COMPUTER GRAPHICS (DEC 2019)

Q.P.Code:76033

Q.1) Attempt any five from the following:- **(20 M)**

a) Define the following terms: Resolution, Aspect ratio, Phosphorescence and fluorescence. **(5 M)**

Ans:

- **Resolution:** In computers, resolution is the number of pixels (individual points of colour) contained on a display monitor, expressed in terms of the number of pixels on the horizontal axis and the number on the vertical axis. The sharpness of the image on a display depends on the resolution and the size of the monitor. The same pixel resolution will be sharper on a smaller monitor and gradually lose sharpness on larger monitors because the same number of pixels are being spread out over a larger number of inches.

- **Aspect Ratio:** An aspect ratio is an attribute that describes the relationship between the width and height of an image. Aspect ratio is expressed by the symbolic notation: X:Y. The values of X and Y are not the actual width and height of the image, but describe the relationship between them. Aspect ratio is generally used to determine the relative horizontal and vertical sizes of computer graphics. For example, if a computer graphic has an aspect ratio of 3:1, this means the width of the graphic is three times of the height of the image. Aspect ratio plays an important role in resizing. During resizing, the aspect ratio must remain same in order to keep the image undistorted. A distorted aspect ratio leads to stretching of the image.

- **Phosphorescence:** Phosphorescence is luminescence that occurs when energy is supplied by electromagnetic radiation, usually ultraviolet light. The energy source kicks an electron of an atom from a lower energy state into an "excited" higher energy state; then the electron releases the energy in the form of visible light (luminescence) when it falls back to a lower energy state.

- **Fluorescence:** Fluorescence occurs when electrons move from their ground state to an excited state. These electrons keep the same spin as in the ground state, but when they return to the ground state they emit energy. This energy has a longer wavelength than the originally absorbed energy. If this longer wavelength is within the visible spectrum, then we can see a glowing light.

**b) What is the purpose of Inside-Outside test, explain anyone method.**

(5 M)

Ans:

- One method of doing this is to construct a line segment between a point in question i.e. point to test whether inside or outside, and a point which is surely outside the polygon. But ow we are going to find out a point which is surely outside the polygon? It is very easy to find out that point.
- For example, pick a point with an x co-ordinate smaller than the smallest co-ordinate of the polygons vertices and the y co-ordinate will be any y value, or for simplicity we will take y value same as the y value of point in question.
- In this case point A is one, which we want to check i.e. whether point A is inside polygon or not.
- As we are using arrays to store vertices of polygon we can easily come to know the vertex which is having lowest value of x and that is x_1. So we have to select a point smaller than x_1 and generally we select same value of y as that of point A, in order to draw straight line. But even if you select any y value for outside point, it will not make any difference.
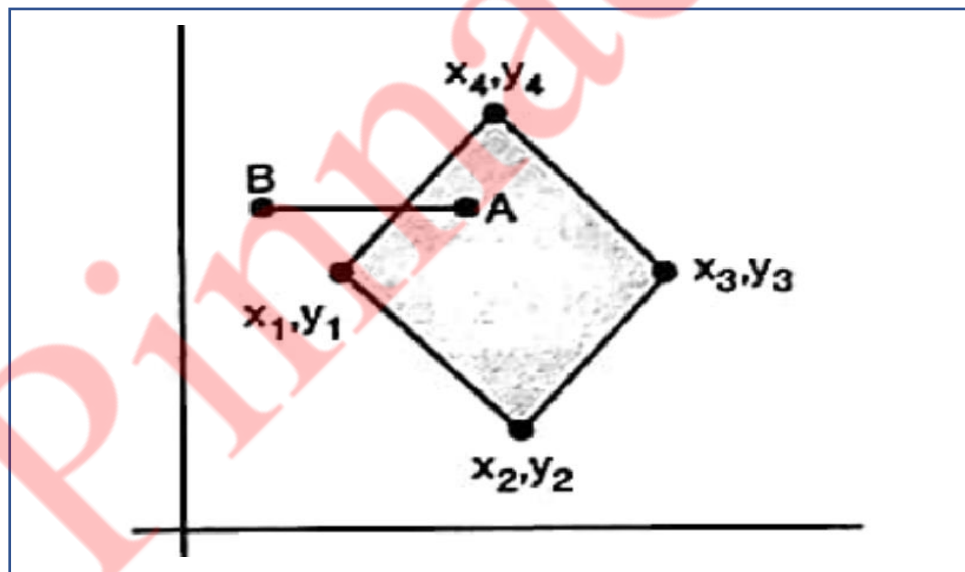

- Then count how many intersections are occurring with polygon boundary by this line till the point in question i.e. 'A', is reached. If there are an odd number of intersections then the point is outside the polygon.
- This is called even-odd method to determine interior points of polygon.
- But this even odd test fails for one case i.e. when the intersection point is vertex. To handle this case we have to make few modifications we must look at other end points of two segments of a polygon which meet at this vertex.
- If these points lie on the same side of the constructed line AB, then the intersection point counts as an even number of intersection.
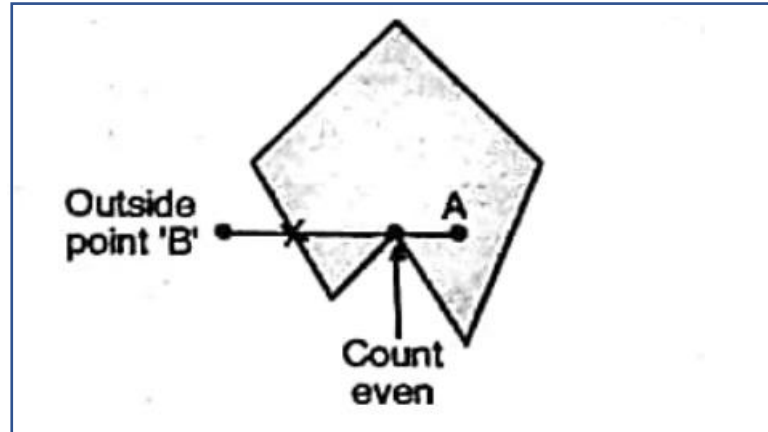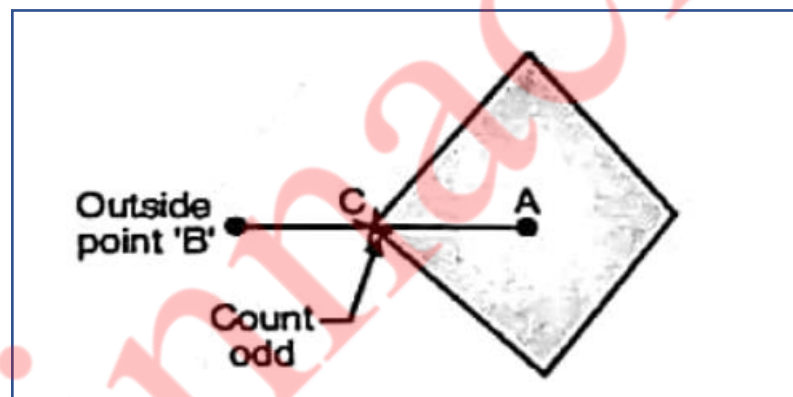
- But if they lie on opposite sides of the constructed line AB, then the intersection point is counted as a single intersection.

- In this case the constructed line AB intersects polygon in a vertex 'C'. here the other points of both the line segments which meets at vertex 'C' are lieing in opposite sides of this constructed line Ab. So the intersection at vertex 'C' is counted as odd count i.e. 1. The total number of C intersection made by this line with polygon is 1 i.e. odd and as it is odd therefore the point 'A' is inside.

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c) **Draw the diagram of CRT and explain is working.** **(5 M)**

Ans:

- CRT stands for Cathode Ray Tube. CRT is a technology used in traditional computer monitors and televisions. The image on CRT display is created by firing electrons from the back of the tube of phosphorus located towards the front of the screen.

- Once the electron heats the phosphorus, they light up, and they are projected on a screen. The color you view on the screen is produced by a blend of red, blue and green light.

Cathode Ray Tube
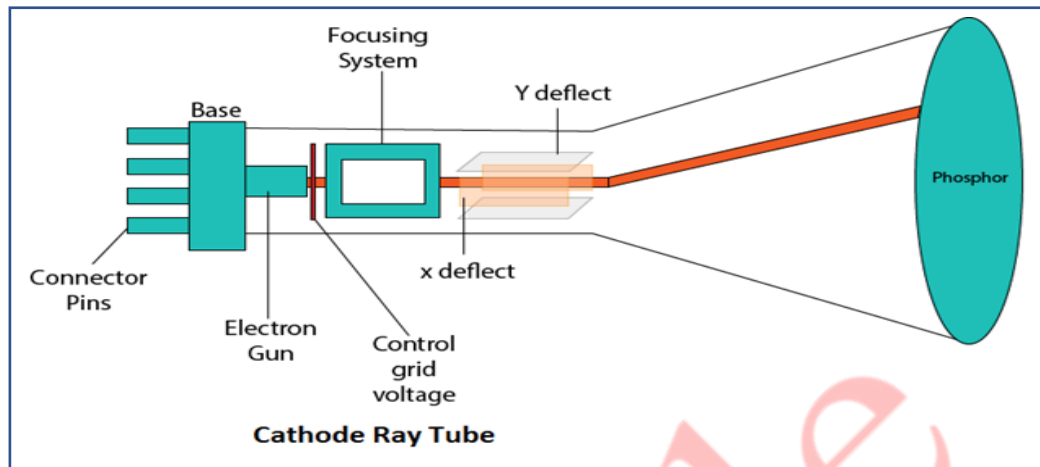
- Main Components of CRT are:
- **Electron Gun:** Electron gun consisting of a series of elements, primarily a heating filament (heater) and a cathode. The electron gun creates a source of electrons which are focused into a narrow beam directed at the face of the CRT.
- **Control Electrode:** It is used to turn the electron beam on and off.
- **Focusing system:** It is used to create a clear picture by focusing the electrons into a narrow beam.
- **Deflection Yoke:** It is used to control the direction of the electron beam. It creates an electric or magnetic field which will bend the electron beam as it passes through the area. In a conventional CRT, the yoke is linked to a sweep or scan generator. The deflection yoke which is connected to the sweep generator creates a fluctuating electric or magnetic potential.
- **Phosphorus-coated screen:** The inside front surface of every CRT is coated with phosphors. Phosphors glow when a high-energy electron beam hits them. Phosphorescence is the term used to characterize the light given off by a phosphor after it has been exposed to an electron beam.

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d) What do you understand by Control Points, Degree of Continuity, Local and Global control w.r.t Curve Generation. **(5 M)**

Ans:

- **Control Points:** In computer-aided geometric design a control point is a member of a set of points used to determine the shape of a spline curve or, more generally, a surface or higher-dimensional object.
- **Degree of Continuity:**

Q.2)

a) Explain DDA Line drawing algorithm and Plot the points for line AB (A(10, 15) B(5, 25)) using it. **(10 M)**

Ans:

- Digital differential analyser is based on incremental method. The slope intercept equation for a straight line is, $y = mx + b$, where m is slope and b is y-intercept. We can determine the value of m as,

$$M = (y2 - y1)/(x2 - x1) = Dy / Dx$$

- For lines with slope(m) is <1 i.e. lines with positive gentle slopes, we are moving in x-direction by uniform steps of calculating the corresponding y-value by using

$$Dy/Dx = m$$

$$Dy = m . Dx$$

$$(y_a + 1) - (y_a) = m.[(x_a + 1) - (x_a)]$$

But as we are moving in x-direction by 1 unit i.e. distance between two columns;

$$(x_a + 1) - (x_a) = 1$$

$$(y_a + 1) - (y_a) = m(1)$$

$$y_a + 1 = m + y_a$$

i.e. $y_{new} = slope + y_{old}$

- Similarly when the slope is > 1 i.e. lines with positive steep slopes, we are moving in y-direction by uniform steps and calculating the corresponding x-value.

$$Dx/Dy = m$$

i.e. $Dx = Dy/m$

$$(x_a + 1) - (x_a) = (y_a + 1)-(y_a) / m$$

$$(x_a + 1) - x_a = 1/m$$

$$X_a + 1 = 1/m + x_a$$

i.e. $x_{new} = 1/slope + x_{old}$

- When the slope(m) is = 1 then as x changes, values of y also changes.

i.e. $Dy/Dx = m$

but m = 1

$$Dy = Dx$$

$$Y_{new} = y_{old} + 1 \text{ and } x_{new} = x_{old} + 1$$

- Given line A(10, 15) and B(5, 25)

$X_1 = 10, Y1 = 15$ and $X2 = 5, Y2 = 25$

Dx = X2-X1 = (5-10) = -5

Dy = Y2-Y1 = (25-15) = 10

|Dx|<|Dy|

$X_{increment}$ = Dx/steps = 5/5 = 1

$Y_{increment}$ = Dy/steps = 10/25 = 0.4

x_{new} = x_{old} + $x_{increment}$ = 10+1=11

y_{new} = y_{old} + $y_{increment}$ = 15+0.4 = 15.4

now loop steps are tabulated as follows:

I	X	Y	Plot
1	10	15	10,15
2	11	15.4	11,15
3	12	15.8	12,16
4	13	16.2	13,16
5	14	16.6	14,17
6	15	17.0	15,17
7	16	17.4	16,17
8	17	17.8	17,18
9	18	18.2	18,18
10	19	18.6	19,19

b) Explain area subdivision algorithm for hidden surface removal. (10 M)

Ans:

- The area-subdivision method takes advantage by locating those view areas that represent part of a single surface.

- Divide the total viewing area into smaller and smaller rectangles until each small area is the projection of part of a single visible surface or no surface at all.

- Continue this process until the subdivisions are easily analysed as belonging to a single surface or until they are reduced to the size of a single pixel.

- The algorithm is a recursive procedure based on a 2-step strategy.

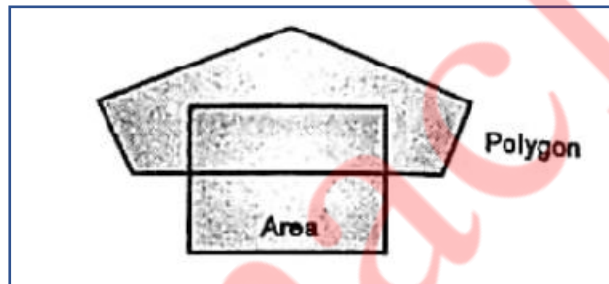1. Decide which polygons overlap the given area on the screen.

2. Which polygons are visible in that area.

- Categories of polygons are:
- **Surrounding polygon:** In this case a polygon completely covers the given screen area
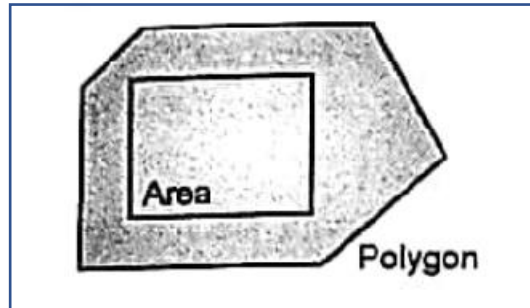
- **Intersection Polygon:** In this case a polygon is getting intersected with the screen area i.e. the polygon is partially inside the screen area.

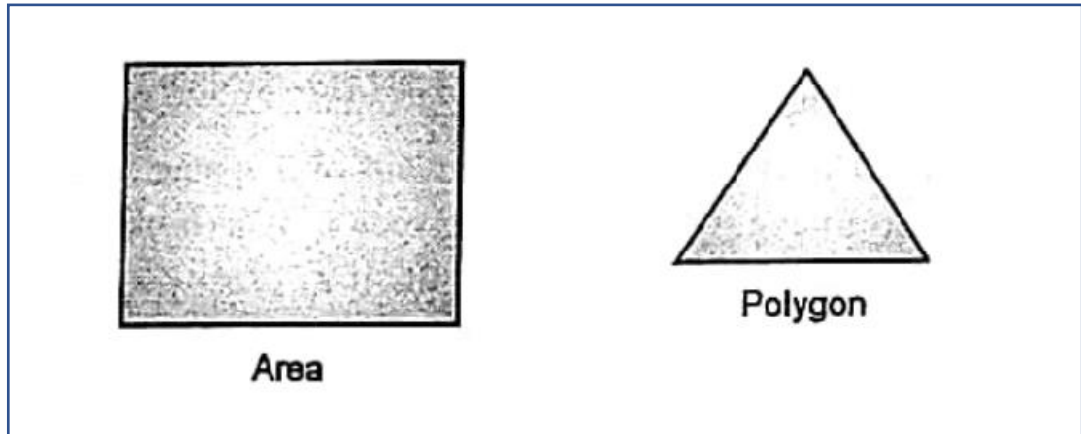- **Contained Polygon:** In this case a polygon is lying completely inside the given screen area.
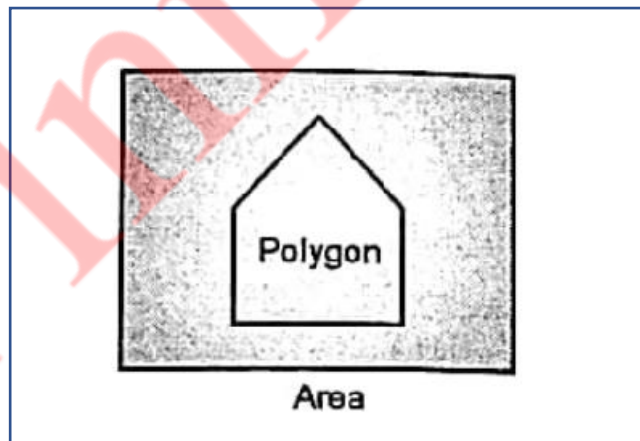
- **Disjoint polygon:** Whenever the polygon is lying completely outside the given screen area, it is called as disjoint polygon.

Q.3)

a) **What is aliasing, how it affects the appearance of an object. Explain any two anti-aliasing methods.** **(10 M)**

Ans:

- In computer graphics, the process by which smooth curves and other lines become jagged because the resolution of the graphics device or file is not high enough to represent a smooth curve.

- In the line drawing algorithms, we have seen that all rasterized locations do not match with the true line and we have to select the optimum raster locations to represent a straight line. This problem is severe in low resolution screens. In such screens line appears like a stair-step, as shown in the figure below. This effect is known as aliasing. It is dominant for lines having gentle and sharp slopes.
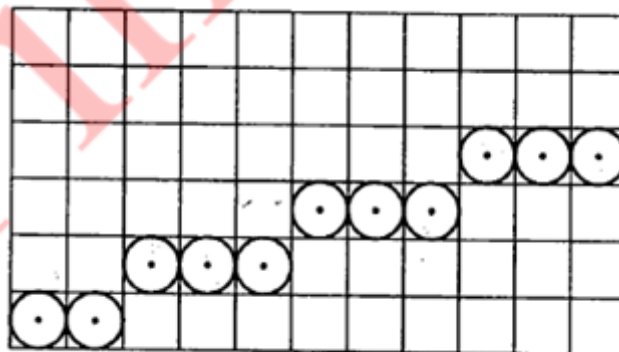

Fig. Aliasing effect

- The **aliasing effect** can be reduced by adjusting intensities of the pixels along the line. The process of adjusting intensities of the pixels along the line to minimize the effect of aliasing is called antialiasing.
- **Antialiasing** is a term for techniques that are designed to mitigate the effects of aliasing.

- The idea is that when a pixel is only partially covered by a shape, the colour of the pixel should be a mixture of the colour of the shape and the colour of the background.
- When drawing a black line on a white background, the colour of a partially covered pixel would be grey, with the shade of grey depending on the fraction of the pixel that is covered by the line.
- The technique of anti-aliasing is:
- **Prefiltering:** This is technique that determines pixel intensity based on the amount of that particular pixel coverage by the object in the scene i.e. It computes pixel colours depending on the objects coverage.
- It means how much part or fraction of that pixel is covered by the object and depending on that, it sets the value of the pixel. It requires large number of calculations and approximations. Prefiltering generates more accurate antialiasing effect. But due to its high complexity of calculations it is not used.
- **Postfiltering**: Super sampling or postfiltering is the process by which aliasing effects in graphics are reduced by increasing the frequency of the sampling grid and then averaging the results down. This process means calculating a virtual image at a higher spatial resolution than the frame store resolution and then averaging down to the final resolution. It is called postfiltering as the filtering is carried out after sampling.

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b) **Explain Liang Barsky line clipping algorithm, what is benefit over Cohen Sutherland algorithm? Clip the line with co-ordinates (5, 10) and (35, 30) against window (x_{min}, y_{min}) = (10, 10) and (x_{max}, y_{max}) = (20, 20).**

(10 M)

Ans:

- The Liang-Barsky algorithm uses the parametric equation of a line and inequalities describing the range of the clipping box to determine the intersections between the line and clipping box. With these intersections it knows which portion of the line should be drawn. This algorithm is more efficient than Cohen-Sutherland. The ideas for clipping line of Liang-Barsky and cyrus-Beck are the same. The only difference is Liang-Barsky algorithm has been optimized for an upright rectangular clip window. So we will study only the idea of Liang-Barsky.

- Liang and Barsky have created an algorithm that uses floating-point arithmetic but finds the appropriate ends points with at most four computations. This algorithm uses the parametric equations for a line and solves for inequalities to find the range of the parameter for which the line is in the viewport.
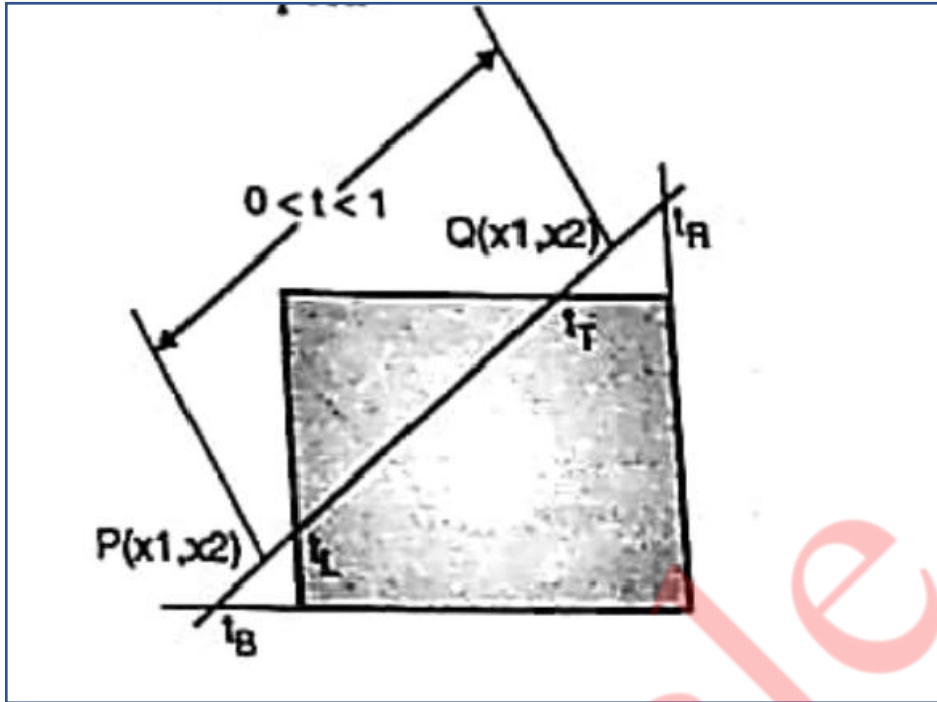
- Let P(X1, Y1), Q(X2, Y2) be the line which we want to study. The parametric equation of line segment from gives x-values and y-values for every point in terms of a parameter that ranges from 0 to 1. The equations are
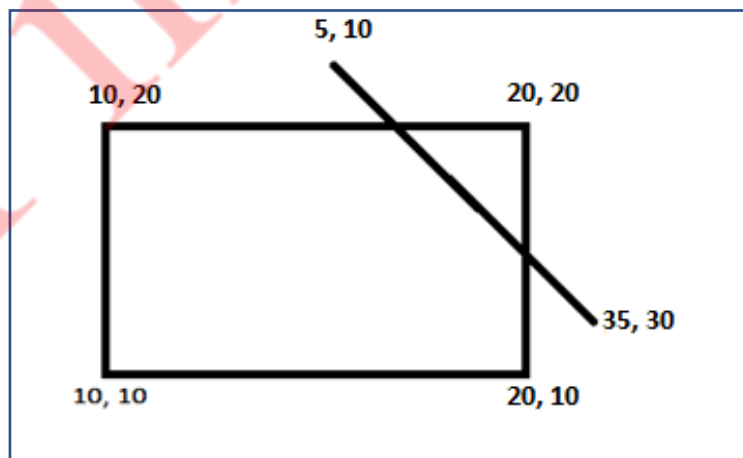
$$X = X1 + (X2 - X1)*t = Y1 + dY*t$$
And
$$Y = Y1 + (Y2 - Y1)*t = X1 + dX*t$$

We can see that when t=0, the point computed is P(x1, y1) and when t =1, the point computed is Q(x2, y2).

- Lets first draw the window and line as shown in fig.

Given things are XL = 10, YB = 10, XR = 20, YT = 20

Lets call a line AB with its coordinates as X1 = 5, Y1 = 10, X2 = 35, Y2 = 30

Now we have to find Dx and Dy as

Dx = X2 − X1 = 35 - 5 = 30

$Dy = Y2 - Y1 = 30 - 10 = 20$

Lets calculate the values of parameters P and Q as

$P1 = -Dx = -30$

$P2 = Dx = 30$

$P3 = -Dy = -20$

$P4 = Dy = 20$

Now,

$Q1 = X1 - XL = 5 - 10 = -5$

$Q2 = XR - X2 = 20 - 15 = 5$

$Q3 = Y1 - YB = 10 - 10 = 0$

$Q4 = YT - Y2 = 20 - 10 = 10$

Now lets find P,

$P1 = Q1/P1 = -5/(-30) = (1/6)$

$P2 = Q2/P2 = 15/(30) = (1/2)$

$P3 = Q3/P3 = 0/(-20) = (0)$

$P4 = Q4/P4 = 10/(20) = (1/2)$

Now,

$t1 = Max(1/6, 0, 0) = 1/6$

$t2 = Min(1/2, 1/2, 0) = 1/2$

Now,

$X1' = X1 + Dx*t1$

$= 5+30*(1/6)$

$= 10$

$Y1' = Y1 + Dy*t1$

$= 10+(20)*(1/6)$

$= 13.33$

And with t2 it will be

$X2' = X1 + Dx*t2$

$= 5+30*(1/2)$

= 20

Y2' = Y1 + Dy*t2

= 10+(20)*(1/2)

= 20

From this we will come to know that a point (20, 20) is an intersection point with respect to the edge of the window boundary. So we need to discard the line from point (5, 10) to (5, 83.33) and consider line (20, 20) to (35, 30).

Q.4)

a) What is shading? Explain Gourard and Phong Shading with their pros and cons. (10 M)

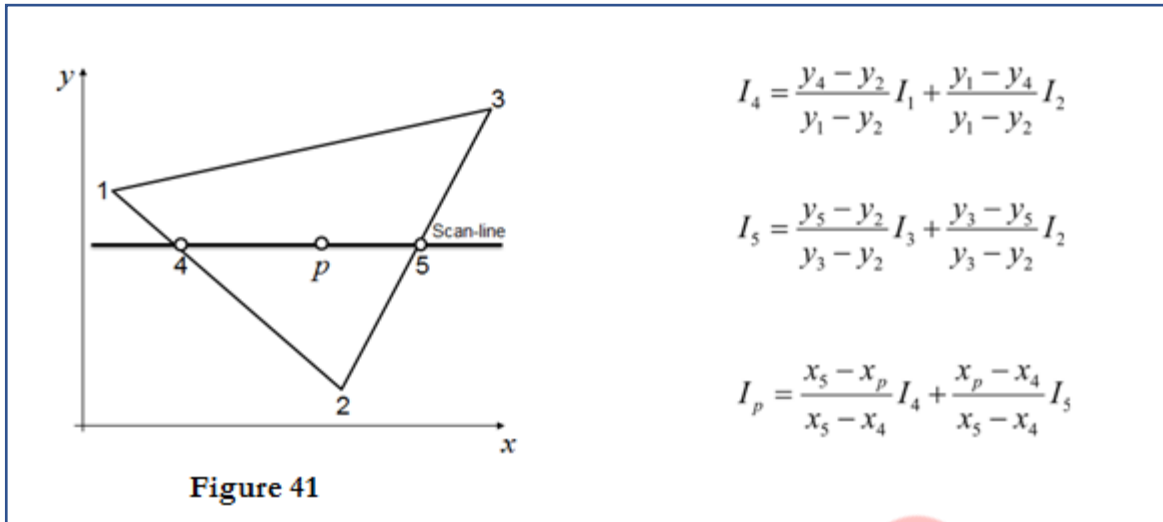**Ans:**

Gouraud Shading:

1. Gouraud surface shading was developed in the 1970s by Henri Gouraud.

2. It is the interpolation technique.

3. Intensity levels are calculated at each vertex and interpolated across the surface.

4. Intensity values for each polygon are matched with the values of adjacent polygons along the common edges.

5. This eliminates the intensity discontinuities that can occur in flat shading.

6. To render a polygon, Gouraud surface rendering proceeds as follows:

   o Determine the average unit normal vector at each vertex of the polygon.

   o Apply an illumination model at each polygon vertex to obtain the light intensity at that position.

   o Linearly interpolate the vertex intensities over the projected area of the polygon

Illumination values are linearly interpolated across each scan-line as shown in figure 41.

$$I_4 = \frac{y_4 - y_2}{y_1 - y_2} I_1 + \frac{y_1 - y_4}{y_1 - y_2} I_2$$

$$I_5 = \frac{y_5 - y_2}{y_3 - y_2} I_3 + \frac{y_3 - y_5}{y_3 - y_2} I_2$$

$$I_p = \frac{x_5 - x_p}{x_5 - x_4} I_4 + \frac{x_p - x_4}{x_5 - x_4} I_5$$

Figure 41

Advantages: Removal of discontinuities associated with the constant shading model.

Disadvantages: Highlighted surfaces are sometimes displayed with anomalous shape and the linear intensity interpolation can use bright or dark intensity interpolation can use bright or dark intensity strips. This effect can be reduced by sung phong shading method.

Phong Shading:

1. A more accurate interpolation based approach for rendering a polygon was developed by Phong Bui Tuong.

2. Basically the Phong surface rendering model is also called as normal-vector interpolation rendering.

3. It interpolates normal vectors instead of intensity values.

4. To render a polygon, Phong surface rendering proceeds as follows:

5. Determine the average unit normal vector at each vertex of the polygon.

6. Linearly interpolate the vertex normal over the projected area of the polygon.

7. Apply an illumination model at positions along scan lines to calculate pixel intensities using the interpolated normal vectors as shown in figure 42


$$N = \frac{y - y_2}{y_1 - y_2} N_1 + \frac{y_1 - y}{y_1 - y_2} N_2$$

Figure 42
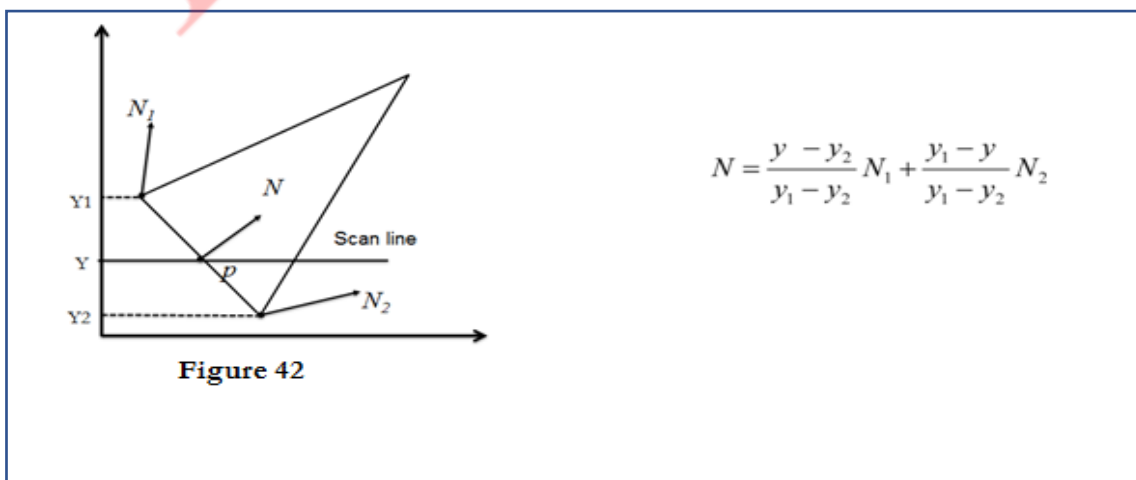
Advantages: It is very effective in dealing with specular highlights.

Disadvantages: This technique is relatively time-consuming since the illumination model is evaluated at every point using interpolated normal vectors.

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b) Explain what is meant by B spline curve? State the various properties of spline curve. (10 M)

Ans:

- A set of blending functions which takes this approach is called B-splines. Basically spline means a strip, which we have to move around the sample points. Generally the B-spline blending functions were designed to eliminate sharp corners in the curve and the curve does not usually pass through the sample points. But if we need sharp corners we can produce it by using many identical sample points.

(a)   (b)   (c)
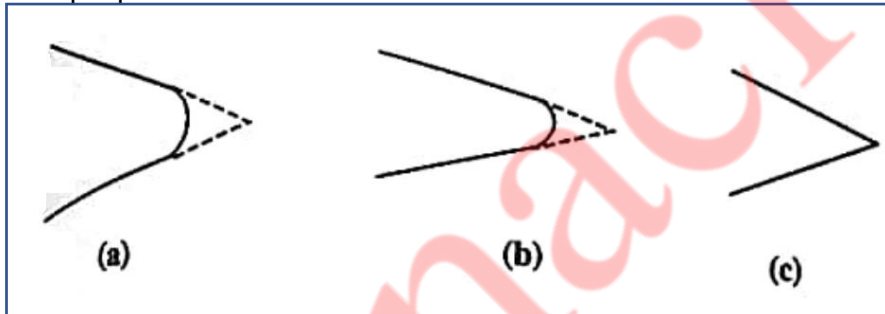
- Fig(a) shows the curve using one sample point. Fig(b) shows the curve using two identical sample points. It means we are calling the blending function for same sample point twice. And fig(c) shows if three identical sample points are used the curve will be forced to pass through the sample points.
- **Properties of B-spline Curve:**
  - The sum of the B-spline basic functions for any parameter value u is 1 i.e.
    $$\sum_{i=1}^{n+1} N_{i,k}(u) = 1$$
  - Except for k=1 each basis function has precisely one maximum value.
  - The maximum order of the curve is equal to the number of vertices of defining polygon.
  - The degree of B-spline polynomial is independent of the number of vertices of defining polygon.
  - B-spline allows local control over the curve surface because each vertex affects the shape of a curve only over a range of parameter values where its associated basic function is nonzero.
  - The curve exhibits the variation diminishing property. The curve does not oscillate about any straight line move often then its defining polygon.
 - The curve is generally follows the shape of defining polygon.

o Any affine transformation can be applied to the curve by applying it to the vertices of defining polygon.
o The curve line within the convex hull of its defining polygon.

Q.5)

a) Explain Scan line polygon fill algorithm with the help of suitable diagrams. (10 M)

Ans:

- Boundary fill algorithm and flood fill algorithm is defined at pixel level.

- Scan line fill algorithm is defined at geometric level i.e. coordinates, edges, vertices etc.

- The algorithm starts with first scan line and proceeds line by line to the last scan line.

- It checks whether every pixel on that scan line satisfies inside point test or not i.e. it checks which points on that scan line are inside the polygon.

- This method avoids the need for seed point.

- Consider this example of convex polygon to explain this algorithm.
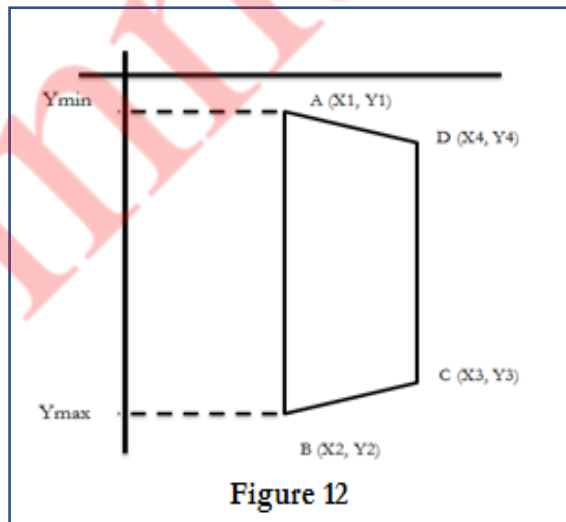
Figure 12

- As shown in figure 12, algorithm begins with first scan line i.e. Ymax and proceed line by line towards the last scan line i.e. Ymin.

- Here we are considering only the first and line scan and not individual edges.

- For each edge of polygon we are storing 5 attributes along with the slope.

- For AB we are storing:

  o Xmax: X2

- o Xmin: X1

- o Ymax: Y2

- o Ymin: Y1

- Likewise we find for AD, CD and BC.

Edge	Ymax	Xmax	Ymin	Xmin	Slope
AB	Y2	X2	Y1	X1	M1
AD	Y4	X4	Y1	X1	M2
CD	Y3	X3	Y4	X4	M3
BC	Y2	X2	Y3	X3	M4

- In this we have to select only those edges which are getting intersected by scan line.

- For this we are using Ymax of particular edge to find out whether it is intersecting by scan line or not

- Now sort the Ymax array.

EDGE	Ymax	Xmax	Ymin	Xmin	SLOPE
AB	Y2	X2	Y1	X1	M1
BC	Y2	X2	Y3	X3	M4
CD	Y3	X3	Y4	X4	M3
AD	Y4	X4	Y1	X1	M2

- So from the table we can find out that edge AB and BC are intersection of scan line.

- Every time we are decreasing the scan line by 1, from Ymax to Ymin of polygon. Refer figure13

Figure 13
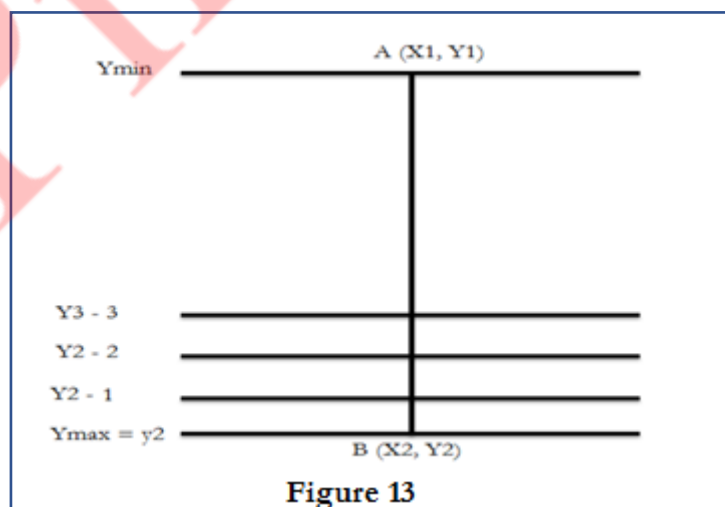
- Now we have to find the corresponding X value for the intersection point.

  Slope (m) = DY/DX = Change in Y / Change in X.

= Ynew – Yold / Xnew – Xold

= 1 / Xnew – Xold

Xnew – Xold = 1 / m

Therefore, Xnew = Xold + 1/m.

- Like this we are finding intersecting of scan line with every edge of polygon.

- Once we have found the intersecting points with both edges i.e. selected edges like AB and BC, then join these two intersecting points by solid line and continue.

- Again decrease Y by 1 and find out new intersection points for those edges till one of the edges gets over i.e. the scan line goes below Ymin of one edge.
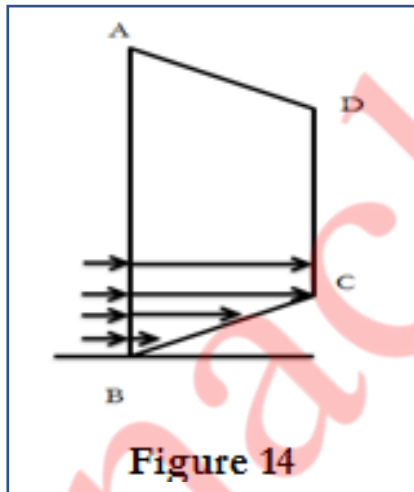

Figure 14

- In this case edge BC gets over earlier, so discard edge BC and select next edge from sorted table, which is CD and continue the process.

- The process continues till scan line reaches to Ymin of the polygon.

b) Explain the step for 2D reflection w.r.t. line y=mx and also derive a composite transformation matrix. (10 M)

Ans:

- To rotate an object about an arbitrary point, (Xp ,Yp) we have to carry out three steps:
    - Translate point (Xp, Yp) to the origin.
    - Rotate it about the origin and,
    - Finally, translate the centre of rotation back where it belongs (See figure 1.).

- we have already seen that matrix multiplication is not commutative, i.e. multiplying matrix A by matrix B will not always yield the same result as multiplying matrix B by matrix A. Therefore, in obtaining composite transformation matrix, we must be careful to order the matrices so that they correspond to the order of the
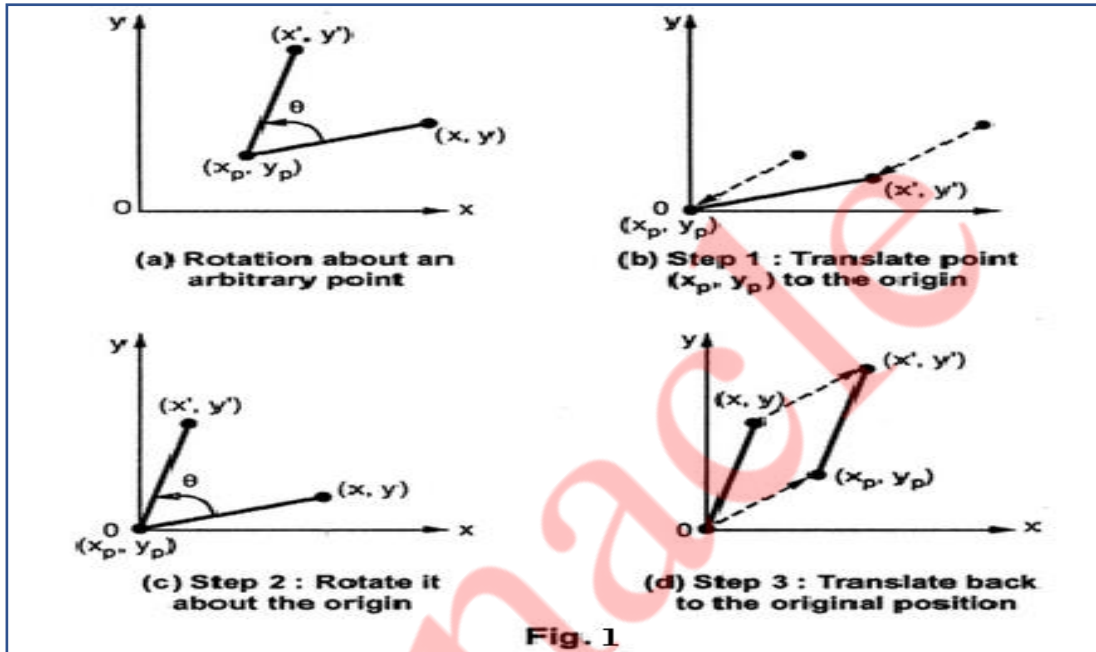
transformations on the object. Let us find the transformation matrices to carry out individual steps.

- The translation matrix to move point (x_p, y_p) to the origin is given as, x_p

$$T_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -xp & -yp & 1 \end{bmatrix}$$

(a) Rotation about an arbitrary point

(b) Step 1 : Translate point (x_p, y_p) to the origin

(c) Step 2 : Rotate it about the origin

(d) Step 3 : Translate back to the original position

Fig. 1

The translation matrix to move point (x_p, y_p) to the origin is given as, x_p

$$T_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -xp & -yp & 1 \end{bmatrix}$$

The rotation matrix for counterclockwise rotation of point about the origin is given as,

$$R = \begin{bmatrix} cos\Theta & sin\Theta & 0 \\ -sin\Theta & cos\Theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

The translation matrix to move the center point back to its original position is given as,

$$T_2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ xp & yp & 1 \end{bmatrix}$$

Therefore the overall transformation matrix for a counterclockwise roatation by an angle Θ about the point (xp, yp) is given as,

$$T_1*R*T_2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -xp & -yp & 1 \end{bmatrix} * \begin{bmatrix} cos\Theta & sin\Theta & 0 \\ -sin\Theta & cos\Theta & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ xp & yp & 1 \end{bmatrix}$$

$$= \begin{bmatrix} cos\Theta & sin\Theta & 0 \\ -sin\Theta & cos\Theta & 0 \\ -xpcos\Theta + ypsin\Theta & -xpsin\Theta - ypcos\Theta & 1 \end{bmatrix} * \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ xp & yp & 1 \end{bmatrix}$$

$$= \begin{bmatrix} cos\Theta & sin\Theta & 0 \\ -sin\Theta & cos\Theta & 0 \\ -xpcos\Theta + ypsin\Theta + xp & -xpsin\Theta - ypcos\Theta + yp & 1 \end{bmatrix}$$

Q.6) Write short notes on:

a) Fractals:

Ans:

- A fractal is defined as a rough or fragmented geometric shape that can be split into parts, each of which is approximately a reduced-size reproduction of the complete shape based on the property known as self- similarity. It was derived from the Latin word fractus which means broken or fractured. Natural objects can be realistically described using fractal geometry methods. Example.- cloud, mountains, trees, stone etc.
- Fractal methods use procedures rather than equations to model objects. so it uses procedural modelling. The major characteristic of any procedural model is that the model is not based on data ,but rather on the implementation of the procedure following a particular set of rules.
- A fractal combines the following characteristic:
- Its parts have the same form or structure as a whole, except that they are at a different scale and may be slightly deformed.
- Its form is extremely irregular or fragmented, and remains so, whatever the scale of examination.
- It is formed by iteration i.e. the procedure is used repeatedly(recursively)
- Example: if P0 = (X0, Y0, Z0) is a selected initial position, the successive levels P1 = F (P0), P2 = F (P1), …… Pn = F (Pn-1) are generated by a transformation function F.
- Fractional dimensions.

View of coast line from certain distance   Closer view   More closer view
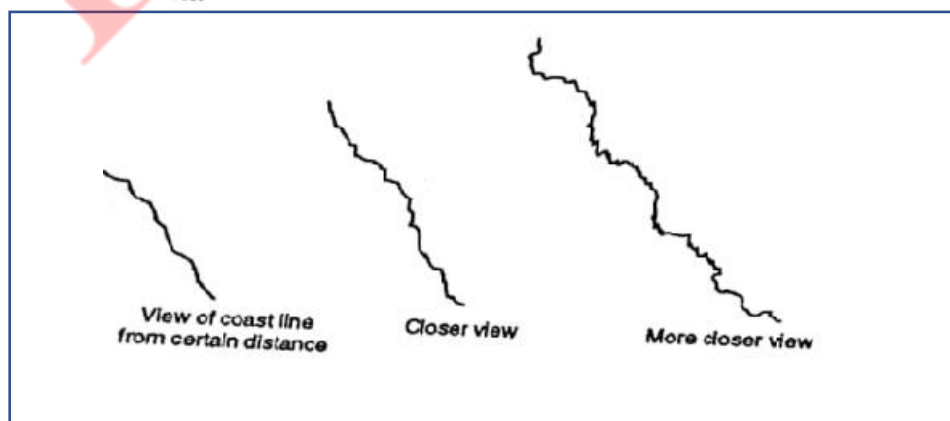
- Imagine that one object is made up of clay. If we break that objects in terms of line or line segments, then we will give the dimensions $D_1 = 1$. If the object is broken into a plane, then we will give the dimension $D_t = 2$. And if the object is broken into 3D objects like cube, sphere etc. then we will give the transformation as $D_t = 6$. Here the variables D_t is called topological dimensions.

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b) Sweep representation and CSG method.

Ans:

- Sweep representations are used to construct three dimensional objects from two dimensional shape .There are two ways to achieve sweep: Translational sweep and Rotational sweep. In translational sweeps, the 2D shape is swept along a linear path normal to the plane of the area to construct three dimensional object. To obtain the wireframe representation we have to replicate the 2D shape and draw a set of connecting lines in the direction of shape, as shown in the figure (8)

(a) 2D shape   (b) 3D object   (c) Wire frame representation

Fig. (8) Translational sweep
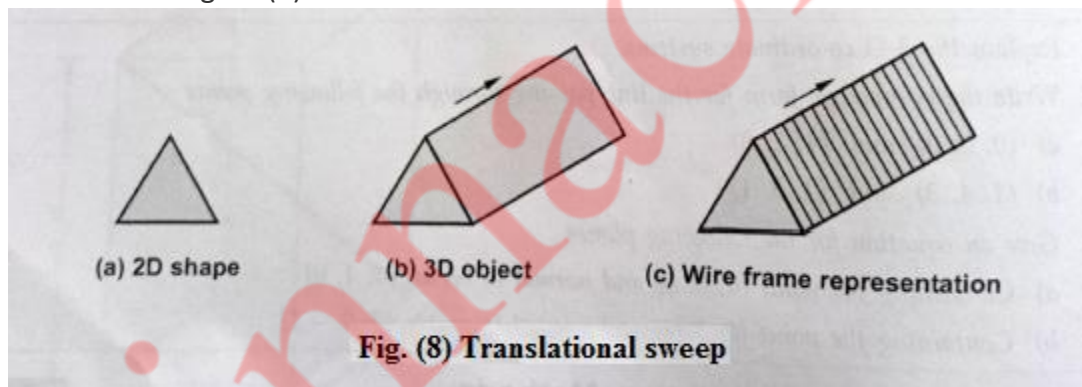
- In general we can specify sweep constructions using any path. For translation we can vary the shape or size of the original 2D shape along the sweep path. For rotational sweeps, we can move along a circular path through any angular distance from 0° to 360°.
- These sweeps whose generating area or volume changes in size, shape or orientation as they are swept and that follow an arbitrary curved trajectory are called general sweeps .General sweeps are difficult to model efficiently for example, the trajectory and object shape may make the swept object intersect itself, making volume calculations complicated.

- **CSG Method:** Another technique for solid modelling is to combine the volumes occupied by overlapping three-dimensional objects using Boolean set operations.
- This modelling technique is called Constructive Solid Geometry (CSG). It creates a new volume by applying Boolean operators such as union. intersection, or difference to two specified objects.

- The Fig. (10), Fig. (11), Fig. (12) show the example for forming new shapes using Boolean set operations The Fig. 10 (a) shows that two rectangular blocks are placed adjacent to each other. We can obtain the combined object with the union operation as shown in Fig. 10 (b).

(a) Objects   (b) Combined objects

Fig. (10) Combined object by union operator.
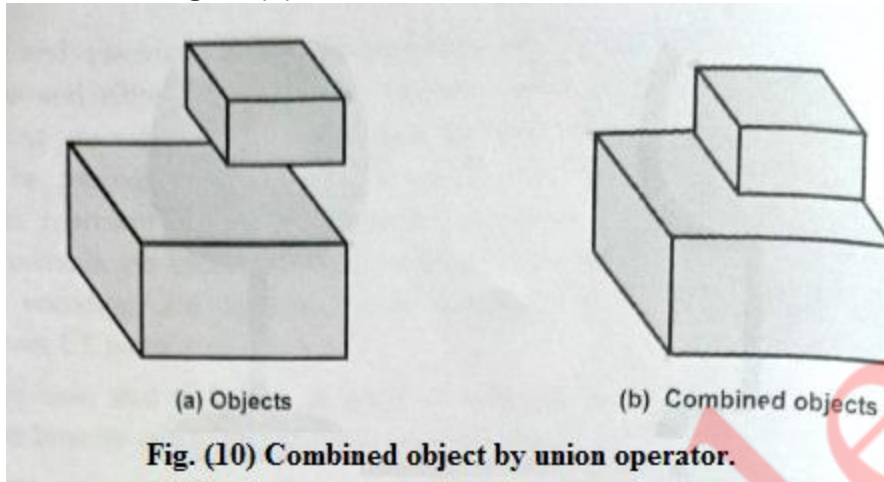
- The Fig.(11) shows the result of intersection operation obtained by overlapping cylinder and cube.
- With the difference operation, we can obtain the resulting solid as shown in Fig. (12).
- The CSG method Uses three dimensional objects such as blocks, pyramids, cylinders, cones, spheres, and closed spline surfaces to generate other solid objects In this method, an object is stored as a tree with operators at the internal nodes and simple primitives at the leaves.
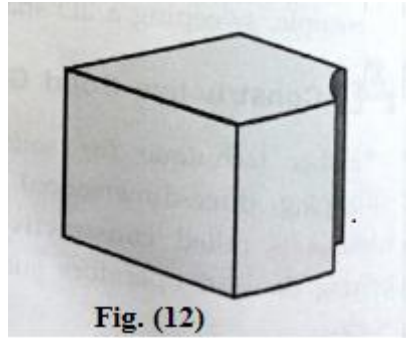

(a)   (b)

Fig. (11)
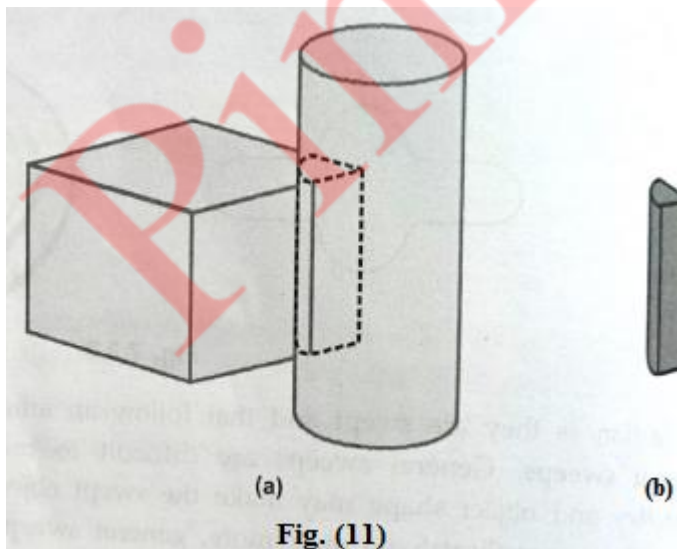
Fig. (12)

- Some nodes represent Boolean operators, whereas others represent operations such as translation, rotation, and scaling. It is important to note that Boolean operations are not, in general, communicative Therefore the edges of the trees must be in proper order.

c) Bezier Curve and the properties. (10 M)

Ans:

- It is a different way of specifying a curve, rather same shapes can be represented by B-spline and Bezier curves. The cubic Bezier curve require four sample points, these points completely specify the curve.
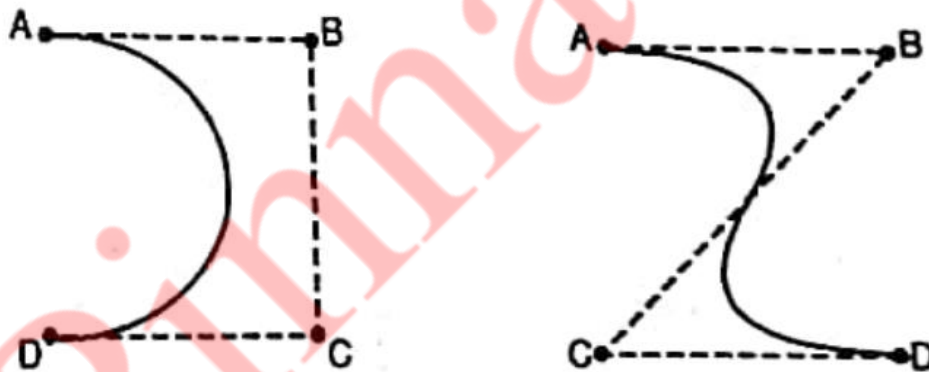
- The curve begins at the first sample point and ends at fourth point. If we need another Bezier curve then we need another four sample points. But if we need two Bezier curves connected to each other, then with six sample points we can achieve it. For this, the third and fourth point of first curve should be made same as first and second point of curve.
- The equation for the Bezier curve are as follows:

$$X = X_4 a^3 + 3X_3 a^2(1-a) + 3X_2 a(1-a)^2 + X_1(1-a)^3$$

$$Y = Y_4 a^3 + 3Y_3 a^2(1-a) + 3Y_2 a(1-a)^2 + Y_1(1-a)^3$$

$$Z = Z_4 a^3 + 3Z_3 a^2(1-a) + 3Z_2 a(1-a)^2 + Z_1(1-a)^3$$

- Here as the value of 'a' moves from 0 to 1, the curve travels from the first to fourth sample point. But we can construct a Bezier curve without referencing to the above expression. It is constructed by simply taking midpoints.
- Properties of Bezier curve are as follows:
    1. The basic function are real in nature.
    2. Bezier curve always passes through the first and last control points i.e. curve has same end points as the guiding polygon.
    3. The degree of polynomial defining the curve segment is one less than the number of defining polygon point.
    4. The curve generally follows the shape of the defining polygon.
    5. The direction of the tangent vector at the end points is the same as that of the vector determined by first and last segments.
    6. The curve lies entirely within the convex hull formed by four control points.
    7. The curve exhibits the variation diminishing property. This means that the curve does not oscillate about any straight line more than the defining polygon.
    8. The curve is invariant under an affine transformation.

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d) Halftone and Dithering. (10 M)

Ans:

Half toning

1. Many displays and hardcopy devices are bi-level

2. They can only produce two intensity levels.

3. In such displays or hardcopy devices we can create an apparent increase in the number of available intensity value.

4. When we view a very small area from a sufficient large viewing distance, our eyes average fine details within the small area and record only the overall intensity of the area.

5. The phenomenon of apparent increase in the number of available intensities by considering combine intensity of multiple pixels is known as half toning.

6. The half toning is commonly used in printing black and white photographs in newspapers, magazines and books.

7. The pictures produced by half toning process are called halftones.

8. In computer graphics, halftone reproductions are approximated using rectangular pixel regions, say 2*2 pixels or 3*3 pixels.

9. These regions are called halftone patterns or pixel patterns.

Dithering Techniques

- Dithering refers to techniques for approximating halftones without reducing resolution, as pixel grid patterns do.

- The term dithering is also applied to halftone approximation method using pixel grid, and something it is used to refer to color halftone approximations only.

- Random values added to pixel intensities to break up contours are often referred as dither noise.

- Number of methods is used to generate intensity variations.

- Ordered dither methods generate intensity variations with a one-to-one mapping of points in a scene to the display pixel.

- To obtain $n2n2$ intensity levels, it is necessary to set up an n*n dither matrix DnDn whose elements are distinct positive integers in the range of 0 to $n2-1n2-1$.