Biyani's Think Tank

Concept based notes

Computer Graphics

BCA Part-III

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Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the "Teach Yourself" style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

This book covers basic concepts related to the microbial understandings about diversity, structure, economic aspects, bacterial and viral reproduction etc.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this Endeavour. They played an active role in coordinating the various stages of this Endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

Author

Syllabus
BCA III
Computer Graphics

1.) Introduction to Computer Graphics :
Definition, Application areas of Computer graphics, Graphical user interface, Cathode ray tubes, Random scan displays, Raster scan displays (with introduction to flickering, interlacing. American standard video etc), Color CRT monitors, Flat panel displays (Plasma Panels, Liquid crystal displays, Electroluminescent displays), Graphics software (GKS, PHIGS), Color Models (RGB, CMYK, HSV, Lookup tables etc.)

2.) Raster Graphics Algorithms:
Line drawing algorithms (DDA, Bresenham's algo), Circle and Ellipse drawing algorithms, Filling (Scan-converting Polygon filling, Inside outside tests boundary fill and area fill algo).

3.) Transformations and Projections:
2-D transformations (Rotation, Reflection, shearing, scaling), Homogeneous coordinate representation, Translation, 3-D transformations, Projection classification, Parallel projections, Perspective projections (One point, Two point).

4.) Two dimensional Clipping and visible surface detection methods:
Viewing pipeline, window and viewport, Sutherland Cohen sub division algorithm, Cyrus-beck algorithm, classification of visible surface detection algorithm, Backface algo, Depth sorting method, Area subdivision method etc.

5.) Introduction to Digital Image Processing:
Definition application areas Digital Image Processing, difference between computer graphics and Image processing. The storage and capture of digital images. File forms, Basic digital Image processing techniques like antialiasing, Convolutions, Thresholding etc, Image enhancement.

Content

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Chapter-1

Graphics Application and Hardware

Q.1   What is Computer Graphics? What is its application?

Ans.: Computer has become a powerful tool for rapid and economical production of pictures. There is virtually no area in which graphical displays cannot is used to some advantage. To day computer graphics is used delusively in such areas as science, medicine, Engineering etc.

Application of computer graphics :

(1)   **Computer – Aided Design :** Generally used in the design of building, automobiles, aircrafts, textiles and many other products.

(2)   **Presentation Graphics :** This is used to produce illustration for or to generate 35-cm slides or trans pare miss for use with projectors.

(3)   **Computer Art :** Computer graphics methods are widely used in both fine arts and Commercial Arts Applications.

(4)   **Entertainment :** Computer graphics methods are now commonly used in making motion pictures, music videos, television shows.

(5)   **Education and Training :** Computer generated models of physical, financial, and economic systems are after used as education aids.

(6)   **Visualization :** This is used in connation with data sets related to commerce, industry and other scientific areas.

(7)   **Image Processing :** It applies techniques to modify or inter put existing pictures such as photographs.

(8)   **Graphical user Interface :** It is common now for software packages to provide a graphical Interface.

Q.2   What are Video Display Devices?

or

Explain how Cathode Ray Tube works including details how colors are achieved?

Ans.: The primary output device in a graphics system is a video controller. The operation of most video monitors is based on the standard cathode-ray tube (CRT) design.

Refresh Cathode Ray Tube : Fig (1) illustrates the basic operation of a CRT

Fig.1
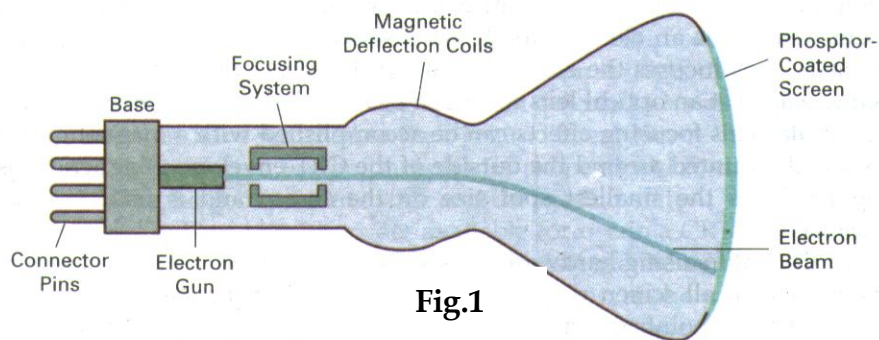
Here electron beam is emitted by the electron gun in a CRT. It passes through focusing and deflection system that directs the beam towards specified position on the phosphor coated system. The light emitted by the phosphor fades very rapidly. In order to maintain the screen picture or to keep the phosphor is to redraw the picture repeatedly by quickly directing the electron beam over the same point. This process is called refresh CRT.
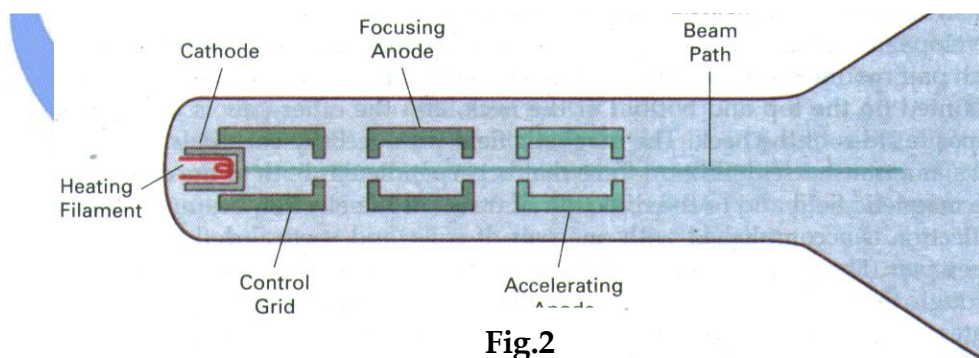
Fig.2

The primary components of an electron gun in a CRT are the heated metal cathode and control guide as in Fig 2.

Heat is supplied to the cathode by directing a current through a coil of wire called filament, inside the cylindrical cathode structure this heats up the electrons & the heated up electrons move with high positive voltage towards the phosphor screen.

Intensity of the electron beam is controlled by setting voltage levels on the control grid. A high negative voltage will shut off the beam by repelling electrons & stopping them from passing through. Amount of light emitted depend on number of electron striking the screen.

Focusing system in a CRT is needed to force the electron beam to coverage into a small spot as it strikes the phosphor. Otherwise electron would repel each other.

Focusing is accomplished with either electric or magnetic fields. Electrostatic focusing is commonly used in television and computer graphics monitors. With electrostatic focusing, the electron beam passes through a positively charged metal cylinder that forms an electron lens, as shown in Fig. 2-3, The action of the electrostatic lens focuses the electron beam at the center of the screen, in exactly the same way that an optical lens focuses a beam of light at a particular focal distance. Similar lens focusing effects can be accomplished with a magnetic field setup by a coil mounted around the outside of the CRT envelope. Magnetic lens focusing produces the smallest spot size on the screen and is used in special purpose device.

Additional focusing hardware is used in high-precision system to keep the beam in focus at all screen position. The distance that the electron beam must travel to different points on the screen varies because the radius of curvature for most CRTs is greater than the distance from the focusing system to the screen center. There fore, the electron beam properly only at the center of the screen. As the beam moves to the outer edges of the screen, displayed images become blurred. To compensate for this, the system can adjust the focusing according to the screen position of the beam.

As with focusing, deflection of the electron beam can be controlled either with electric fields or with magnetic fields. Cathode-ray tubes are now commonly constructed with magnetic deflection coils mounted on the outside of the CRT envelope, as illustrated in Fig. 2-2. Two pairs of coils are used, with the coils in each pair mounted on opposite sides of the neck of the CRT envelop. One pair is mounted on the top and bottom of the neck, the magnetic field produced by each pair of coils results in a transverse deflection force that is perpendicular both to the direction of the magnetic field and to the direction of travel of the electron beam. Horizontal deflection is accomplished with one pair of coils, and vertical deflection by the other pair. The proper deflection amounts are attained by adjusting the current

through the coils. When electrostatic deflection is used, two pairs of parallel palates are mounted inside the CRT envelope. One pair of plates is mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control horizontal deflection (Fig. 2-4).
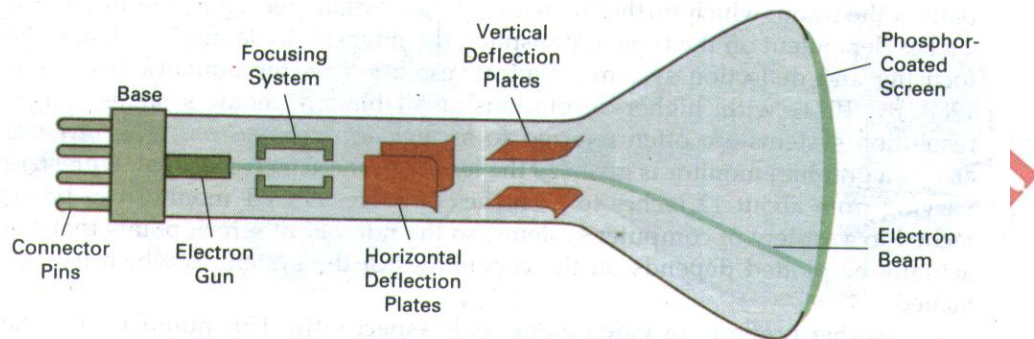
Spots of light are produced on the screen by the transfer of the CRT beam energy to the phosphor. When the electrons in the beam collide with the phosphor coating, they are stopped and their energy is absorbed by the phosphor. Part of the beam energy is converted by friction into heat energy, and the remainder causes electrons in the phosphor atoms to move up to higher quantum-energy levels. After a short time, the "excited" phosphor electrons begin dropping back to their stable ground state, giving up their extra energy as small quantum's of light energy. What we see on the screen is the combined effect of all the electron light emissions: a glowing spot that quickly fades after all the excited phosphor electrons have returned to their ground energy level. The frequency (or color) of the light emitted by the phosphor is proportional to the energy difference between the excited quantum state and the ground state.

Difference kinds of phosphor are available for use in a CRT. Besides color, a major difference between phosphor is their **persistence** : how long they continue to emit light (that is, have excited electrons returning to the ground states) after the CRT beam is removed. Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity. Lower-persistence phosphor requires higher refresh rates to maintain a picture on the screen without flicker. A phosphor with low persistence is useful for displaying highly complex, static, graphics monitors are usually constructed with persistence in the range from 10 to 60 microseconds.

Figure 2-5 shows the intensity distribution of a spot on the screen. The intensity is greatest at the center of the spot, and decreases with a Gaussian

distribution out to the edge of the spot. This distribution corresponds to the cross-sectional electron density distribution of the CRT beam.

The maximum number of points that can be displayed without overlap on a CRT is referred to as the **resolution.** A more precise definition of resolution is the number of points per centimeter that can be plotted horizontally and vertically, although it is often simply stated as the total number of points in each direction. Spot intensity has a Gaussian distribution (Fig. 2-5), so two adjacent spot will appear distinct as long as their separation is greater than the diameter at which each spot has intensity in Fig. 2-6. Spot size also depends on intensity. As more electrons are accelerated toward the phosphor per second, the CRT beam diameter and the illuminated spot increase. In addition, the increased excitation energy tends to spread to neighboring phosphor atoms not directly in the path of the beam, which further increases the spot diameter. Thus, resolution of a CRT is dependent on the type of phosphor, the intensity to be displayed, and the focusing and deflection system. Typing resolution on high-quality system is 1280 by 1024, with higher resolution available on many systems. High resolution systems are often referred to as high-definition system. The physical size of a graphics monitor is given as the length of the screen diagonal, with sizes varying form about 12 inches to 27 inches or more. A CRT monitor can be attached to a variety of computer systems, so the number of screen points that can actually be plotted depends on the capabilities of the system to which it is attached.

Another property of video monitors is **aspect ratio**. This number gives the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen. (Sometimes aspect ratio is stated in terms of the ratio of horizontal to vertical points.) An aspect ratio of ¾ means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.

Q.3 **Write short note on Raster–Scan Displays and Random Scan Displays.**

Ans.: **Raster–Scan Displays :** The most common type of graphics monitor employing a CRT is the **raster-scan** display, based on television technology. In a rater-scan system, the electron beam is swept across the screen, one row at a time from top to bottom. As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots. Picture definition is stored in a memory area called the **refresh buffer**

or **frame buffer.** This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and "Painted" on the screen one row **(scan line)** at a time (Fig. 2-7). Each screen point is referred to as a **pixel** or **pel** (shortened forms of **picture element**). The capability of a raster-scan system to store intensity information for each screen point makes it well suited for the realistic display of scenes containing subtle shading and color patterns. Home television sets and printers ate examples are examples of other system using raster-scan methods.

Intensity range for pixel positions depends on the capability of the raster system. In a simple black-and –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. For a bi-level system, a bit value of 1 indicates that the electron beam is to be turned on at that position, and a value of 0 indicates that the beam intensity is to be off. Additional bits are needed when color and intensity variations can be displayed. Up to 24 bits per pixel are included in high-quality system, which can require several megabytes of storage for the frame buffer, depending on the resolution of the system. A system with 24 bits per pixel and a screen resolution of 1024 by 1024 requires 3 megabytes of storage for the frame buffer. 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 often referred to as a **pixmap.**

Refreshing on raster-scan displays is carried out at the rate of 60 to 80 frames per second, although some systems are designed for higher refresh rates. Sometimes, refresh rates are described in units of cycle per second, or Hertz (Hz), where a cycle corresponds to one frame. Using these units, we would describe a refresh rate of 60 frames per second as simply 60 Hz. At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line. The return to the left of the screen, after refreshing each scan line, is called the **horizontal retrace** of the electron beam. And at the end of each frame (displayed in $1/80^{th}$ to $1/60^{th}$ of a second), the electron beam returns (**vertical retrace**) to the top left corner of the screen to begin the next frame.

(a)   (b)   (c)   (d)
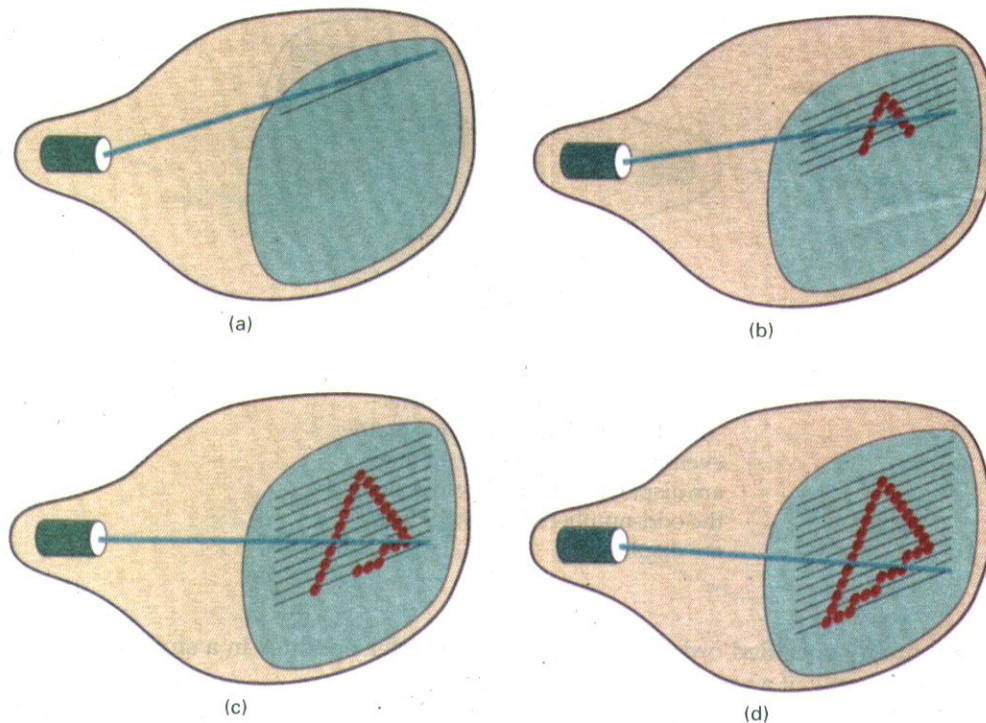
On some raster-scan system (and in TV sets), each frame is displayed in two passes using an interlaced refresh procedure. In the first pass, the beam sweeps across every other scan line form top to bottom. Then after the vertical retrace, the beam sweeps out the remaining scan lines (Fig. 2-8). Interlacing of the scan lines in this way allows us to see the entire screen displayed in one-half the time it would have taken to sweep across all the lines at once from top to bottom. Interlacing is primarily used with slower refreshing rates. On an older, 30 frame-per-seconds, no interlaced display, for instance, some flicker is noticeable. But with interlacing, each of the two passes can be accomplished in $1/60$th of a second, which brings the refresh rate nearer to 60 frames per second. This is an effective technique for avoiding flicker, providing that adjacent scan lines contain similar display information.

Random Scan Displays : When operated as a **random-scan** display unit, a CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn. Random-scan monitor draw a picture one line at a time and for this reason are also referred to as **vector** displays (or **stroke-writing** of **calligraphic** displays). The component lines of a picture can be drawn and refreshed by a random-scan system in any specified order (Fig. 2-

9). A pen plotter in a similar way and is an example of a random-scan, hard-copy device.
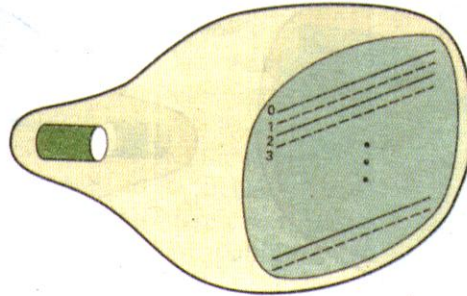
Refresh rate on a random-scan system depends on the number of lines to be displayed. Picture definition is now stored as a set of line-drawing commands in an area of memory referred to as the **refresh display file**. Sometimes the refresh display file is called the **display list, display program,** or simply the refresh **buffer**. To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn. After all line drawing commands have been processed, the system cycle back to the first line command in the list. Random-scan displays are designed to draw all the component lines of a picture 30 to 60 times each second. High-quality vector systems are capable of handling approximately 100,000 "short" lines at this refresh rate. When a small set of lines is to be displayed, each refresh cycle is delayed to avoid refresh rates greater than 60 frames per second. Otherwise, faster refreshing of the set of lines could burn out the phosphor.

Random-scan systems are designed for line-drawing applications and can-not display realistic shaded scenes. Since picture definition is stored as a set of line-drawing instruction and not as a set of intensity values for all screen points, vector displays generally have higher resolution then raster system. Also, vector displays produce smooth line drawings because the CRT beam directly follows the line path. A raster system, in contrast, produces jagged lines that are plotted as discrete point sets.

Q.4 **Write short note on Color CRT Monitor. Explain Shadow Mask Method.**

Ans.: A CRT monitor displays color picture by using a combination of phosphor that emit different-colored light. By combining the emitted light from the different phosphor, a range of colors can be generated. The two basic techniques for producing color displays with a CRT are the beam-penetration method and the shadow-mask method.

The **beam-penetration** method for displaying color pictures has been used with random-scan monitors. Two layers of phosphor, usually red and green, are coated onto the inside of the CRT screen, and the displayed color depends on how far the electron beam penetrates into the phosphor layers. A beam of slow electrons excites only the outer red layer. A beam of very fast electron penetrates through the red layer and excites the inner green layer. At intermediate beam speeds, combinations of red and green light are emitted to show two additional colors, orange and yellow. The speed of the electrons, and hence the screen color at any point, is controlled by the beam-acceleration voltage. Beam penetration has been an inexpensive way to produce color in random-scan monitor, but only four colors are possible, and the quality of picture is not as good as with other methods.

(a)

(b)

(c)

(d)
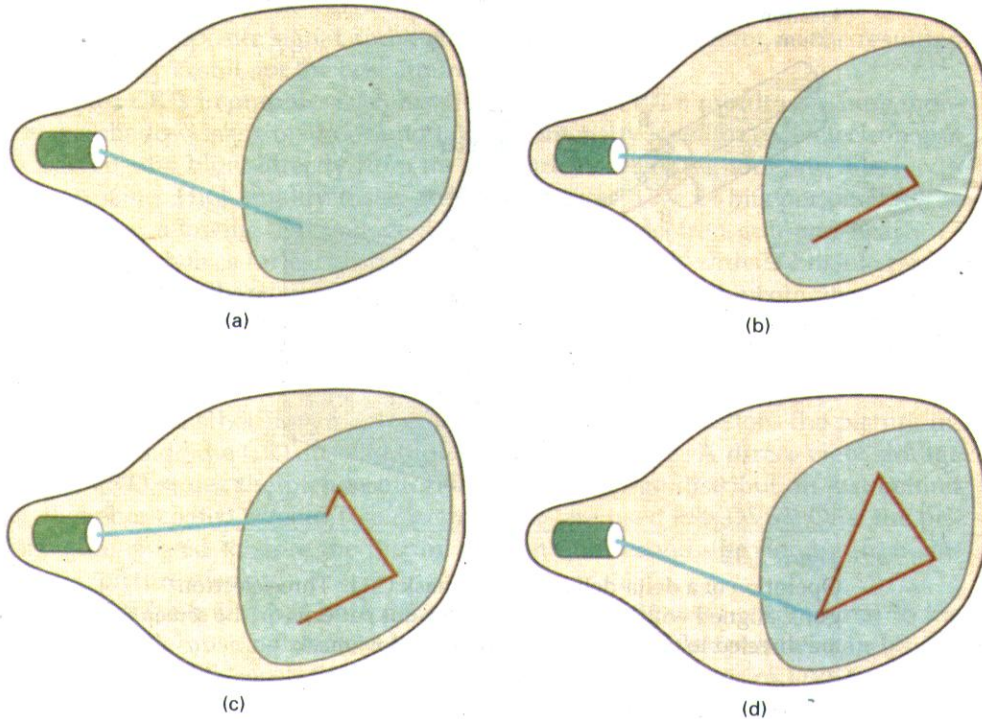
Shadow-mask methods are commonly used in raster-scan system (including color TV) because they produce a much wider range of colors than the beam penetration method. A shadow-mask CRT has three phosphor color dots at each pixel position. One phosphor dot emits a red light, another emits a green light, and the third emits a blue light. This type ofCRT has three electron guns, one for each color dot, and a shadow-mask grid just behind the phosphor-coated screen. Figure 2-10 illustrates the delta-delta shadow-mask method, commonly used in color CRT system. The three beams are deflected and focused as a group onto the shadow mask, which contains a series of holes aligned with the phosphor-dot patterns. 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. The phosphor dots in the triangles are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask. Another configuration for the three electron guns is an in-line arrangement in which the three electron guns, and the corresponding red-green-blue color dots on the screen, are aligned along one scan line instead of in a triangular pattern. This in-line arrangement of electron guns is easier to keep in alignment and is commonly used in high-resolution color CRTs.
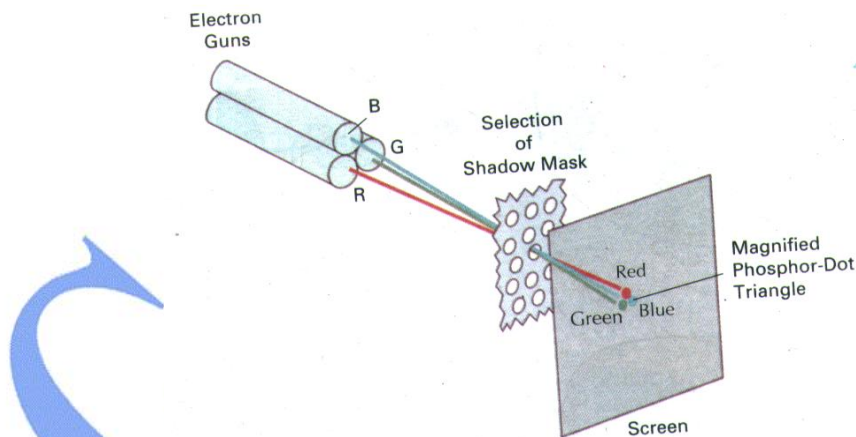
We obtain color variations in a shadow-mask CRT by varying the intensity levels of the three electron beams. By turning off the red and green guns, we get only the color coming from the blue phosphor. Other combinations of beam intensities produce a small light spot for each pixel position, since our eyes tend to merge the three colors into one composite. The color we see depends on the amount of excitation of the red, green, and blue phosphors. A white (or gray) area is the result of activating all three dots with equal intensity. Yellow is produced with the green and red dots only, magenta is produced with the blue and red dots, any cyan shows up when blue and green are activated equally. In some low-cost systems, the electron beam can only be set to on or off, limiting displays to eight colors. More sophisticated

systems can set intermediate intensity level for the electron beam, allowing several million different colors to be generated.

Color graphics systems can be designed to be used with several types of CRT display devices. Some inexpensive home-computer system and video games are designed for use with a color TV set and an RF (radio-frequency) modulator. The purpose of the RF modulator is to simulate the signal from a broad-cast TV station. This means that the color and intensity information of the picture must be combined and superimposed on the broadcast-frequency carrier signal that the TV needs to have as input. Then the circuitry in the TV takes this signal from the RF modulator, extracts the picture information, and paints it on the screen. As we might expect, this extra handling of the picture information by the RF modulator and TV circuitry decreased the quality of displayed images.

Q. 5   Differentiate between Raster Scan and Random Scan Display?

Ans. :

S.No.	Raster Scan	Random Scan
1.	In this, the electron beam is swept across the screen, one row at a time from top to bottom.	In this, the electron beam is directed only to the parts of the screen where a picture is to be drown.
2.	The pattern is created by illuminated spots.	Here a picture is drawn one line at a time.
3.	Refreshing on Raster Scan display is carried out at the rate of 60 to 80 frames per second.	Refresh cycle is displayed to aroid refresh rate greater than 60 frames per second for small set of lines. Refresh rate depends on number of lines to be displayed.
4.	This display porous produces smooth line drawings as the CRT beam directly follows the line path.	In this display it produces jagged lines that are potted as discrete point sets.
5.	This provides higher resolution.	This provides lower resolution.

Chapter-2

Transformation

Q.1   What is Transformation? What are general Transformations Techniques?

Ans.: Transformation are basically applied to an object to reposition and resize two dimensional objects. There are three transformation techniques.

(1)   **Translation :** A translation is applied to an object by repositioning it along a straight line path from one coordinate location to another. We translate a two-dimensional point by adding translation distances t_x and t_y to the original coordinate position (x, y) to more the point to a new position (x', y').

$$x' = x + t_x \quad , \quad y' = y + t_y \qquad \qquad \text{\_ \_ \_ (1)}$$

The translation distance pair (t_x, t_y) is called translation vector on shift vector :

$$P = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad , \quad P' = \begin{bmatrix} x'_1 \\ x'_2 \end{bmatrix} \quad , \quad T = \begin{bmatrix} t_x \\ t_y \end{bmatrix} \qquad \text{\_ \_ \_ (2)}$$

2 – dimensional translation matrix form :

$$P' = P + T \qquad \qquad \text{\_ \_ \_ (3)}$$

In this case, we would write in matrix as row :

$$P = [x, y] \quad , \quad T = [t_x , t_y]$$

Translation is a rigid body transformation that moves object without deformation.

That is T_1 every point on the object is translated by the same amount. A straight line segment is translated by applying the transformation equation (3) to each of the line end point & redrawing the line between the new end point positions.

(2)   **Rotation :** A two dimensional rotation is applied to an object by repositioning it along a circular path in the xy plane. To generate a

rotation, we specify a rotation angle and the position (x, y) of the rotation point (or pivot pt) about which the object is to be rotated figure (1)
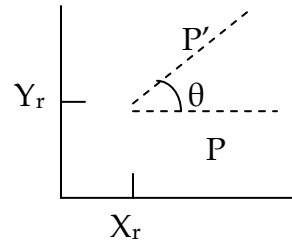
This transformation can be described as a rotation about a rotation axis that is perpendicular to the xy plane & passes through the pivot point.

We can express the transformation in terms of angle θ & $\emptyset$ as :

$$x' = r \cos(\emptyset + \theta) = r \cos \emptyset \cos\theta - r \sin \emptyset \sin \theta$$

$$y' = r \sin(\emptyset + \theta) = r \cos \emptyset \sin \theta + r \sin \emptyset \cos \theta \qquad \_\_\_ (4)$$

The original coordinates of the point in polar coordinators :

$$x = r \cos \emptyset \quad , \qquad y = r \sin \emptyset \qquad\qquad \_\_\_ (5)$$

Substituting expression (5) into (4) we obtain transformation equations for rotating a point at position (x, y) through an angle θ about the origin :

$$x' = x \cos \theta - y \sin \theta \quad , \quad y' = x \sin \theta + y \cos \theta \qquad \_\_\_ (6)$$

We can write the rotation equation for rotating a point at position (x, y) through an angle θ about the origin equation in matrix form :

$$P' = R \cdot P \qquad\qquad \_\_\_ (7)$$

Where rotation matrix form :

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

When coordinate positions are represented as row vectors instead of column vectors, the matrix product in rotation eq.(7) is transposed so that the transformed row coordinate vector [x', y'] is calculated as :

$$P'^T = (R \cdot P)^T = P^T \cdot R^T \qquad\qquad \_\_\_ (8)$$

$(x_r, y_r) \rightarrow$ Pivot Point

Where $P^T = [x, y]$ transposing R^T of matrix R obtained by interchanging rows & columns.

By rotating major & minor axis of ellipse
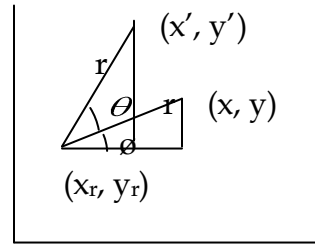
$$x' = x_r + (x - x_r) \cos \theta - (y - y_r) \sin \theta$$
$$y' = y_r + (x - x_r) \sin \theta - (y - y_r) \cos \theta \qquad \_\_\_ (9)$$

(3) **Scaling :** A scaling transformation attars the size of an object. This operation can be carried out for polygons by multiplying the coordinate values (x, y) for each vertex by scaling factors S_x and S_y to produce the transformed coordinates (x', y')

$$x' = x \cdot S_x \qquad ' \qquad y' = y \cdot S_y \qquad \_\_\_ (10)$$

Scaling factors S_x scales objects in the x direction while S_y scales in the y direction.

The transformation equation (10) can also be written in the matrix form :

$$\begin{bmatrix} x' \\ \hline y' \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \qquad \_\_\_ (11)$$

Or $P' = S \cdot P$ \qquad ___ (12)

Where S is 2x2 scaling in eq.(11) any positive numeric values can be assigned to the scaling factors S_x and S_y values less than 1 reduce the size of object; values greater than 1 reduce the size of object & specifying a value of 1 for both S_x and S_y leaves the size of object unchanged. When S_x and S_y are assigned the same value, a uniform scaling is produced that maintains relative object proportions unequal values of S_x and S_y result in a differential scaling that is often used in design application where picture are constructed form a few basic shapes that can be adjusted by scaling & positioning transformation.

Q.2   What are composite Transformation? Give the 3-types of Composite Transformation.

Ans.: Composite transformation Matrix can be obtained by calculating. The matrix product of the individual transformations forming products of

transformation matrix is often referred to as concatenation or composition of matrices.

(1) **Translation :** If two successive translation vectors (t_{x1}, t_{y1}) and (t_{x2}, t_{y2}) are applied to a coordinate position P, final transformed location P′ is calculated as :

$$P' = T(t_{x2}, t_{y2}) \cdot \{T(t_{x1}, t_{y1}) \cdot P\} = \{T(t_{x2}, t_{y2}) \cdot T(t_{x1}, t_{y1})\} \cdot P \qquad \_\_\_ (3)$$

Where P and P′ are represented as homogenous – coordinate column vectors. We can verify this result by calculating the matrix product for the tow associative groupings. Composite Matrix for this sequence is :

$$\begin{bmatrix} 1 & 0 & t_{x2} \\ 0 & 1 & t_{y2} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & t_{x1} \\ 0 & 1 & t_{y1} \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & t_{x1} + t_{x2} \\ 0 & 1 & t_{y1} + t_{y2} \\ 0 & 0 & 1 \end{bmatrix} \qquad \_\_\_ (4)$$

Or $\qquad T(t_{x2}, t_{y2}) \cdot T(t_{x1}, t_{y1}) = T(t_{x1} + t_{x2}, t_{y1} + t_{y2}) \qquad \_\_\_ (5)$

Which shows that two successive translations are additive.

(2) **Rotations :** Two successive rotations applied to point P produce the transformed position :

$$P' = R(\theta_2) \cdot \{P(\theta_1) \cdot P\} = \{R(\theta_2) \cdot R(\theta_1)\} \cdot P \qquad \_\_\_ (6)$$

By multiplying 2–rotation matrices, we can verify that two successive rotations are additive :

$$R(\theta_2) \cdot R(\theta_1) = R(\theta_1 + \theta_2) \qquad \_\_\_ (7)$$

So that final rotated coordinates can be calculated with the composite rotation matrix as :

$$P' = R(\theta_1 + \theta_2) \cdot P \qquad \_\_\_ (8)$$

(3) **Scaling :** Concatenating transformation matrices for 2-successive scaling operations produce the following composite scaling matrix:

$$\begin{bmatrix} s_{x2} & 0 & 0 \\ 0 & s_{y2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} s_{x1} & 0 & 0 \\ 0 & s_{y1} & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} s_{x1} , s_{x2} & 0 & 0 \\ 0 & s_{y1} , s_{y2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \_\_\_ (9)$$

Or $\qquad S(S_{x1}, S_{y2}) \cdot S(S_{x1}, S_{y1}) = S(S_{x1} \cdot S_{x2}, S_{y1} \cdot S_{y2}) \qquad \_\_\_ (10)$

The resulting matrix in this case indicates that successive scaling operations are multiplicative. That is if we were to triple the size of an object twice in successive the final size would be nine times that of the original.

Q.3   Write short notes on following -

(1)   Reflection

(2)   Shear

Ans.: (1)   **Reflection :** A reflection is a transformation that produces a mirror Image of an object. The mirror image for a 2-D reflection is generated relative to an axis of reflection by rotating the object 180^0 about the reflection axis we can choose an axis of reflection in the xy plane or perpendicular to x-y plane.

- When the reflection axis is a line in the xy plane, the rotation path about this axis is in a plane perpendicular to xy plane.

- For reflection axis that is perpendicular to xy plane, the rotation is in xy plane.
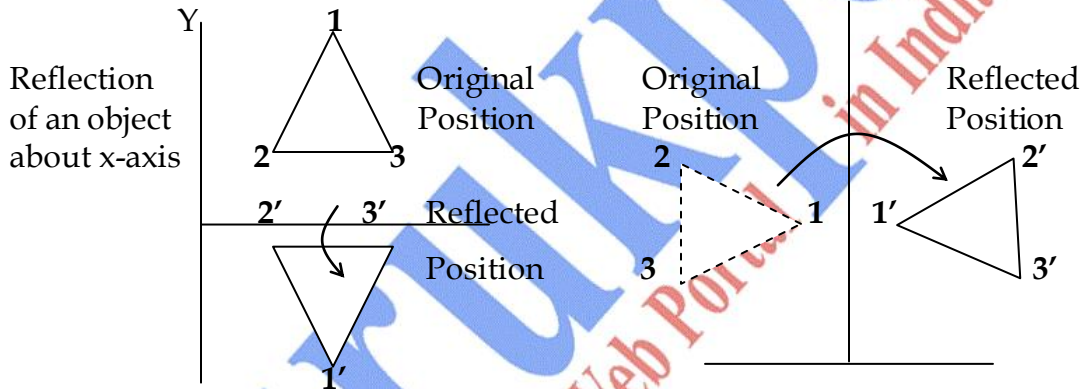
Fig. 1   Fig-2 : Reflection of an object about y-axis

(i)   Reflection about the line y =o, the x-axis is accomplished with transformation   matrix :

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \text{---(8)}$$

This transformation keeps x-values the same but flips the y-values of coordinate positions.

(ii)   Reflection about the y-axis flips x-coordinates keeping y-coordinates the same The matrix for this transformation is :

$$\begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \text{---(9)}$$

Now elements of the reflection matrix can be set to values other then ±1 values whose magnitudes are greater than 1 shift the mirror Image farther from the reflection axis & values with magnitude less than 1 brings the mirror image closer to the reflection axis.

(2)   **Shear :** A transformation that distorts the shape of an object such that the transformed shape appears as if the object were composed of internal layer that had been caused to slide over each other is called a shear two common shearing transformations are those that shift coordinate x values and those that shift y values.

An x-direction shear relative to the x-axis is produced with transformation Matrix.

$$\begin{bmatrix} 1 & Sh_x & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \qquad --- (3)$$

Which transforms coordinate position as :

$$x' = x + Sh_x \cdot y \qquad \qquad y' = y \qquad \qquad --- (4)$$

Any real number can be assigned to shear parameter Sh_x.

We can rene5rate x-direction shears relative to other reference lines with.

$$\begin{bmatrix} 1 & Sh_x & - Sh_x \cdot y_{ry} \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \qquad --- (5)$$

With coordinate position transformed as :

$$x' = x + Sh_x \ (y - y_{ry}) \qquad , \qquad y' = y \qquad --- (6)$$

A y-direction shear relative to the line $x = x_{ry}$ is generated with translation matrix :

$$\begin{bmatrix} 1 & 0 & 0 \\ Sh_y & 1 & - Sh_y \cdot x_{ry} \\ 0 & 0 & 1 \end{bmatrix} \qquad \qquad --- (7)$$

Which generates transformed coordinate position

$$x' = x \qquad , \qquad y' = Sh_y \ (x - x_{ry}) + y \qquad --- (8)$$

Q.4   **Explain 3-different types of Transformations in 3- dimension?**

Ans.: The there different types of transformations are :

(1)   Translation

(2)   Rotation

(3)   Scaling

(1)   **Translation :** In three dimensional homogenous coordinate representation a point is translated from position $P = (x, y, z)$ to position $P' = (x', y', z')$ with the matrix operation :

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad \_\_\_ (1)$$

Or $P' = T . P$ $\_\_\_ (2)$

Parameter t_x, t_y, t_z specifying translation distance for the coordinate direction x, y, z are assigned any real values.

The matrix representation in eq.(1) is

$x' = x + t_x$, $y' = y + t_y$, $z' = z + t_z$ $\_\_\_ (3)$
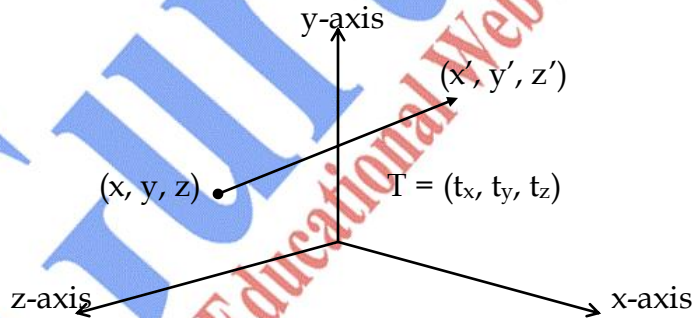
Fig(i): Translating a point with translation under

$T = (t_x, t_y, t_z)$

An object is translated in 3-diminision by transforming each of the defining points of the object. For an object represented as a set of polygon surfaces. We translate each vertex of each surface and redraw the polygon facts in the new position.

(2) **Rotation :** To generate a rotation transformation for an object, we must designate an axis of rotation (about which the object is to be rotated) and the amount of angular rotation unlike the two dimensional application, where all transformation are carried out in the xy plane, a three dimensional rotation can be specified around any line in space.

Now we have the following equations for x, y, z coordinates

$$x' = x \cos \theta - y \sin \theta$$
$$y' = x \sin \theta + y \cos \theta \qquad \_\_\_ (4)$$
$$z' = z$$

Parameter θ specifies the rotation angle In homogenous coordinate form, the 3-d, z – axis rotation equations are expressed as :

$$\begin{bmatrix} x^1 \\ y^1 \\ z^1 \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad \_\_\_ (5)$$

Which can be written as :

$$P' = R_x(\theta) \cdot P \qquad \_\_\_ (6)$$

Now equation for x axis rotation

$$y' = y \cos\theta - z \sin\theta$$
$$z' = y \sin\theta + z \cos\theta \qquad \_\_\_ (7)$$
$$x' = x$$

Which are represented in matrix form as :

$$\begin{bmatrix} x^1 \\ y^1 \\ z^1 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad \_\_\_ (8)$$

$$P' - R_x(\theta) \cdot P \qquad \_\_\_ (9)$$

Now we have equation for y-axis rotation is

$$\begin{bmatrix} x^1 \\ y^1 \\ z^1 \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad \text{---(8)}$$

Equations are :

$$z' = z\cos\theta - x\sin\theta$$
$$x' = z\sin\theta + x\cos\theta \qquad \text{---(11)}$$
$$y' = y$$
$$P' = R_y(\theta) \cdot P \qquad \text{---(12)}$$

(3) **Scaling :** The matrix expression for the scaling transformation of a position P=(x,y,z) relative to the coordinate origin can be written as :

$$\begin{bmatrix} x^1 \\ y^1 \\ z^1 \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad \text{---(13)}$$

$$P' = S \cdot P \qquad \text{---(14)}$$

Where scaling Parameters S_x, S_y, and S_z are assigned any positive values.

$$x' = x \cdot S_x \quad , \qquad y' = y \cdot S_y \quad , \qquad z' = z \cdot S_z \quad \text{---(15)}$$

Scaling an object with transformation changes the size of the object and repositions the object relative to the coordinate origin. Also if the transformation is not all equal relative dimensions in the object are changed. We pressure the original shape of an object with uniform scaling ($S_x = S_y = S_z$).

Scaling with respect to a selected fixed position (x_f. y_f. z_f) can be represented with following transformation sequence

(i) Translate the fixed point to the origin.

(ii) Scale the object relative to the coordinate origin.

(iii) Translate the fixed point to its original position.

                                         □ □ □

Chapter-3

Output Primitives

Q.1 **Explain the Line Drawing Algorithms? Explain DDA and Bresenham's Line Algorithm.**

Ans.: Slope intercept equation for a straight line is

$$y = m x + b \qquad \_\_\_ (1)$$

with m representing the slope of the line and b as the y intercept. Where the two end point of a line segment are specified at positions (x_1, y_1) and (x_2, y_2) as shown is Fig.(1) we can determine values for the slope m and y intercept b with the following calculations.

$$M = \frac{y_2 - y_1}{x_2 - x_1} \qquad \_\_\_ (2)$$

$$b = y_1 - mx_1 \qquad \_\_\_ (3)$$

Obtain value of y interval

$$\Delta y - m . \Delta x \qquad \_\_\_ (4)$$

Similarly we can obtain Δx interval **Fig. (1) Line Path between endpoint**

$$\Delta x = \frac{\Delta y}{m}$$

position (x_1, y_1) & (x_2, y_2)
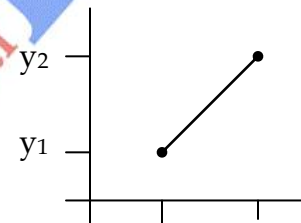
For lines with slope magnitude $|m| < 1$, Δx can be set Proportional to a small horizontal deflection voltage and the corresponding vertical deflection is then set proportional to Δy.

For lines with slope magnitude $|m| > 1$, Δy can be set proportional to a small deflection voltage with the corresponding horizontal deflection voltage set proportional to Δx.

For lines with $m = 1$ $\Delta x = \Delta y$.

DDA Algorithm : The Digital Differential Analyzer (DDA) is a scan. Conversion line Algorithm based on calculating either Δy or Δx using

equation (4) & (5). We sample the line at unit intervals in one coordinate and determine corresponding integer values nearest. The line paths for the other coordinate.

Now consider first a line with positive slope, as shown in Fig.(1). If the slope is less than one or equal to 1. We sample at unit x intervals ($\Delta x = 1$) compute each successive y values as :

$$y_{k+1} = y_k + m \qquad \_\_\_ (6)$$

Subscript k takes integer values starting form 1, for the first point & increase by 1 until the final end point is reached.

For lines with positive slope greater than 1, we reverse the role of x and y. That is we sample at unit y intervals ($\Delta y = 1$) and calculate each succeeding x value as :

$$x_{k+1} = x_k + \frac{1}{m} \qquad \_\_\_ (7)$$

Equation (6) and (7) are based on assumption that lines are to be processed form left end point to the right end point.

If this processing is reversed the sign is changed

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

$$y_{k+1} = y_k - m \qquad \_\_\_ (8)$$

$$x_{k+1} = x_k - \frac{1}{m} \qquad \_\_\_ (9)$$

Equations (6) to (9) are used to calculate pixel position along a line with negative slope.

When the start endpoint is at the right we set $\Delta x = -1$ and obtain y position from equation (7) similarly when Absolute value of Negative slope is greater than 1, we use $\Delta y = -1$ & eq.(9) or we use $\Delta y = 1$ & eq.(7).

Bresenham's Line Algorithm : An accurate and efficient raster line generating Algorithm, developed by Bresenham, scan concerts line using only incremental integer calculations that can be adapted to display circles and other curves. The vertical axes show scan-line position, & the horizontal axes identify pixel columns as shown in Fig. (5) & (6)
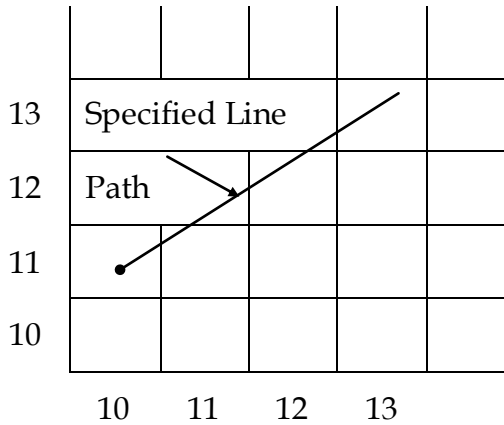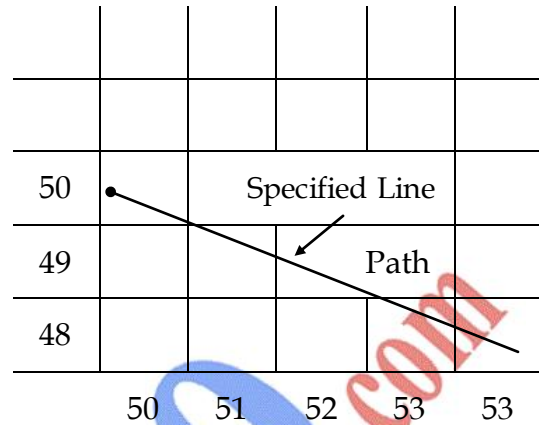
Fig.5   **Fig.6**

To illustrate Bresenham's approach we first consider the scan conversion process for lines with positive slope less than 1. Pixel position along a line path are then determined by sampling at unit x intervals starting form left and point (x_0, y_0) of a given line, we step at each successive column (x position) & plot the pixel whose scan line y is closest to the line path.

Now assuming we have to determine that the pixel at (x_k, y_k) is to be displayed, we next need to divide which pixel to plot in column x_{k+1}. Our choices are the pixels at position (x_{k+1}, y_k) and (x_{k+1}, y_{k+1}).

At sampling position x_{k+1}, we label vertical pixel separations from the mathematical line path as d_1 and d_2 Fig.(8). The y coordinate on the mathematical line at pixel column position x_{k+1} is calculated as :

$$y = m(x_k + 1) + b \qquad \_\,\_\,\_(10)$$

Then $d_1 = y - y_k = m(x_k + 1) + b - y_k$

and $d_2 = (y_k + 1) - y = y_k + 1 - m(x_k + 1) - b$

The difference between these two separations is

$$d_1 - d_2 = 2m(x_k + 1) - 2y_k + 2b - 1 \qquad \_\,\_\,\_(11)$$

A decision Parameter P_k for the Kth step in the line algorithm can be obtained by rearranging eq.(11) so that it involves only integer calculation. We accomplish this by substituting $m = \Delta y / \Delta x$. where Δy & Δx are the vertical & horizontal separation of the endpoint positions & defining.

$$P_k = \Delta x(d_1 - d_2) = 2\Delta y. x_k - 2\Delta x\, y_k + c \qquad \_\,\_\,\_(12)$$

The sign of P_k is same as the sign of d_1 - d_2. Since $\Delta x > 0$ for our example Parameter C is constant & has the value $2\Delta y + \Delta x$ (2b -1), which is independent of pixel position. If the pixel position at y_k is closer to line path than the pixel at y_{k+1} (that is $d_1 < d_2$), then decision Parameter P_k is Negative. In that case we plot the lower pixel otherwise we plot the upper pixel.

Coordinate changes along the line owner in unit steps in either the x or directions. Therefore we can obtain the values of successive decision Parameter using incremental integer calculations. At step k = 1, the decision Parameter is evaluated form eq.(12) as :

$P_{k+1} = 2\Delta y \cdot x_{k+1} - 2\Delta x \cdot y_{k+1} + C$
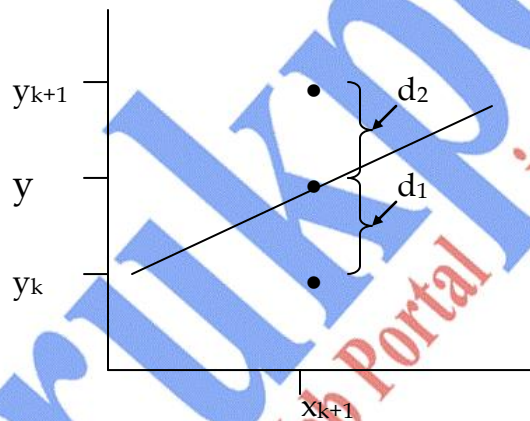
Fig.8

Subtracting eq.(12) from the preceding equation we have

$P_{k+1} - P_k = 2\Delta y (x_{k+1} - x_k) - 2\Delta x (y_{k+1} - y_k)$

But $x_{k+1} = x_k + 1$

So that, $P_{k+1} = P_k + 2\Delta y - 2\Delta x (y_{k+1} - y_k)$ _ _ _ (13)

Where the term $y_{k+1} - y_k$ is either 0 or 1, depending on sign of Parameter P_k.

This recursive calculation of decision Parameter is performed each integer x position, starting at left coordinate endpoint of the line. The first parameter P_0 is evaluated from equation (12) at starting pixel position (x_0, y_0) and with m evaluated as $\Delta y/\Delta x$.

$P_0 = 2\Delta y - \Delta x$ _ _ _ (14)

Bresenham's Line Drawing Algorithm for $|m|$ <1 :

(1)   Input the two line endpoints & store the left end point in (x_0, y_0).

(2)   Load (x_0, y_0) into frame buffer that is plot the first point.

(3) Calculate constants Δx, Δy, $2\Delta y$ and $2\Delta y - 2\Delta x$ and obtain the starting value for the decision parameter as : $P_0 = 2\Delta y - \Delta x$.

(4) At each x_k along the line starting at $k = 0$, perform the following test if $P_k < 0$ the next point to plot is (x_{k+1}, y_k) and $P_{k+1} = P_k + 2\Delta y$ otherwise the next point to plot is (x_{k+1}, y_{k+1}) and $P_{k+1} = P_k + 2\Delta y - 2\Delta x$.

(5) Repeat step 4 Δx times.

Q.2 Digitize the line with end points (20, 10) & (30, 18) using Bresenham's Line Drawing Algorithm.

Ans.: slope of line, $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{18 - 10}{30 - 20} = \dfrac{8}{10} = 0.8$

$\Delta x = 10$, $\Delta y = 8$

Initial decision parameter has the value

$P_0 = 2\Delta y - \Delta x = 2 \times 8 - 10 = 6$

Since $P_0 > 0$, so next point is $(x_k + 1, y_k + 1)$ (21, 11)

Now $k = 0$, P_{k+1} = $P_k + 2\Delta y - 2\Delta x$

P_1 = $P_0 + 2\Delta y - 2\Delta x$

= $6 + (-4)$

= 2

Since $P_1 > 0$, $\therefore$ Next point is (22, 12)

Now $k = 1$, P_{k+1} = $P_k + 2\Delta y - 2\Delta x$

P_2 = $2 + (-4)$

= -2

Since $P_2 < 0$, $\therefore$ Next point is (23, 12)

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

P_2 = $-2 + 16$

= 14

Since $P_3 > 0$, $\therefore$ Next point is (24, 13)

Now $k = 3$ P_{k+1} = $P_k + 2\Delta y - 2\Delta x$

P_4 = $14 - 4$

= 10

Since $P_4 > 0$, $\therefore$ Next point is (25, 14)

Now $k = 4$ P_{k+1} = $P_k + 2\Delta y - 2\Delta x$

P_5 = $10 - 4$

		=	6

Since $P_5 > 0$, $\therefore$ Next point is (26, 15)

Now k = 5 P_{k+1} = $P_k + 2\Delta y - 2\Delta x$

P_6 = 6 – 4

= 2

Since $P_6 > 0$, $\therefore$ Next point is (27, 16)

Now k = 6 P_{k+1} = $P_k + 2\Delta y - 2\Delta x$

P_7 = 2 + (- 4)

= - 2

Since $P_7 < 0$, $\therefore$ Next point is (28, 16)

Now k = 7 P_{k+1} = $P_k + 2\Delta y$

P_8 = - 2 + 16

= 14

Since $P_8 > 0$, $\therefore$ Next point is (29, 17)

Now k = 8 P_{k+1} = $P_k + 2\Delta y - 2\Delta x$

P_9 = 14 – 4

= 10

Since $P_9 > 0$, $\therefore$ Next point is (30, 18)

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

Plot the graph with these following points.

Q.3 **Write the properties of a Circle. Explain the Mid Point Circle Algorithm.**

Ans.: A circle is a set of points that are at a given distance r form the center position (x_c, y_c). This distance relationship is given as :

$$(x - x_c)^2 + (y - y_c)^2 - r^2 = 0$$

This equation is used to calculate the position of points along the circle path by moving in the x direction from $(x_c - r)$ to $(x_c + r)$ and determining the corresponding y values as :

$$y = y_c \pm \sqrt{(x_c - x)^2 - r^2}$$

However this method is not the best method to calculate the circle point as it requires heavy computation. Moreover spacing between the points is not uniform. Another method that can be used by calculating the polar coordinates r and θ where

$$x = x_c + r \cos \theta$$
$$y = y_c + r \sin \theta$$

Although this method results in equal spacing between the points but it also requires heavy computation. The efficient method is incremental calculation of decision parameter.

Mid Point Algorithm : We move in unit steps in the x-direction and calculate the closed pixel position along the circle path at each step. For a given radius r & screen center position (x_c, y_c). We first set our Algorithm to calculate the position of points along the coordinate position (x_0, y_0).

These calculated positions are then placed at this proper screen position by adding x_c to x and y_c to y.

For a circle from x = 0 to x = y in first quadrant, the slope varies from 0 to 1. We move in the positive x direction and determine the decision parameter to find out the possible two y values along the circle path. Points in the other 7 octants are calculated by symmetry.
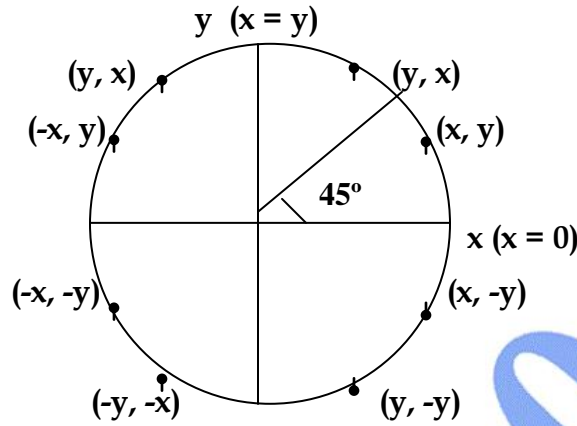
To apply this method we define a circle function as :

$$f_{circle}(x, y) = x^2 + y^2 - r^2 \qquad \_\_\_ (1)$$

Any point (x, y) on the boundary of the circle with radius r satisfy the equation of $f_{circle}(x, y) = 0$

'The relative position of any point (x, y) can be determined by checking the sign of circle function.

$$f_{circle}(x, y) \begin{cases} < 0 \text{ if } (x, y) \text{ is inside circle boundary.} \\ = 0 \text{ if } (x, y) \text{ on circle boundary.} \qquad \_\_\_ (2) \\ > 0 \text{ if } (x, y) \text{ is outside circle boundary.} \end{cases}$$
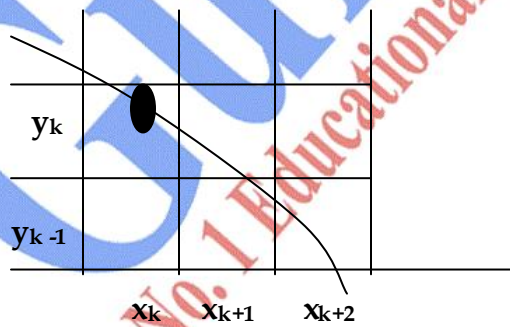
Assuming we have just plotted a pixel at (x_k, y_k). We next need to determine whether the pixel (x_{k+1}, y_k) or (x_{k+1}, y_{k-1}) is closer.

Our decision parameter is the circle function evaluated at the mid point between these two pixels.

$$P_k = f_{circle} (x_k + 1, y_k - \tfrac{1}{2})$$

Or $\quad P_k = (x_k + 1)^2 + (y_k - \tfrac{1}{2})^2 - r^2$ $\qquad\qquad$ _ _ _ (3)

If $P_k < 0$, $\quad$ Mid point is inside the circle boundary and the pixel on the scan line y_k is closer to the circle boundary.

Otherwise, $\quad$ Mid point is on or outside the circle boundary and the point on the scan line $y_k - 1$ is closer.

Successive decision parameters are obtained by incremental calculations.

Next decision parameter at next sampling position.

$$x_{k+1} + 1 = x_k + 2$$

$$P_{k+1} \quad = \quad f_{circle}(x_{k+1} + 1, y_{k+1} - \tfrac{1}{2})$$

Or $\quad P_{k+1} \quad = \quad [(x_k + 1) + 1]^2 + (y_{k+1} - \tfrac{1}{2})^2 - r^2$

Or $\quad P_{k+1} \quad = \quad P_k + 2(x_k + 1) + (y_{k+1}^2 - y_k^2) - (y_{k+1} - y_k) + 1$ $\quad$ _ _ _ (4)

Successive increment for P_k is $2x_{k+1} + 1$ (If $P_k < 0$) otherwise $(2x_{k+1} + 1 - 2y_{k+1})$ where

$$2x_{k+1} = 2x_k + 2 \qquad \& \qquad 2y_{k+1} = 2y_k - 2$$

Initial decision parameter P_0 is obtained as $(0, r) = (x_0, y_0)$

$$P_0 = f_{circle}(x, y) = f_{circle} (1, r - \tfrac{1}{2}) = 1 + (r - \tfrac{1}{2})^2 - r^2$$

Or $\quad P_0 = \dfrac{5}{4} - r$

If r is a integer then $P_0 = 1 - r$

Algorithm :

(1) $\quad$ Input radius r and circle center (x_c, y_c) and obtain the first point on circumference of a circle centered on origin $(x_0, y_0) = (0, r)$

(2) $\quad$ Calculate the initial value of the decision parameter as : $P_0 = \dfrac{5}{4} - r$

(3) $\quad$ At each x_k position, starting at $k = 0$ if $P_k < 0$ the next point along the circle is (x_{k+1}, y_k) and $P_{k+1} = P_k + 2x_{k+1} + 1$, otherwise the next point along the circle is $(x_k + 1, y_k - 1)$ and $P_{k+1} = P_k + 2x_{k+1} + 1 - 2y_{k+1}$ where $2x_{k+1} = 2x_k + 2$ & $2y_{k+1} = 2y_k - 2$.

(4) $\quad$ Determine symmetry points in other seven octants.

(5)   Move each calculated pixel position (x, y) onto the circular path centered on (x_c, y_c) & plot coordinate values $x = x + x_c$ & $y = y + y_c$.

(6)   Repeat step (3) through (5) until $x \geq y$.

Q.4   Demonstrate the Mid Point Circle Algorithm with circle radius, r = 10.

Ans.: $P_0 = 1 - r = 1 - 10 = -9$

Now the initial point $(x_0, y_0) = (0, 10)$ and initial calculating terms for calculating decision parameter are

$2x_0 = 0$, $2y_0 = 20$	Since $P_k < 0$, $\therefore$ Next point is $(1, 10)$
$P_1 = -9 + 3 = -6$	Now $P_1 < 0$, $\therefore$ Next point is $(2, 10)$
$P_2 = -6 + 5 = -1$	Now $P_2 < 0$, $\therefore$ Next point is $(3, 10)$
$P_3 = -1 + 7 = 6$	Now $P_3 > 0$, $\therefore$ Next point is $(4, 9)$
$P_4 = 6 + 9 - 18 = -3$	Now $P_4 < 0$, $\therefore$ Next point is $(5, 9)$
$P_5 = -3 + 11 = 8$	Now $P_5 > 0$, $\therefore$ Next point is $(6, 8)$
$P_6 = 8 + 13 - 16 = 5$	Now $P_6 > 0$, $\therefore$ Next point is $(7, 7)$

K	(x_{k+1}, y_{k+1})	$2x_{k+1}$	$2y_{k+1}$
0	(1, 10)	2	20
1	(2, 10)	4	20
2	(3, 10)	6	20
3	(4, 9)	8	18
4	(5, 9)	10	18
5	(6, 8)	12	16
6	(7, 7)	14	14

Plot the graph with these points.

Q.5   Give the properties of Ellipse & explain the Algorithm.

Ans.:   An ellipse is defined as a set of points such that the sum of distances from two fixed points (foci) is same for all points given a point $P = (x, y)$, distances are d_1 & d_2, equation is :

$$d_1 + d_2 = \text{constant} \qquad\qquad --- (1)$$

In terms of local coordinates

$$F_1 = (x_1, y_1) \quad \& \qquad F_2 (x_2, y_2)$$

Equation is :

$$\sqrt{(x - x_1)^2 + (y - y_1)^2} + \sqrt{(x - x_2)^2 + (y - y_2)^2} = 0 \qquad --- (2)$$

This can also be written in the form :

$$Ax^2 + By^2 + Cxy + Dx + Ey + F = 0 \qquad --- (3)$$

(More A, B, C, D, E, & F are evaluated in terms of focal coordinates & major minor axis).

- Major axis – which extends form 1 point to other through foci.

- Minor axis – which spans the shouter dimension bisecting major axis at ellipse center.

An interactive method for specifying an ellipse in an arbitrary orientation is to input two foci & a point on ellipse boundary & evaluate constant in equation (1) & so on.

Equation can be simplified if ellipse is in "standard position" with major & minor axis oriented parallel to x and y axis.
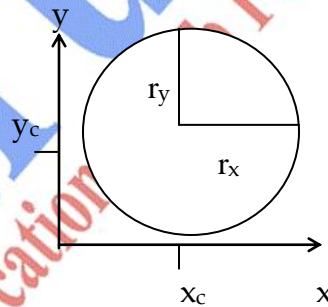
$$\left(\frac{x - x_c}{rx}\right)^2 + \left(\frac{y - y_c}{ry}\right)^2 = 1 \qquad ---(4)$$

Now using polar coordinates r & θ

Parameter equations are :

$$x = x_c + r_x \cos \theta$$

$$y = y_c + r_y \sin \theta$$

Mid Point Ellipse Algorithm : Here approach is similar to that used in circle r_x and r_y and (x_c, y_c) obtain points (x, y) for ellipse centered on origin.

Mid point ellipse algorithms process the quadrants in 2 parts. Figure shows the division of quadrant with $r_x < r_y$.
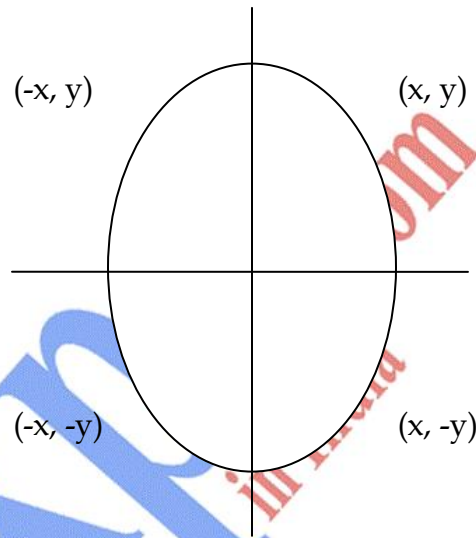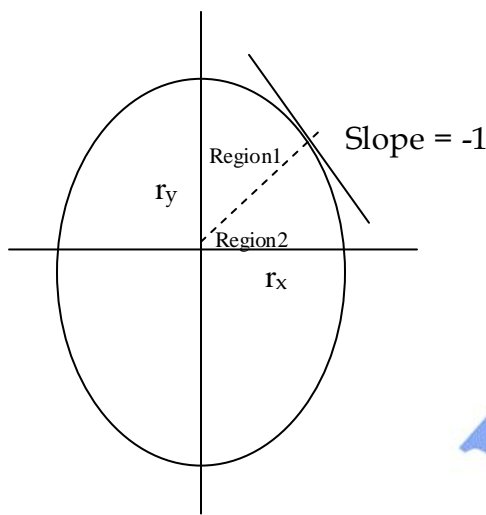
Fig.-1 : Ellipse processing regions over region l, the ellipse slope is less than 1. Over region 2, the magnitude of slope is greater than 1.

Fig.-2 : Shows the symmetry of an ellipse

Region 1 & 2 can be processed in different ways: Region 1 is processed starting at $(0, r_y)$ we step clockwise along the path in unit steps in x- direction & then unit steps in y- direction.

Ellipse function can be written as :

$$f_{ellipse}(x, y) = (0, r_y)$$

$$f_{ellipse}(x, y) = r_y^2 x^2 + r_x^2 y^2 - r_x^2 r_y^2 \qquad \qquad ---(5)$$

Which has the following properties :

$$f_{ellipse} \begin{cases} < 0 \ (x, y) \text{ is inside boundary.} \\ = 0 \ (x, y) \text{ is on the boundary.} \\ > 0 \ (x, y) \text{ is outside the boundary.} \end{cases}$$

Thus the ellipse function $f_{ellipse}(x, y)$ serves as a decision parameter in the mid point Algorithm. Starting at $(0, r_y)$ we step in x direction until we reach boundary between Region 1 & 2 slope is calculated at each step as :

$$\frac{dy}{dx} = \frac{-2r_y^2 x}{2r_x^2 x} \qquad - \{from\ eq.(5)\}$$

At boundary $\frac{dy}{dx} = -1$ So, $2r_y^2 x = 2r_x^2 y$

$\therefore$ We move out of Region 1 when $2r_y^2 x \geq 2r_x^2 y$ _ _ _ (7)

Figure (1) shows mid point between 2-candidate pixel at (x_{k+1}), we have selected pixel at (x_k, y_k) we need to determine the next pixel.

y_k

y_{k-1} mid point
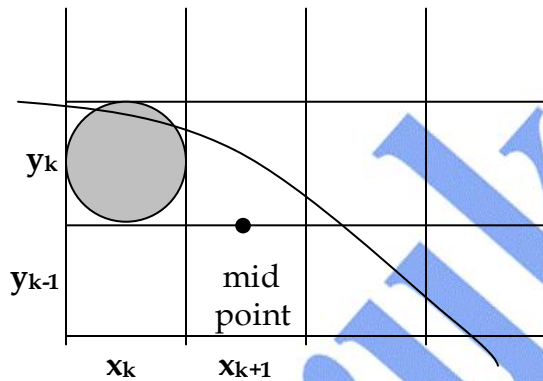
x_k x_{k+1} **Fig.:1**

$P1_k = f_{ellipse}(x_k + 1, y_k - \frac{1}{2}) = r_y^2(x_k + 1)^2 + r_x^2(y_k - \frac{1}{2})^2 - r_x^2 r_y^2$ _ _ _ (8)

Next symmetric point $(x_{k+1} + 1, y_{k+1} - \frac{1}{2})$

$\qquad P1_{k+1} = r_y^2[(x_k + 1) + 1]^2 + r_x^2[(y_{k+1} - \frac{1}{2})^2 (y_k - \frac{1}{2})^2]$ _ _ _ (9)

Where y_{k+1} is either y_k or $y_k -1$ depending on sign of P_{1k}

$$Increments = \begin{cases} 2r_y^2 x_{k+1} + r_y^2 & if\ P_k < 0 \\ \\ 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_y^2 & if\ P_k \geq 0 \end{cases}$$

With initial position $(0, r_y)$ the two terms evaluate to

$\qquad 2r_y^2 x = 0$, $\qquad 2r_x^2 y = 2r_x^2 r_y$

Now when x & y are incremented the updated values are

$\qquad 2r_y^2 x_{k+1} = 2r_y^2 x_k + 2r_y^2$, $\qquad 2r_x^2 y_{k+1} = 2r_x^2 y_k - 2r_x^2$

And these values are compared at each step & we move out of Region 1 when condition (7) is satisfied initial decision parameter for region 1 is calculated as :

$\qquad P1_0 = f_{ellipse}(x_0, y_0) = (1, r_y - \frac{1}{2}) = r_y^2 + r_x^2(r_y - \frac{1}{2})^2 - r_x^2 r_y^2$

$$P1_0 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2 \qquad \_\_\_ (10)$$

Over Region 2, we step in (-)ve y-direction & mid point selected is between horizontal pixel positions

$$P2_k = f_{ellipse}(x, y) = (x_k + \frac{1}{2}, y_k - 1)$$

$$P2_k = r_y^2(x_k + \frac{1}{2})^2 + r_x^2(y_k - 1)^2 - r_x^2 r_y^2 \qquad \_\_\_ (11)$$
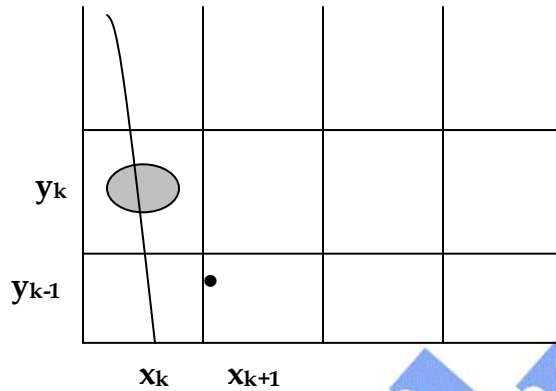
If $P2_k > 0$ then we select pixel at x_{k+1}

Initial decision parameter for region (2) is calculated by taking (x_0, y_0) as last point in Region (1)

$$P2_{k+1} = f_{ellipse}(x_{k+1} + \frac{1}{2}, y_{k+1} - 1) = r_y^2(x_{k+1} + \frac{1}{2})^2 + r_x^2[(y_k - 1) - 1]^2 - r_x^2 r_y^2$$

$$P2_{k+1} = P2_k - 2r_x^2(y_k - 1) + r_x^2 + r_y^2[(x_{k+1} + \frac{1}{2})^2 - (x_k + \frac{1}{2})^2] \qquad \_\_\_ (12)$$

At initial position (x_0, y_0)

$$P2_0 = f_{ellipse}(x_0 + \frac{1}{2}, y_0 - 1) = r_y^2(x_0 + \frac{1}{2})^2 + r_x^2(y_0 - 1)^2 - r_x^2 r_y^2 \qquad \_\_\_ (13)$$

Mid Point Ellipse Algorithm :

(1)   Input r_x, r_y and ellipse centre (x_c, y_c) obtain the first point $(x_0, y_0) = (0, r_y)$

(2)   Calculate the initial value of the decision parameter in region 1 as

$$P1_0 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2$$

(3)   At each x_k position in region 1, starting at K = 0. If $P_k < 0$, then next point along ellipse is (x_{k+1}, y_k) and $P1_{k+1} = P1_k + 2r_y^2 x_{k+1} + r_y^2$ otherwise next point along the circle is $(x_k + 1, y_k - 1)$ and $P1_{k+1} = P1_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_y^2$ with $2r_y^2 x_{k+1} = 2r_y^2 x_k + 2r_y^2$, $2r_x^2 y_{k+1} = 2r_x^2 y_k - 2r_x^2$ and continue until $2r_y^2 x \geq 2r_x^2 y$.

(4) Calculate the initial value of the decision parameter in region (2) using last point (x_0, y_0) calculated in region 1 as $P2_0 = r_y^2 (x_0 + \frac{1}{2})^2 + r_x^2 (y_0 - 1)^2 - r_x^2 r_y^2$.

(5) At each y_k position in region (2), starting at k = 0 perform following test : If $P2_k > 0$ next point is $(x_k, y_k - 1)$ and $P2_{k+1} = P2_k - 2r_x^2 y_{k+1} + r_x^2$ otherwise next point is $(x_k + 1, y_k - 1)$ and $P2_{k+1} = P2_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_x^2$.

(6) Determine the symmetry points in other three quadrants.

(7) More each calculated pixel position (x, y). Center on (x_c, y_c), plot coordinate values $x = x + x_c$ & $y = y + y_c$.

(8) Repeat the steps for region 1 until $2r_y^2 x \geq 2r_x^2 y$.

Q.6 **Illustrate the Mid Point Ellipse Algorithm by ellipse parameter $r_x = 8$ $r_y = 6$**

Ans.: $r_x^2 = 64$, $r_y^2 = 36$

$2r_x^2 = 128$, $2r_y^2 = 72$

$P1_0 = 36 - (64 \times 6) + \frac{1}{4} \times 64 = 36 - 384 + 16 = -332$

$P1_0 < 0$ ∴ Next point is (1, 6)

$P1_1 = -332 + 72 \times 1 + 36 = -332 + 108 = -224$

$P1_1 < 0$ ∴ Next point is (2, 6)

$P1_2 = -224 + 72 \times 2 + 36 = -224 + 144 + 36 = -44$

$P1_2 < 0$ ∴ Next point is (3, 6)

$P1_3 = -44 + 72 \times 3 + 36 = -44 + 216 + 36 = 208$

$P1_3 > 0$ ∴ Next point is (4, 5)

$P1_4 = 208 + 72 \times 4 - 128 \times 5 + 36 = 208 + 288 - 640 + 36 = -108$

$P1_4 < 0$ ∴ Next point is (5, 5)

$P1_5 = -108 + 72 \times 5 + 36 = 288$

$P1_5 > 0$ ∴ Next point is (6, 4)

$P1_6 = 288 + 72 \times 6 - 128 \times 4 + 36 = 244$

$P1_6 > 0$ ∴ Next point is (7, 3)

$P1_7 = 244 + 72 \times 7 - 128 \times 3 + 36 = 1168$

K12	$P1_k$	(x_{k+1}, y_{k+1})	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
1	– 332	(1, 6)	72	768
1	– 224	(2, 6)	144	768
2	– 44	(3, 6)	216	768
3	208	(4, 5)	288	640
4	– 108	(5, 5)	360	640
5	288	(6, 4)	432	512
6	244	(7, 3)	504	384

Now we move to region 2 since $2r_x^2 > 2r_x^2 y$

Now For region the initial point is $(x_0, y_0 = (7, 3)$ the initial decision parameter is

$P2_0 = f(7 + ½, 3 – 1) = 36 (7 + ½)^2 + 64 (2)^2 – 64 \times 36 = 2025 + 256 – 2304 = – 23$

The remaining positions are then calculated as :

K	$P1_k$	(x_{k+1}, y_{k+1})	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
0	– 23	(8, 2)	576	256
1	– 215	(8, 1)	576	128
2	– 279	(8, 0)	-	-

Now Plot these point on the graph.

Q.7   Why is DDA Algorithm not good & efficient Algorithm?

Ans.: (1)   DDA traces out the successive x & y values by simultaneously increasing x & y by small steps proportional to their first derivative. In our example the x increment is 1 but y increment is $\dfrac{dy}{dx}$ = m. since the real values have limited Precision, the accumulation of round off error in "m" causes the accumulative error. Build up which drifts the pixel positions from the true line path in most lines.

(2) Moreover the round off operations & floating point incrementation is still time consuming.

Q.8 What do you understand by Area Filling? Discuss any one Algorithm.

Ans.: A standard out put primitive in general graphics package is a solid-color or patterned polygon area. There are two basic approaches to area filling on raster system :

(1) To fill an area is to determine the overlap intervals for scan lines that cross the area.

(2) Another is t start from a given interior position & point outward from this point until we specify the boundary conditions.

Now scan line approach is typically used in general graphics package to still polygons, circles, ellipses and simple curses.

Fill methods starting from an interior point are useful with more complex boundaries and in interactive painting systems.

Boundary Fill Algorithm : Another approach to area filling is to start at a point inside a region and paint the interior outward toward the boundary. If the boundary is specified in a single color, the fill Algorithm precedes outward pixel by pixel until the boundary color is encountered. This method is called Boundary Fill Algorithm.

Boundary Fill Algorithm procedure accepts as input the coordinates of an interior point (x, y), a fill color and a boundary color. Starting with (x, y), neighbouring boundary points are also tested. This process continues till all the pixels up to the boundary color for the area is tested.

Diagram
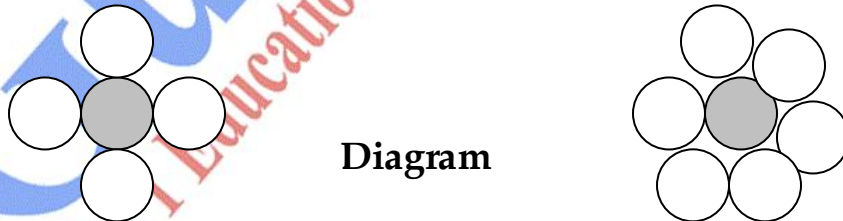
1	Fill method applied to 4-connuted area.	2	Fill method applied to 8-connuted area.

Recursive boundary fill Algorithm may not fill regions correctly if some interior pixels are already displayed in the fill color. This occurs because the Algorithm checks next point both for boundary color and for fill color.

The pixel positions are stored in form of a stack in the Algorithm.

Flood Fill Algorithm : Sometimes we want to fill in (or recolor) an area that is not defined within a single color boundary suppose we take an area which is bordered by several different color. We can paint such area by replacing a specified interior color instead of searching for a boundary color value. This approach is called flood fill Algorithm.

We start from interior paint (x, y) and reassign all pixel values that are currently set to a given interior color with the desired fill color. If the area we want to paint has move than one interior color, we can first reassign pixel value so that all interior points have the same color.

□ □ □

Chapter-4

Clipping Algorithm

Q.1 **What is Clipping? How can a point be clipped?**

Ans. : Any procedure that identifies those portion of a picture that are either inside or outside of a specified region of space is referred to as a clipping Algorithm or clipping. This region against which an object is to be clipped is called a clip window.

Application of Clipping :

(1) Extracting parts of defined scene for veiwing.

(2) Identifying visible surface in three dimentional views.

(3) Antialising line segments or object boundaries.

(4) Creating objects using solid-modeling procedures.

(5) Displaying multi window environment.

(6) Drawing and painting operations.

Point Clipping : Assuring that clip window is a rectangle in standard Position, we save a point $P = (x, y)$ for display if following inequalities are satisfied.

$$xw_{min} \leq x \leq xw_{max}$$

$$yw_{min} \leq y \leq yw_{max}$$

Where the edges of clip window (xw_{min}, xw_{max}, yw_{min}, yw_{max}) can be either would coordinate window boundaries or view port boundaries. If any one of these inequalities is not satisfied the point is clipped.

Application : Point clipping can be applied to scenes involving explosions or sea foam that are modeled with particles (points) distributed in some region of the scene.

Q. 2 **What is Line Clipping? Explain Cohen Sutherland Method of Line Clipping.**

Ans. A line clipping procedure involves several parts First, we can test a given line segment to determine whether it lies completely inside the clipping window. If it does not, we try to determine whether it lies completely outside the window. Finally if we can not identify a line as completely inside or completely outside we must perform intersection calculation with one or move clipping boundaries. We process lines through inside-outside tests by checking the line end points.
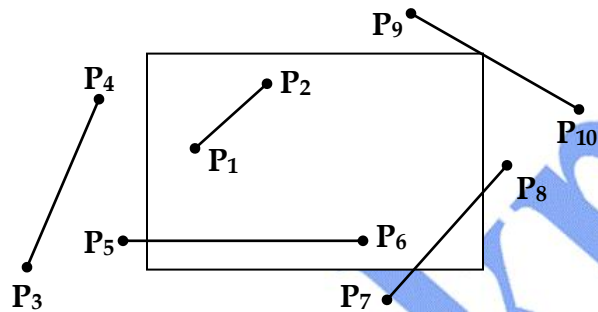
- A line with both end paints inside all clipping boundaries such as line form P_1 to P_2 is saved.

- A line with both end points outside any one of the clip boundaries (line P_3, P_4 in Fig.) is outside the window.

- All other lines cross one or more clipping boundaries and may require calculation of multiple intersection point. For a line segment with end points (x_1, y_1) and (x_2, y_2) and one or both end points outside clipping rectangle, the parametric representation.

$$x = x_1 + u(x_2 - x_1)$$

$$y = y_1 + u(y_2 - y_1), \ 0 \le u \le 1$$

Could be used to determine values of parameter u for intersections with the clipping boundary coordinates. If the value of u for an intersection with a rectangle boundary edge is outside the range 0 to 1, the line does not enter the interior of the window at that boundary. If the value of u is within the range from 0 to 1, the line segment does indeed cross into the clipping area.

Cohen - SutherlandLline Clipping : This is one of the oldest and most popular line clipping procedures. Generally, the method speeds up the processing of line segments by performing initial test that reduces the

number of intersections that must be calculated. Every line end point in a picture is assigned a four digit binary code called, a region code, that identifies the location of the points relative to the boundaries of the clipping rectangle. Regions are set up in reference to the boundaries as shown is Fig.:

1001	1000	1010
0001	0000 WINDOW	0010
0101	0100	0110

Each bit position in the region code is used to indicate one the four relative coordinate positions of the point with respect to the clip window: to the left, right, top and bottom. By numbering the bit position in the region code as 1 through 4 right to left, the coordinate regions can be correlated with the bit positions as :

bit 1 : left   ;   bit 2 : right   ;   bit 3 : below ;   bit 4 : above

A value of 1 in any bit position indicates that point is in that relative position otherwise the bit position is set to 0.

- Now here bit values in the region are determined by comparing end point coordinate values (x, y) to the clip boundaries.

   Bit 1   is set to 1 if $x < xw_{min}$

   Bit 2   is set to 1 it $xw_{max} < x$

Now   Bit 1 sign bit of $x - xw_{min}$

   Bit 2 sign bit of $xw_{max} - x$

   Bit 3 sign bit of $y - yw_{min}$

   Bit 4 sing bit of $yw_{max} - y$

(1)   Any lines that are completely inside the clip window have a region code 0000 for both end points few points to be kept in mind while checking.

(2)   Any lines that have 1 in same bit position for both end points are considered to be completely outside.

(3)   Now here we use AND operation with both region codes and if result is not 0000 then line is completely outside.

Now for lines that cannot be identified as completely inside or completely outside the window by this test are checked by intersection with window boundaries.

For eg.
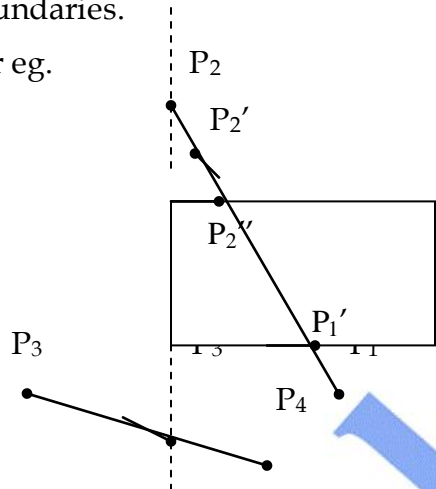
We check P_1 against left right we find it is below window. We find intersection point P_1' and then discard line section P_1 to P_1' & Now we have P_1 to P_2. Now we take P_2 we find it in left position outside window then we take an intersection point P_2''. But we find it outside window then we again calculate final intersection point P_2'''. Now we discard line P_2 to P_2'''. We finally get a line P_2'' to P_1' inside window similarly check for line P_3 to P_4.

For end points (x_1, y_1) (x_2, y_2) y–coordinate with vertical boundary can be calculated as

$$y = y_1 + m(x - x_1) \text{ where x is set to } xw_{min} \text{ to } xw_{max}$$

Q.3   Discuss the Cyrus Beck Algorithm for Clipping in a Polygon Window.

Ans.   Cyrus Beck Technique : Cyrus Beck Technique can be used to clip a 2–D line against a rectangle or 3–D line against an arbitrary convex polyhedron in 3-d space.

Liang Barsky Later developed a more efficient parametric line clipping Algorithm. Now here we follow Cyrus Beck development to introduce parametric clipping now in parametric representation of line Algorithm has a parameter t representation of the line segment for the point at which that segment intersects the infinite line on which the clip edge lies, Because all clip

edges are in general intersected by the line, four values of t are calculated. Then a series of comparison are used to check which out of four values of (t) correspond to actual intersection, only then are the (x, y) values of two or one actual intersection calculated.

Advantage of this on Cohen Sutherland :

(1)   It saves time because it avoids the repetitive looping needed to clip to multiple clip rectangle edge.
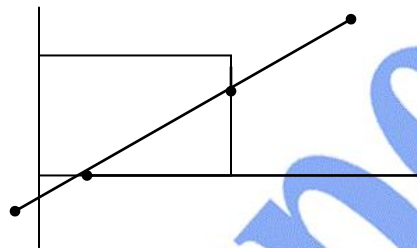
(2)   Calculation in 3D space move complicated than 1-D
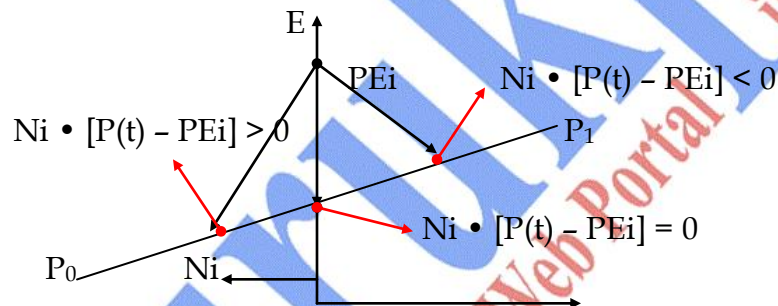
Fig.1

Cyrus Beck Algorithm is based on the following formulation the intersection between 2-lines as in Fig.1 & shows a single edge Ei of clip rectangle and that edge's outward normal Ni (i.e. outward of clip rectangle).

Either the edge or the line segment has to be extended in order to find intersection point.

Now before this line is represented parametrically as :

$$P(t) = P_0 + (P_1 - P_0)t$$

Where $t = 0$ at P_0

             $t = 1$ at P_1

Now pick an arbitrary point PEi on edge Ei Now consider three vectors $P(t) - PEi$ to three designated points on P_0 to P_1.

Now we will determine the endpoints of the line on the inside or outside half plane of the edge.

Now we can determine in which region the points lie by looking at the dot product $\quad$ Ni • [P(t) – PEi].

Ni • [P(t) – PEi] $\quad$ → Negative if point is inside half plane

→ Zero if point is on the line containing the edge

→ Positive if point lies outside half plane.

Now solve for value of t at the intersection $P_0 P_1$ with edge.

$$\text{Ni} \bullet [P(t) – PEi] = 0$$

Substitute for value P(t)

$$\text{Ni} \bullet [P_0 + (P_1 – P_0) t – PEi] = 0$$

Now distribute the product

$$\text{Ni} \bullet [P_0 – PEi] + \text{Ni} [P_1 – P_0] t = 0$$

Let $D = (P_1 – P_0)$ be the from P_0 to P_1 and solve for t

$$t = \frac{\text{Ni} \bullet [P_0 - PEi]}{- \text{Ni} \bullet D} \qquad \text{\_ \_ \_ (1)}$$

This gives a valid value of t only if denominator of the expression is non-zero.

Note : Cyrus Beck use inward Normal Ni, but we prefer to use outward normal for consistency with plane normal in 3d which is outward. Our formulation differs only in testing of a sign.

(1)   For this condition of denominator to be non-zero. We check the following :

$\qquad$ Ni ≠ 0 (i. e Normal should not be Zero)

$\qquad$ D ≠ 0 (i.e P_1 ≠ P_0)

Now hence Ni • D ≠ 0 (i.e. edge Ei and line between P_0 to P_1 are not parallel. If they were parallel then there cannot be any intersection point.

Now eq.(1) can be used to find the intersection between the line & the edge.

Now similarly determine normal & an arbitrary PEi say an end of edge for each clip edge and then find four arbitrary points for the "t".

(2)   Next step after finding out the four values for "t" is to find out which value corresponds to internal intersection of line segment.

(i)   Now 1st only value of t outside interval [0, 1] can be discarded since it lies outside P_0P_1.

(ii)   Next is to determine whether the intersection lies on the clip boundary.
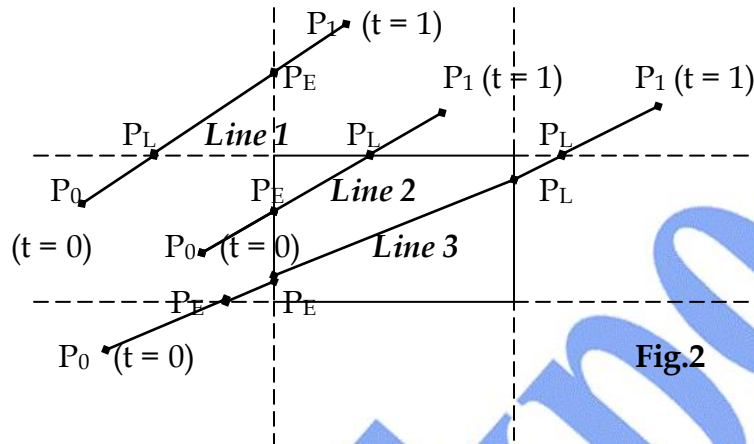
Fig.2

Now simply sort the remaining values of t choose the intermediate value of t for intersection points as shown in Fig.(2) for case of line 1.

Now the question arises how line 1 is different from line 2 & line 3.

In line 2 no portion of the line lies on the clip boundary and so the intermediate value of t correspond to points not on the clip boundary.

In line 3 we have to see which points are on the clip boundary.

Now here intersections are classified as :

PE ⟶ Potential entering

PL ⟶ Potential leaving

(i)   Now if moving from P_0 to P_1 and the line causes to cross a particular edge t enter the edge inside half plane the intersection is PE.

(ii)   Now if it causes to leave the inside plane then it is denoted as P_L.

Formally it can be checked by calculating angle between P0, P1 and Ni.

Ni • D < 0   ⟶   PE (angle is greater than 90°)

Ni • D > 0   ⟶   PL (angle is less than 90°)

(3)   Final steps are to select a pair (PE, PL) that defines the clipped line.

Now we suggest that PE intersection with largest t value which we call t_E and the PL intersection with smallest t value t_L. Now the intersection line segment is then defined by range (t_E, t_L). But this was in case of an infinite line. But we want the range for P_0 to P_1 line. Now we set this as :

t = 0   is a upper bound for t_E

t = 1   is a upper bound for t_L

But if $t_E > t_L$

Now this is case for line 2, no portion of P_0P_1 is in clip rectangle so whole line is discarded. Now t_E and t_L that corresponds to actual intersection is used to find value of x & y coordinates.

Table 1 : For Calculation of Parametric Values.

Clip edge i	Normal Ni	PEi	P_0 – PEi	$t = \dfrac{Ni.(P_0 - PEi)}{-Ni.D}$
Left : x = x_{min}	(– 1, 0)	(x_{min}, y)	($x_0 - x_{min}$, $y_0 - y$)	$\dfrac{-(x_0 - x_{min})}{(x - x_0)}$
right : x = x_{max}	(1, 0)	(x_{max}, y)	($x_0 - x_{max}$, $y_0 - y$)	$\dfrac{(x_0 - x_{max})}{-(x_1 - x_0)}$
bottom : y = y_{min}	(0, – 1)	(x, y_{min})	($x_0 - x$, $y_0 - y_{min}$)	$\dfrac{-(y_0 - y_{min})}{(y_1 - y_0)}$
top : y = y_{max}	(0, 1)	(x, y_{max})	($x_0 - x$, $y_0 - y_{max}$)	$\dfrac{(y_0 - y_{max})}{-(y_1 - y_0)}$

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Chapter-5

Visible Surface Detection

Q.1 **Explain the Depth Buffer Method in detail or Z–Buffer Method.**

Ans.: This is commonly used image space approach to detecting visible surfaces is the depth buffer method, which compares surface depths at each pixel position on the projection plane. This procedure is referred to as the z-buffer method since object depth is usefully me as used from the view plane along z-axis of the viewing system. Each surface of a scene is processed separately, one point at a time across the surface. This method is mainly applied to scenes containing only polygon surfaces, because depth values can be computed very quickly and method is easy to implement.

With object descriptions converted to projection coordinates, each (x, y, z) position on the polygon surface corresponds to the orthographic projection point (x, y) on the view plane. Therefore, for each pixel position(x, y) on the view plane, object depths can be compared by comparing z-values.

This Fig.(1) shows three surfaces at varying distances along the orthographic projection line form position (x, y) in a view plane taken as $x_v y_v$ plane. Surface S_1 is closest at this position, so its surface intensity value at (x, y) is saved.

As implied by name of this method, two buffer areas are required. A depth buffer is used to store depth values for each (x, y) position as surfaces are processed and the refresh buffer stores the intensity values for each position.
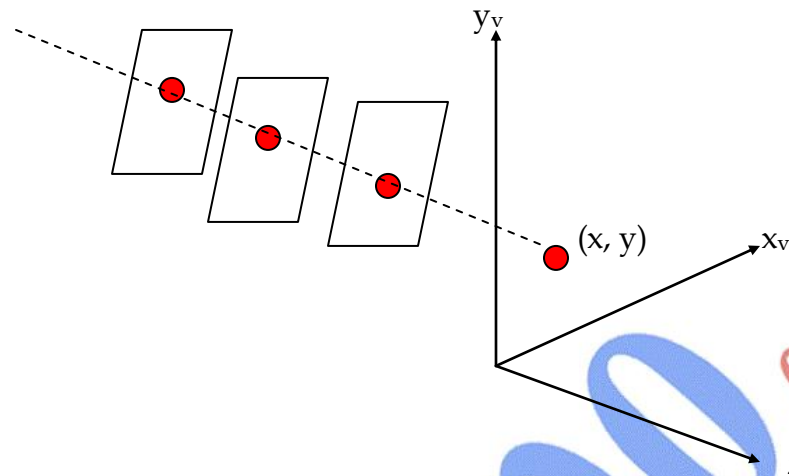
Fig.(1) : At view plane position (x, y) surface s_1 has the smallest depth form the view plane and so is visible at that position.

Initially all values/positions in the depth buffer are set to 0 (minimum depth) and the refresh buffer is initialized to the back ground intensity. Each surface listed in polygon table is then processed, one scan line at a time, calculating the depth (z-values) at each (x, y) pixel position. The calculated depth is compared to the value previously stored in the depth Buffer at that position. If the calculated depth is greater than the value stored in the depth buffer, the depth value is stored and the surface intensity at that position is determined and placed in the same xy location in the refresh Buffer.

Depth Buffer Algorithm :

(1)   Initialize the depth buffer and refresh buffer so that for all buffer position (x, y).

depth (x, y) = 0   ,   refresh (x, y) = $I_{Backgnd}$

(2)   For each position on each polygon surface, compare depth values to previously stored values in the depth buffer, to determine visibility.

•   Calculate the depth z for each (x, y) position on the polygon.

•   If z > depth (x, y) : then set

depth (x, y) = z   ,   refresh (x, y) = $I_{surf.}$(x, y)

Where $I_{backgnd.}$ is the value for the background intensity $I_{surf.}$(x, y) is the projected intensity value for the surface at pixel (x, y). After all surfaces have been processed, the depth Buffer contains depth values

for the visible surfaces and the refresh Buffer contains the corresponding intensity values for those surfaces.

Depth values for a surface position (x, y) are calculated form the plane equation for each surface :

$$Z = \frac{-Ax - By - D}{C} \qquad \qquad ---\ (1)$$
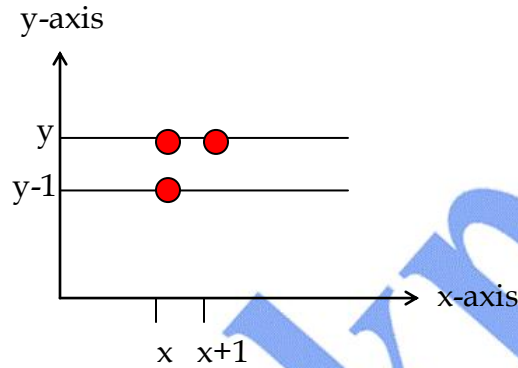
Fig.(2) : From position (x, y) on a scan line, the next position across the line has coordinate (x+1, y) and the position immediately below on the next line has coordinate (x, y–1).

The depth z′ of the next position (x+1, y) along the scan line is obtained from equation (1) as :

$$Z' = \frac{-A(x+1) - By - D}{C} \qquad \qquad ---\ (2)$$

$$Z' = Z - \frac{A}{C} \qquad \qquad ---\ (3)$$

The ratio – A/C is constant for each surface, so succeeding depth values across a scan line are obtained form preceding values with a single addition.

Depth values for each successive position across the scan line are then calculated by equation (3).

Now we first determine the y–coordinate extents of each polygon and process the surface from the topmost scan line to the bottom scan line as shown in Fig.(3).
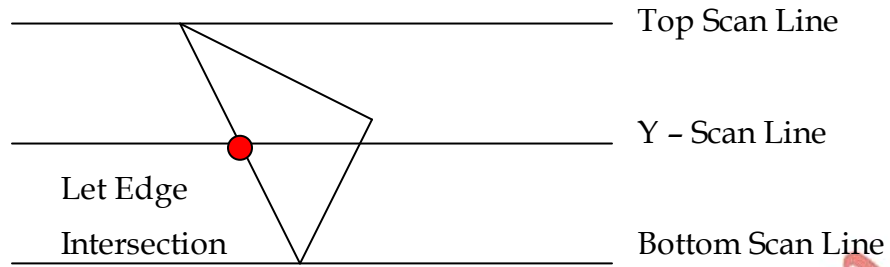
Fig.(3) : scan lines intersecting a polygon surface.

Starting at a top vertex we can recursively calculate x–positions down a left edge of the polygon as $x' = \dfrac{1}{m}$, where m is the slope of the edge.

Depth values down the edge are then obtained as :

$$Z' = Z + \frac{\dfrac{A}{m} + B}{C} \qquad\qquad --- (4)$$

If we process down a vertical edge, the slope is infinite and the recursive calculation reduce to

$$Z' = Z + \frac{B}{C} \qquad\qquad --- (5)$$

One way to reduce storage requirement is to process one section of the scene at a time, using smaller depth buffer. After each view section is processed, the buffer is reused for next section.

Q.2   **How is Depth Buffer Method different form A Buffer Method?**

Ans.:

S.No.	Z – Buffer Method	A – Buffer Method
1.	In Z–Buffer method alphabet Z – represents depth.	The A–Buffer method represents an antialised, area averaged, accumulation Buffer method.
2.	It can find only one visible surface at each pixel position that is it deals only with opaque surfaces.	In this each position in the buffer can reference a linked list of surfaces.

3.	This can't accumulate intensity values for more than one surface.	More than one surface intensity can be taken into consideration at each pixel position.

Q.3 What is Object Space Method of Visible Surface Detection?

Ans.: Visible surface detection algorithm is broadly classified according to whether they deal with object definitions directly or with their projected Images. These two approaches are called.

- **object –** space methods
- **Image –** space methods.

An object – space method compares objects and parts of objects to each other within the scheme definition to determine which surfaces, as a whole, we should label as visible.

Object space methods can be used effectively to locate visible surfaces in some cases.

Line display algorithm uses object space method to identify visible lines in wire frame displays.

Q. 4 Differentiate between Object Space Method and Image Space Method?

Ans.:

S.No.	Z – Buffer Method	A – Buffer Method
1.	This method deals with object definition directly	This method deals with their projected Images.
2.	This method compares objects and parts of objects to each other within the scene definition.	In this visibility is decided point by point at each pixel position on the projection plane.
3.	This method can be used effectively to locate visible surfaces in some cases.	Most visible surfaces use this Method.

Q.5 Explain Painter's Algorithm for removing hidden surfaces?

Ans.: Depth sorting methods for solving hidden surface problem is often refered to as Painter's Algorithm.

Now using both image space and object space operations, the depth sorting method performs following basic functions :

(1)   Surfaces are sorted in order of decreasing depth.

(2)   Surfaces are scan consented in order, starting with the surface of greatest depth.

Sorting operations carried out in both image and object space, the scan conversion of the polygon surface is performed in image space.

For e.g. : In creating an oil painting, an artist first paints the background colors. Next the most distant objects are added, then the nearer objects and so forth. At the final step, the foreground objects are painted on the canvas over the Background and other objects that have been painted on the canvas. Each layer of paint covers up the previous layer using similar technique, we first of sort surfaces according to their distances form view plane. The intensity value for the farthest surface are then entered into the refresh Buffer. Taking each succeeding surface in turn (in decreasing depth) we paint the surface intensities onto the frame buffer over the intensities of the previously processed surfaces.

Painting polygon surfaces onto the frame buffer according to depth is carried out in several steps.

Viewing along Z – direction, surfaces are ordered on the first pass according to smallest Z value on each surface with the greatest depth is then compared to other surfaces S in the list to determine whether there are any overlaps in depth. if no depth overlaps occurs, S is scan converted.

Fig.1 : Two surfaces with no depth overlap
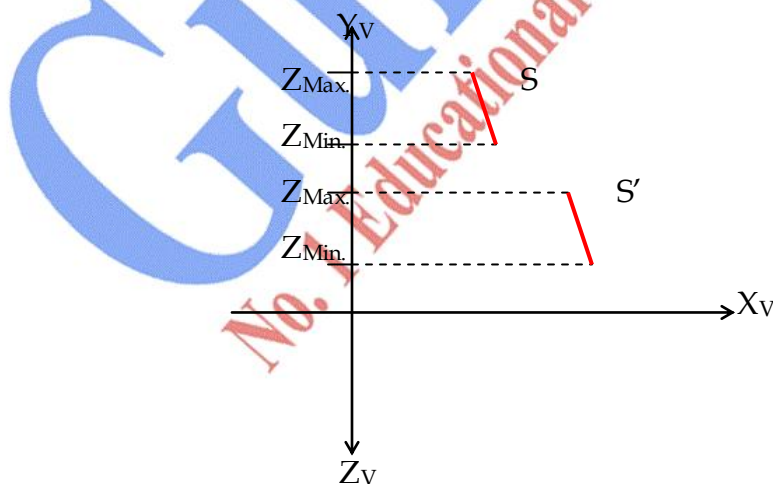
This process is then repeated for the next surface in the list. As long as no overlaps occur, each surface is processed in depth order until all have been scan converted.

If a depth overlap is detected at any point in the list we need to make some additional comparison tests. We make the test for each surface that overlaps with S. If any one of these test is true, no reordering is necessary for that surface.

(1)   The bounding rectangle in the xy plane for the two surfaces does not overlap.

(2)   Surface S is completely behind the overlapping surface relative to the viewing position.

(3)   The overlapping surface is completely in front of S relative to the viewing position.

(4)   The projection of the two surfaces onto the view plane do not overlap.

We perform these tests in the order listed and processed to the next overlapping surface as soon as we find one of the test is true. If all the overlapping surfaces pass at least one of these tests none of them is behind S. No reordering necessary and S is scan converted.

(1)   Test 1 is performed in two parts. We first check for overlap in x direction, then we check for overlap in y direction. If either of these directions shows no overlap the two planes can't obscure one another.

Fig.(2) shows depth overlap that is overlap in z – direction but no overlap in x – direction.
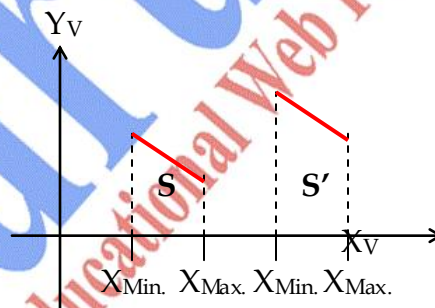
(2)   Test 2 and 3 with an inside outside polygon test. That is, we substitute the coordinates for all vertices of S into the plane equation for the overlapping surface and check the sign of the result. If the plane equations are set u, so that the outside of the surface is towards the viewing position, then S is behind S′ if all the vertices of S are inside S′. similarly S′ is completely in front of S it all vertices of S are outside of S′
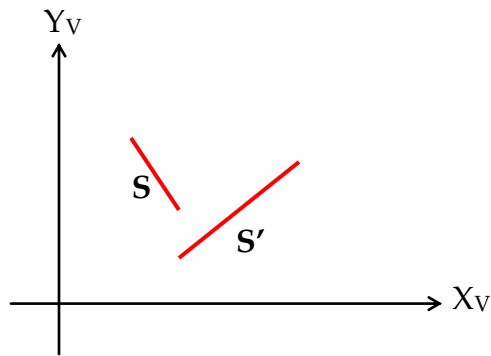
Fig.(3) shows an overlapping surface S that is completely in front of S but s is not completely inside S'. (i. e test 2 is not true)
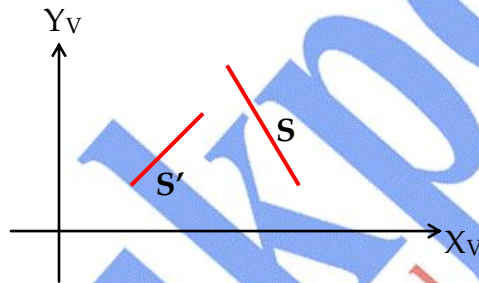
Fig.(4) shows overlapping surface S' is completely in front ("outside") of surface S but S is not completely behind S'.

Now if test 1 through 3 has all failed, we try test 4 by checking for intersection between the bounding edges of the two surfaces using line equation in xy plane.

Fig.(5) Two surfaces with overlapping bounding rectangle in the xy plane.

(a)   (b)
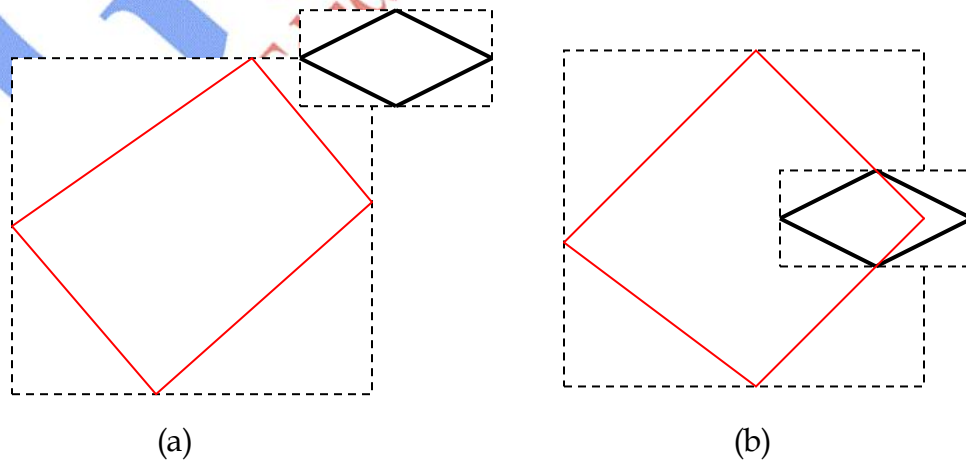
If all four tests fail with a particular overlapping surface S′, we interchange surfaces S and S′ in the sorted list.

Q.6 **Write short notes on -**

(i) **Back Face Detection**

(ii) **A – Buffer Method**

(iii) **Scan Line Method**

Ans.: **Back Face Detection :** A fast and simple object space method for identifying the back faces of a polyhedron is based on "inside-outside" tests discussed. A point (x, y, z) is inside a polygon surface with plane parameters A, B, C and D if

$$Ax + By + Cz + D < 0 \qquad \_\_\_(1)$$

When an inside point is along the line of sight to the surface, the polygon must be back face (we are inside that face and can't see the front of it from our viewing position). We can simplify this test by considering the normal vector N to a polygon surface which has Cartesian components (A, B, C). In general if v is a vector in the viewing direction from the eye (a camera) Position shown in fig we then this polygon is a back if

$$V. N > 0 \qquad \_\_\_(2)$$

If object description have been converted to projection coordinates and our viewing direction is parallel to the viewing Z_v axis then $V = (0, 0, V_z)$ and

$$V. N = V_z C$$

So that we only need to consider sign of C the Z component of Normal vector N.

N (A, B, C)

V
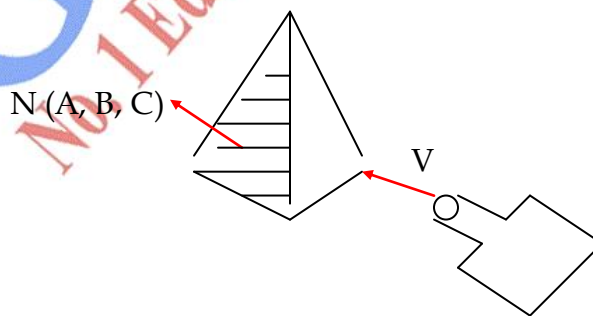
Fig.(1) : Vector V in the viewing direction and a back face normal vector N of the Polyhedron.

In right handed viewing system with viewing direction along negative Z_v axis Fig.(2).

Fig.(2)
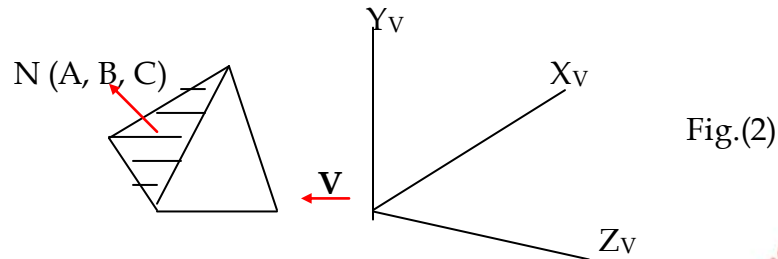
The polygon surface is back face if C < 0, Also we can't see any face whose normal has Z component C = 0. Since our viewing direction is grazing that polygon. Thus in general, we label any polygon as a back face if its normal vector has a Z – component value.

$$C \leq 0$$

By examining Parameter C for the different planes defining an object, we can immediately identify all the Back faces. For a single convex polyhedron such as pyramid in Fig.(2) this test identifies all the hidden surfaces on the object, since each surface is either completely visible or completely hidden. For other objects such as concave polyhedron more tests need to be performed to determine whether these are additional faces that are to tally or partly obscured by other Faces.

A – Buffer Method : An extension of the ideas in the depth Buffer method is A – Buffer method. The A – buffer method represents an antialised, area averaged, accumulation buffer method.

The A – Buffer method expands the depth buffer so that each position in the buffer can reference a linked list of surfaces. Thus move than one intensity can be taken into consideration at each pixel position and object edges can be antialised.

Each position A in A – Buffer has two fields :

(1) **Depth Field :** Stores a positive and negative real Number.

(2) **Intensity Field :** Stores surface Intensity Information or a painter value.

| d > 0 | I | d < 0 | | Surf 1 | | Surf 1 | |

depth field | Intensity field | depth field | Intensity field | | | | • • •
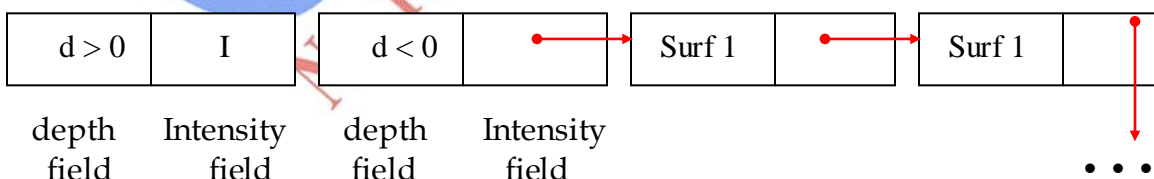
Fig.(1) organization of A – Buffer pixel position :

(a)   Shows single surface overlap of corresponding pixel area.

(b)   Shows multiple surface overlap.

If the depth field is positive, the member stored at that position is the depth of a single surface overlapping the corresponding pixel area. The intensity field then stores RGB components of surface color at that point and the percentage of pixel coverage as shown in Fig.(1).

Data for each surface in the linked list includes :

1)   RGB Intensity Component   5) Surface Identifier

2)   Opacity Parameter   6) Other Surface Rendering Parameter

3)   Depth   7) Pointer to Next Surface

4)   Percent of Area Coverage

Scan – Line Method : The image space method for removing hidden surfaces is a extension of the scan line Algorithm for filling Polygon interior of filling first one surface we now deal with the multiple surfaces. As each scan line is processed, all Polygon surfaces intersecting that line are examined to determine which are visible. Across each scan line depth calculations are made for each overlapping surface to determine which is nearest to the view plane. When the visible surface has been determined, the intensity value for that position is entered into the refresh Buffer.

Two tables are used for various surfaces :

(i)   Edge Table   (ii)   Polygon Table

Edge Table : contains coordinate end points for each line in the scene, the inverse slope of each line and pointers into the polygon table to identify the surface bounded by each line.

Polygon Table : Contains coefficient of the plane equation for each surface, intensity information for the surfaces and possible pointers into the edge table.

□ □ □

Chapter-6

Curves and Surfaces

Q.1 **What are Bezier Curves and Surfaces. Write the properties of Bezier Curves.**

Ans.: This spline approximation method was developed by French Engineer Pierre Bezier for use in the design of Renault automobile bodies Bezier splines have a number of properties that make them highly useful and convenient for curves and surface design. They are easy to implement. Bezier splines are widely available in CAD systems.

Bezier Curves : A Bezier curve can be fitted to any number of control points. The number of control point to be approximated and their relative position determine the degree of Bezier polynomial. As with interpolation splines, a Bezier curve can be specified with boundary conditions, with characterizing matrix or with blending functions.

Suppose we have $(n + 1)$ control point positions: P_k – $(x_k, y_k, z_k,)$ with K varying from 0 to n. These coordinate points can be blended to produce the following position vector $P(u)$, which describes the path of an approximating Bezier Polynomial function between P_0 & P_n.

$$P(u) = \sum_{K=0}^{n} P_k \, BEZ_{k,n}(u) \qquad 0 \le u \le 1 \qquad \qquad ---(1)$$

The Bezier blending functions $BEZ_{k,n}(u)$ are the Bernstein polynomial.

$$BEZ_{k,n}(u) = C(n, k) \, u^k \, (1 - u)^{n-k} \qquad \qquad ---(2)$$

Where $C_{(n,k)}$ are the binomial coefficients

$$C_{(n,k)} = \frac{n|}{k|\underline{n-k}|} \qquad \qquad ---(3)$$

Equivalently we can define Bezier blending function with recursive calculation :

$BEZ_{k,n}(u) = (1 - u) BEZ_{k,n-1}(u) + u BEZ_{k-1,n-1}(u)$ $n > k \geq 1$ _ _ _ (4)

Three parametric equations for individual curve coordinates :

$$x(u) = \sum_{K=0}^{n} x_k \, BEZ_{k,n}(u) \qquad y(u) = \sum_{K=0}^{n} y_k \, BEZ_{k,n}(u) \qquad z(u) = \sum_{K=0}^{n} z_k \, BEZ_{k,n}(u)$$

A Bezier Curve is a polynomial of degree one less than the number of control points used.

Three points generates Parabola.

Four points generates Cubic Curve.

(a)   (b)
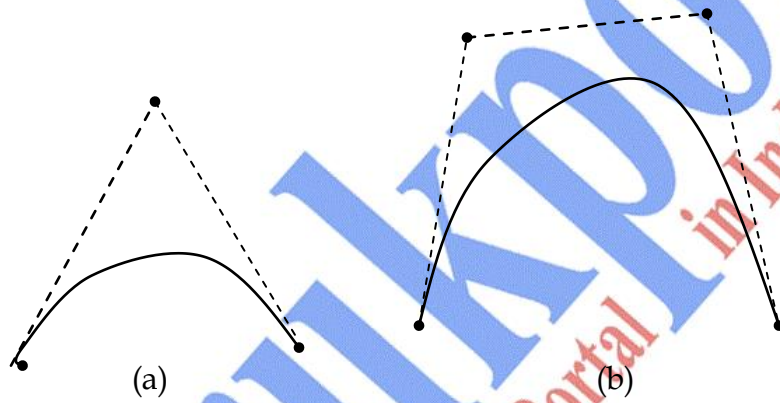
Bezier Curves generated from three or four control points. Dashed lines connect the control point positions.

Properties of Bezier Curve :

(1)   It always passes through the first and last control points. That is boundary condition at two ends of the curve are :

For two end points $P(0) = P_0$

$P(1) = P_n$ _ _ _ (6)

Now value for the first derivative of a Bezier Curve at the end points can be calculated from control point coordinates as :

$P'(0) = -nP_0 + nP_1$ $\Big[$ First derivative for the

$P'(1) = -nP_{n-1} + nP_n$ first & last 2 end points _ _ _ (7)

$\therefore$ Slope of the curve at the beginning of curve is calculated by joining the beginning 2- points.

Slope of the curve at the end of curve is calculated by joining the 2 – end points.

Similarly second derivative of Bezier Curve at the end point are : -

$$P''(0) = n\,(n-1)\,[(P_2 - P_1) - (P_1 - P_0)]$$

$$P''(1) = n\,(n-1)\,[\,(P_{n-2} - P_{n-1}) - (P_{n-1} - P_n)] \qquad \_\_\_ (8)$$

(2)   Another property of Bezier Curve is, it lies within the convex hull. Therefore this follows the properties of Bezier blending function. That is they are all positive & their sum is always 1.

$$\therefore \qquad \sum_{K=0}^{n} BEZ_{k,n}\,(u) = 1 \qquad\qquad \_\_\_ (9)$$

So that any curve position is simply weighted sum of the control points positions.

The convex hull also ensures that polynomial smoothly follows the control points without erratic oscillations.

Bezier Surfaces : Two sets of orthogonal Bezier Curves can be used to design an object surface by specifying by an input mesh of control points.

Blending function are :

$$P(u, v) = \sum_{j=0}^{m}\ \sum_{k=0}^{n}\ P_{j,k}\,BEZ_{j,m}\,(v)\,BEZ_{k,n}\,(u) \qquad \_\_\_ (10)$$

With $P_{j,k}$ specifying location of $(m + 1)$ by $(n + 1)$ control points.

Bezier surfaces have same properties as Bezier Curves. Zero order continuity is obtained by matching control points at the boundary.

First order continuity is obtained by choosing control points along a straight line across the boundary & by maintaining a constant ratio of collinear line segments for each set of specified control points across section boundaries.

NOTE : In context to Cubic Bezier Curve. Derive Bezier Matrix.

$$\begin{bmatrix} 1 & 0 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

Write the same answer as the above one.

Q.2 What are B-Spline Line, Curves and Surfaces? Write the properties of B-Spline Curves?

Ans.: These are most widely used class of approximating splines B-splines have two advantage over Bezier splines.

(1) The degree of a B – spline polynomial can be set independently of the number of control points (with certain limitations).

(2) B – spline allow local control over the shape of a spline curve or surface.

The trade of off is that B – splines are move complex than Bezier splines.

B – spline Curves : Blending function for B – spline curve is :

$$P(u) = \sum_{K=0}^{n} P_k B_{k,d}(u) \qquad \begin{array}{l} u_{min} \le u \le u_{max} \\ 2 \le d \le n+1 \end{array}$$

Where the P_k are an input set of (n + 1) control points. There are several differences between this B-spline formulation and that for Bezier splines. The range of parameter u now depends on how we choose the B – spline parameters. And the B – spline blending functions $B_{k,d}$ are polynomials of degree d – 1, where parameter d can be chosen to be any integer. Value in the range from 2 up to the number of control points , n + 1, Local control for B – splines is achieved by defining the blending functions over subintervals of the total range of u.

Blending function for B – spline curves are defined by Cox – de Boor recursion formulas :

$$B_{k,d}(u) = \begin{cases} 1 & \text{if } u_k \le u \le u_{k+1} \\ 0 & \text{otherwise} \end{cases}$$

$$B_{k,d}\ u\ = \frac{u - u_k}{u_{k+d-1} - u_k} B_{k,d-1}\ u\ + \frac{u_{k+d} - u}{u_{k+d} - u_{k+1}} B_{k=1,d-1}\ u$$

Where each blending function is defined over d subintervals of the total range of u. values for u_{min} and u_{max} then depends on the number of control points we select, we can increase the number of values in the knot vector to aid in curve design.

Properties of B – spline Curve :

(1) The polynomial curve has degree (d – 1) and C^{d-2} continuity over the range of u.

(2)   For (n + 1) control points, the curve is described with (n + 1) blending function.

(3)   Each blending function $B_{k,d}$ is defined over d subintervals of the total range of u, starting at knot value u_k.

(4)   The range of parameter u is divided into (n + d) subintervals by the (n + d + 1) values specified in knot vector.

(5)   With knot values labeled as { u_0 , u_1 , - - - , u_{n+d}} the resulting B – spline over is defined only in the interval from knot value u_{d-1} up to the knot value u_{n+1}.

(6)   Each section of the spline curve (between two successive knot values) is influenced by d – control points.

(7)   Any one control points can affect the shape of almost d curve section.

For any vale of u in the interval from knot value u_{d-1} to u_{n-1} the sum over all basis function is 1.

$$\sum_{K=0}^{n} B_{k,d}(u) = 1$$

We need to specify the knot values to obtain the blending function using recurrence relation.

Classification of B – splines according to the knot vectors :

Uniform, Periodic B – splines : When spacing between knot values is constant. The resulting curve is called a uniform B – spline.

For e.g. : { - 1.5, -1.0, -0.5, 0.0}
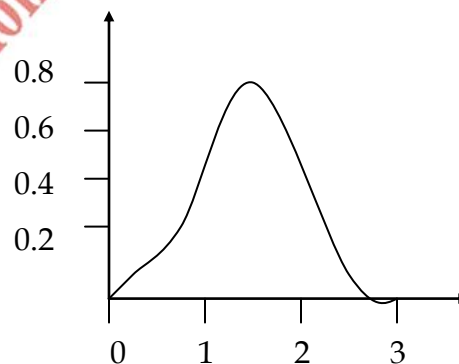
Periodic B - spline blending functions for n = d = 3 and a uniform, integer knot vector.

Uniform B – splines have periodic blending functions shifted version of previous function :

$$B_{k,d} (u) = B_{k+1}, d (u + \Delta u) = B_{k+2}, d (u + 2\Delta u)$$

Cubic Periodic B – spline : Periodic splines are particularly useful for generating certain closed Curves. If any three consecutive control points are identical, the curve passes through that coordinate position.

The boundary condition for periodic cubic B – spline with four consecutive control points labeled P_0, P_1, P_2, P_3 are.

$$P(0) = \frac{1}{6} (P_0 + 4P_1 + P_2)$$

$$P(1) = \frac{1}{6} (P_1 + 4P_2 + P_3)$$

$$P'(0) = \frac{1}{2} (P_2 - P_0)$$

$$P'(1) = \frac{1}{2} (P_3 - P_1)$$

Matrix formulation for periodic cubic polynomial is :-

$$P (u) = [u^3 \ u^2 \ u \ 1] . M_B . \begin{bmatrix} P_0 \\ P_1 \\ P_2 \\ P_3 \end{bmatrix}$$

where B – spline Matrix is

$$M_B = \frac{1}{6} \begin{bmatrix} 1 & 0 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

Open Uniform B – spline : This class of B – spline is a cross between uniform B – spline and non uniform B – spline. For open uniform B – spline or simply open B – spline, the Knot spacing is uniform except at the ends where Knot values are repeated d – times.

For eg.:   [0, 0, 1, 2, 3, 3] for d = 2 and n = 3

            [0, 0, 0, 0, 1, 2, 2, 2, 2] for d = 4 and n = 4

Non uniform B – splines : With non uniform B – spline, we can choose multiple Knot values and unequal spacing between the Knot values.

For eg.:   [0, 1, 2, 3, 3, 4]

                  [0, 2, 2, 3, 3, 6]

Non uniform B – spline provides increased flexibility in controlling a curve shape.

We can obtain the blending function for a non uniform B – spline using methods similar to those discussed for uniform and open B – spline.

B – spline Surfaces : Cartesian product of B – spline blending function in the form

$$P(u, v) = \sum_{K_1=0}^{n_1} \sum_{K_2=0}^{n_2} P_{K_1, K_2} B_{K_1, d_1} (u) B_{K_2, d_2} (v)$$

Where vector values for P_{k_1, k_2} specify position of the $(n_1 + 1)$ by $(n_2 + 1)$ control points.

Q. 3   What is Hermite Interpolation?

Ans. A hermite spline is an interpolating piecewise cubic polynomial with a specified tangent at each control point. Hermite splines can be adjusted locally because each curve section is only dependent on its end point constraints. If P(u) represents a parametric cubic point function for the curve section between control points P_k and P_{k+1}.

Boundary conditions that define this Hermite curve section are :

$$
\left.
\begin{aligned}
P(0) &= P_k \\
P(1) &= P_{k+1} \\
P'(0) &= DP_k \\
P'(1) &= DP_{k+1}
\end{aligned}
\right\} \qquad \_\_\_ (1)
$$

With DP_k and DP_{k+1} specifying values for the parametric derivatives (slope of the curve) at control points P_k and P_{k+1} respectively.

Vector equivalent equation :

$$P(u) = au^3 + bu^2 + cu + d \qquad 0 \le u \le 1 \qquad \_\_\_ (2)$$

Where x component of P is $x(u) = a_x u^3 + b_x u^2 + c_x u + d_x$ and similarly for y and z components. The Matrix is

$$P(u) = [u^3 \ \ u^2 \ \ u \ \ 1] \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} \qquad \text{---(3)}$$

Derivative of the point function as :

$$P'(u) = [3u^2 \ \ 2u \ \ 1 \ \ 0] \begin{bmatrix} a \\ b \\ C \\ d \end{bmatrix} \qquad \text{---(4)}$$

P_K

$P(u) = [x(u), y(u), z(u)]$

P_{K+1}
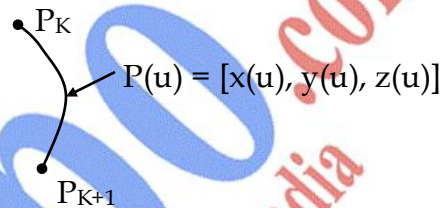
Fig.(1) Parametric point function P(u) for a Hermite curve section between control point P_k and P_{k+1}.

Now we express the hermite boundary condition in matrix form.

$$\begin{bmatrix} P_k \\ P_{k+1} \\ DP_k \\ DP_{k+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 3 & 2 & 1 & 0 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} \qquad \text{---(5)}$$

Solving this equation for the polynomial coefficients : -

$$\begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 3 & 2 & 1 & 0 \end{bmatrix}^{-1} \begin{bmatrix} P_k \\ P_{k+1} \\ D_{Pk} \\ DP_{k+1} \end{bmatrix} = M_H \begin{bmatrix} P_k \\ P_{k+1} \\ D_{Pk} \\ DP_{k+1} \end{bmatrix} \qquad \text{---(6)}$$

Where M_H, the Hermite Matrix is the inverse of the boundary constraint Matrix.

Equation (3) can thus be written in terms of boundary condition as :

$$P(u) = [u^3 \; u^2 \; u \; 1] M_H \begin{bmatrix} P_k \\ P_{k+1} \\ DP_k \\ DP_{k+1} \end{bmatrix}$$

Now we obtain the blending function by carrying out Matrix Multiplication :

$P(u) = P_k (2u^3 - 3u^2 + 1) + P_{k+1} (-2u^3 + 3u^2) + DP_k (u^3 - 2u^2 + u) + DP_{k+1} (u^3 - u^2)$

$\quad = P_k H_0 (u) + P_{k+1} H_1 (u) + DP_k H_2 (u) + DP_{k+1} H_3 (u)$

$H_k(u)$ are refered to as blending function for $K = 0, 1, 2, 3$.

Q.4   Differentiate between Hermite Curve and B - spline Curve?

Ans.:

S.No.	Hermite Curve	B – spline Curve
1.	This spline is interpolation spline with a specified tangent at each control point.	This is a class of approximating spline.
2.	It does not require any input values for curve slope or other geometric information, in addition to control point coordinates.	It requires many I/P values like Knot vector, range of Parameter u etc.

Q.5   Explain Zero Order, First Order, and Second Order Continuity in Curve Blending?

Ans.: To ensure a smooth transition form one section of a piecewise curve to the next. We can suppose various continuity conditions, at the connection point. Each section of a spline is described with a set of parametric coordinate function of the form :

$x = x(u), \ y = y(u), \ z = z(u), \qquad u_1 \leq u \leq u2 \qquad \qquad \_\,\_\,\_ \ (1)$
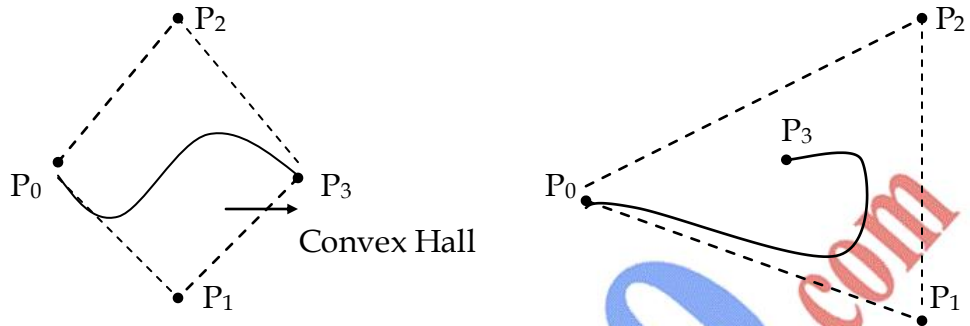
Fig.(1) convex hull shapes for two sets of control points.

Parametric Continuity : We set parametric continuity by matching the parametric derivative of adjoining section at their common boundary.

Zero – Order Parametric Continuity : Described as C^0 continuity means simply that curves meet. That is the values of x, y, z evaluated at u_2 for first curve section is equal to values of x, y, z evaluated at u_1 for the next curve section.

First – Order Parametric Continuity : Refered as C^1 continuity means that the first Parametric derivatives (tangent lines) of the coordinate functions in eq.(1) for two successive curve sections are equal at their joining point.

Second - Order Parametric Continuity : Described as C^2 continuity means that both first and second parametric derivatives of the two curve sections are the same at the intersection.

With second order continuity, the rates of change of the tangent vector for connecting sections are equal at their intersection. Thus the tangent line transitions smoothly from one section of the curve to the Next like in Fig.(2).
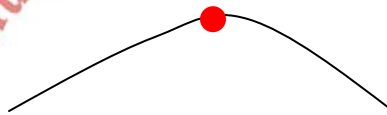
Fig.(2) : Showing second order continuity.

With First order continuity, the change of tangent vectors for two sections can be quite different, so that the general shape of the two adjacent section can change abruptly.

Applications :

(1)   First order continuity is often sufficient for digitizing drawings and some design applications.

(2)   Second order continuity is useful for setting up animation paths for camera motion and for many precision CAD Requirements.

Geometric Continuity Conditions : An alternate method for joining two successive curve sections is to specify conditions for geometric continuity. In this case, we only require parametric derivatives of the two sections to be **proportional** to each other at their common boundaries instead of **equal** to each other.

Zero Order Continuity : Described as G^0 continuity, is same as zero order parametric continuity. That is two curve section must have the same coordinate position at the boundary point.

First Order Geometric Continuity: - Described as G^1 continuity means those parametric first derivatives are proportional at the intersection of two successive sections.

Suppose if we denote the parametric position on the curve as $P(u)$ the direction of the tangent vector $P'(u)$, but not necessarily its magnitude will be same of two successive curve sections at their joining point under G^1 Continuity.

Second Order Geometric Continuity : Described as G^2 continuity means that both the first and second parametric derivative of the two curve sections are proportional at their boundary under G^2 continuity, curative of two curve section will match at the joining position**.**

A curve generated with geometric continuity conditions is similar to one generated with parametric continuity but with slight difference in curve shape.

□ □ □

Chapter-7

Image Processing

Q.1 What is Image Processing? What are the operations of Image Processing?

Ans.: Image Processing is any form of signal, processing for which Input is an Image such as photographs or frames of video, the output of Image processing can be either an Image or a set of characteristics or parameters related to the Image. Most Image processing techniques in values treating the image as 2–d signal and applying standard signal processing technique to it. Image processing usually refers to digital Image processing but optical and analog image Processing are also possible.

Operations of Image Processing :

(1) Geometric Transformation (Such as enlargement, reduction and rotation)

(2) Color Correction (Such as brightness and contrast adjustment quantization or conversion of different color)

(3) Digital compositing or optical compositing (combination of two or more Images)

(4) Interpolation and recovery of full image from a draw image format.

(5) Image editing

(6) Image registration

(7) Image stabilization

(8) Image segmentation

(9) Extending dynamic range by combining differently exposed Images.

Q.2 What are the Applications of Image Processing?

Ans.: The applications of Image Processing are :

(1)   **Computer vision :** This is a science and technique of machine that can see computer vision is concern with the theory for building artificial system that obtains information form Images.

This include system for :

(i)   Controlling Process (e.g. : Industrial Robot)

(ii)   Detecting Events (for like Counting People)

(iii)   Organizing Information

(iv)   Modeling Objects or Environment (Medical Image Analyses)

(v)   Interaction (as the Input to a Device for Computer Human Interaction)

(2)   **Face Detection :** This Computer technology that determines the location and sizes of human faces in arbitrary digital Images. It detects facial features and ignores everything else like trees buildings.

(3)   **Feature Detection :** This refers to methods that air at comforting, abstracting of image Information and making decision at every Image point whether an image feature of a given type at that point or not.

(4)   **Land Departure Warning System :** This mechanism is designed to warn a driver when vehicle begins to move out of its lane.

(5)   **Medical Image Processing :** This refers to techniques and process used to create Images of human body for clinical purposes like entropy radiology.

(6)   **Microscope Image Processing :** This is the broad term that covers to use the digital image processing technique to process analyze and Present Images obtained from microscope like in drug testing and metallurgical processes.

(7)   **Morphological Image Processing :** Theoretical model for digital images built upon lattice theory and topology also uses Image Processing Technique.

(8)   **Remote sensing :** This is a small or large scale acquisition of information of an object or phenomenon by the use of either recording or real time sensing device that is not physical but way of air craft, space craft & satellites.

(9)   **Photo Manipulation**

Q.3 What is Image Enhancement? What are different Image Enhancement techniques?

Ans.: Image enhancement refers to sharpening of Image features such as edges, boundaries or contrast to make a graphic display more useful for display and analysis. The enhancement process doesn't increase the inherent information content in the data but it does increase the dynamic range of the chosen features show that they can be detected easily. Image enhancement includes grey level and contrast manipulation, noise reduction, as christening, sharpening, filtering, interpolation and magnification, pseudo coloring and so on.

The greatest difficulty in Image enhancement is quantifying the criteria for enhancement.

Image Enhancement Technique

Point Operation	Spatial Operation	Transformation Information	Pseudo coding
(i) Contrast Stretching	(i) Noise Smoothing	(i) Linear Filtering	(i) False Coloring
(ii) Noise Clipping	(ii) Median Filtering	(ii) Root Filtering	(ii)Pseudo Coloring
(iii) Window Slicing	(iii) Unsharp Masking	(iii) Homographic Filtering	
(iv) Histogram Modeling	(iv) Low Pass, High Pass Band Pass Filter		
	(v) Zooming		

(1) **Point Operation :** These operation are zero order Memory operations where a given grey level UE [0, L] is mapped into a grey level VE [0, L] according to Transformation.

(a) **Contrast Stretching :** Low contrast Images occur often due to poor or non uniform lightening conditions or due to non – sincerity or small dynamic range of the Image sensor.

Contrast stretching Transformations are applied slope of the transformation is chosen greater than unity in the region of stretch.

for $\alpha > 1$ a $= \dfrac{1}{3}$

for $\beta > 1$ b $= \dfrac{2}{3}$ L

for $\gamma > 1$ c = L
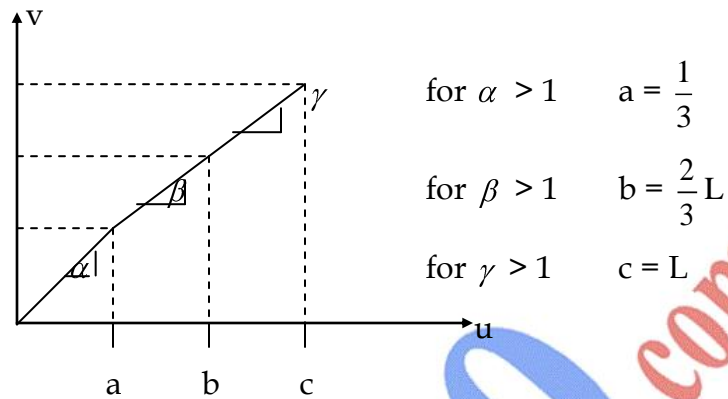
For dark region stretch $\alpha > 1$ for mid region $\beta > 1$ and for brighter region $\gamma > 1$

(b)   **Noise Clipping :** A special case of contrast stretching is called clipping. This is useful for noise reduction when the Input signal is known to lie in the range (a, b). Threshold is a special case of clipping were a = b= t and the output becomes binary.

For e.g. : A binary image such as a printed page doesn't give binary o/p when scanned doesn't output because of sensor noise background illusion variation.
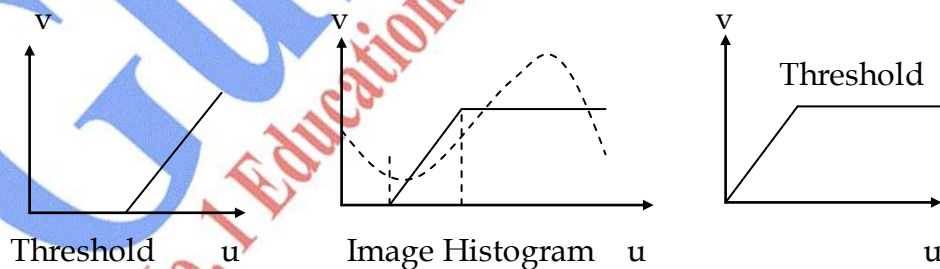
Digital Negative : A negative Image can be obtained by reverse scaling of the grey levels according to the transformation $v = t - u$
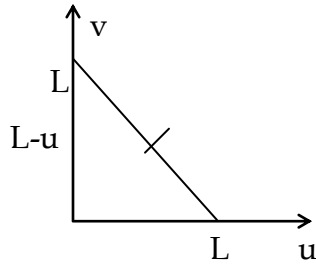
(c) **Window Slicing (Intensity Level Slices) :**

- without background condition

$$V = \begin{cases} L & a \leq u \leq b \\ 0 & \text{otherwise} \end{cases}$$

- without Background condition

$$V = \begin{cases} L & a \leq u \leq b \\ u & \text{otherwise} \end{cases}$$
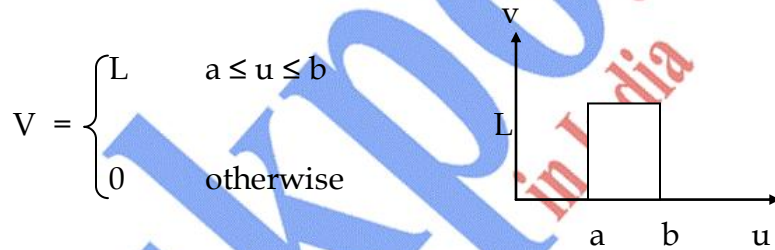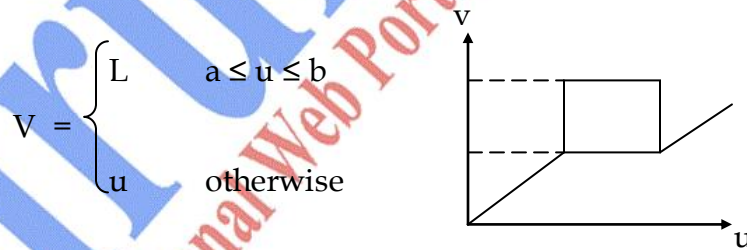
These transformation permit segmentation of certain grey level regions from the rest of the image. This technique is useful when different features of an image are contained in different grey levels.

Bit extraction (It is a minor part of point operation) : Suppose each image pixel is uniformly quantized to b bits. It is desired to extract the nth most significant bit and display it then apply the transformation. This transformation is useful in determine the no of visually significant bit in an Image.

(d) **Histogram Modeling :** The histogram of an Image represents the relative frequency of occurrence of the various grey levels in the Image histogram modeling Technique modify an image so that its histogram has a desired shape. This is useful in

stretching the low contrast level of Images with narrow histogram. Histogram modeling has been found to be a powerful technique for image enhancement.

(i) **Histogram Equalization :** In this goal is to obtain uniform histogram for the out put Image.

(ii) **Histogram Modification** (measures frequency basically) : A generalization of procedure is taken the output grey level v is first transformed non linearly by F(u) and the output is uniformly quantized. The histogram is equalization function.

$$f(u) = \sum_{x_i=0}^{u} P_u(x_i)$$

P_u is the probability at a point.

(iii) **Histogram Specification :** Suppose the random variable is greater then Zero with probability density $P_u(u)$ is to be transform to $v \geq 0$ such that it has a specified probability density $P_v(v)$.

(2) **Spatial Operations :** Many image enhancement techniques are based on special operation performed on local neighborhood of input pixels often the image is convolved with the finite response filter called spatial Mask.

(a) **Noise Smoothening :** Here each pixel is replaced by a weighted average of its neighborhood pixel.

$$v(m, n) = \sum a(k, l) \, y(m-k, n-l) \qquad (k, l) \in w$$

y (m, n) & v (m, n) are input & out put image respectively.

a (k, l) are filter weight.

w = chosen window

Spatial averaging is used for noise smoothening low pass filtering & sub sampling of Images.

The observed Image is given as

$$y(m, n) = u(m, n) + n(m, n)$$

denotes noise ratio which has mean value 0.

Directional Smoothening : To protect the edge from blurring while smooth using a directional averaging filter can be useful v (m, n, o).

(b)   **Median Filtering :** Here the input pixel is obtained by the median of the pixel contained in the video around the pixel.

$$V(m, n) = \text{median } \{y(m-k, n-l), (k, l) \in w\}$$

Where w is suitable window.

The Algorithm of median filtering requires arranging the pixel values in the window in increasing & decreasing order & picking the middle value. Generally the window size is chosen so that n_w is added. If n_w is even then. The median is taken as the average of two values in the meddle.

The median filter has the following properties :

(i)   It is the non linear filter thus for 2-sequences $x(m)$ & $y(m)$
        $$\text{median } \{x(m) + y(m)\} \neq \text{median } \{x(m)\} + \text{median } \{y(m)\}$$

(ii)   It is useful for removing isolated line of pixels while preserving spatial resolution.

(iii)   Its performance is poor when the number of noise pixels in the window is greater than or ½ the number of pixels in the window.

(c)   **Un sharp Masking Technique :** This is used commonly in the printing industry for cry penning the edges

$$V (m, n) = u (m, n) + \lambda g (m, n)$$

Where $\lambda > 0$ & $g (m, n)$ is suitable defined gradient at (m, n) a commonly used gradient f^n is the discrete lap lace formula.

(d)   **Low Pass, High Pass Band Pass Filter :** Earlier it was mentioned spatial avenging operation is a low Pass filter.

$$h_{HP}(m, n) = \int m,n \ - \ h_{LP} \ m,n$$

h_{HP} denotes high pass filter h_{LP} denotes low Pass filter such a filter can be implemented by simply subtracting the low Pass filter output form its Input. Low Pass filter are useful for Noise smoothening & interpolation. High Pass filter are useful in extracting edges & in sharpening Images Band pass filters are useful in enhancement of edges & other high Pass image characteristics in presence of noise.

□ □ □

Multiple Choice Questions

1) The smallest addressable screen element. Is called?
    A. Pixel
    B. Graph
    C. voltage level
    D. color information

2) Pixel on the graphics display represents?
    A. mathematical point
    B. a region which theoretically can contain an infinite number of points
    C. voltage values
    D. picture

3) The process of determining the appropriate pixels for representing picture or graphics object is known as?
    A. rasterization
    B. animation
    C. both a and b
    D. representation

4) The relationship among the data and objects which are stored in the database called application database, and referred by the?
    A. Application programs
    B. application model
    C. graphics display
    D. both a and b

5) Selective or part erasing of screen is not possible in?
    A. raster scan display
    B. vector scan display
    C. DVST
    D. both a and b

6) display processor is also called a?
   A. graphics controller
   B. display coprocessor
   C. both a and b
   D. out put device for graphics

7) Graphics software acts as a very powerful tool to create?
   A. Images
   B. animated pictures
   C. both a and b
   D. system interface

8) The purpose of display processor is __from the graphics routine task?
   A. to free the CPU
   B. To free the secondary memory
   C. to free the main memory
   D. Both a & c

9) random-scan monitors typically offer __color choices?
   A. Only a few
   B. wide range
   C. just 1 or 2
   D. moderate range of

10) RGB system needs __of storage for the frame buffer?
   A. 100 megabytes
   B. 10 megabytes
   C. 3 megabytes
   D. 2 Gb

11) The SRGP package provides the __to wide the variety of display devices?
   A. interface
   B. connection
   C. link
   D. way

12) Length of shift register in bits is equal to __?
   A. one word

B. A single scan lines
C. number of scan lines
D. One bit

13) Display controller is not required for __?
   A. display system with only frame buffer
   B. Display system with display controller
   C. both a and b
   D. display system with color

14) The basic principle of Bresenham`s line algorithm is __?
   A. to select the optimum raster locations to represent a straight line
   B. to select either Δx or Δy, whichever is larger, is chosen as one raster unit
   C. we find on which side of the line the midpoint lies
   D. both a and b

15) The midpoint circle drawing algorithm also uses the __ of the circle to generate?
   A. two-way symmetry
   B. four-way symmetry
   C. eight-way symmetry
   D. both a & b

16) a polygon in which the line segment joining any 2 points within the polygon lies completely inside the polygon is called __?
   A. convex polygon
   B. concave polygon
   C. both a and b
   D. both a and b

17) A polygon in which the line segment joining any 2 points within the polygon may not lie completely inside the polygon is called __?
   A. convex polygon
   B. concave polygon
   C. both a and b
   D. Hexagon

18) Rectangular patterns are sometimes referred as__?
   A. tiling patterns
   B. Filling patterns
   C. coloring patterns
   D. both a and b

19) Replicating pixels is one of the methods of__?
   A. Thick primitives
   B. Thin primitives
   C. stylish primitives
   D. both a and b

20) Line produced by moving pen is __ at the end points than the line produced by the pixel replication?
   A. thin
   B. straight
   C. thicker
   D. both a and b

21) The process of selecting and viewing the picture with different views is called__?
   A. Windowing
   B. clipping
   C. projecting
   D. both a and b

22) The process which divides each element of the picture into its visible and invisible portions, allowing the invisible portion to be discarded is called__?
   A. clipping
   B. Windowing
   C. both a and b
   D. Projecting

23) The region against which an object is to be clipped is called__?
   A. clip window or clipping window
   B. Drawing window
   C. image window
   D. both b and c

24) The region code 0000 represents the__?
   A. viewing window
   B. left clipping window
   C. right clipping window
   D. bottom clipping window

25) A method used to test lines for total clipping is equivalent to the__?
   A. logical XOR operator
   B. logical OR operator
   C. logical AND operator
   D. both a and b

26) A process of changing the position of an object in a straight line path from one coordinate location to another is called__?
   A. Translation
   B. rotation
   C. motion
   D. both b and c

27) Data hazards occur when__?
   A. Greater performance loss
   B. Pipeline changes the order of read/write accesses to operands
   C. some functional unit is not fully pipelined
   D. machine size is limited

28) A two dimensional rotation is applied to an object by repositioning it along a?
   A. circular path in the x-y plane
   B. straight path in the x-y plane
   C. diagonals path in the x-y plane
   D. upward in the x-y plane

29) A scaling transformation changes the__of an object?
   A. size
   B. location
   C. shape
   D. both a and b

30) In two dimensional viewing we have?

A. 3D window and 2D viewport
B. 3D window and 3D viewport
C. 2D window and 2D viewport
D. 2D window and 2D viewport

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	A	A	C	B	C	A	A	C	A	C	A	A	C
16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	B	A	A	C	A	A	A	A	C	A	C	A	A	A

Case study

1.) Implement the *polyline* function using the DDA algorithm, given any number (n) of input points.

2.) How much time is used up scanning across each row of pixels for the duration of screen refresh on a raster system with a resolution of 1290 by 1024 and a refresh rate of 60 frames per second?

3.) Implement a procedure to perform a one-point perspective projection of an object.

4.) Implement a procedure to perform a one-point perspective projection of an object.

Glossary

2D Graphics

Displayed representation of a scene or an object along two axes of reference: height and width (x and y).

3D Graphics

Displayed representation of a scene or an object that appears to have three axes of reference: height, width, and depth (x, y, and z).

3D Pipeline

The process of 3D graphics can be divided into three-stages: tessellation, geometry, and rendering. In the tessellation stage, a described model of an object is created, and the object is then converted to a set of polygons. The geometry stage includes transformation, lighting, and setup. The rendering stage, which is critical for 3D image quality, creates a two dimensional display from the polygons created in the geometry stage.

Anti-aliasing

Anti-aliasing is sub pixel interpolation, a technique that makes edges appear to have better resolution.

Bitmap

A Bitmap is a pixel by pixel image.

Blending

Blending is the combining of two or more objects by adding them on a pixel-by-pixel basis.

Depth Cueing

Depth cueing is the lowering of intensity as objects move away from the viewpoint.

Dithering

Dithering is a technique for archiving 24-bit quality in 8 or 16-bit frame buffers. Dithering uses two colors to create the appearance of a third, giving a smooth appearance to an otherwise abrupt transition.

Flat Shading

The flat shading method is also called constant shading. For rendering, it assigns a uniform color throughout an entire polygon. This shading results in the lowest quality, an object surface with a faceted appearance and a visible underlying geometry that looks 'blocky'.

Hidden Surface Removal

Hidden Surface Removal or visible surface determination entails displaying only those surfaces that are visible to a viewer because objects are a collection of surfaces or solids.

Interpolation

Interpolation is a mathematical way of regenerating missing or needed information. For example, an image needs to be scaled up by a factor of two, from 100 pixels to 200 pixels. The missing pixels are generated by interpolating between the two pixels that are on either side of the pixel that needs to be generated. After all of the 'missing' pixels have been interpolated, 200 pixels exist where only 100 existed before, and the image is twice as big as it used to be.

Lighting

There are many techniques for creating realistic graphical effects to simulate a real-life 3-D object on a 2-D display. One technique is lighting. Lighting creates a real-world environment by means of rendering the different grades of darkness and brightness of an object's appearance to make the object look solid.

Line Buffer

A line buffer is a memory buffer used to hold one line of video. If the horizontal resolution of the screen is 640 pixels and RGB is used as the color space, the line buffer would have to be 640 locations long by 3 bytes wide. This amounts to one location for each pixel and each color plane. Line buffers are typically used in filtering algorithms.

Projection

The process of reducing three dimensions to two dimensions for display is called Projection. It is the mapping of the visible part of a three dimensional object onto a two dimension screen.

Rasterization

Translating an image into pixels.

Rendering

The process of creating life-like images on a screen using mathematical models and formulas to add shading, color, and lamination to a 2D or 3D wireframe.

Transformation

Change of coordinates; a series of mathematical operations that act on output primitives and geometric attributes to convert them from modeling coordinates to device coordinates.

Z-buffer

A part of off-screen memory that holds the distance from the viewpoint for each pixel, the Z-value. When objects are rendered into a 2D frame buffer, the rendering engine must remove hidden surfaces.

Z-buffering

A process of removing hidden surfaces using the depth value stored in the Z-buffer. Before bringing in a new frame, the rendering engine clears the buffer, setting all Z-values to 'infinity'. When rendering objects, the engine assigns a Z-value to each pixel: the closer the pixel to the viewer, the smaller the Z value. When a new pixel is rendered, its depth is compared with the stored depth in the Z-buffer. The new pixel is written into the frame buffer only if its depth value is less than the stored one.

Z-sorting

A process of removing hidden surfaces by sorting polygons in back-to-front order prior to rendering. Thus, when the polygons are rendered, the forward-most surfaces are rendered last. The rendering results are correct unless objects are close to or intersect each other. The advantage is not requiring memory for storing depth values. The disadvantage is the cost in more CPU cycles and limitations when objects penetrate each other.

Filtering

This is a broad word which can mean the removal of coffee grinds from the coffee. However, within the narrow usage of this book, a filtering operation is the same as a convolution operation (see "convolution"). Anti-aliasing is usually done by filtering.

flat projection

A method of projecting a 3D scene onto a 2D image such that the resulting object sizes are not dependent on their position. Flat projection can be useful when a constant scale is needed throughout an image, such as in some mechanical drawings.

Frame

One complete video image. When interlacing is used, a frame is composed of two fields, each containing only half the scan lines.

GIF

A file format for storing images. GIF stands for Graphics Interchange format, and is owned by Compuserve, Inc.

key frame

A selected frame of an animation at which all the scene state is defined. In the key frame animation method, the scene state at key frames is interpolated to create the scene state at the in-between frames.

key frame animation

An animation control method that works by specifying the complete scene state at selected, or key, frames. The scene state for the remaining frames is interpolated from the state at the key frames.

Raster Scan

The name for the pattern the electron beam sweeps out on a CRT face. The image is made of closely spaced scan lines, or horizontal sweeps.

Refresh Rate

The rate at which parts of the image on a CRT are re-painted, or refreshed. The horizontal refresh rate is the rate at which individual scan lines are drawn. The vertical refresh rate is the rate at which fields are drawn in interlaced mode, or whole frames are drawn in non-interlaced mode.

Refresh Rate, Horizontal

The rate at which scan lines are drawn when the image on a CRT is re-drawn, or refreshed.

Refresh Rate, Vertical

The rate at which fields are re-drawn on a CRT when in interlaced mode, or the rate at which the whole image is re-drawn when in non-interlaced mode.

Scan Line

One line in a raster scan. Also used to mean one horizontal row of pixels.

BACHELOR OF COMPUTER APPLICATIONS
(Part III) EXAMINATION
(Faculty of Science)
(Three – Year Scheme of 10+2+3 Pattern)
PAPER 311
COMPUTER GRAPHICS AND IMAGE PROCESSING

Year - 2011

Time allowed : Three Hour   *M. Marks : 50*

Answers of all the questions (objectives as well as descriptive) are to be given in the main answer-book only. Answers of objective type questions must be given in sequential order. Similarly all the parts of one questions of descriptive part should be answered at one place in the answer book. One complete questions should not be answered at different places in the answer book.

No supplementary answer-book will be given to any candidate, hence the candidates should write their answers precisely.

Objective : Part-I
Maximum Marks: 20

It contains 40 multiple choice questions with four choice and student will have to pick the correct one (each carrying 1/2 mark)

1.   Sub-dividing the total and determining the number of sub-pixels inside the area boundary is called:
(a)   Pixel Phasing
(b)   Pixel Weighting
(c)   Filtering
(d)   Super Sampling   ( )

2.   The region against which an object is to be clipped is called:

(a)   Clipping
(b)   Clip Window
(c)   View Port

    (d)   All of the above   ( )

3.   DAC is:
    (a)   Direct Access Code
    (b)   Digital Align Code
    (c)   Direct Area Clipping
    (d)   Digital to Analog converter   ( )

4.   In Cohen-Sutherland line clipping, every line end-point in a picture is assigned a four digit binary code, called:
    (a)   Front point
    (b)   End point
    (c)   Region code
    (d)   All of the above   ( )

5.   In Raster scan displays picture definition is stored in a memory area called:
    (a)   Refresh buffer   (b)   Picture element
    (c)   Pixels   (d)   None of the above   ( )

6.   Polygon-Clipping algorithms include the:
    (a)   Sutherland-Hodgeman method
    (b)   Liang-Barsky method
    (c)   Weiler-Atherton method
    (d)   All of the above   ( )

7.   Oblique projection is:
    (a)   An orthographic projection
    (b)   A perspective projection
    (c)   a parallel projection
    (d)   an axonometric projection   ( )

8.   Two-dimensional viewing transformation is referred as:
    (a)   Window to view port transformation
    (b)   Windowing transformation
    (c)   Both (a) and (b)
    (d)   None of the above   ( )

9.   Typical Raster functions often provided in graphic packages are:
    (a)   Copy
    (b)   Read
    (c)   Write
    (d)   All of the above   ( )

10.   The convolution operation in anti-aliasing is known as:
    (a)   Half-toning   (b)   Filtering

(c)   Shielding   (d)   None of the above   ( )

11.   In LCDs picture definition are stored in a refresh buffer, and the screen is refreshed at the rate of:
(a)   50 Frames per second
(b)   60 Frames per second
(c)   70 Frames per second
(d)   80 Frames per second   ( )

12.   Lower persistence phosphors require:
(a)   lower refresh rate   (b)   high refresh rat e
(c)   any rate
(d)   Specific rate of maintain a smooth picture   ( )

13.   In Wailer-Atherton algorithm for polygon clipping the subject polygon is:
(a)   Clipping window
(b)   Polygon to be clipped
(c)   Any to the above
(d)   None of the above   ( )

14.   In which LCD displays transistors are used to control the voltage at pixel   locations and to prevent charges from leaking out of the liquid crystal cells;
(a)   Passive matrix LCD
(b)   Active Matrix LCD
(c)   Both (a) and (b)
(d)   None of the above   ( )

15.   The process of extracting a portion of a database or a picture:
(a)   Clipping
(b)   Database querying
(c)   Dithering
(d)   None of the above   ( )

16.   Line clipping can also be carried out for:
(a)   Concave
(b)   Polygon clipping windows
(c)   Clipping window
(d)   All of the above   ( )

17.   Conceptually drawing a line from any position P to a distant point outside the coordinate extents of the object and counting the number of edge crossing along   the lines:
(a)   Odd-even rule
(b)   Odd priority rule
(c)   Even-of rule

(d)   All of the above   ( )

18.   Shadow Mask method are used in:
       (a)   Raster Scan monitors
       (b)   Random scan monitors
       (c)   Both (a) and (b)
       (d)   None to the above   ( )

19.   45 degree rotation about y axis will move a vector on x axis to:
       (a)   xz-plane
       (b)   xy-plane
       (c)   yz - plane
       (d)   z-axis   ( )

20.   Active Edge lists are used in:
       (a)   Seed Fill Area Filling
       (b)   Scan Line Area Filling
       (c)   Sutherland-Cohen Algorithm
       (d)   Cyrus-Beck Clipping Algorithm   ( )

21.   A random scan (Vector) system stores point plotting instruction in the:
       (a)   View list
       (b)   Display list
       (c)   Both (a) and (b)
       (d)   None of the above   ( )

22.   The result of mid-point division algorithm is to perform:
       (a)   Breadth First Search
       (b)   Depth First Search
       (c)   Logarithmic Search
       (d)   Best First Search   ( )

23.   Panning on the screen is achieved by:
       (a)   Translation
       (b)   Only translation
       (c)   Scaling translation and back scaling
       (d)   Translation, scaling and back translating   ( )

24.   Which one is an orthographic projection?
       (a)   Cavalier
       (b)   Cabinet
       (c)   Isometric
       (d)   None of the above   ( )

25. In computer graphics Dragging can be achieved through the following transformations:
     (a) Mirror Reflection
     (b) Rotation
     (c) Scaling
     (d) Translation   ( )

26. Foreshortening factors are associated with:
     (a) Orthographic projection   (b) Cabinet projection
     (c) Cavalier projection   (d) Axonometric projection   ( )

27. The set of points such that the sum of the distances from fixed positions the same for all points, is called:
     (a) Mid-point circle
     (b) Ellipse
     (c) Line function
     (d) All of the above   ( )

28. GKS is called as:
     (a) Geometric Kernel System
     (b) Graphical Kernel Shell
     (c) Graphical Kernel System
     (d) None of the above   ( )

29. An image scanner can be used for:
     (a) Text material
     (b) Engineering drawing
     (c) Pictures
     (d) All of the above   ( )

30. Which of the following algorithm follows "Error Term"?
     (a) Brakeman's Line Drawing Algorithm
     (b) Bresenham's Circle Drawing Algorithm
     (c) DDA Line Algorithm
     (d) Mid-point Circle Drawing Algorithm   ( )

31. Interlacing in raster scanning eliminates:
     (a) Only the horizontal retrace   (b) Only the vertical retrace
     (c) Both (a) and (b)   (d) None of the above   ( )

32. Beam penetration method for displaying color pictures has been used with:
     (a) Random scan monitors
     (b) Raster scan monitors
     (c) Both (a) and (b)
     (d) None of the above   ( )

33. A video sequence is usually capered by a video recorder at the rate of:
    (a) 1 Frame/sec.
    (b) 2 frames/sec
    (c) 25 frame/sec.
    (d) 100 frames/sec. ( )

34. Translation operation can resulting:
    (a) Panning
    (b) Zooming
    (c) Interlacing
    (d) Viewing ( )

35. The transformation that distorts the shape of the object such that the shape appears as if the object were composed of internal layer is:
    (a) Scaling   (b) Shearing
    (c) Rotation   (d) Reflection ( )

36. The meaning of the PNG is:
    (a) Portable Network Graphics
    (b) Printable Network Graphics
    (c) Passive Node Graphics
    (d) Pannable Network Graphics ( )

37. CRT is known as:
    (a) Cathode Ray Tude
    (b) Cathode Raw Tude
    (c) Cathode Ray Terminal
    (d) None of the above ( )

38. Which of the following algorithms has the usage of parametric line equation?
    (a) Z-buffer algorithm   (b) Painter's Algorithm
    (c) Sutherland-Cohen Algorithm (d) Cyrus-Beck Algorithm ( )

39. Which of the following is/are considering as graphical input device?
    (a) Scanner
    (b) OCR
    (c) MICR
    (d) All of the above ( )

40. The intensity distribution of the spot on the screen of CRT follows:
    (a) Poisson distribution
    (b) Gaussian distribution
    (c) Any of the above
    (d) None of the above ( )

DESCRIPTIVE PART – II

Year – 2011

Time allowed : 2 Hours   *Maximum Marks : 30*

Attempt any four questions out of the six. All questions carry 7½ marks each.

1. (a)   Explain Bresenham's circle drawing algorithm.
    (b)   Give the advantages and disadvantages of the DDA and Bresnham's algorithm.

2. (a)   What do you mean by Aliasing? How can we remove it ?
    (b)   Differentiate between Random and Raster displays in detail.

3. What is Raster Graphic Algorithm? Describe the granulized Brenham's line algorithm. Also give a suitable example.

4. What is two-dimensional clipping? Explain depth sorting method for visible surface detection method.

5. (a) Explain shadow mask method in detail.
    (b) What do you mean by Flickering? Explain.

6. Write short notes on any three:
    (a) Applications of computer graphics;
    (b) Thresholding
    (c) Parallel Projections;
    (d) Graphics software
    (e) Digital image processing

Computer Graphics and Image Processing

Paper – 311
OBJECTIVE PART – I

Year – 2010

Time : 1 Hr. M. M. : 20

The question paper contains 40 multiple choice questions with four choices and students will have to pick the correct one (each carrying ½ mark).

1. Oblique projection with an angle of 45^0 to the horizontal plane is called as :
   (a) Cabinet projection (b) Isometric projection
   (c) Cavalier projection (d) None of the above ( )

2. The perspective anomaly in which the object behind the centre of projection is projected
   (a) Perspective foreshortening
   (b) Vanishing view
   (c) View confusion
   (d) Topological distortion ( )

3. The entire graph of the function: $f(x) = x^2 + kx - x + 9$ is strictly above the –axis if and only if :
   (a) $-3 < k < 5$ (b) $-3 < k < 2$
   (c) $-3 < k < 7$ (d) $-5 < k < 7$ ( )

4. Raster scan systems display a picture from a definition in a :
   (a) Display file program (b) Frame buffer
   (c) Display controller (d) None of the above ( )

5. Back face removal is an example of :
   (a) Object space method (b) Image space method
   (c) Heuristic method (d) Both (a) and (b) ( )

6. Hue of a color is related to its :
   (a) Luminance (b) Saturation
   (c) Incandescence (d) Wavelength ( )

7. The best suited hidden surface algorithm to deal with non-polygonal non-planar surface patches is:

(a) Painter's algo   (b) Z-buffer algo

(c) Ray Tracing   (d) Scan-line algo   ( )

8.   A view graph is :
      (a) An oversized slide designed for presentation on an O.H.P.
      (b) Designed and created by exposing film to the output of the graphics system.
      (c) A hard copy chart
      (d) None of the above   ( )

9.   The best hidden surface removal algorithm is :
      (a) Painters   (b) Depth buffer
      (c) Area subdivision   (d) Depends on application   ( )

10.   The basic elements a picture in volume graphics is:
      (a) pixel   (b) volsel
      (c) voxel   (d) none of the above   ( )

11.   The point at which a set of projected parallel lines appear to converge in called as a :-
      (a) Convergence point   (b) Vanishing point
      (c) Point of illusion   (d) Point of delusion   ( )

12.   A circle of scaled in only one-dimension becomes a/an :
      (a) Parabola   (b) Hyperbola
      (c) Ellipse   (d) Remains a circle   ( )

13.   If the eccentricity of a conic is less than one then it is a :
      (a) Circle   (b) Parabola
      (c) Ellipse   (d) Hyperbola   ( )

14.   Which of the following device has a relative origin ?
      (a) Joystick   (b) Track ball
      (c) Mouse   (d) None of the above   ( )

15.   Back face removal is an example of :
      (a) Object space method   (b) Image space method
      (c) Both (a) and (b)   (d) Raster scan   ( )

16.   When the computer is not able to maintain operations and display, bright spot occurs
      on the screen? This is called :
      (a) Dropping out   (b) Snowing
      (c) Flickering   (d) Blanking   ( )

17.   Which display device is best suited for CAD systems ?
      (a) A CRT with Raster scan monitor
      (b) A CRT with vector refresh monitor

(c) Plasma panel display

(d) Led display ( )

18. All the following hidden surface algorithm employ image space approach except :
(a) Depth buffer method   (b) Back face removal
(c) Scan line method   (d) Depth sort method ( )

19. $x = at^2$, y=2 at is the parametric equation of a :
(a) Circle   (b) Hyperbola
(c) Parabola   (d) Ellipse ( )

20. Pixel phasing is a technique for :
(a) Shading   (b) Anti-aliasing
(c) Computer object model   (d) None of the above ( )

21. COM stands for :
(a) Component object model   (b) Control method model
(c) Computer object model   (d) None of the above ( )

22. ADO stands for :
(a) Active and Data Object   (b) Active data object
(c) Access data object   (d) Active digital organization ( )

23. The process by which one object acquires the properties of another object is :
(a) Polymorphism   (b) Inheritance
(c) Encapsulation   (d) All of the above ( )

24. Protocol is set of …….and …………that governs data communication.
(a) Rules, common protocol   (b) Rules, model
(c) Rules, common language   (d) Rules, common model ( )

25. A TV broadcast in an example of :
(a) Half duplex   (b) Duplex
(c) Half simplex   (d) Simplex ( )

26. The …………….. layer lies between the transport and application layer.
(a) Data link   (b) Physical
(c) Network   (d) Session ( )

27. To provide comfort to computer user, the graphics screen must be refreshed at the rate of ………………
(a) 5 frames / sec   (b) 20 frames / sec
(c) 90 frames / sec   (d) 200 f/s ( )

28. Dragging in computer graphics can be achieved

(a) Translation　　　　　　　　　(b) Rotation

(c) Scaling　　　　　　　　　　　(d) Modelling　　　　　　( )

29. 45 degree volution about y-axis will move a vector on x-axis to:
    (a) xz-plane　　　　　　　　　(b) xy-plane
    (c) yz-plane　　　　　　　　　(d) z-axis　　　　　　( )

30. Seed fill algorithms using a stack use the principle of :
    (a) Last in first out　　　　　　(b) F.I.F.O
    (c) F.I.L.O　　　　　　　　　　(d) None of the above　　( )

31. A multimedia PC get booted through :
    (a) RAM　　　　　　　　　　　(b) ROM
    (c) Cache　　　　　　　　　　　(d) DVD　　　　　　　( )

32. The format for storing digital audio is multimedia application :
    (a) JPEG　　　　　　　　　　　(b) TIFF
    (c) WAV　　　　　　　　　　　(d) BMP　　　　　　　( )

33. Data mining consist of:
    (a) Extraction of data
    (b) Comparison of database
    (c) Arranging the data
    (d) All of the above　　　　　　　　　　　　　　　　( )

34. Which of the following class of statements usually produce no object code when compiled ?
    (a) Assignment　　　　　　　　(b) Declaration
    (c) Unreachable　　　　　　　　(d) Control　　　　　　( )

35. Val is a well known :
    (a) Real time language　　　　　(b) Object oriented language
    (c) Command language　　　　　(d) Data flow language　　( )

36. The period of time betweenan allocation and its subsequent disposal is called :
    (a) Scope　　　　　　　　　　(b) Binding
    (c) Lifetime　　　　　　　　　(d) Longevity　　　　　( )

37. Heap allocation is required for languages that :
    (a) Support recursion　　　　　(b) Support dynamic data structure
    (c) Use dynamic scope rules　　　(d) None of the above　　( )

38. Assuming that one allows 256 depth value levels to be used how much memory would a 512 x 512 pixel display require to store the z-buffer :
    (a) 5l2 k　　　　　　　　　　(b) 256 k
    (c) 1024 k　　　　　　　　　　(d) 128 k　　　　　　　( )

39. A surface appearing block ;
    (a) Reflects all the incident colors
    (b) Reflects all the incident colors expect block
    (c) Reflects only block and absorbs the rest
    (d) Reflects none ( )

40. E-R modelling technique is a :
    (a) Top-down approach   (b) Bottom up approach
    (c) Left-right approach   (d) None of the above ( )

Answer key:

1. (c)	2. (c)	3. (c)	4. (b)	5. (a)	6. (d)	7. (b)	8. (b)	9. (a)	10. (a)
11. (b)	12. (c)	13. (c)	14. (b)	15. (a)	16. (c)	17. (a)	18. (b)	19. (c)	20. (b)
21. (a)	22. (b)	23. (b)	24. (d)	25. (d)	26. (d)	27. (c)	28. (a)	29. (a)	30. (a)
31. (b)	32. (c)	33. (d)	34. (c)	35. (d)	36. (c)	37. (b)	38. (a)	39. (b)	40. (c)

DESCRIPTIVE PART – II

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Year – 2010

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Time allowed : 2 Hours   *Maximum Marks : 30*

Attempt any four questions out of the six. All questions carry 7½ marks each.

Prob.1 (a) What is gray scale? Write the applications of Raster scan displays.
      (a) What is homogenous coordinate system?

Prob. 2 (a) Write the line drawing algorithm. What is graphical data?
      (b) What are the elements of digital image processing system? What is image enhancement?

Prob. 3 (a) What is stereo imaging? Write area fill algorithm.
      (b) What is depth sorting method? Write a note on convolutions.

Prob. 4 (a) Explain the terms 'scaling' and translation in the context of 3-D transformation.
      (b) Write Sutheriand-Cohen sub-division algorithm.

Prob. 5 (a) What is LCD technology? What do you mean by visual quantization?
      (b) How is a digital image captured and stored? What is parallel projection?

Prob. 6 Write short notes on the following:
(a)   Inverse transformation
(b)   Graphics softwares (GKS, PHIGS)
(c)   Look-up tables.

Computer Graphics and Image Processing

Paper – 311
OBJECTIVE PART – I

Year – 2009

Time : 1 Hr. M. M. : 20

The question paper contains 40 multiple choice questions with four choices and students will have to pick the correct one (each carrying ½ mark).

1. Pixel is:
   (a) The smallest addressable point on the screen
   (b) An input device
   (c) A memory block p
   (d) A deals structure ( )

2. Resolution is defined as:
   (a) The number of pixels in the horizontal direction $\times$ the number of pixels in the vertical direction .
   (b) The number of Pixel in the vertical direction $\times$ the number of pixels in the horizontal direction .
   (c) The number of pixels in the horizontal direction + the number of pixels in the vertical direction
   (d) The number of pixels in the vertical direction -the number of pixels in the horizontal direction
   ( )

3. Aspect ratio is :
   (a) The ratio of image's width to its height.
   (b) The ratio of window to view port height .
   (c) The ratio of image's intensity levels .
   (d) The ratio of image's height to its width. ( )

4. World co-ordinate system is :
   (a) The co-ordinate system in which the image is defined
   (b) The co-ordinate system in which the object is defined
   (c) The co-ordinate system in which the surfaces are defined
   (d) The co-ordinate system in which transfer motors are performed ( )

5. Frame buffer is :
   (a) The memory area in which the image being displayed is stored

(b) The device which controls the refresh rate

(c) The device used to displaying the colors of an image

(d) The memory area in which the graphics package is stored ( )

6. Aliasing means :
   (a) Rendering effect (b) Shading effect
   (c) Staircase effect (d) Cueing effect ( )

7. A 512 $\times$ 512 raster requires .... bits in a bit plane.
   (a) 2^{12} (b) 2^{18}
   (c) 2^{10} (d) 2^{8} ( )

8. The look up table technique .... the number of intensity levels.
   (a) Decreases (b) Increases
   (c) Removes (d) Gives no effect on ( )

9. A simple 3-bit plane frame buffer can have .... number color combinations.
   (a) 8 (b) 16
   (c) 24 (d) 3 ( )

10. RGB stands for :
    (a) Resolution Global Bright (b) Resolution of Green and Blue
    (c) Red-Green-Blue (d) None of the above ( )

11. In a 3 -bit plane buffer 011 represents .... color.
    (a) Red (b) Cyan
    (c) Black (d) Green ( )

12. If blue is represented by 1001 then yellow is represented as:
    (a) 001 (b) 010
    (c) 101 (d) 011 ( )

13. A 24-bit plane color frame buffer with three 10-bit wide color look up table can have .... number of colors.
    (a) 2^{24} (b) 2^{8}
    (c) 2^{48} (d) 2^{30} ( )

14. DAC stands for ....
    (a) Direct Accessing Code (b) Digitally Activated Compression
    (c) Direct Area Clipping (d) Digital to Analog Converter ( )

15. .... acts as anode in CRT.
    (a) The phosphorous coating (b) Thee glass panel
    (c) The deflectors (d) None of the above ( )

16. The slope of the line joining the points (1, 2) and (3, 4) is :
    (a) 0   (b) 1
    (c) 2   (d) 3   ( )

17. Bresenhamn's circle generation algorithm will take reflections of ....
    (a) Two octets   (b) One octet ·
    (c) Three octets   (d) None of the above   ( )

18. In Bresenhamn's circle generation algorithm, if (x, y) is the current pixel position then y-value of the next pixel position is :
    (a) y or y + 1   (b) y alone
    (c) y + 1 or y - 1   (d) y or y—1   ( )

19. Run length coding is used for :
    (a) Image smoothening   (b) Image compression
    (c) Image coloring   (d) Image dithering   ( )

20. The property that adjacent pixels on a scan line are likely to have the same characteristics is called:
    (a) Spatial coherence   (b) Area coherence
    (c) Scan line coherence   (d) Pixel coherence   ( )

21. The technique of using a minimum number of intensity levels to obtain increased visual resolution is called:
    (a) Dithering   (b) Half toning
    (c) Depth cueing   (d) Rendering   ( )

22. If X_L, X_R, Y_B, Y_T represent the four parameters of x-left, x-right, y—bottom and y-top of a clipping window and (x, y) is a point such that $y > y_T$ then (x, y) lies:
    (a) Inside the Window
    (b) Outside the Window
    (c) On the boundary of the Window
    (d) None of the above   ( )

23. The Cohen-Sutherland line clipping algorithm decides the entire region into .... number of sub-regions.
    (a) 4   (b) 8
    (c) 9   (d) 10   ( )

24. .... number of bits are used for representing each subregion of Cohen-Sutherland line clipping algorithm :
    (a) 1   (b) 2
    (c) 3   (d) 4   ( )

25. lf bits are zeros and two bits are ones in a code of subregion in Cohen-Sutherland line clipping algorithm then the subregion is :
    (a) Comer region (b) Middle region
    (c) Central region (d) None of the above ( )

26. In the Cohen-Sutherland line clipping algorithm, if codes of the two points P and Q are 0101 and 0001 then the line segment joining the points P and Q will be the clipping window:
    (a) Totally outside (b) Partially outside
    (c) Totally inside (d) None of the above ( )

27. 1f X_L, .X_R, Y_B, Y_T represent the four parameters of x-left, x—right, y—bottom and y-top of a clipping window and (x, y) is a point inside the window such that $x > X_L$ and $x > X_L$ and $Y_B \leq y \leq Y_T$, then the code of the point (x, y) in Cohen—Sutherland algorithm :
    (a) 1100 (b) 1000
    (c) 1110 (d) 0000 ( )

28. Suppose (x_1, y_1), (x_2, y_2) .... (x_n, y_n) are n vertices of a closed polygon and (x, y) is a point such that x is less than the minimum of { x_1, x_2 .... x_n} then the point (x, y) lies .... the polygon.
    (a) inside (b) outside
    (c) on (d) as vertex of ( )

29. Suppose (x_1, y_1), (x_2, y_2) .... (x_n, y_n) are n vertices of a closed polygon and (x, y) is a point such that y is less than the minimum of {y_1, y_2 .... y_n} then the point (x, y) lies .... the polygon.
    (a) inside (b) outside
    (c) on (d) as vertex of ( )

30. ln a polygon inside test, if the winding number of a point is zero, then the point lies .... the polygon.
    (a) inside (b) outside
    (c) on (d) as vertex of ( )

31. The even-odd method of polygon inside test fails for :
    (a) Self intersecting polygons (b) Convex polygons
    (c) Concave polygons (d) Similar polygons ( )

32. z-buffer algorithm is used for ....
    (a) Frame buffer removal (b) Hidden line removal
    (c) Rendering (d) Animation ( )

33. The blending functions of Bezier curves are :
    (a) Splines (b) Berstien polynomials

(c) Lagrangian polynomial   (d) Newton polynomials   ( )

34. The equivalent representation of a two-dimensional point (x, y) in the homogeneous co-ordinate system is :
(a) (x,y,1)   (b) (x,y,0)
(c) (x/w; y/w)   (d) (x, y, x—y)   ( )

35. If (x, y, w), $w \not\subset 0$ is a point in a homogeneous co-ordinate system then its equivalent in two-dimensional system is:
(a) (my. 1)   (b) (x,y,0)
(c) (x/w, y/w)   (d) (x,y, x—y)   ( )

36. The two dimensional matrix transformation for scaling with a units along x-axis and b-units along y-axis is:

(a) $\begin{pmatrix} a & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & 1 \end{pmatrix}$ (b) $\begin{pmatrix} -a & 0 & 0 \\ 0 & -b & 0 \\ a & b & 1 \end{pmatrix}$

(c) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ a & -b & 1 \end{pmatrix}$ (d) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ b & a & 1 \end{pmatrix}$ ( )

37. The two-dimension at matrix transformation for reflection of a point with respect to x-axis is :

(a) $\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ (b) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

(c) $\begin{pmatrix} 1 & 0 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ (d) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$ ( )

38. Perspective projection is characterized by the :
(a) View plane alone
(b) Direction of the projection and the view plane
(c) Centre of projection and view plane
(d) Center of projection alone   ( )

39. Oblique projection is :
(a) An orthographic projection
(b) A perspective projection
(c) A parallel projection
(c) Axonometric projection   ( )

40.   The three-dimensional matrix transformation for relation with an angle θ with respect to y-axis in the positive direction is :

(a) $\begin{pmatrix} \cos\theta & 0 & -\sin\theta & 0 \\ \sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(b) $\begin{pmatrix} \cos\theta & 0 & \sin\theta & 0 \\ \sin\theta & 0 & -\cos\theta & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(c) $\begin{pmatrix} 1 & \cos\theta & \sin\theta & 0 \\ 0 & -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(d) $\begin{pmatrix} \cos\theta & \sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ ( )

Answer Key:

1. (a)	2. (a)	3. (a)	4. (c)	5. (d)	6. (c)	7. (b)	8. (a)	9. (d)	10. (c)
11. (b)	12. (d)	13. (a)	14. (a)	15. (a)	16. (b)	17. (a)	18. (d)	19. (c)	20. (c)
21. (b)	22. (b)	23. (c)	24. (d)	25. (a)	26. (a)	27. (d)	28. (b)	29. (b)	30. (b)
31. (a)	32. (b)	33. (a)	34. (a)	35. (a)	36. (a)	37. (b)	38. (c)	39. (c)	40. (a)

DESCRIPTIVE PART – II

Year – 2009

Time allowed : 2 Hours   *Maximum Marks : 30*

Attempt any four questions out of the six. All questions carry 7½ marks each.

Prob. 1 (a) Discuss the terms lookup table and aspect ratio in detail.
    (b) Explain the RGB color model in brief.

Prob. 2   (a) Discuses the terms: Pixel, Frame Buffer, bit plane and dpi.
    (b) What is the rate of a 1024 x 1024 frame buffer with an average access rate per pixel of 200 nanoseconds on a simple color display?

Prob. 2   Write and discuss the line drawing algorithms. Which one is best? Why?

Prob. 3 (a) How many geometrical transformation are there? Write their names. Discuss one of them in brief.
    (b) Derive the transformation that rotates an object point 0° a about the origin. Write the matrix representation for the rotation.

Prob. 4 (a) Explain the term windows and viewport in detail.
    (b) Write the Cohen-Sutherland algorithm.

Prob. 5 (a) Explain the scaling and translation in the context of three dimensional transformations.
    (b) Define the tilting as a rotation about the x-axis followed by the rotation about y-axis. Find the tilting matrix for the same.

Prob. 6 (a) Define digital image processing. Write and explain the difference between DIP and computer graphics.
    (b) How can you store and capture a digital image? Discuss.

Computer Graphics and Image Processing

Paper – 311
OBJECTIVE PART – I

Year – 2008

Time : 1 Hr.   M. M. : 20

The question paper contains 40 multiple choice questions with four choices and students will have to pick the correct one (each carrying ½ mark).

1. Shadow-mask methods are used in :
    (a) Raster-scan monitors   (b) Random-scan monitors
    (c) Both (a) and (b)   (d) None of the above   ( )

2. In LCD's picture definition are stored in a refresh buffer, and the screen is refreshed at the rate of:
    (a) 50 frames per second   (b) 60 frames per second
    (c) 70 frames per second   (d) 80 frames per second   ( )

3. In which LCD displays transistors are used to control the voltage at pixel locations and to prevent charges from leaking out of the liquid crystal cells:
    (a) Passive Matrix LCD   (b) Active Matrix LCD
    (c) Both (a) and (b)   (d) None of the above   ( )

4. The region against which an object is to be clipped is called :
    (a) Clipping   (b) Clip window
    (c) View port   (d) All of the above   ( )

5. In raster-scan displays picture definition is stored in a memory area called:
    (a) Refresh buffer   (b) Picture element
    (c) Pixels   (d) None of the above   ( )

6. Typical raster functions often provided on graphic packages are;
    (a) Copy   (b) Read
    (c) Write   (d) All of the above   ( )

7. I f a user wants to recolor an area that is not defined within a single color boundary, then the algorithm is used :
    (a) Boundary fill algorithm

(b) Recursive boundary till algorithm

(c) Flood till algorithm A

(d) All of the above ( )

8. Subdividing the total area and determining the number of sub pixels inside the area boundary is called:

(a) Pixel phasing (b) Pixel weighting

(c) Filtering (d) Super sampling ( )

9. To generate a rotation, we have to specify :

(a) A rotation angle (b) Rotation point

(c) Both (a) and (b) (d) None of the above ( )

10. Two-Dimensional viewing transformation is referred as :

(a) Window to view port transformation

(b) Windowing transformation

(c) Both (a) and (b)

(d) None of the above ( )

11. In Cohen-Sutherland line clipping, every line end point in a picture is assigned a four digit binary code, called:

(a) Front point (b) End point

(c) Region point (d) All of the above ( )

12. Line clipping can also be carried out for:

(a) Concave (b) Polygon clipping window

(c) Clipping window (d) All of the above ( )

13. Polygon-clipping algorithms include the:

(a) Sutherland-Hodgeman method

(b) Liang-Barsky method

(c) Weiler-Atherton method

(d) Both (a) and (c) ( )

14. Graphics software includes:

(a) PHIGS (b) GKS

(c) Both (a) and (b) (d) None of the above ( )

15. CGI refers as :

(a) Common Graphics Interface

(b) Computer Graphics Interface

(c) Computer Graphics Interconnection

(d) None of the above ( )

16. A random scan (vector) system stores point plotting instructions in the :

(a) View list   (b) Display list
(c) Both (a) and (b)   (d) None of the above   ( )

17.   The set of points such that the sum of the distances from two fixed positions is the
       same for all points, is called :
       (a) Midpoint circle   (b) Ellipse
       (c) Line function   (d) All of the above   ( )

18.   Conceptually drawing a line from any position P to a distant point outside the
       coordinate extents of the object and counting the number of edge crossing along the
       lines:
       (a) Odd-even rule   (b) Odd priority rule
       (c) Even-odd rule   (d) All of the above   ( )

19.   Lookup table contains :
       (a) 1000 entries   (b) 255 entries
       (c) 256 entries   (d) None   ( )

20.   DDA is defined as :
       (a) Digital different algorithm (b) Digital difference analyzer I
       (c) Digital diierential analyzer (d) None of the above   ( )

21.   Which one is an orthographic projection :
       (a) Cavalier   (b) Cabinet
       (c) lsometric   (d) None of the above   ( )

22.   Lower persistence phosphors requires :
       (a) Lower refresh rate
       (b) High refresh rate
       (c) Any rate
       (d) Specific rate to maintain a smooth picture   ( )

23.   Beam penetration method for displaying color pictures has been used with :
       (a) Random scan monitors   (b) Raster scan monitors
       (c) Both (a) and (b)   (d) None of the above   ( )

24.   ln Weiler-Atherton algorithm for polygon clipping the subject polygon is:
       (a) Clipping window   (b) Polygon to be clipped
       (c) Any of the above   (d) None of the above   ( )

25.   Dragging in computer graphics can be achieved through the following transformation
       :
       (a) Translation   (b) Rotation
       (c) Scaling   (d) Mirror retlection   ( )

26. An image scanner can be used for storing :
    (a) Textmaterial (b) Engineering drawing
    (c) Pictures (d) All of the above ( )

27. Bresenhamn's circle drawing algorithm involves :
    (a) Solving equation of the circle A
    (b) Calling a look up table to get points corresponding to a particular value of radius
    (c) Completion of location of individual pixel on each part of the circle
    (d) Only integer calculations ( )

128. lnterlacing in raster scanning eliminates :
    (a) Only the horizontal retrace (b) Only the vertical retrace
    (c) Both (a) and (b) (d) None of the above ( )

29. Translation operation can result in :
    (a) Panning (b) Zooming
    (c) lnterlacing (d) Viewing ( )

30. A homogeneous coordinate system corresponding to N dimensional coordinate
    system provides :
    (a) N dimensions (b) N+1 dimension `
    (c) N+2 dimension (d) None of the above ( )

31. The electron beam in CRT can be cancelled with :
    (a) Electric field (b) Magnetic field
    (c) Any of the above. (d) None of the above ( )

32 The intensity distribution of the spot on the screen of CRT follows :
    (a) Poisson distribution (b) Gaussian distribution 1
    (c) All of the above (d) None of the above ( )

33. The transformation that distorts the shape of the object such that the shape appears as
    if the object were composed of internal layer is : X
    (a) Scaling (b) Shearing .
    (c) Rotation (d) Reflection ( )

34. Foreshortening factors are associated with :
    (a) Orthographic projection (b) Cabinet projection
    (c) Cavalier projection (d) Axonometric projection ( )

35. Active Edge lists are used in :
    (a) Seed Fill Area Filling (b) Scan Line Area Filling
    (c) Sutherland Cohen Algorithm (d) Cyrus-Beck Clipping Algorithm ( )

36. GKS stands for :

(a) Graphical Kernel System   (b) Graphical Kernel Shell
(c) Geometric Kernel System   (d) None of the above   ( )

37.   The meaning of the PNG is :
       (a) Portable Network Graphics
       (b) Printable Network Graphics
       (c) Passive Node Graphics
       (d) Pannable Network Graphics   ( )

38.   A video sequence is usually captured by a video recorder at the rate of :
       (a) l frame/sec   (b) 2 frames/sec
       (c) 25 frames/sec   (d) 100 names/sec   ( )

39.   Which of the following algorithms has the usage of parametric line equation:
       (a) Z-buffer Algorithm
       (b) Painter's Algorithm
       (c) Sutherland Cohen Algorithm
       (d) Cyrus-Beck Algorithm   ( )

40.   Which of the following algorithm follows 'Error Term' :
       (a) Bresenhamn's Line Drawing Algorithm
       (b) Bresenhamn's Circle Drawing Algorithm
       (c) DDA Line Algorithm
       (d) Mid-point Circle Drawing Algorithm   ( )

Answer Key:

1. (a)	2. (b)	3. (b)	4. (b)	5. (a)	6. (d)	7. (c)	8. (b)	9. (c)	10. (a)
11. (c)	12. (b)	13. (d)	14. (c)	15. (b)	16. (b)	17. (b)	18. (a)	19. (c)	20. (c)
21. (c)	22. (b)	23. (a)	24. (b)	25. (c)	26. (d)	27. (d)	28. (c)	29. (d)	30. (b)
31. (a)	32. (b)	33. (a)	34. (a)	35. (a)	36. (a)	37. (a)	38. (c)	39. (d)	40. (c)

DESCRIPTIVE PART – II

Year – 2008

Time allowed : 2 Hours   *Maximum Marks : 30*

Attempt any four questions out of the six. All questions carry 7½ marks each.

Prob. 1 (a) Explain the midpoint ellipse drawing algorithm.
      (b) Explain the HSV color model.

Prob. 2 (a) What is the concept of 'Flickering'? Explain it.
      (b) Define image processing. What are the application areas of digital image
        processing?

Prob. 3 (a) Describe the generalized Bresenhamn's line algorithm. Also give a suitable
        example.

Prob. 4 What do you mean by clipping operations? Explain different types of clipping
        operation algorithms. Also give a suitable example.

Prob. 5 (a) Explain Two-Dimensional viewing function.
      (b) Define the concept of antialiasing in detail.

Computer Graphics and Image Processing

Paper – 311
OBJECTIVE PART – I

Year – 2007

Time : 1 Hr.   M. M. : 20

The question paper contains 40 multiple choice questions with four choices and students will have to pick the correct one (each carrying ½ mark).

1.   Raster scan display means that the screen is scanned :
        (a) Top to bottom and right to left
        (b) Left to right and top to bottom
        (c) Bottom to top and left to right
        (d) Bottom to top and right to left   ( )

2.   To provide comfort to the computer user, the graphics screen must be refreshed at the rate of :
        (a) 5 Eames per second   (b) 20 Eames per second
        (c) 50 Eames per second   (d) 200 Eames per second   ( )

3.   An image scanner can be used for storing :
        (a) Text material   (b) Engineering drawing
        (c) Pictures   (d) All of the above   ( )

4.   One of the following applications is not directly linked with multimedia :
        (a) Advertising   (b) Games development
        (c) CBT   (d) Accounting   ( )

5.   Dragging in computer graphics can be achieved through following transformations :
        (a) Translation   (b) Rotation
        (c) Scaling   (d) Mirror reflection   ( )

6.   ln 2D graphics [420] represent a point :
        (a) Lying at infinity   (b) (4,2)
        (c) (4, 2) and also (2, l)   (d) Invalid representation   ( )

7.   A rectangle has been drawn on the screen. lt is desired to carry out a zoom-in-process to double the size of the rectangle. This process would involve :

(a) Only scaling
(b) Scaling and translation
(c) Scaling and rotation
(d) Translation, scaling and translation back ( )

8. Which of the following pairs has similar functions ?
(a) Track ball and light pen (b) Digitizing tablet and mouse
(c) Mouse and light pen (d) Light pen and digitizing tablet ( )

9. The scanline Seed till algorithm :
(a) Can work for figures with holes
(b) Cannot work for figures with holes
(c) Can work only for figures with straight edges
(d) Cannot work for concave figure ( )

10. 45 degree rotation about y-axis will move a vector on x-axis to :
(a) xz-plane (b) XY-plane
(c) yz-plane (d) z-axis ( )

11. Which of the following attributes is important for presenting text in multimedia document:
(a) Font (b) Character format
(c) Colour (d) All the three mentioned. above ( )

12. The dot product of two vector is 12. If one of the vector is 3I, the other ? vector is 2 I
(a) 4J (b) 4I + 4J +4K
(c) 4K (d) 2J + 2 K ( )

13. Bresenhamn's circle drawing algorithm involves
(a) Solving equation of the circle
(b) Calling a look up table to get points corresponding to a particular value of radius
(c) Computation of location of individual pixel on each part of the circle
(d) Only integer calculation ( )

14. Panning on the screen is achieved by :
(a) Translation
(b) Back Scaling ,
(c) Scaling translation and back scaling
(d) Translation, scaling and back translation ( )

15. Seed fill algorithms, using a stack use the principle of :
(a) Last in first out (b) First in first out
(c) First in last out (d) Last in last out ( )

16. The result of midpoint subdivision algorithm is to perform :

(a) Breadth first search   (b) Depth first search
(c) Logarithmic search   (d) Best first search   ( )

17. The end points of a given line are (0, 0) and (6, 8). The slope and y intercept are computed as :
(a) 3, 3   (b) 0, 3
(c) 3, 0   (d) 3,-3   ( )

18. Interlacing in raster scanning eliminates :
(a) Only the horizontal retrace
(b) Only the vertical retrace
(c) Both horizontal and vertical retrace
(d) None of the above   ( )

19. The principal vanishing points for the standard probative transformation are :
(a) Three   (b) Two
(c) One   (d) None of the above 4   ( )

20. If the window parameters- are $X_{w_{min}} = 1$, $X_{w_{min}} = 3$ and the viewport parameters $X_{V_{min}} = O$, $X_{V_{min}} = 1$, the scale S_X is :
(a) 1   (b) 1/2
(c) 2   (d) 1/4   ( )

21. A homogeneous coordinate system corresponding to N-dimensional " coordinate system provides:
(a) N-dimensions   (b) N + 1 dimensions
(c) N + 2 dimensions   (d) None of the above   ( )

22. The following matrix :,

$$\begin{bmatrix} 1 & a & 0 \\ b & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

defines a transformation called :
(a) Translation   (b) Rotation
(c) Scaling   (d) Shearing   ( )

23. Display resolution of a typical monitor would be around :
(a) 10 dpi   (b) 60 dpi
(c) 200 dpi   (d) 300 dpi   ( )

24. Which one of the following transmits digital information to computer :
(a) Joystick   (b) Mouse
(c) Graphics tablet   (d) None of the above   ( )

25. An object is viewed by using perspective transformation equations. Then the maximum number of principal vanishing points possible are :
    (a) 1   (b) 2
    (c) 3   (d) Infinite   ( )

26. One of the following is not related to multimedia :
    (a) FoxPro   (b) Authorware
    (c) Director   (d) Animatorpro   ( )

27. A multimedia PC get booted through :
    (a) ROM   (b) RAM
    (c) Cache   (d) CD-ROM   ( )

28. Translation operations can result in :
    (a) Panning   (b) Zooming s
    (c) lnterlacing   (d) Viewing   ( )

29. A video sequence is usually captured by a video recorder at the rate of :
    (a) 1 frame/sec   (b) 2 frames/sec
    (c) 25 frames/sec   (d) 100 frames/sec   ( )

30. ln 3D graphics the homogeneous coordinates (0, 5, 0, 0) :
    (a) Are not allowed
    (b) Represent a point x = 0, y = 5, z = 0 C
    (c) Represent a point in y-axis at infinity 5
    (d) Represent a point on x-axis or z-axis at infinity   ( )

31. For carrying out Sutherland-Cohen clipping the end point codes of 4 line are given below. Find out which one will be totally invisible from the clipping window :
    (a) 0000, 0000   (b) 0l00, 1000
    (c) 000l, 1000   (d) 0ll0, 1010   ( )

32. Hypermedia :
    (a) ls another media like graphics, text etc
    (b) Provides link between two media .
    (c) Is a facility to permit two media to be played together
    (d) Is another name for multimedia   ( )

33. AutoCAD is :
    (a) An abbreviation for automatic calculation and drawing
    (b) A standard software for drawing and building machine parts
    (c) A software to generate scenarios
    (d) Used to provide shading effects in drawings   ( )

34. The quality of a picture produced by a laser printer would depend on :

(a) Its resolution

(b) Size of picture file

(c) Its internal memory

(d) Resolution of the monitor where it is displayed before it is sent for printing   ( )

35. The scope of a Cubic Benzier curve at the shut of the curve is controlled by :

     (a) First control point   (b) First 2 control points

     (c) First 3 control points   (d) All 4 control points   ( )

36. The format for storing digital audio in multimedia application is :   ( )

     (a) JPEG   (b) TIFF

     (c) WAV   (d) BMP   ( )

37. The cross product of two vector :

     (a) Lies in the same plane as the vectors

     (b) Has a smaller magnitude than either of the vector

     (c) Has a large magnitude than either of the vector

     (d) Is perpendicular to a plane containing the vector   ( )

38. Data mining consists of :

     (a) Extraction of data   (b) Comparison of database

     (c) Arranging the data   (d) All of the above   ( )

39. The use of look up tables in display monitor is to :

     (a) Increase the resolution of the picture on the screen

     (b) Increase the range of colour shades

     (c) Provides a variety of color palettes but number of available colours remain same

     (d) Store the colour information of the pictures   ( )

40. To store good quality sound the audio signal in a multimedia PC is sampled at the rate of :

     (a) 44.l Hz   (b) 4.4l kHz

     (c) 44kHz   (d) 4.4l MHz   ( )

Answer Key:

1. (b)	2. (b)	3. (d)	4. (d)	5. (c)	6. (d)	7. (a)	8. (c)	9. (c)	10. (a)
11. (d)	12. (a)	13. (d)	14. (d)	15. (a)	16. (a)	17. (a)	18. (c)	19. (b)	20. (b)
21. (b)	22. (d)	23. (c)	24. (c)	25. (c)	26. (a)	27. (d)	28. (d)	29. (c)	30. (a)
31. (d)	32. (b)	33. (b)	34. (b)	35. (d)	36. (c)	37. (d)	38. (a)	39. (d)	40. (a)

DESCRIPTIVE PART – II

Year – 2007

Time allowed : 2 Hours   *Maximum Marks : 30*

Attempt any four questions out of the six. All questions carry 7½ marks each.

Prob. 1 Describe briefly Bresenhamn's circle drawing algorithm.

Prob. 2 What are the various input devices used for graphics? Explain Scan Line Seed Fill Algorithm.

Prob. 3 (a) Discuss the merits and demerits of various clipping algorithms.
(b) Distinguish between windows and viewport.

Prob. 4 Write short notes on the following:
    (a)   Liquid crystal display
    (b)   Homogeneous coordinate system.

Prob. 5 (a) Explain the back face removal method.
(b) What are orthographic projections? When do we need them?

Prob. 6 (a) Define 'Flickering'. What is its solution?
(b) Discuss the HSV colour model.

Computer Graphics and Image Processing

Paper – 311
OBJECTIVE PART – I

Year – 2006

Time : 1 Hr.   M. M. : 20

The question paper contains 40 multiple choice questions with four choices and students will have to pick the correct one (each carrying ½ mark).

1.   What is full form of the acronym GKS ?
     (a) Graphical Kernel System   (b) Graphical Korn Shell
     (c) Geometric Kemal System   (d) None of the above   ( )

2.   Digital zoom operation of a digital camera is :
     (a) Increasing resolution of image after capture
     (b) Same as the zoom operation performed in an image editing utility on computer
     (c) Used to bring farther objects closer before image capture
     (d) None of the above   ( )

3.   Which of the following is not a type of logical input device ?
     (a) Locator   (b) Stroke
     (c) Tablet   (d) Pick   ( )

4.   How many principal vanishing points are possible ?
     (a) Two   (b) Three
     (c) Four   (d) Infinite   ( )

5.   In Surtherland Cohen Algorithm for clipping, an end point lying outside the left margin of the window has the following code
     (a) 00l0   (b) 1001
     (c) 1000   (d) 0001   ( )

6.   Which of the following projections are oblique in nature ?
     (a) Trimetric   (b) Orthographic
     (c) Cavalier   (d) Three-point   ( )

7.   In an inkjet printer, colour printing is possible through generation of colour by :
     (a) Four colour cartridges

(b) Seven colour cartridges

(c) Spraying liquid droplets of different colours and shades on the paper

(d) A device which mixes different colours inside the printer to produce the desired shade ( )

8. During a projection, if the projectors appear to be converting at some distance from the plane of projection, then it is :
   (a) Perspective projection (b) Parallel projection .
   (c) Oblique projection (d) All of the above ( )

9. Foreshortening factors are associated with :
   (a) Orthographic projection (b) Cabinet projection r
   (c) Cavalier projection (d) Axonometric projection ( )

10 Which of the following is not a Hidden Surface Removal or Visible Surface Detection Algorithm
   (a) Floating Horizon Algorithm
   (b) Warnock's Algorithm
   (c) Area Subdivision Algorithm
   (d) Active Edge List Algorithm ( )

11. The homogenous coordinate equivalent to 12, 31 is :
   (a) [231] (b) [4621]
   (c) {12 18 6} (d) All of the above ( )

12. Which of the following display devices support 'selective erasing' ?
   (a) DVST (b) Random Scan
   (c) Raster Scan (d) None of the above ( )

13. In computer animation, each frame is called ;
   (a) Still (b) Pixmap
   (c) Key frame (d) Image ( )

I4. In which type of parallel projections, the foreshortening factors are all different ? .
   (a) Axonometric (b) Trimetric
   (c) Isometric (d) Diametric ( )

15. The conduction operation in antialiasing is also called as :
   (a) Filtering (b) Pre-sampling
   (c) Aliasing (d) None of the above ( )

16. In cavalier oblique projection, the angle between the oblique projector and the plane of projection is :
   (a) 63.43° (b) 30° 1
   (c) 45° V A (6) 60° - ( )

17. What does 'K' in the CMYK colour model stand for ?
    (a) Krimson
    (b) Black P
    (c) Kohen
    (d) 'There isnosiiclimodelasCMYK ( )

18. If a line is drawn by using DDA, brightness will be uniform only in case of : t — §
    (a) Horizontal lines   (b) Vertical lines t
    (c) inclined-lines with slopes   (d) All of the above ( )

19. Flat panel displays have one of the following advantages :
    (a) Reduced weight   (b) Reduced volume
    (c) Better display   (d) All of the above ( )

20. Which of the following term is not associated with computer graphics ?
    (a) Locator   (b) Stroke e
    (c) Pick   (d) Roll-over ( )

21. PNG stands for:
    (a) Portable Network Graphics   (b) Printable Network Graphics
    (c) Passive Node Graphics   (d) Pannable Network Graphics ( )

22. Image aspect ratio in windows is :
    (a) 4 : 3   (b) 1 : 1
    (c) 3 : 4   (d) None of the above ( )

23. Which of the following is not an image file format ?
    (a) TIFF   (b) PSD
    (c) lCO   (d) 1MG ( )

24. Seed Fill Algorithm, using a stack, use the principle of :
    (a) Last in first out   (b) First in first out
    (c) First in last out   (d) Last in last out ( )

25. A 14 inch monitor implies :
    (a) The screen is »l4 inches wide _ .
    (b) The screen is 14 inches high
    (c) A circle of 14 inches diameter is available for display
    (d) The diagonal across the screen in 14 inches ( )

26. Resolution of an image scarmer is measured in :
    (a) ppi   (b) dpi

(c) H3   (d) Magapixel ( )

27. The process of determining the portion of a primitive lying within a region is called :
(a) Back Face Removal   (b) Visible Surface Detection
(c) Clipping   (d) Area Filling ( )

28. How many bits per pixel are generally required for 'true colour' system :
(a) 32 bits   (b) 24 bits
(c) l6 bits   (d) 8 bits ( )

29. Jaggies or stair-casing are an instance of a phenomenon, known as :
(a) Filtering   (b) Sampling
(c) Thresholding   (d) Anti-aliasing ( )

30. In mid-point ellipse algorithm, the basic equation that is used to identify whether a point (x, y) is outside, or inside or on the boundary of ellipse is; A
X2 y2
ta x'+y' =r;..... oi g+;g·' e
x2` y2 _ A '
. (c) ';? ij? = 0 (d) None ofthe above ` g ( ) .

31. The means of accomplishing changes in orientation, size and shape that alter the coordinate description of objects :
(a) Translation   (b) Transformation
(c) Projection   (d) Objection ( )

32. Active Edge Lists are used in :
(a) Seed Fill Area Filling
(b) Scan Line Area Filling
(c) Sutherland Cohen Clipping Algorithm
(d) Cyrus-Beck Clipping Algorithm ( )

33. Cyrus-Beck clipping algorithm is also suitable for :
(a) Polygonal Clipping   (b) Rectangular Clipping .
(c) Both (a) and (b)   (d) Hidden Face Removal ( )

34. Which ofthe following algorithm has the usage of pamnetric line equation?
(a) Painter's Algorithm   (b) Z-Buffer Algorithm
(c) Sutherland OohenAlgorithm   (d) Cyrus-Beck Algorithm ( )

35. Which of the following is not a colour model '?
(a) ClE   (b) XYZ
(c) CMYKW   (d) RGB ( )

36. Creatinganenlargedviewofaportionoftliesceneintiteirnageiscalled:

(a) Zooming in   (b) Zooming out 9

3 · (¤)B<>th(¤) and Cb) (<i>P¤¤¤i¤g U   ( )

37.   'Error Term' is associated with
         (a) DDALine DrawingAlgorithm r
         (b) Bresenhamn's Line Drawing Algorithm
         (c) Bresenhaum's Circle Drawing Algorithm
         (d) Mid—point Circle Drawing Algorithm   ( )

38.   'Dead Pixels' are associated with :
         (a) Plasma Panel Displays   (b) Liquid Crystal Displays
         (c) Electroluminescent Displays   (d) Raster Scan Displays   ( )

39.   Which of the following criteria must be fulfilled by a line drawing algorithm '?
         (a) Line should appear as a straight line
         (b) It should start and end accurately
         (c) Line should have constant brightness .
         (d) All of the above   ( )

Answer Key:

1. (a)	2. (c)	3. (a)	4. (b)	5. (c)	6. (c)	7. (c)	8. (a)	9. (a)	10. (d)
11. (a)	12. (b)	13. (c)	14. (b)	15. (c)	16. (c)	17. (b)	18. (d)	19. (d)	20. (a)
21. (a)	22. (b)	23. (d)	24. (a)	25. (c)	26. (b)	27. (d)	28. (b)	29. (d)	30. (b)
31. (b)	32. (b)	33. (c)	34. (d)	35. (b)	36. (a)	37. (a)	38. (b)	39. (d)	40. (a)

DESCRIPTIVE PART – II

Year – 2006

Time allowed : 2 Hours   *Maximum Marks : 30*

Attempt any four questions out of the six. All questions carry 7½ marks each.

Prob. 1 (a) Define 'Flickering'. What is its solution?
      (b) Delineate the various application areas of computer graphics?
      (c) Define 'Bit Depth'.

Prob. 2 Describe the generalized Bresenbamn's line drawing algorithm in detail. Give example.
      (Hint: General Bresenhamn's line drawing Algorithm is different from DDA)

Prob. 3 Discuss the Cyrus-Beck Algorithm for clipping lines in a non-rectangular clipping window.
      (Hint: Consider the clipping window to be polygonal)

Prob. 4 Write the transformation matrix for the following 2 – dimensional transformations in homogeneous coordinate system:
(a)   Reflection about $y = -x$ axis.
(b)   Rotation by 0° in counterclockwise direction.
(c)   Moving an object 2.5 units right and 4 units down.
(d)   Move an object 3 unit left and reflect about the x axis.
(e)   Simultaneous shearing.

Prob. 5 (a) How is an orthographic projection different from axonometric projection?
      (b) Discuss the mid-point ellipse drawing algorithm in detail.

Prob. 6 (a)   Explain how the light (and its path) is changed in context of liquid crystal displays.
      (b)   How can a digital image be captured? List out four file formats to store digital image.
      (c)   Discuss the HSV colour model.

Bibliography

1. J. Foley, A. Van Dam, S. Feiner, J. Hughes: Computer Graphics- Principles and Practice, Pearson
2. Hearn and Baker: Computer Graphics, PHI.

3 Computer Graphics by Pradeep K. Bhatia

4 Computer Graphics: Principles & Practice In C Foley

5 Computer graphics: Francis S. Hill

Best sites for computer graphics:-

1. http://www.cgsociety.org/
2. http://forums.cgsociety.org/
3. http://www.maacindia.com/
4. http://cg.tutsplus.com/
5. http://programmedlessons.org/VectorLessons/index.html