1) In this m/d, color displayed will depend on the no. of guns that are on at a time.
2) Realistic image can not be produced	2) Realistic image can be produced.
3) It is used in random scan system.	3) It is used in raster scan system
4) It is cheaper m/d	4) It is expensive m/d
5) Only four colors as red, yellow, green and orange can be generated with this m/d.	5) Millions of colors can be generated.
6). Convergence problem cann't be occur.	6) Convergence problem can be occur.
7). The Screen is coated with two layers of phosphorous red & Green.	7), Three electron gun are used one for each dot as Red, Green, Blue.

⇒ **Random Scan display** → The original CRT, created ~~crat~~ and pictures lines by lines on the tube surface in any order or direction given in vertical fashion. In RSD, the electron beam is directed only to the parts of the screen where a picture is to be drawn. These displays are suitable for engg. and scientific drawings. Random SD monitor draw a picture one line at a time and that is why also called as vector display. The component lines of a picture can be drawn & refreshed by a RS system in any specified order. A pen plotter operat in a similiar way and is an exampl of random scan.

Picture definition is now stored as a set of line drawing commands in the aera of memory referred to as display list or simply refresh buffer. RSD are designed for line drawing application and cann't display realistic shaded screen.

RSD have higher resolution than raster system. These displays produc smooth line drawing bcz CRT beam directly follows line path.



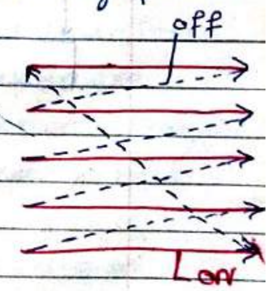
Advantages → ① RCS are designed for Line drawing applications.
② Any modification if needed is easy.
③ Since picture definition is stored as a set of line drawing instruction and not as a set of intensity value for all screen points, rsd have higher resolution than raster system.
④ Vector display produce smooth line drawing bcz the CRT beam follow the line path directly.

Disadvantage → ① It can't display realistic shaded scenes.
② Solid pattern is difficult to fill

Raster Scan graphics → are based on the television technology. In this 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

the beam intensity is turned on & off to create a pattern of spots. Picture definition is stored in a memory aera called the refresh buffer or frame buffer which holds the set of intensity value for all the screen points. Each screen point is referred to as a pixel.

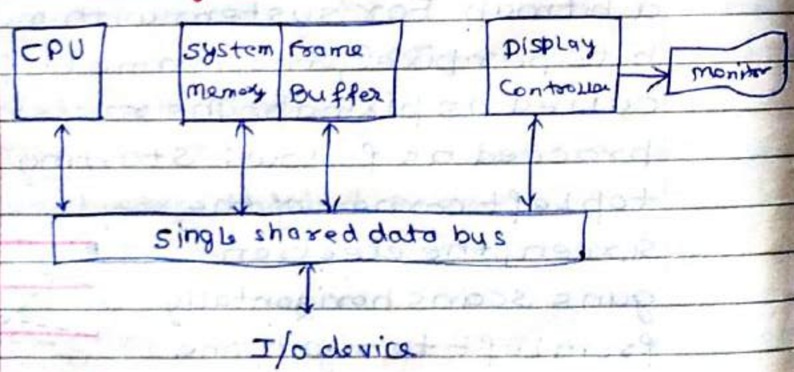
In a simple black & white system, each screen point is either on or off, so only one bit per pixel is needed to control the intensity of screen position. On a black and white system with one bit per pixel the frame buffer is commonly called a bitmap. For system with multiple bits per pixel, the frame buffer is called as pixmap. The raster scan proceed as follow: starting from top left corner of the screen, the electron guns scans horizontally from left to right, one scanline that is one row at a time, jumping to the left end of next lower row until the bottom right corner is reached. Then it jumps to the top left



corner and starts again, finishing one complete refresh cycle.

Hence, the beam is swept back and forth from left to right across the screen, when beam is moved from the right to the left as shown by dotted lines. RSD process is similiar to reading different lines on the pages of a book. In RSD, the screen image is maintained by repeatedly scanning the same image. This process is known as refreshing of screen. It is completed in about 1/30th of a second.

Advantages→



① The RSD is capable of storing intensity information for each screen point. This makes it well suited

for realistic display of scenes containing suitable shading & color patterns.

2) while application for these high-quality displays have been increa-sing, the cost of RSD equipment has been decreasing.

3) It offers full color display at relatively low cost.

Disadvantages→ 1) modification is difficult.

2) Its resolution is low, which prevent display of fine detail.

3) Its slow speed of scan conversion

Ques-11 Difference b/w Raster scan & Random scan?

Ans→

Raster Scan	Random Scan
1) Higher resolution	1) Lower resolution
2) more expensive.	2) Less Expensive
3) Uses monochrome or beam penetration type.	3) Uses monochrome or shadow mask type.
4) Give continuous & smooth lines	4) Give mathematically smooth line polygon & boundaries of curved primitives only by approximating them with pixel

Random	Raster
5) Editing is easy.	5) Editing is difficult.
6) Refresh rate depends directly on picture complexity	6) Refresh rate independent of picture Complexity.
7) Scan Conversion is not required	7). Graphics primitives are specifies in terms of their end points & must be scan Converted into their corresponding pixels into framebuffer
8). It draws Lines & characters.	8). It has ability to display aera filled with solid Colors or patterns.
9) Don't use interlacing	9). Uses Interlacing.
10). Invector scan display, the beam is moved b/w end points of graphics primitives	10). In RSD, the beam is moved all over the screen one scan Line at a time from top to bottom & back to top.

Ques 12 Explain in details of Direct View storage tube?

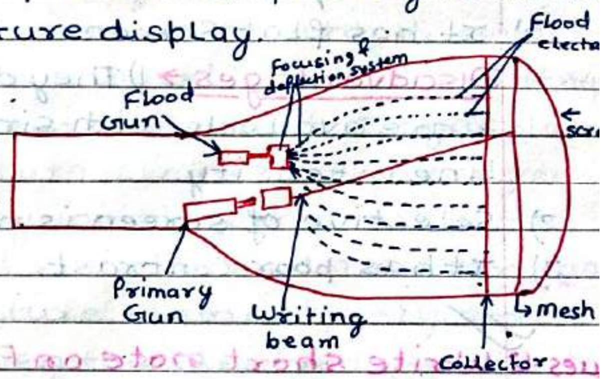
Ans→ A DVST give the alternative m/d of maintaining the screen image. A DVST uses the storage grid which store the picture information as a

charge distribution just behind the phosphor-Coated screen. It consist of two electron guns

a). Primary Gun

b). Flood Gun.

A primary Gun stores the picture pattern & flood gun maintai[n] the picture display.



In DVST, there is no refresh buffe[r] the images are created by drawing ve[ctor] with a relatively slow moving electro[n] beam. The beam is designed not to dr[aw] directly on phosphor but on a fine wire mesh coated with dielectric mounted. A pattern of +ve charge is deposited on grid.

The DVST contain also a second gr[id] just behind the storage mesh is cal[led] collector. The main purpose of colle[ctor] is smooth out the flow of flood e^-. These e^- pass through the collector at low velocity and are attracted to the +ve charged portion of storage mesh but repelled the rest. e^- not repelled by storage mesh pass rt. through it & strike the phosphor.

Advantages → 1) Refreshing of CRT is not required.
2) It has flat Screen.

Disadvantages → 1) They don't display color & are available with single level of line intensity.
2) Selective of screen is not possible.
3) It has poor contrast.

Ques-12 Write short note on Flat panel display

Ans A number of display m/d are in use that is designed to reduce the depth of the CRT display caused by the length of the tube. These devices are collectively known as FPD. These types of FPD commonly in use with computer system are Liquid crystal displays, gas plasma display & electroluminescent display (ELD).

The screens of these FPD are made up of pair of e^-. Each pair of electrode is used to generate one picture element.

The LCD differs from the gas plasma and ELD that it doesn't generate its own light for the picture element. The LCD require an external light source called a backlight for computer application. The LC material b/w the charged electrodes becomes translucent when voltage is applied & allow the backlight to shine through as a picture element. In gas plasma the picture element light is generated by ionizing a gas b/w the charged electrode. In either case the picture element only emits light when the electrode have voltage applied to them. One of adv. of fpd is that smaller voltage are required for their operation than for a CRT. Gas plasma display use 200 volts to charge the electrode & ELD require only 20 volts. The term FPD refers to a class of video device that have reduced volume, wt. & power requirement compared to a CRT. They are thinner CRT and we can hang them on walls or wear them on our wrist. Current uses of these are in small TV & monitor calculator, Laptop computer etc. There are 2 types of FPD–

ⓐ Emissive display → The emissive display are devices that convert electrical engry into Light. Plasma panel, LED are example of ED.

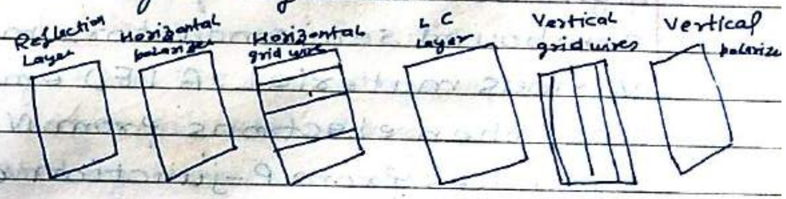
ⓑ Nonemissive display → NED use of optical effects to convert sunlight or Light from some other source into graphic pattern. example– LCD.

Ques-13 What are LCD & LED. How LCD is differ from Plasma panel display?

Ans LCD → are commonly used in small system such as * calculators, portable and Laptop computers. It is non-emissive device which uses optical effect to convert Light from sun or other source into graphic pattern. The term LCD implies that its componends have a crystalline arrangement of molecule they flow Like a Lipuid. In simple words, Liquid crystal are compounds with crystalline arrange-ment of molecule & they flow Like a Liquid. Thus LCD are those device device in which picture is produced by passing polarized light through a LC material.

A LCD is made up following six Layers-

1). The front Layer is a vertical polarizer plate.
2). Next is a Layer with grid wires electrode posited on surface adjoining the crystals.
3). Next is a thin Liquid crystal Layer
4). Then a Layer with horizontal grid wire on the surface next to crystals.
5). Then a polarizer &
6). Finally a reflector.



The Layer of a LCD are sandwiched together to form a thin Layer. Light entering through front Layer is polarized Vertical & then runs to horizontal due to spherical nature of molecule.

Plasma panel	LCD
1) are gas discharge displays.	1) They are Liquid CD.
2). They are often used for Large display	2). Best suited in small system.
3). Emissive device	3). Non emissive device
4). Low production cost	4). Expensive
5). high & good resolution	5) have not good resolution.

LED → is a emissive device. A matrix of diode is arranged to form the pixel position in the display & picture definition is stored in a refresh buffer information is read from refresh buffer & converted to voltage levels that are applied to diodes to produce the light pattern in the display. LED is a semiconductor light emitting device which various colors of light with light sources being consituted by compound semiconductors made of various material. A LED emits a light when electrons from N-junction and holes from P-junction are moved to a PN junction section when a forward voltage is applied. Since engry released when free e^- are coupled is radiated as light the light emitted from the LED is light in a narrow wavelength range, i.e light of a single color such as red or blue

14) what do you mean by computer graphics standard?

Ans- Graphics standards are rule & speafications →

International & national standards planning organisations in many countries have set a generally accepted standard for CG.

The standardization is needed-

* To increase their utility.
* To make the application programs more portable.
* To allow them to use in different element enviornment.

Some popular standard developed are

1) GKS → stands for Graphical kernel system. It was developed by inter-national standard organization (ISO) and by various national standard organizational including the ANSI). It is a standard graphics package. This system was adopted as the first graphics software standard. GKS was originally designed as a 2-D graphics package (GK-2D). later 3-D GKS extension. Its aim at delivery of product; it may be h/w or s/w. It offered flexibility of adding more fn to library.

2) PHIGS → stands for programmer's Hierarchial interactive graphics std. It is the second graphics s/w standard developed. It is an extension of GKS

It was approved by standard organisation. Later an extension of PHIGS, called PHIGS+ was developed. PHIGS+ provided 3D surface shading capabilities not available in PHIGS. The PHIGS+ Extension provided many facilities for controlling rendering including specification of the material properties of objects their placement & interaction with light etc which was essential for realistic graphics.

3). CORE → It was developed in 1970. It provides some set of commands for controlling the graphics generation & display. It can be used for display of 2D as well as 3D images. The end product of a graphical application is a pictorial rep. of data. It can be obtained by using three components of graphics system.

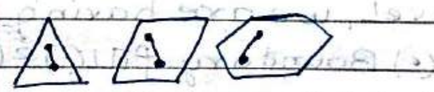
a) A digital memory – This component store the intensity value of the displayed image as a matrix.

b) A television monitor – It enable to view the image & plan further action

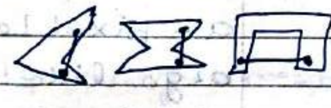
c) Display controller – This component server to pass content to frame buffer to monitor.

Ques-15 Describe in detail polygon filling?

Ans – A polygon may be rep. as a no. of line segments connected end to end to form a closed figure. Alter-native, it may be rep. as the points where the sides of the polygon are connected. The line segment which make up the polygon boundary are called side or edges. The end points of the sides are called the polygon 'vertices'. The simplest polygon is the triangle having three sides & three vertex points. Polygon can be divided into two classes: (1) A convex polygon is a polygon in which all points on the line segment connecting any 2 points inside the polygon are also inside the polygon. A concave polygon is one which is not convex.



convex



concave

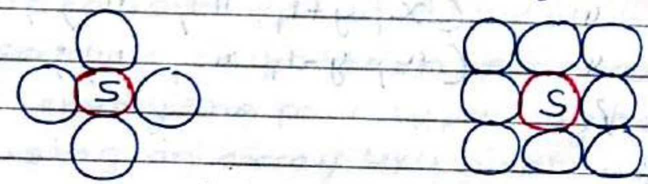
Polygon filling → is the process of filling the aera of a polygon either completely or by some desired pattern or It is the process of "colouring in" a fixed aera or region. Completely filling the polygon is called solid filling. Filling the polygon by some desired pattern is known as pattern filling as in mechanical drawing or drafting. The aera of a polygon is described as the total no. of pixel it contains by the bounding pixels that outline the polygon. Filling can be happen in boundary or interior region and hence the corresponding algo. are termed as boundary fill or flood fill algorithm. The flood fill algorithm & boundary fill algo. need some points inside the polygon which is termed as seed & so the algo. are termed as seed fill algo. Aera or region may be defined as pixel level or geometry level. when the regions are defined at pixel level, we are having diff. algo. like (•) Boundary fill (•) Flood fill (•) Edge fill (•) Fence fill.

① **Flood fill algo** → The algo. used for filling the interior of a polygon is called FFA. This start with a pixel or a seed which is interior to the region. The algo. also begin with a Seed (starting pixel) inside the region

It checks to see if the pixel has the regions original color. If the ans is yes, it fill the pixel with a new color & uses each of pixel neighbour as a new seed. If answer is no, it returns to the caller. This starts with a pixel or a seed which is interior to the region. This process is a recursive one. starting with the seed point adjacent pixels are checked. If they have a diff. color, then each is colored with the desired color.

4 connected & 8 connected pixel concept

In 4 Connected m/d, the pixel may have upto 4 neighbouring pixels, as



rt., above, left & below of current pixel. In 8 cp m/d, the pixels may have 8 neighbour pixels.

The's process continues till all the interior pixels are inspected. The process stop when no neighbouring pixel that can be coloured is left. This algorithm is simplest but slow as each and every pixel in the polygon has to be tested for coloring. For large polygon it may fails as it require a large frame buffer, more knowledge about pixel or shape of polygon is required.

algo →

```
void floodfill(int x, int y, int fill, int oldcolor)
{
if(getpixel(x,y) == oldcolor)
  {
  setColor(fill);
  set_pixel(x,y);
  floodfill(x+1, y, fill, oldcolor);
   "      (x-1, y,  "  ,  "  );
   "      (x, y+1,  "  ,  "  );
   "      (" , y-1,  "  ,  "  );
  }
}
```

② Boundary fill algo → First of all a starting pixel called as seed is considered. Recursive m/d for filling the whole boundary is applied. The m/d start with initial-point the seed & continue to identify the pixel to rt. or left of it, till the leftmost & rt. most boundary

pixel. If pixel is already filled with desired color then leaves it otherwise fills it.

Next step to check the pixel from top to bottom from the seed point having boundary color or not & the process is repeated till all the pixels are tested. This algo. takes more time & memory if size of polygon is large.

Pattern filling → A region can be filled using a solid color or using a specified pattern or design. A pattern style is created by which aera is to filled. A prototype or sample of pattern is stored in the memory. The prototype may be drawn using an array 4x4 pixels or 8x8 pixels or of any suitable dimension.

Stack based seed fill algo →

① Push the initial pixel on the stack
② while stack is not empty repeat step (3) & (4)
③ Pop out seed pixel from the top of stack & fill it with a color.
④ Find all the neighbour pixel of seed pixel & push it on to stack if-

(a) It is not a boundary pixel &
(b) It is not already filled.
(5) stop.

Q-16 Write a short note on animation?

Ans The word 'animation' is derived from 'animate' which mean 'to give life to'. Thus animation refer to making Some-thing alive. Animation is generally achieved from still picture by flashing a series of stills with varying position of the moving object at speed which can cheat the human eye into believing that it is actually seeing movement. The speed should be faster than about 20 images per sec. Animation can also be defined as a process by which we can still picture 'move'. A is the illusion of motion that is created by displaying a series of image or frame each one slightly different from the last, over a brief period of time. A seq. of images or still picture each with a slight change in position of objects if rapidly projected on the eye, creates an imp. of movement.

A include change of position, time-varying visual effect like in shape color, transparency etc. Thus A involves generation of many frames that are displayed in a very short period of time such that it creates an illusion of motion of objects in a picture. A is used mainly in cartooning for entertainment purpose. Other imp. aeras are

- Advertisement
- Business
- Engineering
- Science & many more

Type of Animation→

Animation graph can be created by hand or with Computer Assistance. Animation are two type

(1) **Cel Animation→** is created on celluloi sheet by drawing various frame & identifying it in terms of key fra & intermediately frame are genera called "tweening". The motion seq. is defined by the main events in the stor A series of picture drawn acc. to imp. movement in the story form th

storyboard. A no. of individual picture or frame are created. The frame where major changes take place within the seq. are called Key frame. The Gap b/w the key frame are filled with inbetween frame. The process of producing a no. of frames inbetween the key frame is called "Tweening." Generally, the no. of in between or intermediate frame may be 24/25 frame per sec. to achieve the effect of smooth motion of an object.
Ex- Drawing of cartoons.

② **Computer animation** → is very effective for designing & processing the object. Computer animation can be 2D or 3D.

- 2-D CA → C A s/w creating the inbetween frame. Computer assistance is best suited for inbetweening or colouring. In traditional based animation the inb/w frame are created by junior assistant or less skilled who require more time to create frame. Computer animation s/w programs program have grid & alignment command to help animation. Most cartoon movies are based on 2D animation.
- 3-D computer animation—

With the help of computer, 3-D object can be generated. A mathematical model of a 3D object is created to display its 3D i.e width, ht. & depth. The graphics symbol based on concept of 3D graphics are used to create char. scenery etc.

Steps in animation process—
Animation process include following steps

① **Story** → In this step, a story is developed. For this purpose the writer work with customers to have a detail description of actors & their role.
② **Story board** → It is a graphic synopsis of the animation which illustrate the appearance & flow of story.
③ **Script** → will include detailed positioning & movement of actor, Camera & Light.
④ **Simulation** – provide the motion of animation for science related application.
⑤ **models** – Each actor is defined within geometric model to define its appearance.
⑥ **Preview** – In this phase a fast preview of animation is generally looked.
⑦ **Render** – It is used for producing shaded image for giving realistic effect

(8) Recording - The last step is the recording of image on a film.

Q-17 Explain the tweening technique used to ease out animation?

Ans T is an imp. fn. used in animation. In animation, moving image are created with some change in each picture. The storyboard defines an outline of the action & motion seq. A series of picture is drawn showing the imp. moments in the seq. A key frame is a detailed drawing of a scene at a certain time in the animation seq.

To create the impact of movement a no. of frames with slight changes are inserted in b/w the key frames. This process of inserting the inter-mediate frame is called tweening.

In traditional animation -

- The lead artists or experts draw the key frame.
- Assistants or less skilled draw a no. of frames b/w the key frame i.e tweening is applied.

However in computer animation the extreme i.e the first & the final key frame are drawn, the others

are easily generated with computer's help. Generally, to create the effect of smooth motion 24 or 25 frame are displayed/sec.

Thus tweening is a m/d used for creating animation. Tweened animation is an effective way to create movements & changes over time in a scene.

Tweened animation is of 2 types -

① Motion tweening - In MT, the propertie like position, size & rotation are define & can be changed. Also the motion path can be drawn in MT.

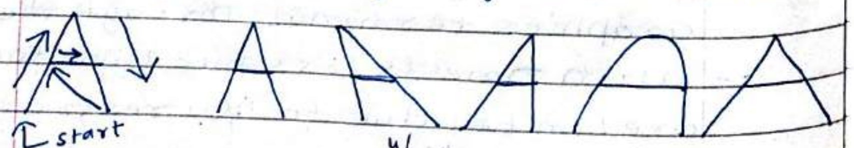
② Shape tweening - In ST, a shape to appear at one pt. of time can be drawn. This shape is then changed again or replaced by new one. This will help to create an effect similiar to morphing making one shape appear to change into one over time.

Q-18 Describe the process of char. gen-eration in graphics?

Ans Usually char. are generated by h/w. In the h/w based m/d the logic for generating char. is built into the graphics terminal. Through the gener-ation time is less but type faces are limited due to h/w restriction.

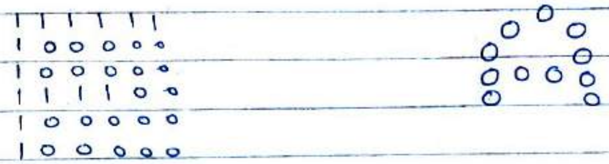
We can generate char. by s/w also. char. graphics involve display of picture, lines, designs & other graphics. These picture & graphics will belong to some data. Some information & inst. should be given to the user about this data. This is possible with the help of text display. Since text consist of String of char. So a char. is basic unit of text. To generate these char. h/w & s/w are required. There are three m/d for char. generation-

① **Stroke m/d →** In this, the char. are developed using a set of polyLines & spline that approximate the char. outline. This form of char. rep. is completely device independent. To produce a char. we will give a seq. of commands that defined the start pt. & end points of the st. lines. By using we can change the scale of char. we can make a char. twice as Large as its original size. we can get char. standard also, we can also change the style of char. also



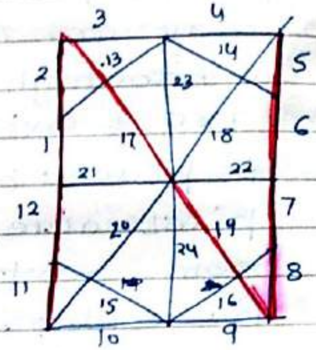
SM is based on natural m/d of text writing by human being.

② **Dotmatrix / Bit-Map m/d →** It is called dot matrix bcz in this m/d char. are rep. by an array of dots in the matrix form. It is a 2-D array having column & rows. The size of this array may vary. An array of 5 dot wide & 7 dot high in generally used but 7x9 & 9x13 are also used. The char. is placed on the screen by copying pixel value from char. array into some portion of screen frame buff. Basic idea is put 1 in the matrix of dots which are needed in char. generation. All those dot which are not required are value as 0. since only two values are possible either 1 or 0 it is called bitmap m/d.



③ **Starbust m/d →** A fix pattern of line Segment are used to generate char. These are 24 Line segment & out of these Segment required to display for particular char. are highlighted. This m/d of char. generation is called starbust m/d bcz of its characteristic apperances. The pattern for particular char. are stired in the form of 24 bit code. Each bit rep. one line segment. The bit is set to one to highlight the line segment otherwise it is set to 0.

(Starbust pattern of 24 Line segment)



(S.b.p of char. N)

24 bit code for char. N is

24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1	1

This m/d of char. Generation have disadv.

1. char. quality poor, bcz it is worst for curve shape char.
2. The 24-bit are required to rep. a char. Hence more memory is required

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Q-19 what is anti-aliasing? Explain the reason of alising in c.g & explain the minimization or removing of aliasing?

Ans Aliasing → Aliasing can be termed as a side effect of scan conversion. The raster scan system of screen display of line & symbols by means of char. blocks or pixel grids is an effective technology & quite convenient for programming, whether the image are drawn as char. or pixel. A particular point on a straight or curved line doesn't concide with the centre of the char. or pixel the char. block or the pixel. The reason is that only +ve integer char. or pixel position can be locate. The restriction to int. value leads to two consequence in raster scan:

1. Non-int. value point shift to neare integer location causing deviation of the line.
2. There are step or sudden jump in the line from one int. value to the next.

This phenomenon of the

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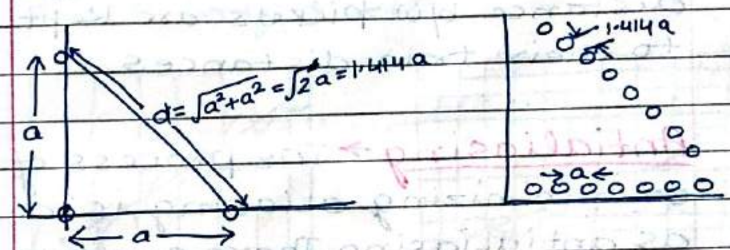
shifting is called Aliasing from the word alias which mean a substi-tute.

Since scanning is restricted at higher value, the st. line & curve do not look smooth when viewed on the monitor. This undesirable effect is the result of the scan conversion process that convert coordinate point on an object to integer pixel positions. Consider the st. line eq^n $y = 5x+4$ while plotting the point (5,4) is a shift location for (5, 5.6). This distortion or shift is called aliasing. Aliasing is a typical image quality problem. The jagged apperance of displayed lines can be improved. Aliasing refer to the plotting of a point in a location other than its true location so that the point fits into the raster. These problem are

1. **Staircase** → The image generated by raster algo. will give jagged or stair-case line problem. These jaggies are essential caused by the problem of trying to map a continuous image of pixels. Pixels so generated at alias location of true object &

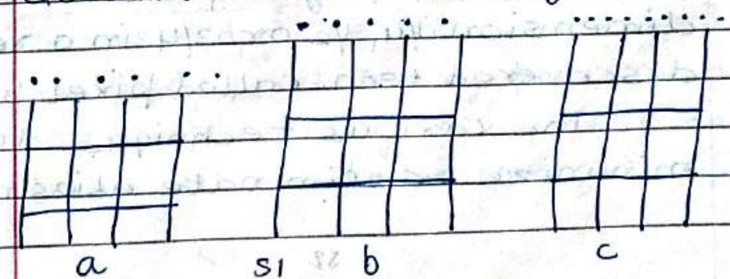
this problem is known as staircase problem.

2. **Unequal brightness** → It means lines of diff. orientation have unequal brightness. A slanted line appear dimmer than a horizontal or vertical line although all are presented at same intensity level.



In the fig, where the pixel on the horizontal & vertical line are placed at 'a' unit apart. Then the distance b/w two pixel on diagonal line will be $d = \sqrt{a^2+a^2} = \sqrt{2}\,a = 1.414a$

3. **The picket fence problem** → occur when an object is not aligned with, or doesn't into the pixel grid property.



In fig(a) show the picket fence where distance b/w two adjacent pickets is not a multiple of unit distance pixels. The fig(b) is called global aliasing, as the overall length of the picket fence is correct. In fig(c), an attempt to maintain equal spacing will greatly distort overall length of the fence. This is called local aliasing as the distance b/w pickets are kept close to their true distances.

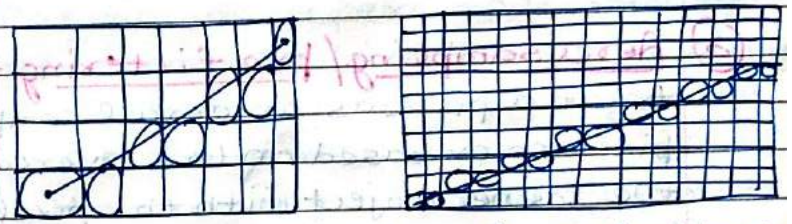
Antialiasing → The process of reducing or minimizing aliasing is called as antialiasing. There are two approach for antialiasing -

① To increase the resolution to such an extent that more pixel become available to coincide with compute value. In other words, to make the step so small and so many that staircase begins to look more like a sloping ramp.

② Shift the pixel by a fraction of dimension 1/4, 1/2 or 3/4 in a recently discovered tech. called pixel phasing.

The various technique to minimize or eliminate aliasing are

① **Increasing no. of resolution →** The aliasing effect can be minimized by increasing resolution of raster display. By increasing resolution & making it twice the original one, the line passes through twice as many column of pixel & therefore has twice as many jags but each jag is half as large in x & in y direcn.

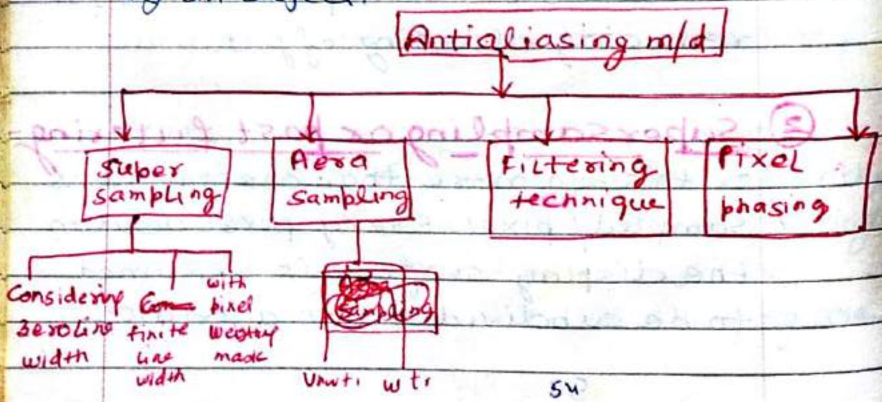


In second fig. line looks better in twice resolution, but this improvement comes at the price of quadrupling the cost of memory bandwidth of memory & scan conversion time. Thus increasing resolution is an expensive m/d for reducing aliasing effect.

② **Supersampling or post filtering**

In this m/d, more than one sample is sampled/pixel. Every pixel area on the display surface is assumed to be subdivided into a grid of smaller subpixels. Thus the screen is treated as having higher resolution than what actually is. A virtual image is calculated at higher resolution & then mapped to the actual frame resolution after combing the result of the subpixels. The intensity value of a pixel is the average of intensity value of all sampled pixel within that pixels.

(3) Aera sampling / pre filtering → It treat a pixel as an aera & compute pixel color based on the overlap of the scene object with the pixel aera i.e pixel intensity is determined by calculating the aera of overlap of each pixel with the object to be displayed. These technique compute the shade of gray based on how much of pixel aera is covered by an object.



Ques-20 Differentiate b/w pointing & positioning. Explain various positioning technique & usefulness of rubber band technique in graphics.

Ans- Pointing refers to selecting of items already on the screen. It is also known as selection. The user select coordinate positions with a pointing device like
- Mouse
- Lightpen
- Trackball
- Joystick

Positioning refers to location of new items. It is also known as locating. The interaction technique for the positioning involves—
- Either moving a screen cursor to the desired location & then pushing a button.
- Or trying the desired position's coordinates.

This means that coordinate are supplied to specify a location in positioning m/d.

	Pointing	Positioning
①	means selecting those items that are already on screen.	① means location of new items.
②	is done by means of pointing device called selectors	② is done by means of positioning device called locators.

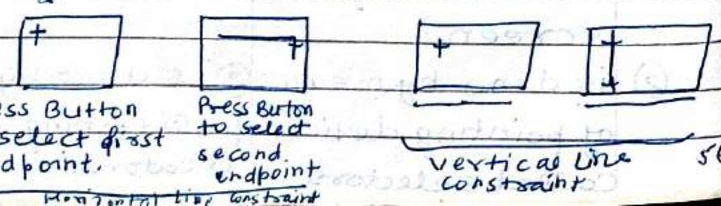
Various positioning technique are

① **Positioning Constraints →** In some graphical applications, the user need to align i/p info. with other info. already on the screen. This is very difficult for the user w/o some assistance from the computer. Thus the computer help to acheieve positioning. A constraint is a rule for altering i/p-coordinate value to produce a specified orientation or alignment of the display coordinate. In other words, it is a rule that we want certain information, such as i/p coordinate to obey.

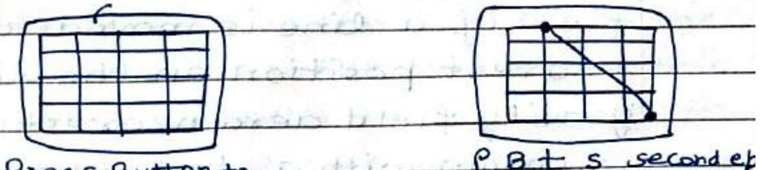
There are many constraint fn. that can be specified but the most common constraint are

* Horizontal
* vertical alignment of st. lines.

Many application use only horizontal & vertical lines and are easier to operate if all i/p lines are constraint to be either horizontal or vertical.



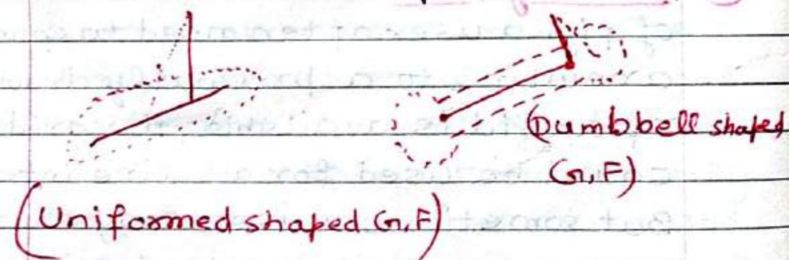
② **Grid →** Intersecting rectangular lines displayed in some part of the screen area is a grid. Grid are imp. visual aid in many positioning tasks.



Griding helps user to generate drawing with a neat apperance. Grid facilitate object construction. A new line can be joined easily to a previously drawn line by selec of one end of displayed line. Grids can be turned on & off.

③ **Gravity field →** In the construction of fig. a user often need to connect a new line to a previously drawn lin If a grid is available, the grid pts could be used for all line intersect But sometimes a user may want to connect two lines at a position b/ grid pt. Since exact positioning of the screen cursor at the connectin pt. can be difficult, graphics pack can be designed to convert any i/ position near a line to a position the line.

This conversion of i/p position is accomplished by creating a gravity field aera around the line. Any selected position within the gravity field of a line is moved to the nearest position on the line. A gravity field aera nearest a line is shown with a dashed boundary Aera around the endpoints are enlarged to make it easier for a user to connect line at their endpt. The size of g.f is chosen large enough to reduce chances of overlap with other lines. Thus G.F effect introduce gravitional pull b/w two or more picture on the screen So that realistic picture is produced.



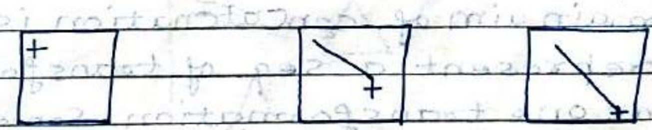
(4) **Rubber band m/d** → St. Lines can also be constructed & positioned by RBM. This m/d allow to stretch out a line

from a starting position as the screen cursor is moved. Thus the image of the line can be seen before positioning it finally. The effect is that of an elastic line stratched b/w the first pt. & the cursor, hence the name for this technique is RBM.

Steps → (1) Select a screen position for one endpoint of the line & hold down the button for this technique to be active.

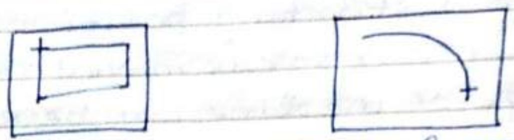
(2) Then, as the cursor moves around, the line is displayed from the start position to the current position of the cursor.

(3) Finally when the user is satisfied with the second screen position & pressed button is released, the other end line point is set. The line is drawn b/w the start and the last position.



RBM is used to construct

* A st. line
* Arcs
* Rectangle
* circle



(Rbm for rectangle & arc drawing)

Adv → The user can see the image of the line before finalizing it. The user is continuously aware of what is going on & has control on whatever is happening.

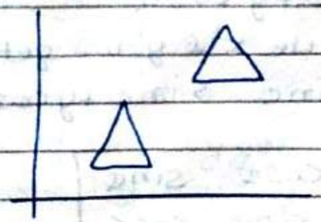
Ques-21 Derive a concatenated transformation that include translation, rotation, scaling & shearing of a point?

Ans changes in orientation, size & shape are accomplished with geometric transformations that alter the coordinate description of objects. seq. of transformation can be combined into one transformation by the concatenation process. The main aim of concatenation is to represent a seq. of transformation as one transformation. Sometimes a graphic item may have to undergo several transformation before the item can be displayed.

① **Translation** – Consists of a shift of the object parallel to itself in any direction in the (x,y) plane. Two consecutive translation transformation T_1 & T_2 are additive. To apply two successive translation to an object, the concatenation of the translation matrix is performed & then composite matrix is applied to the co-ordinate pts. If translation distance of T_1 is (tx_1, ty_1) & that of T_2 is (tx_2, ty_2) then their concatenation gives

$$T_1 . T_2 = \begin{bmatrix} 1 & 0 & tx_1 \\ 0 & 1 & ty_1 \\ 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} 1 & 0 & tx_2 \\ 0 & 1 & ty_2 \\ 0 & 0 & 1 \end{bmatrix}$$

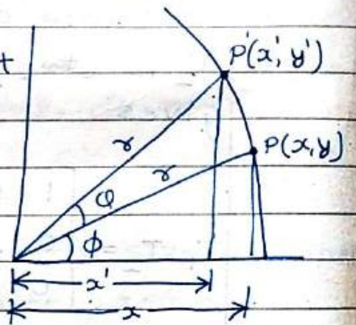
$$= \begin{bmatrix} 1 & 0 & tx_1 + tx_2 \\ 0 & 1 & ty_1 + ty_2 \\ 0 & 0 & 1 \end{bmatrix}$$



② **Rotation** → Two consecutive rotate

transformation are additive. A 2-D rotation is applied to an object by repositioning it a circular path in the XY plane. Points can be rotated through an angle θ ~~through~~ about the origin. The sign of angle determine the direction of rotation, +ve value for the rotation angle defines counter-clockwise rotation & -ve value rotate object in clockwise rotation.

Suppose rotation by θ transform the point $P(x,y)$ into $P'(x',y')$.



$x = r\cos\phi$

$y = r\sin\phi$

& $x' = r\cos(\theta+\phi)$

$= r\cos\theta\cos\phi - r\sin\phi\sin\theta$

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

$= r\sin\theta\cos\phi + r\sin\phi\cos\theta$

Put the value x & y, we get

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

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

Put the value x' & y' we get

$[x\cos\theta - y\sin\theta \quad \sin\theta + y\cos\theta] = [x', y'][T]$

$$[T] = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$$

$|T| = \cos^2\theta + \sin^2\theta = 1$

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

Replace θ by $-\theta$,

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

$\theta \rightarrow -\theta$

$$[T^{-1}] = \begin{bmatrix} \cos(-\theta) & \sin(-\theta) \\ -\sin(-\theta) & \cos(-\theta) \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

$$\text{Now } [T][T^{-1}] = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

$$= \begin{bmatrix} \cos^2\theta + \sin^2\theta & -\cos\theta\sin\theta + \sin\theta\cos\theta \\ \cos\theta\sin\theta + \sin\theta\cos\theta & \cos^2\theta + \sin^2\theta \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = [I]$$

(3) **Scaling** → Scaling is a transformation that changing the size or shape of an object. S with respect to origin can be carried out by multiplying the coordinate value (x, y) of each vertex of a polygon or each endpoint of a line by scaling factor S_x & S_y resp. to produce the coordinate (x', y'). If S_{x_1}, S_{y_1} are scaling factor of first

scaling (S_1) & sx_2, sy_2 are scaling factors of second scaling (S_2) then their concatenation gives:

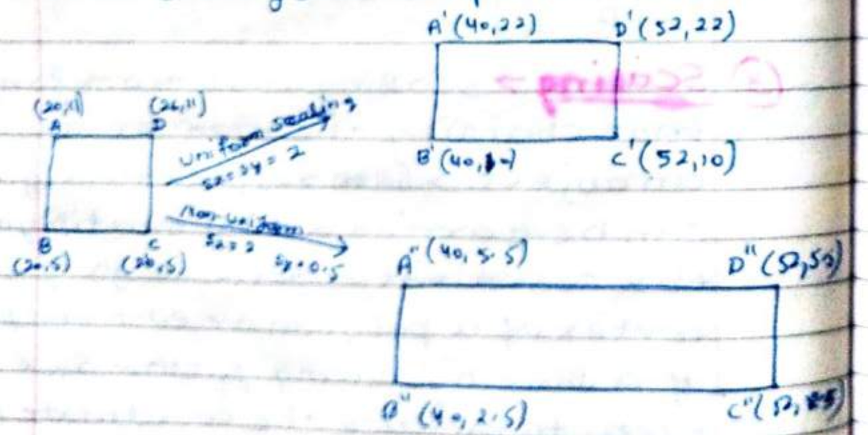
$$S_1 . S_2 = \begin{bmatrix} sx_1 & 0 & 0 \\ 0 & sy_1 & 0 \\ 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} sx_2 & 0 & 0 \\ 0 & sy_2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$S_1 . S_2 = \begin{bmatrix} sx_1 . sx_2 & 0 & 0 \\ 0 & sy_1 . sy_2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

General form is

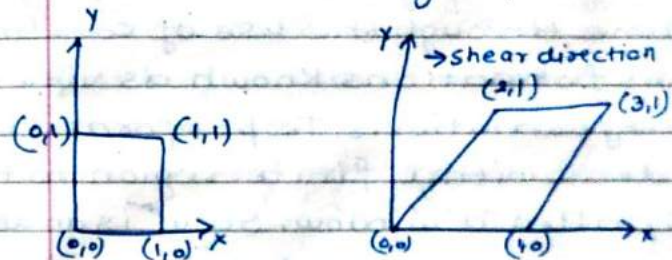
$S_1(sx_1, sy_1) . S_2(sx_2, sy_2) = S(sx_1 . sx_2, sy_1 . sy_2)$

In general, for uniform scaling if $s_x = s_y > 1$, then a uniform compression course i.e the object becomes Larger. if $s_x = s_y < 1$ then a uniform compression occur.

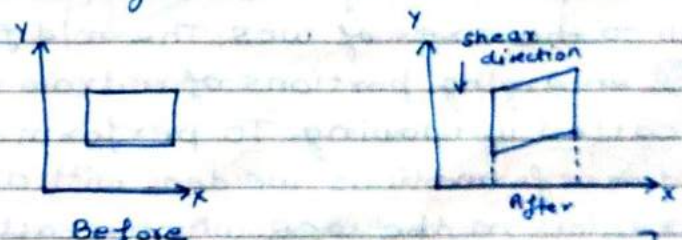


(4) **Shearing →** The transformation "shearing" when applied to any object result only in distortion of shape. In shearing, the opposite & parallel Layers of any object are simply slided with resp. to each other. shearing can be done x direct or y-direction.

(a) X-shear - In x-shear y coordinate remains unchanged, but x is changed



(b) Y-shear - Y-coordinate is changed & x remain Unchanged.



$$Sh_1 . Sh_2 = \begin{bmatrix} 1 & shx_1 & 0 \\ shy_1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} 1 & shx_2 & 0 \\ shy_2 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 + shx_1 shy_2 & shx_2 + shx_1 & 0 \\ shy_1 + shy_2 & shx_2 shy_1 + 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

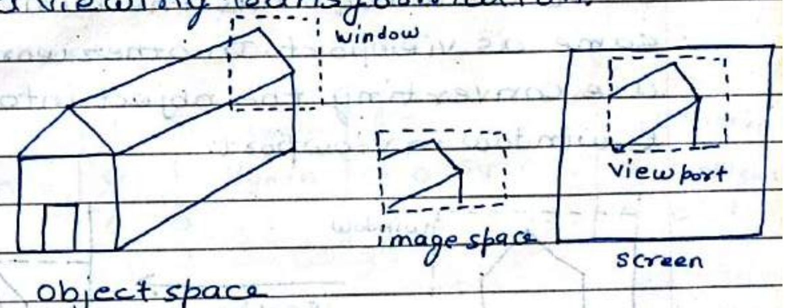
which is not easy interpret physically.

Ques-22 How is a window transformed on a viewport using 2-D viewing trans-formation?

Ans Displaying an image of a picture involves mapping the coordinate of the points & lines that form the picture into the appropriate coordinates on the device where the image is to be displayed. This is done through the use of coordinate transformations known as viewing transformations. To perform a V.T. transformations, we deal with a finite region in the WCS called a window. So w^(indow) is an aera of picture selected for viewing. A rectangular window, used to select the portion of the scene, has its edge || to the axes of WCS. The m/d for selecting & enlarging portions of a drawing is called windowing. To perform a viewing transformations, we deal with a finite region in the WCS, which is called a window. The picture part within the selected aera are then mapped onto specified aera of the display device coordinate. An aera on a display device to which a window is mapped is called a viewport.

Thus, window is an aera which is selected for viewing from world coordinate system. It defines "what is to be viewed" (window); viewport is an aera on a display device to which a window is mapped. It defines (viewport) where it is to be displayed.

Both windows & viewports are rectangles in standard position, with the rectangle edges || to the coordinate axes. The mapping of a part of a world coordinate scene to device coordinate is referred to as a viewing transformation.

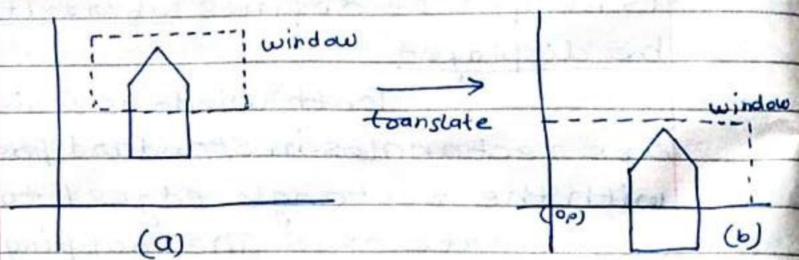


Window to viewport transformation-

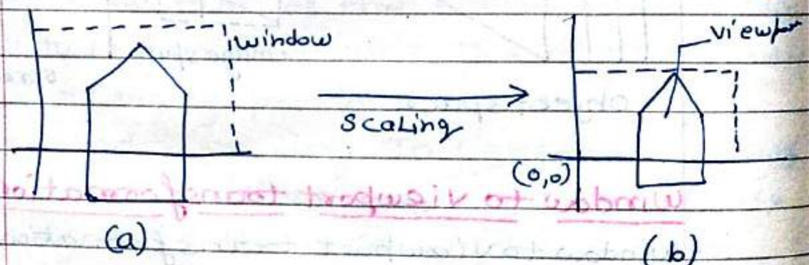
Window to viewport transformation is a mapping of a window to device coordinate. A window is specified by 4 world cordinal $Wx_{min}, Wx_{max}, Wy_{min}, Wy_{max}$, similiarly a viewport is described by 4 coordinate $Vx_{max}, Vx_{min}, Vy_{max}, Vy_{min}$.

The WTV transformation can be done in 3 steps –

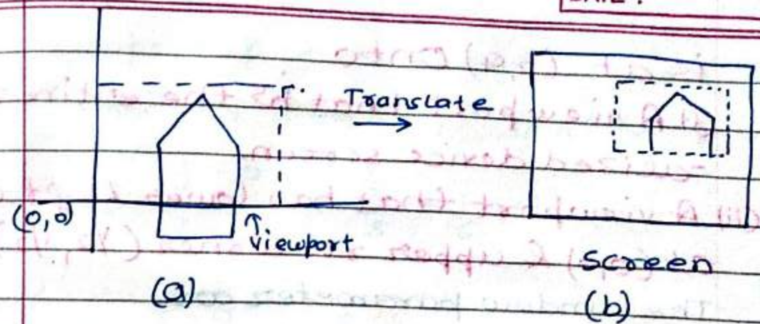
Step 1 The object together with its window is translated until the lower left corner of the window is at the origin.



Step 2 The object & window are now scaled until the window has the dimensions same as viewport. In other words we are converting the object into image & window in viewport.



Step 3 The final transformation step is another translation to move to viewport to its correct position on the screen.



for computing (V_x, V_y) from (w_x, w_y) in terms of a translate-scale-translate transformation N, it can be expressed as

$$\begin{bmatrix} V_x \\ V_y \\ 1 \end{bmatrix} = N \begin{bmatrix} w_x \\ w_y \\ 1 \end{bmatrix}$$

where

$$N = \begin{bmatrix} 1 & 0 & V_{xmin} \\ 0 & 1 & V_{ymin} \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & -w_{xmin} \\ 0 & 1 & -w_{ymin} \\ 0 & 0 & 1 \end{bmatrix}$$

Here $S_x = \dfrac{V_{xmax} - V_{xmin}}{W_{xmax} - W_{xmin}}$

$$S_y = \frac{V_{ymax} - V_{ymin}}{W_{ymax} - W_{ymin}}$$

Q-23 Find the normalization transformation that maps a window whose lower left corner is at (2,1) & upper rt. corner

is at (5,9) onto
(i) A viewport that is the entire normalized device screen.
(ii) A viewport that has lower left corner at (0,0) & upper rt. corner (1/2, 1/2)

Ans The window parameter are

$Wx_{min} = 2,\ Wx_{max} = 5,\ Wy_{min} = 1,\ Wy_{max} = 9$

The viewport parameter are

$V_{xmin} = 0,\ V_{xmax} = 1,\ V_{ymin} = 0,\ V_{ymax} = 1$

$$S_x = \frac{V_{xmax} - V_{xmin}}{W_{xmax} - W_{xmin}} = \frac{1-0}{5-2} = \frac{1}{3}$$

$$S_y = \frac{V_{ymax} - V_{ymin}}{W_{ymax} - W_{ymin}} = \frac{1-0}{9-1} = \frac{1}{8}$$

$$\text{(i) } N = \begin{pmatrix} 1 & 0 & V_{xmin} \\ 0 & 1 & V_{ymin} \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & -Wx_{min} \\ 0 & 1 & -Wy_{min} \\ 0 & 0 & 1 \end{pmatrix}$$

$$N = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1/3 & 0 & 0 \\ 0 & 1/8 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & -2 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{pmatrix}$$

$$N = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \frac{1}{3} & 0 & -\frac{2}{3} \\ 0 & \frac{1}{8} & -\frac{1}{8} \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} \frac{1}{3} & 0 & -\frac{2}{3} \\ 0 & \frac{1}{8} & -\frac{1}{8} \\ 0 & 0 & 1 \end{pmatrix}$$

(ii) Window parameters are

$Wx_{min} = 2,\ Wx_{max} = 5,\ Wy_{min} = 1,\ Wy_{max} = 9$

viewport parameter are

$V_{xmin} = 0,\ V_{xmax} = \frac{1}{2},\ V_{ymin} = 0,\ V_{ymax} = \frac{1}{2}$

$$S_x = \frac{\frac{1}{2} - 0}{5-2} = \frac{\frac{1}{2}}{3} = \frac{1}{6}$$

$$S_y = \frac{\frac{1}{2} - 0}{9-1} = \frac{\frac{1}{2}}{8} = \frac{1}{16}$$

$$N = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \frac{1}{6} & 0 & 0 \\ 0 & \frac{1}{16} & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & -2 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{pmatrix}$$

$$N = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \frac{1}{6} & 0 & -\frac{1}{3} \\ 0 & \frac{1}{16} & -\frac{1}{16} \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} \frac{1}{6} & 0 & -\frac{1}{3} \\ 0 & \frac{1}{16} & -\frac{1}{16} \\ 0 & 0 & 1 \end{pmatrix}$$

Q-24 Diff. b/w world, Normalized & Physical device coordination system?

A **World Coordination system** → It is that coordination system which describe the picture to be displayed with coordinates. The coordinate frame is referred to as WCS.

Normalized device CS → It is that coordinate system in which range of coordination are from (0,0) to (1,1). In NDCS, a unit (1x1) square digital display area

Physical device CS → It is that CS that corresponds to a device or workstation where image of picture is to be displayed.

	Window	Viewport
1.	Window is an aera of picture selected for viewing.	1. The rectangular aera on the display device to which a window is mapped is called
2.	Window defines "what is to be viewed."	2. Viewport defines "where it is to be displayed"
3.	It is selecting a portion.	3. It is displaying a portion.
4.	W specification is given in any Cartesian Coordination system	4. VP specification is given within the range 0 to 1. If a window is to be mapped to the full display aera, the VP specification is as set_viewport(0,1,0,1)
5.	It is in WCS	5. It is in NDCS.

Q-25 What are fractals? illustrate the importance in computer science.

Ans Fractals are geometric shape. The main property of fractals is that their shape is irregular. Equation can be used for describing objects having smooth surface & regular shape. e.g. → DDA algo, Bresenham's algo. can be used to draw lines. But natural object like mountains, trees, clouds & landscape etc. which have irregular or fragmented features can not be described with eq^n. If natural object are being drawn with line or circle drawing algo. then they will not appear natural. To describe natural objects realistically fractals geometry is used, where procedure rather than eq^n are used to model objects. In a way, fractals can be defined as a rough or fragmented geometric shape than can be subdivided into parts." Each part is a reduced copy of the whole. In CG, fractals model are used to generate image of natural objects & for viewing of various mathematical & physical system. Graphics designers & film maker have also shown interest as fractals posses the ability to create new & exciting shapes & artifical but realistic looking worlds.

A fractals object have two char.

(1) Infinite detail at every point
(2) Self-similiarity b/w the object parts & overall features of the object

The amount of variation in the object detail can be described with a no. called fractal dimension. The no. is not necessary an int. The fractal dimension of an object is also referred as the fractional dimension which is the basis for the name 'fractal'.

An object is composed of elastic or clay. If it is deformed in to a lone or line segment, it is one dimensional. It is possible to divide it in no. of equal parts. Similiarly, a square & a cube are 2 & 3 dimensional object that can be divided into equal parts & each part look like a square & a cube only.

Suppose a line segment can be divided into N no. of equal piece then scaling factor is $S_1 = \frac{1}{N}$

The original segment can be obtain back by scaling a segment by S. we get

$N = S'$ where $S' = 1/S_1$

Dividing a square by $S_1 = 0.5$ there are four square i.e $N = 4$ & $S = 1/S_1 = 1/0.5 = 2$

$\therefore N = S^2 \quad [\because 4 = 2^2, N = 4, S = 2]$

If a cube divided then $n = S^3$

For a fractal $N = S^D$ where D is a fractal dimension.

Taking log both sides,

$$\log N = \log(S^D)$$

$$\log N = D \log S$$

$$\therefore D = \frac{\log N}{\log S}$$

Classification of fractals →

fractals can be divided into following type

① **Self-similiar fractals** → have parts that are scaled down version of the entire object. starting with an initial shape, we construct the object subpart by apply a scaling parameter to the overall shape. we can use the same scaling factor for all subpart or we can use diff. scaling fractal for diff. scaled down parts of the object. Self-similar fractals are commonly used to model trees, shrubs & other plants.

(2) Self-affine fractals - have parts that are formed with diff. scaling parameter S_x, S_y, S_z in diff. coordinate direction. Ex- clouds, water

(3) Invariant fractals sets are formed with non-linear transformation. This class of fractals include self-squaring fractals such as Mandelbrot set which are formed with squaring fn. in complex space & self-inverse fractal with inversion procedure.

Importance of fractals →

(1) It can be used for modeling a wide variety of natural phenomena.

(2) It provides a platform where research in pure mathematics is connected with both the natural science & computing

(3) It is used to generate image of natural objects & for viewing of various mathematical & physical systems.

(4) Fractal pattern are also found in distribution of stars, stock market variations, music etc & can be used in graphics application.

(5) It can be used to generate image of physical system.

Q.26 Explain DDA algorithm?

A The digital Differential Analyzer to determine the pixel which should be turned ON. The name comes from the fact that we use the same technique as numerical m/d for solving differential eq^n. we know that slope of a st. linear

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

For any given Δx, we can compute the Δy as

$$\Delta y = m . \Delta x$$

Similiarly, we can obtain x interval Δx corresponding to Δy as

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

The value for x & y are obtained as

$$x_{i+1} = x_i + \Delta x$$

$$x_{i+1} = x_i + \left(\frac{x_2 - x_1}{y_2 - y_1}\right) \Delta y$$

& $y_{i+1} = y_i + \Delta x$

$$y_{i+1} = y_i + \frac{y_2 - y_1}{x_2 - x_1} \Delta x$$

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For simple DDA either Δx or Δy whichever is larger is chosen as some raster unit i.e if $|\Delta x| \geq |\Delta y|$ then

$\Delta x = 1$

else $\Delta y = 1$

if $\Delta x = 1$ then

$y_{i+1} = y_i + \frac{y_2 - y_1}{x_2 - x_1}$ &

$x_{i+1} = x_i + 1$

if $\Delta y = 1$ then

$y_{i+1} = y_i + 1$

$x_{i+1} = x_i + \frac{x_2 - x_1}{y_2 - y_1}$

DDA algo → (1) Read the line end pts (x_1, y_1) & (x_2, y_2).

(2) $\Delta x = |x_2 - x_1|$

$\Delta y = |y_2 - y_1|$

(3) If ($\Delta x \geq \Delta y$) then

length = Δx

else

length = Δy

(4) Select the raster unit i.e

$\Delta x = \frac{(x_2 - x_1)}{length}$

$\Delta y = \frac{y_2 - y_1}{length}$

(5) $x = x_1 + 0.5 * sign(\Delta x)$

$y = y_1 + 0.5 * sign(\Delta y)$

(6) Now plot the points

i = 1

while (i ≤ Length)

{

plot(integer(x), integer(y))

$x = x + \Delta x$

$y = y + \Delta y$

$i = i + 1$

}

stop.

Q-27 Explain Bresenham algorithm & consider the line from (1,1) to (8,5). to draw the line.

Ans Bresenham algo. for $|m| < 1$

(1) Take the two endpoints & store that left endpoint in (x_0, y_0).

(2) load (x_0, y_0) into frame buffer, i.e plot the first point.

(3) Calculate constants $\Delta x, \Delta y, 2\Delta y$ & $2\Delta y - 2\Delta x$ & obtain the starting value for the decision parameter as

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

where $\Delta x = |x_2 - x_1|$ & $\Delta y = |y_2 - y_1|$

(4) At each x_k along the line, starting at k=0, perform the following test

if $p_k < 0$, the next pt. to plot is (x_{k+1}, y_k) &

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

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otherwise ($p_k \geq 0$) the next pt. to plot is $p(x_{k+1}, y_{k+1})$ &

$p_{k+1} = p_k + 2\Delta y - 2\Delta x$

⑤ Repeat step 4 Δx time.

Ex- $(x_1, y_1) = (1,1)$

$(x_2, y_2) = (8,5)$

$\Delta x = 7, \Delta y = 4$

$|m| = \frac{\Delta y}{\Delta x} = \frac{4}{7} < 1$

$p_0 = 2\Delta y - \Delta x = 2 \times 4 - 7 = 8 - 7 = 1$

at $k = 0$, the value of $p_k = 1$ & (x & $y = 1$)

at $k = 1$, then $x = x_{k+1} = 2$, $y = 2$

So

$p_{k+1} = p_k + 2\Delta y - 2\Delta x$

$p_{0+1} = p_0 + 2\Delta y - 2\Delta x = 1 + 8 - 14 = -5$

K	p_k	(x, y)
0	1	1,1
1	$p_k + 2\Delta y - 2\Delta x = -5$	2,2
2	$= p_k + 2\Delta y = -5 + 8 = 3$	3,2
3	$p_k + 2\Delta y - 2\Delta x = 3 + 8 - 14 = -3$	4,3
4	5	5,3
5	-1	6,4
6	7	7,4
7	1	8,5

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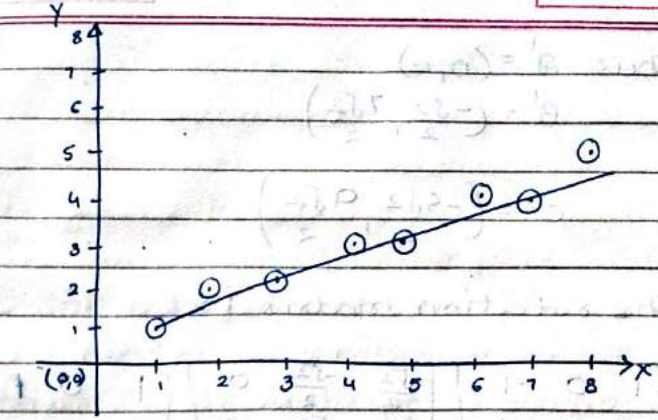


Q-28 Perform a 45° rotation of triangle A(0,0), B(3,4) & C(2,7)
(i) about the origin (ii) about pt. (-1,-1)

Sol Triangle ABC in matrix form as

$$\begin{bmatrix} 0 & 0 & 1 \\ 3 & 4 & 1 \\ 2 & 7 & 1 \end{bmatrix} \text{ or } \begin{bmatrix} 0 & 3 & 2 \\ 0 & 4 & 7 \\ 1 & 1 & 1 \end{bmatrix}$$

(a) matrix of rotation is

$$R_{45°} = \begin{bmatrix} \cos 45° & -\sin 45° & 0 \\ \sin 45° & \cos 45° & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \sqrt{2}/2 & -\sqrt{2}/2 & 0 \\ \sqrt{2}/2 & \sqrt{2}/2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Now find the coordinate A'B'C' of rotated triangle ABC can be found as

$$A'B'C' = R_{45°} \begin{bmatrix} 0 & 3 & 2 \\ 0 & 4 & 7 \\ 1 & 1 & 1 \end{bmatrix} = \begin{bmatrix} \sqrt{2}/2 & -\sqrt{2}/2 & 0 \\ \sqrt{2}/2 & \sqrt{2}/2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 3 & 2 \\ 0 & 4 & 7 \\ 1 & 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -\sqrt{2}/2 & -5\sqrt{2}/2 \\ 0 & 7\sqrt{2}/2 & 9\sqrt{2}/2 \end{bmatrix}$$

Thus $A' = (0,0)$

$B' = \left(-\frac{\sqrt{2}}{2}, \frac{7\sqrt{2}}{2}\right)$

$C' = \left(-\frac{5\sqrt{2}}{2}, \frac{9\sqrt{2}}{2}\right)$

(b) The rotation matrix is

$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & 0 \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$$

same but $-1 = 1$, $+1 = 1$

$$= \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} - \frac{\sqrt{2}}{2} + 0 \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2} + 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & 0 \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \sqrt{2} \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & -1 \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \sqrt{2} \\ 0 & 0 & 1 \end{bmatrix}$$

Now $[A'B'C'] = \begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & -1 \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \sqrt{2} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 3 & 2 \\ 0 & 4 & 7 \\ 1 & 1 & 1 \end{bmatrix}$

Q-29 Describe Hidden surface Removal. Explain the hidden surface " algo?

Ans The hidden or visible surface is totally depend upon point of view. when we see from the front, the front of any Large object is visible while the back side is hidden.

Thus, the surface that are blocked or hidden from view must be "removed" in order to construct a realistic view of 3D scene. The identification & removeal of these surface is called the 'hidden surface problem'.

Hidden Surface problem – The h.s must be removed in order to construct a realistic view of the 3-D scene. The identification & removal of these surface is called hs problem.

The removal of hidden surface or parts from image of solid objects is a challenging problem in cg. In real-Life the opaque material of solid object obstructs the light rays from hidden part & thus cann't be seen. However, in the computer generation of an image, no such automatic elimination take place. Instead, all parts of every object, including parts that should be invisible are displayed. To create a more realistic image, these parts need to be removed. For this, a hidden surface or hidden line algo. is applied to the set of objects.

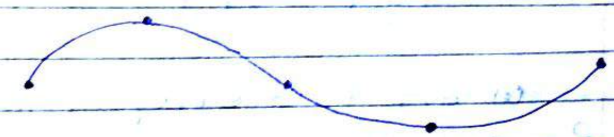
Many algo. have been developed to remove hidden parts of scenes efficiently for diff. types of application. Some m/d require more memory, some involve more processing time & some apply only to special types of objects. Based upon to deal with object directly with their project images, the algorithms are classified as

⇒ Spline Representation :- It is used for designing curves & surface in graphic application like CAD. The curve & surfaces are designed through splines are called spline curves & spline surfaces. Thus to produce a

smooth line through a destinated set of points, a flexible strip called spline is used.

A spline curve is drawn by specifying a set of points known as control points through which or near the curve passes. The main requirement of a spline curve are that it must be a smooth parametric curve should have a continuous shape whose segment to segment piecewise parametric equation may be different from each other. It is of two types

① Interpolation curve :- It is a curve in which the control points are connected with each other directly by the curve i.e the spline curve passes through each control point.



② Approximation curve :-

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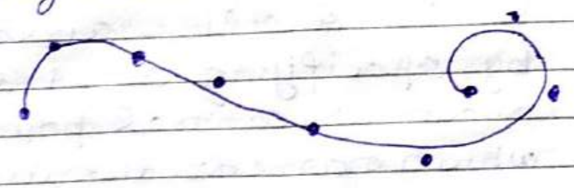
It is curve in which the spline curve is not necessarily passing through all control points.



⇒ Hermite Curve :-

It was named after a french mathematician Charles Hermite.

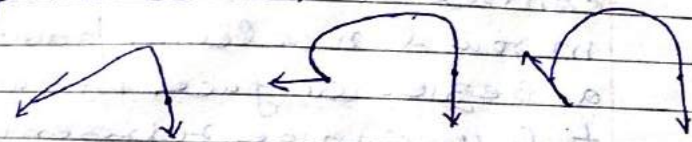
It was specified by the start point and end point, and the tangents at those points. The process then uses a set of blending functions to determine the points on the curve based values. It is given by the equation.

$$c(t) = (2t^3 - 3t^2 + 1)P_0 + (-2t^3 + 3t^2)P_1 + (t^3 - 2t^2 + t)T_0 + (t^3 - t^2)T_1$$

when two endpoints are P_0 & P_1 and their associated tangents are T_0 & T_1 resp.

The blending functions applied to each of these components behave similiarly to those in Bezier & B-spline curves.

Fig. shows below the impact that the direction of the tangent vector can have on the shape of the curve.



Advantages of Hermite curve :-

① This can be adjusted as each section of the curve is dependent on its end point constrains only.

② These are useful for designing spline in some graphics applicati[on] where the curve slopes can be specified easily.

⇒ Bezier surface :-

Two orthogonal Bezier curve can be used to design an object surface by specifying an i/p mesh of ctrl point. The Bezier curve generally does not pass through the control points of the mesh other than the corner points. In fact, the is stretched towards the control points.

suppose there are $m \times n$ control points in the mesh with m row & n column points. Then a Bezier surface in two parameter t & u can be represented by using Cartesian product of the Bezier blending functions of two Bezier Curves as:

$$B(t,u) = \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} P_{i,j} \, BEZ_{i,m}(u) \, BEZ_{j,n}(t)$$

where $P_{i,j}$ specifies the location of $m \times n$ control points.

Usefulness of Bezier surfaces-

It is useful for interactive design of surface of the object in a world scene & were first used by pierre Bezier in car body design.

⇒ B-spline surfaces:-

It can be created using a method similiar to the Bezier surface. suppose, the control net for a B-spline surface is specified by (m+1) rows & (n+1) columns with control points, $P_{i,j}$ where $0 \le i \le m$ & $0 \le j \le n$.

The B-spline surface define by the above information is the following

$$P(u,v) = \sum_{i=0}^{m} \sum_{j=0}^{n} P_{i,j} \, B_{i,p}(u) \, B_{j,q}(v)$$

where $B_{i,p}(u)$ & $B_{i,q}(v)$ are B-spline basic functions of degree p & q resp. The fundamental identities one for each direc^n must hold

i.e $h = m + p + 1$ & $k = n + q + 1$

Therefore, a B-spline surface is another example of tensor product surfaces. As the set of control points is usually to as control net & the range

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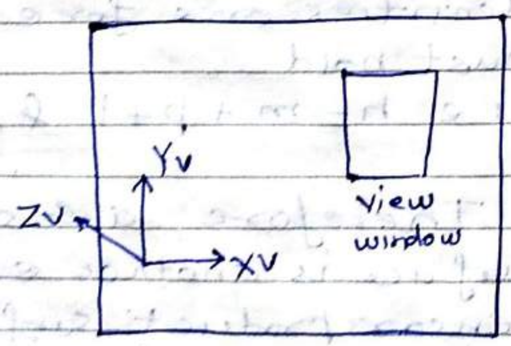
of u, v is 0 & 1.

⇒ View Volumn :-

In a 3D space the region to be projected should be precisely defined. This is called the view-volumn only that part of the object within the view volumn should be displayed leaving the rest outside.

View-Volumn may clip the front, back & sides of an object. This is similiar to real life experience: as a viewer moves towards an object, the object fill the fields of vision & the periphery disappear.

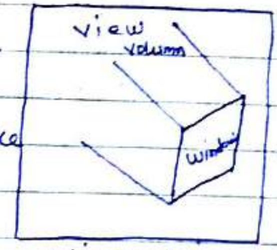


The projection window is used to define a view volumn.

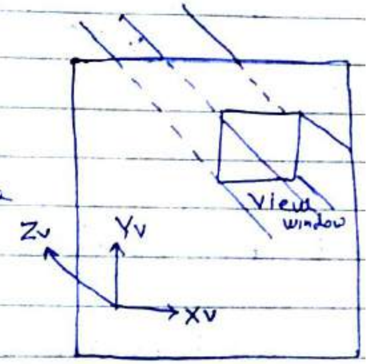
(1) Parallel view volumn:-

For a parallel projection the four sides of the view volumn form an infinite parallelepiped as shown below:-

For an orthographic parallel projection, the projection reference is at an infinite distance from the view plane with projection lines ll to the view plane.



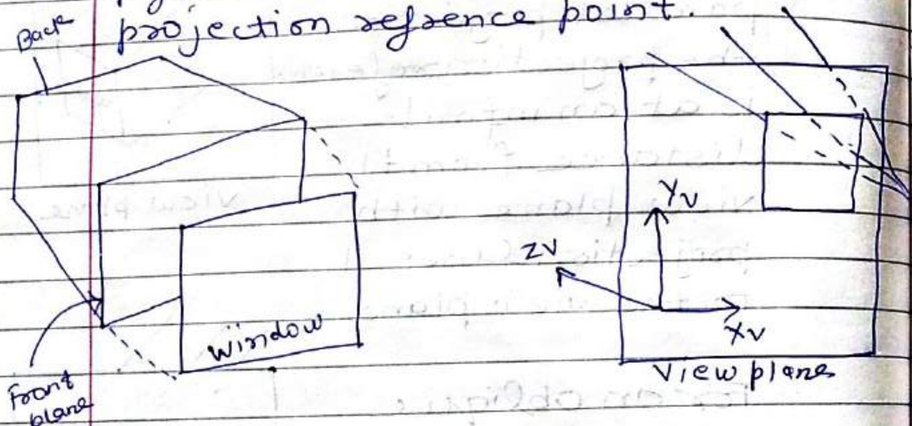
For an oblique ll projection, the projection reference point at again infinite distance from view plane. but the ll projection lines are not ⊥ to the view plane



(2). Perspective view Volume:-

The projection reference point in case

of perspective projection is at a finite distance from the point on the boundaries of view window coverage at the projection point. So the view volumn in case of perspective projection is an infinite pyramid with its apex at the projection reference point.



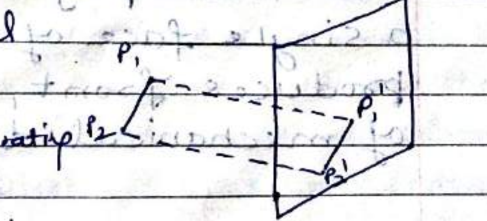
⇒ Projection :-
3D scene or objects which are defined & manipulationed using actual physical units of measurement in a 3D space, has to be transformed at some stage from a 3D rep. to 2D rep. This is done bcz finally the image is viewed on a 2D plane of the display device, such 3D to 2D

transformation is called projection.
Thus, the process of rep. of a 3D object or scene into a 2D object is referred as projection. It is also defined as mapping of object into view plane.

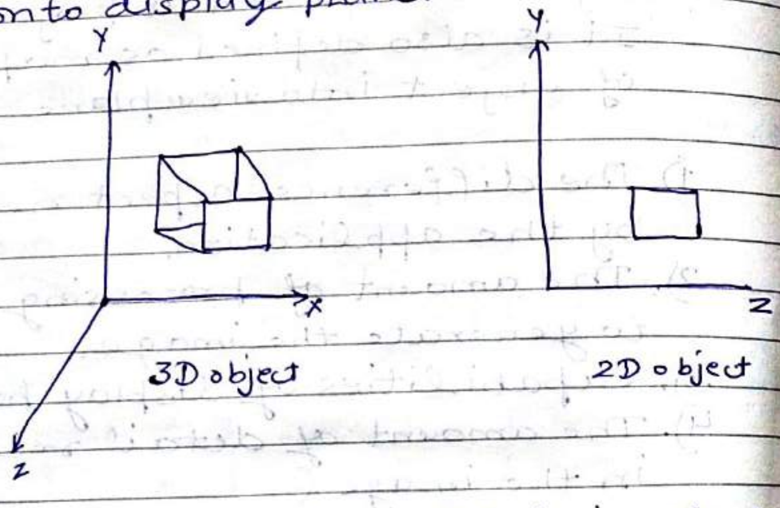
1) The difference aspect needed by the application.
2). The amount of processing required to generate the image.
3). Capabilities of display hardware
4). The amount of detail recorded in the image &
5). The perceptual effect of the image on the observer.

① Parallel projection →
When the co-ordinate positions are transformed to the view plane along parallel lines it is called parallel projection.

This parallel projection involve generating a view of a solid object by



projecting points on the object surface along parallel lines onto display plane.



ⓐ <u>Orthographic parallel projection</u>:-

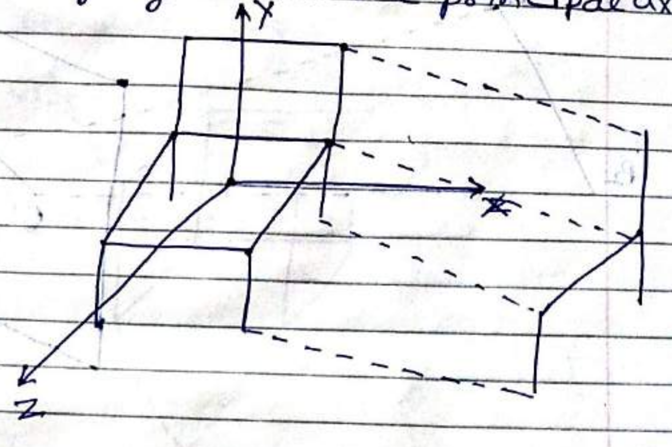
When the projection is ⊥ to the view plane, it is called orthographic parallel projection.

(i) <u>Multiview projections</u>:-

When the direcⁿ of projection is ∥ to any of the principal axes, it is called multiview projection. It displays a single face of a 3D object. It produces front, top & side view of mechanical drawing.

(ii) <u>Axonometric projections</u>:-

In which the direcⁿ of projection is not ∥ to any of the three principal axes.



ⓑ <u>Oblique parallel projection</u>:-

When the projection is not ⊥ to the view plane it is called oblique ∥ projection. It is useful as they combine the advantage of both multiview & axonometric projections.

② <u>Perspective projection</u>:-

When the coordinate positions are transformed to the view plane lines that converge to a point called projection reference

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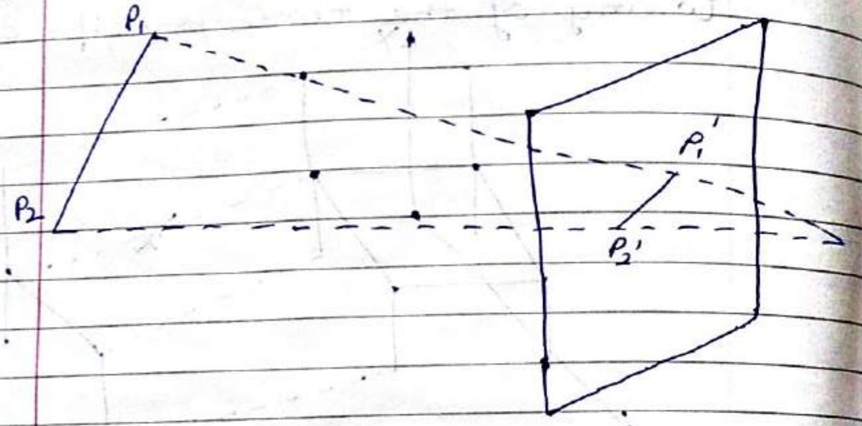
point or centre of projection, it is called perspective projection.

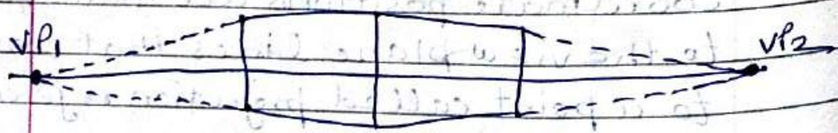


ⓐ <u>One-principal Vanishing point persp.</u>

This perspective occurs when the projection plane is ⊥ to one of principal axes. (x, y or z)

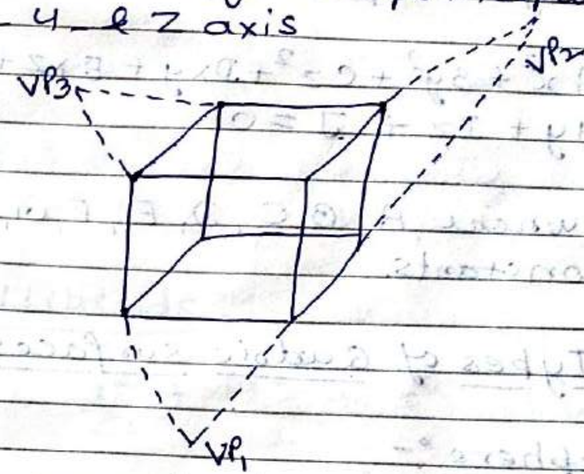
ⓑ <u>Two-principal Vanishing point</u>:-

When the projection plane intersects exactly two of the principal axes.



ⓒ <u>Three-principal vanishing</u> -

This perspective occur when the projection plane intersects all three of the principal axes x, y & z axis



⇒ <u>Quadric Surfaces</u>:-

If a surface is the graph of an eqⁿ of second degree in 3D cartesian coordinate it is called a quadric surfaces.

It is widely used in mechanical CAD/CAM & computer graphics. These are particularly useful in specialized application such as molecular modelling & have also been integrated into solid-modeling system,

A quadratic surface is the graph in space of a second degree eq^n in x, Y & Z.

$$Ax^2 + By^2 + Cz^2 + Dxy + Exz + Fyz + Gx + Hy + Iz + J = 0$$

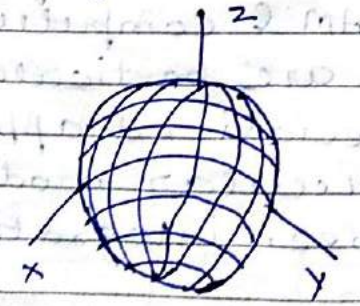
where A, B, C, D, E, F, G, H, I, J are constants.

Types of Quadric surfaces :-

① sphere :-

It is the set of all pt. which are at a distance r from a fixed point in space. The distance r is called radius of the sphere & the fixed point in space is called center of the sphere.

$$x^2 + y^2 + z^2 = r^2$$



$$x = r\cos\phi \cos\theta$$
$$y = r\cos\phi \sin\theta$$
$$z = r\sin\phi$$

where $-\frac{\pi}{2} \le \phi \le \frac{\pi}{2}$ & $-\pi \le \theta \le \pi$

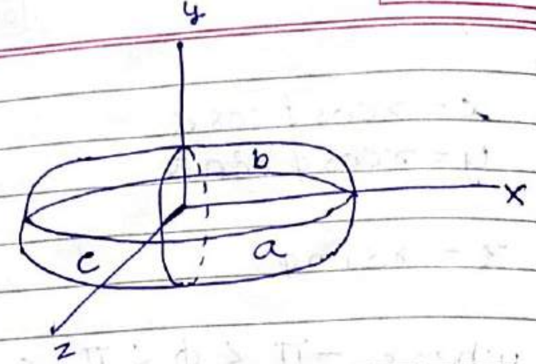
θ & φ are respectively longtitude & Latitude angular parameter.

② Ellipsoids :-

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

where a, b, c are three radii.

One can see that for a=b=c=1 it become the eq^n of a sphere centered at the origin. Therefore an ellipsoid is a "deformation" of the sphere such that the sphere gets either strected or squeezed.



$x = a\cos\phi\cos\theta$

$y = b\cos\phi\sin\theta$

$z = c\sin\phi$

where $-\frac{\pi}{2} \le \phi \le \frac{\pi}{2}$ &

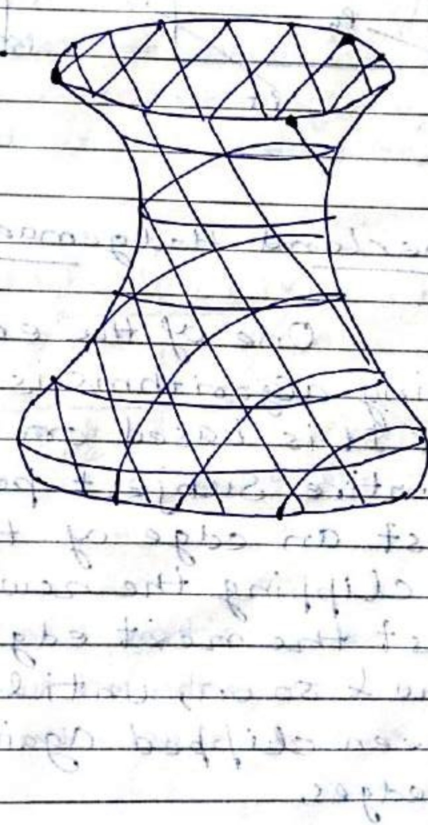
$-\pi \le \theta \le \pi$

③ **Elliptic cylinder :-** An elliptic cylinder is a surface that is obtained by the union of all ellipse stretched about an axis.

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

④ **Hyperboloid :-** A one sheet hyperboloid can be obtained by revolving a hyperbola around its semi-minor axis.

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = 1$$



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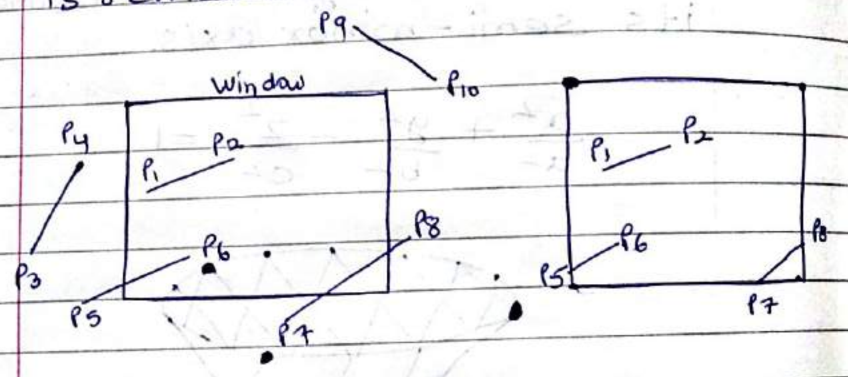
⇒ **clipping :-** It is the process of removing lines or portions of lines outsides of an aera of interest. any line or part which is outside of the viewing aera is removed.



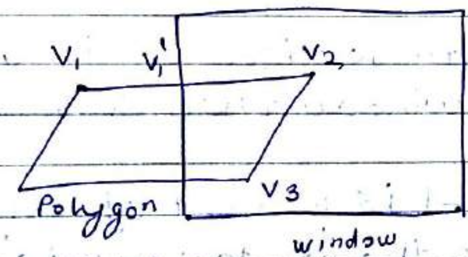
Sutherland Hodgeman algorithm:-

One of the earlist polygon clipping algorithms is the S.H algo: It is based on clipping the entire subject polygon against an edge of the window then clipping the new polygon against the next edge of the window & so on, until the polygon has been clipped against all of four edges.

There are four possibilities

1). It passes from outsides the clip boundary to inside the clip boundary
2). It is entirely inside relative to the clip boundary.
3). It passes from inside the clip boundary to outside the clip boundary.
4). It is entirely outside relatively

① If the first vertex of edges is outside the window boundary & second vertex of edge is inside the window boundary.



② If both vertices are inside the window boundary then only save the second vertex.

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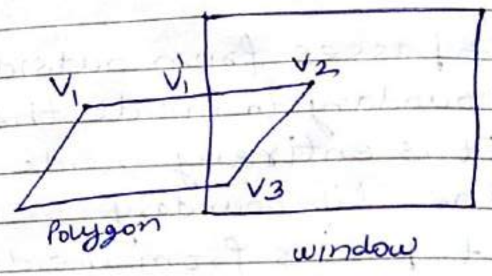


Algorithm :-

① if $V_i - 1$ is outside the window boundary & second vertex V_i is inside the window boundary then save the intersection point of edges ($V_i - 1$, V_i) with window boundary & the second vertex V_i.

② If both vertices $V_i - 1$; V_i are inside the window then save V_i

③ If $V_i - 1$ is to right of edge E i.e inside the window boundary, then save the intersection point of the edge ($V_i - 1$, V_i) & $V_i - 1$

④ If $V_i - 1$, V_i both are to be left or the outside of window boundary, then do not save anything.

⇒ Cohen-SutherLand algorithm :-

① Visible Line :-
A Line is visible if both the end points of the line lie within the window.

② Non-Visible line :-
A line is not visible if it is completely outside the window.

③ Candidate for clipping :-
If line is partially inside & partially outside the window coordinate then it is candidate for clipping

Algorithm :-

① Assign 4 bit region code to all end point.

② If both end point of the line having region codes

③ To find intersection point with the boundaries of window :-

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

(4) Repeat step 3 for 2nd end point & display the line according to the new end points.

(5) Repeat steps 2, 3 & 4 for all lines.

Basic illumination models :-

In the physical universe, illumination is related to the intersection b/w light & matter. In the mathematical universe, this phenomenon is described through illumination models.

Illumination model or a lighting model is the model for calculating light intensity at a single surface point.

Lighting & illumination model in c.g are based on a modular approach in which a programmer or an artists specifies the positions & properties of light surfaces & the surface properties of materials.

The properties of light & material interact to create the illumination colour & shading seen from a given view-port.

A model for the interaction of light with a surface is called an illumination model.

Two basic model are

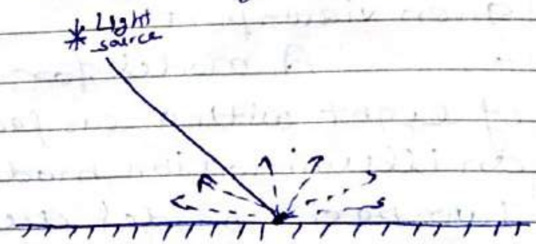
(1) **The phone lighting model :-**

It is simplest & most popular lighting & shading model for 3D c.g. It is popular bcz its flexibility to achieve a wide range of visual effects & ease of implementation in s/w & h/w. It is an efficient lighting model for all graphics h/w for PC, game consoles & other real time application.

It is of 2 types–

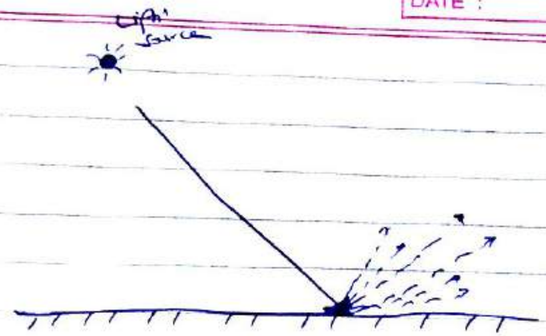
(a) **Diffuse Reflections :-**

Diffusely reflected light is light which is reflected evently in all directions away from the surfaces. This happen in the case of non-shiny or grainy surfaces.

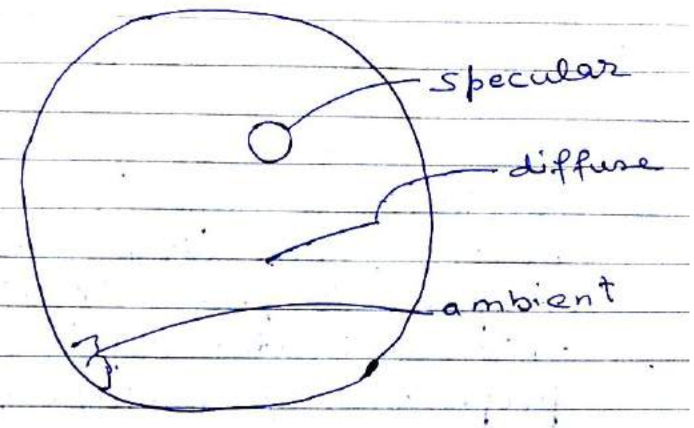


: Diffusely reflected light is reflected equally brightly in all direcⁿ. The surface appears equally bright from all viewing directions.

(b) Specular Reflections :-
It is the light which is reflected in a mirror like manner. This happen in case of smooth or shiny surfaces. This light Leaves the surface with its angle of reflection approximately equal to its angle of incidence. specular reflection causes specular highlights on curved surfaces where intense specular reflection occur.



The phone lighting model treats light or illumination as of following three kinds:-



Specular light :-
The light from a point light source that will be reflected specularly.

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Diffuse light :- The light from a point light source that will be reflected diffusely.

Ambient light :- The light that arrives equally from all direction rather than from a point light source.

② **The Cook - torrance lighting model**

It is computaionly more difficult to implement but gives better flexibility & ability. As compared to phone lighting model this can better capture reflectance properties of a wider range of surface materials.

This model was the first that had a physical basis & was used in C.G. This model assume a surface that consist of flat, smooth & perfectly specular microfacets & the light source located at infinity.

⇒ **Reflection transformation in 3D :**

A reflection can be performed relative to a coordinate axis as well as relative to a coordinate plane. A 3D reflection about a coordinate axis is rotating the object 180° about the axis & reflection about a coordinate plane is equivalent to a rotation by 180° about plane in space.

A reflection is a transformation that produces a mirror image of an object.

① **Reflection about a coordinate axis :-**

In reflection about X-axis, the X- coordinate of the object point remains same whether y - coordinate & z coordinate are inverted in signs :

$$x' = x$$
$$y' = -y$$
$$z' = -z$$

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

i.e $P' = M_x . P$

where M_x is called reflection matrix or mirror image about x-axis

② Reflection about a coordinate plane

In reflection about XY plane, the x-coordinate & y-coordinate of the object point remain unchanged whereas the z-coordinate is inverted in sign.

$$x' = x$$
$$y' = y$$
$$z' = -z$$

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

i.e $P' = M_{xy} . P$

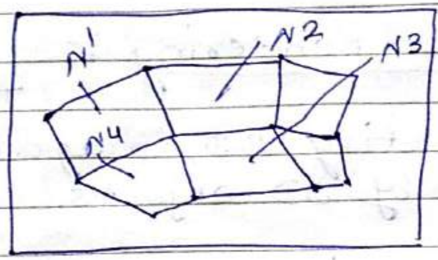
⇒ Polygon Rendering :-

It is a m/d of creating 2D images from a group of 3D objects.

It is generation of display which give the illusion of 3D dimensions. The tasks tends to provide of 3D to 2D computer screen. Depth from shading provides a strong visual cue of 3D. It attempts to provide in a virtual scene, the same 3D cues as provided in a photograph or still image of a natural scene.

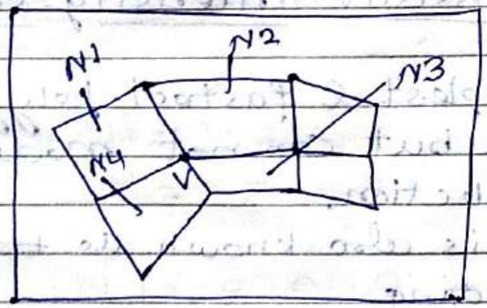
① Constant Intensity shading :-

- simplest & fastest polygon rendering m/d but can not model spectular reflection.
- It is also known as the facet shading.
- Useful for immediate display of the general apperance of a curved surface.
- A single intensity is calculated for entire polygon.



② **Gouraud shading :-**

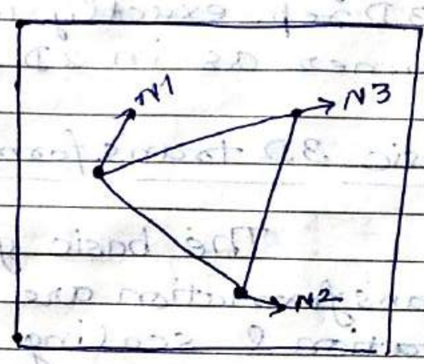
- The intensity value is calculated once for each vertex of a polygon
- The intensity values for the inside of the polygon are obtained by interpolating vertex value



- still not model specular reflection correctly

③ **Phong shading :-**

- instead of interpolating the values, normal vectors are being b/w vertices.



- The intensity value is calculated at each pixel using normal vector.
- This m/d reduces the mach-band problem but it require more computation time.

⇒ **3D Transformation :-** 3D transformation are extended from 2D transformation m/d with an introduced of the Z- coordinate axis.

3D rep. provides a realistic view of the concerned object. In 2D rep. the depth component is missing. It is possible to manipulated a 3D rep. exactly in the same manner as in 2D situation.

Basic 3D transformation :-

The basic geometric transformation are translation, rotation & scaling.

1. Translation :-

It is a process of changing the position of an object in a straight line path from one co-ordinate location to another.

The simply moves the object w/o changing its size, shape or orientation.

$$x' = x + t_x$$
$$y' = y + t_y$$
$$z' = z + t_z$$

The above eq^n can be rep. in matrix form

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix}$$

In the homogenous coordinate system,

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

i.e $P' = T.P$ where

$$P' = \begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} \quad T = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$P = \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Translation is a rigid body tran-sformation that moves object w/o deformation.

② **Scaling :-** A scaling transformation is used to change the size of an object.

Objects can be scaled along any of x, y, z direction or all of them simultaneously. Scaling by scale factors S_x, S_y & S_z along x, y & z direc^n can be expressed mathematically as:

$$x' = x \cdot S_x$$
$$y' = y \cdot S_y$$
$$z' = z \cdot S_z$$

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & S_z \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

In the homogenious coordinate system, the above transformation can be rep. as.

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

③ **Rotation :-** It can be performed in an anticlockwise or a clockwise direc^n. The axis of rotation may be the x-axis, y-axis & z-axis.

Rotation about x-axis :-

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

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$$P' = R_{x}\theta \cdot P$$

$$R^{-1}_{x,\theta} = R_{x-\theta} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & \sin\theta & 0 \\ 0 & -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$