TABLE OF CONTENTS			
S.No	**DATE**	**TOPIC**	**PAGE No**
UNIT-I 2D PRIMITIVES			
1		Output primitives	4
2		Line, Circle and Ellipse drawing algorithms	4
3		Attributes of output primitives	11
4		Two dimensional Geometric transformation	13
5		Two dimensional viewing	14
6		Line, Polygon, Curve and Text clipping algorithms	15
UNIT-II 3D CONCEPTS			
7		Parallel and Perspective projections	18
8		Three dimensional object representation	20
9		Polygons, Curved lines, Splines, Quadric Surfaces	20
10		Visualization of data sets	24
11		3D transformations	25
12		Viewing -Visible surface identification.	29
UNIT-III GRAPHICS PROGRAMMING			
13		Color Models	37
14		RGB, YIQ, CMY, HSV	38
15		Animations	41
16		General Computer Animation, Raster, Keyframe	42
17		Graphics programming using OPENGL	44
18		Basic graphics primitives	48
19		Drawing three dimensional objects	49
20		Drawing three dimensional scenes	49
UNIT IV-RENDERING			
21		Introduction to Shading models	51
22		Flat and Smooth shading	54
23		Adding texture to faces	56
24		Adding shadows of objects	57
25		Building a camera in a program	59
26		Creating shaded objects	60
27		Rendering texture	60
28		Drawing Shadows.	60

UNIT-V FRACTALS			
29		Fractals and Self similarity	62
30		Peano curves	63
31		Creating image by iterated functions	63
32		Mandelbrot sets	64
33		Julia Sets	66
34		Random Fractals – Overview of Ray Tracing	67
35		Intersecting rays with other primitives	68
36		Adding Surface texture	68
37		Reflections and Transparency – Boolean operations on Objects	70
APPENDICES			
A		Glossary	73
B		Question bank	74
C		Previous year question papers	89

SYLLABUS

CS2401 COMPUTER GRAPHICS L T P C 3 0 0 3

UNIT I
2D PRIMITIVES 9
output primitives – Line, Circle and Ellipse drawing algorithms - Attributes of outputprimitives – Two dimensional Geometric transformation - Two dimensional viewing –Line, Polygon, Curve and Text clipping algorithms

UNIT II
3D CONCEPTS 9
Parallel and Perspective projections - Three dimensional object representation – Polygons,Curved lines, Splines, Quadric Surfaces,- Visualization of data sets - 3D transformations –Viewing -Visible surface identification.

UNIT III
GRAPHICS PROGRAMMING 9
Color Models – RGB, YIQ, CMY, HSV – Animations – General Computer Animation,Raster, Keyframe - Graphics programming using OPENGL – Basic graphics primitives –Drawing three dimensional objects - Drawing three dimensional scenes

UNIT IV
RENDERING 9
Introduction to Shading models – Flat and Smooth shading – Adding texture to faces –Adding shadows of objects – Building a camera in a program – Creating shaded objects– Rendering texture – Drawing Shadows.

UNIT V
FRACTALS 9
Fractals and Self similarity – Peano curves – Creating image by iterated functions –Mandelbrot sets – Julia Sets – Random Fractals – Overview of Ray Tracing –Intersecting rays with other primitives – Adding Surface texture – Reflections andTransparency – Boolean operations on Objects
TOTAL = 45

TEXT BOOKS:
1. Donald Hearn, Pauline Baker, Computer Graphics – C Version, second edition, Pearson Education,2004.
2. F.S. Hill, Computer Graphics using OPENGL, Second edition, Pearson Education, 2003.

REFERENCES:
1. James D. Foley, Andries Van Dam, Steven K. Feiner, John F. Hughes, Computer Graphics- Principles and practice, Second Edition in C, Pearson Education, 2007.**UNIT I**

UNIT-I 2D PRIMITIVES

Output primitives – Line, Circle and Ellipse drawing algorithms - Attributes of output primitives – Two dimensional Geometric transformation - Two dimensional viewing – Line, Polygon, Curve and Text clipping algorithms

PREREQUISITE DISCUSSION:

In this unit we discuss about drawing algorithms, clipping algorithms, How to find out a pixel points
In between line path and circle.

1.1.OUTPUT PRIMITIVES

CONCEPT:

A picture is completely specified by the set of intensities for the pixel positions in the display. Shapes and colors of the objects can be described internally with pixel arrays into the frame buffer or with the set of the basic geometric – structure such as straight line segments and polygon color areas. To describe structure of basic object is referred to as output primitives. Each output primitive is specified with input co-ordinate data and other information about the way that objects is to be displayed. Additional output primitives that can be used to constant a picture include circles and other conic sections, quadric surfaces, Spline curves and surfaces, polygon floor areas and character string.

1.2.POINTS AND LINES POINT PLOTTING

It is accomplished by converting a single coordinate position furnished by an application program into appropriate operations for the output device.
With a CRT monitor, for example, the electron beam is turned on to illuminate the screen phosphor at the selected location **Line drawing** is accomplished by calculating intermediate positions along the line path between two specified end points positions.

An output device is then directed to fill in these positions between the end points Digital devices display a straight line segment by plotting discrete points between the two end points. Discrete coordinate positions along the line path are calculated from the equation of the line.

For a raster video display, the line color (intensity) is then loaded into the frame buffer at the corresponding pixel coordinates. Reading from the frame buffer, the video controller then plots "the screen pixels". Pixel positions are referenced according to scan-line number and column number (pixel position across a scan line).

Scan lines are numbered consecutively from 0, starting at the bottom of the screen; and pixel columns are numbered from **0,** left to right across each scan line Figure : Pixel Postions reference by scan line number and column number To load an intensity value into the frame buffer at a position corresponding to column x along scan line y, setpixel (x, y) To retrieve the current frame buffer intensity setting for a **specified** location we use a low level function getpixel (x, y)

SIGNIFICANCE:

It is used to plot the points and lines within the coordinates.

LINE DRAWING ALGORITHMS

CONCEPT:

- Digital Differential Analyzer (DDA) Algorithm
- Bresenham‟ s Line Algorithm
- Parallel Line Algorithm

The Cartesian slope-intercept equation for a straight line is y = m . x + b (1) Where m as slope of the line and b as the y intercept

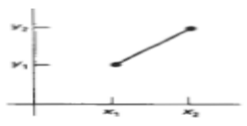
(x2,y2) as in figure we can determine the values for the slope m and y intercept b with the following calculations

Line Path between endpoint positions (x1,y1) and (x2,y2)
m = Δy / Δx = y2-y1 / x2 - x1 (2)
b= y1 - m . x1 (3) For any given x interval Δx along a line, we can compute the corresponding y interval Δ y Δy= m Δx (4) We can obtain the x interval Δx corresponding to a specified Δy as Δ x = Δ y/m (5) For lines with slope magnitudes |m| < 1, Δx can be set proportional to a small horizontal deflection voltage and the corresponding vertical deflection is then set proportional to Δy as calculated from Eq (4). For lines whose slopes have magnitudes |m | >1 , Δy can be set proportional to a small vertical deflection voltage with the corresponding horizontal deflection voltage set proportional to Δx, calculated from Eq (5) For lines with m = 1, Δx = Δy and the horizontal and vertical deflections voltage are equal. Figure : Straight line Segment with five sampling positions along the x axis between x1 and x2

Digital Differential Analyzer (DDA) Algortihm

The digital differential analyzer (DDA) is a scan-conversion line algorithm based on calculation either Δy or Δx The line at unit intervals in one coordinate and determine corresponding integer values nearest the line path for the other coordinate.

A line with positive slop, if the slope is less than or equal to 1, at unit x intervals (Δx=1) and compute each successive y values as yk+1 = yk + m (6) Subscript k takes integer values starting from 1 for the first point and increases by 1 until the final endpoint is reached. ***m*** can **be** any real number between 0 and 1 and, the calculated y values must be rounded to the nearest integer For lines with a positive slope greater than 1 we reverse the roles of x and y, (Δy=1) and calculate each succeeding x value as xk+1 = xk + (1/m) (7) Equation (6) and (7) are based on the assumption that lines are to be processed from the left endpoint to the right endpoint.



If this processing is reversed, Δx=-1 that the starting endpoint is at the right yk+1 = yk – m (8) When the slope is greater than 1 and Δy = -1 with xk+1 = xk-1(1/m) (9) If the absolute value of the slope is less than 1 and the start endpoint is at the left, we set Δx = 1 and calculate y values with Eq. **(**6) When the start endpoint is at the right (for the same slope), we set Δx = -1 and obtain y positions from Eq. (8). Similarly, when the absolute value of a negative slope is greater than 1, we use Δy = -1 and Eq. (9) or we use Δy = 1 and Eq. (7).

Algorithm

#define ROUND(a) ((int)(a+0.5))
void lineDDA
(int xa, int ya, int xb, int yb)
{ int dx = xb - xa, dy = yb - ya, steps, k; float xIncrement, yIncrement, x = xa, y = ya; if (abs (dx) > abs (dy) steps = abs *(dx)* ; else steps = abs dy); xIncrement = dx / (float) steps; yIncrement = dy / (float) steps setpixel (ROUND(x), ROUND(y)) : for (k=0; k<steps; k++)
{ *x* += xIncrement; y += yIncrement; setpixel (ROUND(x), ROUND(y)); } } **Algorithm Description:**
Step 1 : Accept Input as two endpoint pixel positions
Step 2: Horizontal and vertical differences between the endpoint positions *are* assigned to parameters dx and dy (Calculate dx=xb-xa and dy=yb-ya).
Step 3: The difference with the greater magnitude determines the value of parameter steps.
Step 4 : Starting with pixel position (xa, ya), determine the offset needed at each step to generate the next pixel position along the line path.
Step 5: loop the following process for steps number of times
a. Use a unit of increment or decrement in the x and y direction
b. if xa is less than xb the values of increment in the x and y directions are 1 and m
c. if xa is greater than xb then the decrements -1 and – m are used.

Advantages of DDA Algorithm

1. It is the simplest algorithm
2. It is a is a **faster method** for calculating pixel positions

Disadvantages of DDA Algorithm

1. Floating point arithmetic in DDA algorithm is still time-consuming
2. End point accuracy is poor

Bresenham’s Line Algorithm

An accurate and efficient raster line generating algorithm developed by Bresenham, that uses only incremental integer calculations. In addition, Bresenham□s line algorithm can be adapted to display circles and other curves. To illustrate Bresenham's approach, we- first consider the scan-conversion process for lines with positive slope less than 1. Pixel positions along a line path are then determined by sampling at unit x intervals. Starting from the left endpoint (x0,y0) of a given line, we step to each successive column (x position) and plot the pixel whose scan-line y value is closest to the line path.

To determine the pixel (xk,yk) is to be displayed, next to decide which pixel to plot the column xk+1=xk+1.(xk+1,yk) and .(xk+1,yk+1).

At sampling position xk+1, we label vertical pixel separations from the mathematical line path as d1 and d2. The y coordinate on the mathematical line at pixel column position xk+1 is calculated as y =m(xk+1)+b (1) Then d1 = y-yk = m(xk+1)+b-yk d2 = (yk+1)-y = yk+1-m(xk+1)-b To determine which of the two pixel is closest to the line path, efficient test that is based on the difference between the two pixel separations d1- d2 = 2m(xk+1)-2yk+2b-1 (2) A decision parameter Pk for the kth step in the line algorithm can be obtained by rearranging equation (2).

By substituting m=Δy/Δx where Δx and Δy are the vertical and horizontal separations of the endpoint positions and defining the decision parameter as pk = Δx (d1- d2) = 2Δy xk.-2Δx. yk + c (3) The sign of pk is the same as the sign of d1- d2,since Δx>0

Parameter C is constant and has the value 2Δy + Δx(2b-1) which is independent of the pixel position and will be eliminated in the recursive calculations for Pk. If the pixel at yk is "closer" to the line path than the pixel at yk+1 (d1< d2) than decision parameter Pk is negative.

In this case, plot the lower pixel, otherwise plot the upper pixel. Coordinate changes along the line occur in unit steps in either the x or y directions. To obtain the values of successive decision parameters using incremental integer calculations.

At steps k+1, the decision parameter is evaluated from equation (3) as Pk+1 = 2Δy xk+1-2Δx. yk+1 +c Subtracting the equation (3) from the preceding equation Pk+1 - Pk = 2Δy (xk+1 - xk) - 2Δx(yk+1 - yk) But xk+1= xk+1 so that Pk+1 = Pk+ 2Δy-2Δx(yk+1 - yk) (4) Where the term yk+1-yk is either 0 or 1 depending on the sign of parameter Pk

This recursive calculation of decision parameter is performed at each integer x position, starting at the left coordinate endpoint of the line. The first parameter P0 is evaluated from equation at the starting pixel position (x0,y0) and with m evaluated as Δy/Δx P0 = 2Δy-Δx (5) Bresenham□s line drawing for a line with a positive slope less than 1 in the following outline of the algorithm. The constants 2Δy and 2Δy-2Δx are calculated once for each line to be scan converted. **Bresenham's line Drawing Algorithm for |m| < 1**

1. Input the two line endpoints and store the left end point in (x0,y0)
2. load (x0,y0) into frame buffer, ie. Plot the first point.
3. Calculate the constants Δx, Δy, 2Δy and obtain the starting value for the decision parameter as P0 = 2Δy-Δx
4. At each xk along the line, starting at k=0 perform the following test

If Pk < 0, the next point to plot is(xk+1,yk) and Pk+1 = Pk + 2Δy otherwise, the next point to plot is (xk+1,yk+1) and Pk+1 = Pk + 2Δy - 2Δx 5. Perform step4 Δx times.

Implementation of Bresenham Line drawing Algorithm

```
void lineBres (int xa,int ya,int xb, int yb)
{
int dx = abs( xa – xb) , dy = abs (ya - yb); int p = 2 * dy – dx;
int twoDy = 2 * dy, twoDyDx = 2 *(dy - dx);
int x , y, xEnd; /* Determine which point to use as start, which as end * /
if (xa > x b ) { x = xb; y = yb; xEnd = xa; }
else { x = xa; y = ya; xEnd = xb; }
setPixel(x,y); while(x<xEnd) { x++; if (p<0) p+=twoDy;
{ y++; p+=twoDyDx;
 }
setPixel(x,y);
}
```

}

Advantages

Algorithm is Fast
Uses only integer calculations

Disadvantages

It is meant only for basic line drawing.

Circle-Generating Algorithms

General function is available in a graphics library for displaying various kinds of curves, including circles and ellipses.

Properties of a circle

A circle is defined as a set of points that are all the given distance (xc,yc). This distance relationship is expressed by the pythagorean theorem in Cartesian coordinates as
(x – xc)2 + (y – yc) 2 = r2 (1) Use above equation to calculate the position of points on a circle circumference by stepping along the x axis in unit steps from xc-r to xc+r and calculating the corresponding y values at each position as *y = yc +(-) (r2 – (xc –x)2)1/2* (2)

This is not the best method for generating a circle for the following reason Considerable amount of computation Spacing between plotted pixels is not uniform To eliminate the unequal spacing is to calculate points along the circle boundary using polar coordinates r and θ.

Expressing the circle equation in parametric polar from yields the pair of equations x = xc + rcos θ y = yc + rsin θ When a display is generated with these equations using a fixed angular step size, a circle is plotted with equally spaced points along the circumference.

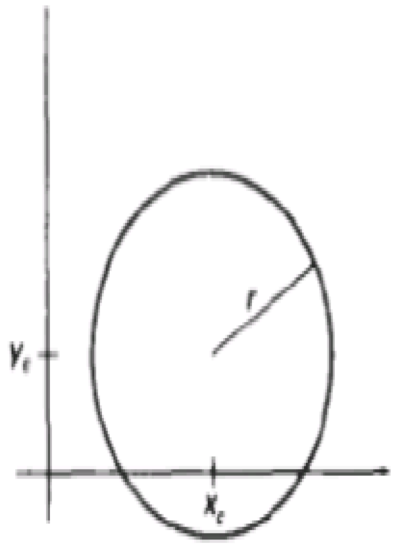
To reduce calculations use a large angular separation between points along the circumference and connect the points with straight line segments to approximate the circular path. Set the angular step size at 1/r. This plots pixel positions that are approximately one unit apart. The shape of the circle is similar in each quadrant.

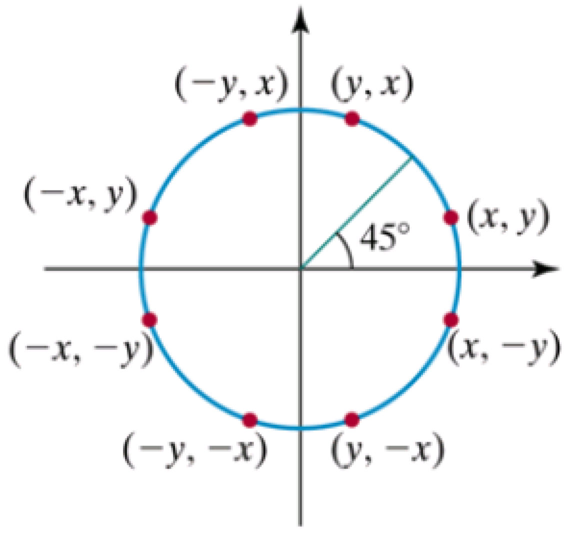
To determine the curve positions in the first quadrant, to generate he circle section in the second quadrant of the xy plane by nothing that the two circle sections are symmetric with respect to the y axis and circle section in the third and fourth quadrants can be obtained from sections in the first and second quadrants by considering symmetry between octants.

\

Circle sections in adjacent octants within one quadrant are symmetric with respect to the 450 line dividing the two octants. Where a point at position (x, y) on a one-eight circle sector is mapped into the seven circle points in the other octants of the xy plane.

To generate all pixel positions around a circle by calculating only the points within the sector from x=0 to y=0. the slope of the curve in this octant has an magnitude less than of equal to 1.0. at x=0, the circle slope is 0 and at x=y, the slope is -1.0.





Midpoint circle Algorithm:

In the raster line algorithm at unit intervals and determine the closest pixel position to the specified circle path at each step for a given radius r and screen center position (xc,yc) set up our algorithm to calculate pixel positions around a circle path centered at the coordinate position by adding xc to x and yc to y.

To apply the midpoint method we define a circle function as fcircle(x,y) = x2+y2-r2 Any point (x,y) on the boundary of the circle with radius r satisfies the equation fcircle (x,y)=0. If the point is in the interior of the circle, the circle function is negative. And if the point is outside the circle the, circle function is positive fcircle (x,y) <0, if (x,y) is inside the circle boundary =0, if (x,y) is on the circle boundary >0, if (x,y) is outside the circle boundary

The tests in the above eqn are performed for the midposition sbteween pixels near the circle path at each sampling step. The circle function is the decision parameter in the midpoint algorithm.

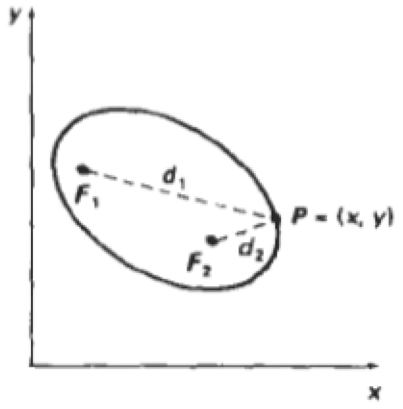
Ellipse-Generating Algorithms

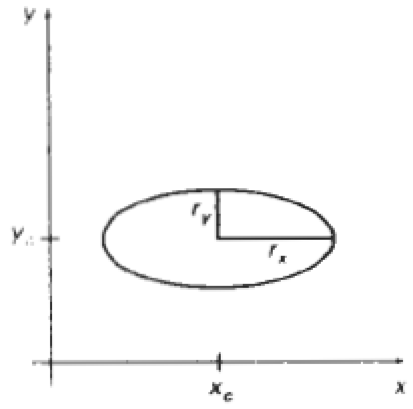
An ellipse is an elongated circle. Therefore, elliptical curves can be generated by modifying circle-drawing procedures to take into account the different dimensions of an ellipse along the major and minor axes.

Properties of ellipses

An ellipse can be given in terms of the distances from any point on the ellipse to two fixed positions called the **foci** of the ellipse. The sum of these two distances is the same values for all points on the ellipse. If the distances to the two focus positions from any point p=(x,y) on the ellipse are labeled d1 and d2, then the general equation of an ellipse can be stated as

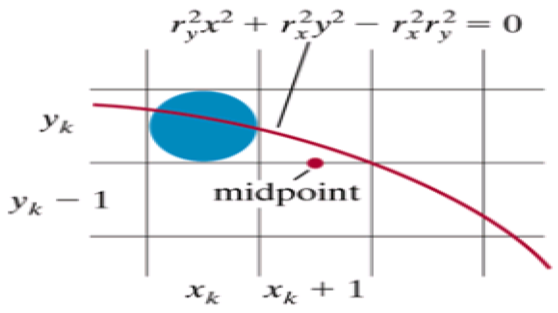
d1+d2=constant





Midpoint ellipse Algorithm

The midpoint ellipse method is applied throughout the first quadrant in two parts. The below figure show the division of the first quadrant according to the slope of an ellipse with rx<ry. In the x direction where the slope of the curve has a magnitude less than 1 and unit steps in the y direction where the slope has a magnitude greater than 1. Region 1 and 2 can be processed in various ways
1. Start at position (0,ry) and step clockwise along the elliptical path in the first quadrant shifting from unit steps in x to unit steps in y when the slope becomes less than -1
2. Start at (rx,0) and select points in a counter clockwise order. 2.1 Shifting from unit steps in y to unit steps in x when the slope becomes greater than -1.0 2.2 Using parallel processors calculate pixel positions in the two regions simultaneously
3. Start at (0,ry) step along the ellipse path in clockwise order throughout the first quadrant ellipse function (xc,yc)=(0,0)
fellipse (x,y)=ry2x2+rx2y2 –rx2 ry2 which has the following properties: fellipse (x,y) <0, if (x,y) is inside the ellipse boundary =0, if(x,y) is on ellipse boundary >0, if(x,y) is outside the ellipse boundary Thus, the ellipse function
fellipse (x,y) serves as the decision parameter in the midpoint algorithm. Starting at (0,ry): Unit steps in the x direction until to reach the boundary between region 1 and region 2. Then switch to unit steps in the y direction over the remainder of the curve in the first quadrant. At each step to test the value of the slope of the curve. The ellipse slope is calculated dy/dx= -(2ry2x/2rx2y) At the boundary between region 1 and region 2 dy/dx = -1.0 and 2ry2x=2rx2y to more out of region 1 whenever 2ry2x>=2rx2y



To determine the next position along the ellipse path by evaluating the decision parameter at this mid point P1k = fellipse (xk+1,yk-1/2) = ry2 (xk+1)2 + rx2 (yk-1/2)2 – rx2 ry2 if P1k <0,
The midpoint is inside the ellipse and the pixel on scan line yk is closer to the ellipse boundary. Otherwise the midpoint is outside or on the ellipse boundary and select the pixel on scan line yk-1 At the

next sampling position (xk+1+1=xk+2) the decision parameter for region 1 is calculated as p1k+1 = fellipse(xk+1 +1,yk+1 -½) =ry2[(xk +1) + 1]2 + rx2 (yk+1 -½)2 - rx2 ry2

Mid point Ellipse Algorithm

1. Input rx,ry and ellipse center (xc,yc) and obtain the first point on an ellipse centered on the origin as

(x0,y0) = (0,ry)

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

P10=ry2-rx2ry +(1/4)rx2

3. At each xk position in region1 starting at k=0 perform the following test. If P1k<0, the next point along the ellipse centered on (0,0) is (xk+1, yk) and

p1k+1 = p1k +2 ry2xk +1 + ry2 Otherwise the next point along the ellipse is (xk+1, yk-1) and p1k+1 = p1k +2 ry2xk +1 - 2rx2 yk+1 + ry2 with 2 ry2xk +1 = 2 ry2xk + 2ry2 2 rx2yk +1 = 2 rx2yk + 2rx2 And continue until 2ry2 x>=2rx2 y

4. Calculate the initial value of the decision parameter in region 2 using the last point (x0,y0) is the last position calculated in region 1.

p20 = ry2(x0+1/2)2+rx2(yo-1)2 – rx2ry2

5. At each position yk in region 2, starting at k=0 perform the following test, If p2k>0 the next point along the ellipse centered on (0,0) is (xk,yk-1) and

p2k+1 = p2k – 2rx2yk+1+rx2 Otherwise the next point along the ellipse is (xk+1,yk-1) and
p2k+1 = p2k + 2ry2xk+1 – 2rxx2yk+1 + rx2 Using the same incremental calculations for x any y as in region 1.

6. Determine symmetry points in the other three quadrants.
7. Move each calculate pixel position (x,y) onto the elliptical path centered on (xc,yc) and plot the coordinate values
x=x+xc, y=y+yc
8. Repeat the steps for region1 unit 2ry2x>=2rx2y

SIGNIFICANCE:

Draw a circle ,lines and ellipse using Differant types of algorithms.

1.3.ATTRIBUTES OF OUTPUT PRIMITIVES

CONCEPT:

Any parameter that affects the way a primitive is to be displayed is referred to as an attribute parameter.
1. Line Attributes
2. Curve Attributes
3. Color and Grayscale Levels
4. Area Fill Attributes
5. Character Attributes
6. Bundled Attributes

Line Attributes

Basic attributes of a straight line segment are its type, its width, and its color. In some graphics packages, lines can also be displayed using selected pen or brush options
Line Type
Line Width
Pen and Brush Options
Line Color

Line type

Possible selection of line type attribute includes solid lines, dashed lines and dotted lines. To set line type attributes in a **PHIGS** application program, a user invokes the function

setLinetype (lt)

Line width

Implementation of line width option depends on the capabilities of the output device to set the line width attributes.
setLinewidthScaleFactor(lw)

Line Cap

We can adjust the shape of the **line** ends to give them a better appearance by adding line caps. There are three types of line cap. They are

Butt cap
Round cap
Projecting square cap

Pen and Brush Options

With some packages, lines can be displayed with pen or brush selections. Options in this category include shape, size, and pattern. Some possible pen or brush shapes
setPolylineColourIndex (lc)

Curve attributes

Parameters for curve attribute are same as those for line segments. Curves displayed with varying colors, widths, dot –dash patterns and available pen or brush options

Area fill Attributes

Options for filling a defined region include a choice between a solid color or a pattern fill and choices for particular colors and patterns **Fill Styles** Areas are displayed with three basic fill styles: hollow with a color border, filled with a solid color, or filled with a specified pattern or design. A basic fill style is selected in a **PHIGS** program with the function

Character Attributes

The appearance of displayed character is controlled by attributes such as font, size, color and orientation. Attributes can be set both for entire character strings (text) and for individual characters defined as marker symbols

Text Attributes

The choice of font or type face is set of characters with a particular design style as courier, Helvetica, times roman, and various symbol groups.

SIGNIFICANCE:

Different types of functions used to implement line circle.

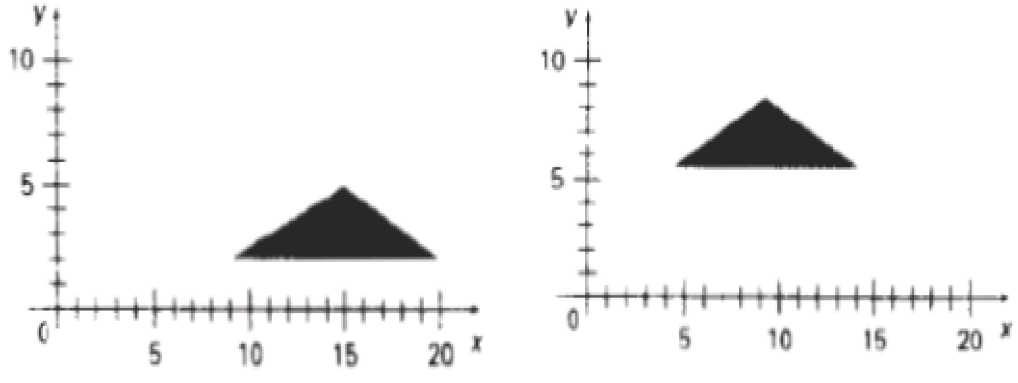
1.4.TWO DIMENSIONAL GEOMETRIC TRANSFORMATIONS

CONCEPTS:

Changes in orientations, size and shape are accomplished with geometric transformations that alter the coordinate description of objects. Basic transformation
Translation
T(*tx*, *ty*)
Translation distances Scale
S(*sx*,*sy*)
Scale factors Rotation
R()
Rotation angle

Translation

A translation is applied to an object by representing it along a straight line path from one coordinate location to another adding translation distances, tx, ty to original coordinate position (x,y) to move the point to a new position (x,y) to **x' = x + tx, y' = y + ty** The translation distance point (tx,ty) is called translation vector or shift vector. Translation equation can be expressed as single matrix equation by using column vectors to represent the coordinate.



Rotations:

A two-dimensional rotation is applied to an object by repositioning it along a circular path on xy plane. To generate a rotation, specify a rotation angle θ and the position (xr,yr) of the rotation point (pivot point) about which the object is to be rotated.

Scaling :

A scaling transformation alters the size of an object. This operation can be carried out for polygons by multiplying the coordinate values (x,y) to each vertex by scaling factor Sx & Sy to produce the transformed coordinates (x′,y′).

SIGNIFICANCE:

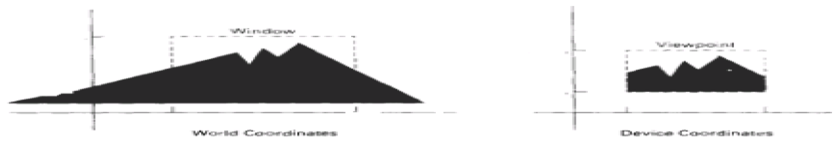
This concept is used to implement a object transformation,resize and rotating in different angle.

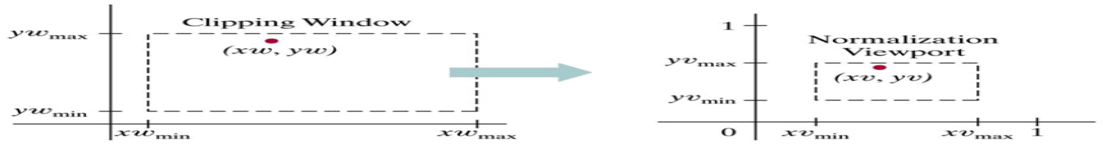
1.5.TWO DIMENSIONAL VIEWING

CONCEPT:

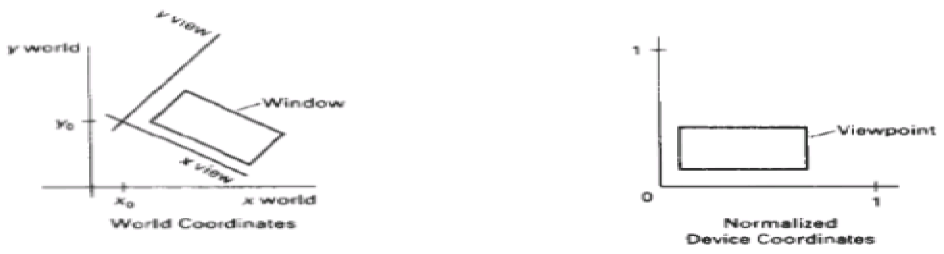
The viewing pipeline

A world coordinate area selected for display is called a window. An area on a display device to which a window is mapped is called a view port. The window defines what is to be viewed the view port defines where it is to be displayed. The mapping of a part of a world coordinate scene to device coordinate is referred to as viewing transformation. The two dimensional viewing transformation is referred to as window to view port transformation of windowing transformation.





A point (xw, yw) in a world-coordinate clipping window is mapped to viewport coordinates (xv, yv), within a unit square, so that the relative positions of the two points in their respective rectangles are the same.



The viewing transformation in several steps, as indicated in Fig. First, we construct the scene in world coordinates using the output primitives. Next to obtain a particular orientation for the window, we can set up a two-dimensional viewing-coordinate system in the world coordinate plane, and define a window in the viewing-coordinate system.

The viewing- coordinate reference frame is used to provide a method for setting up arbitrary orientations for rectangular windows. Once the viewing reference frame is established, we can transform descriptions in world coordinates to viewing coordinates.

We then define a viewport in normalized coordinates (in the range from 0 to 1) and map the viewing-coordinate description of the scene to normalized coordinates. At the final step all parts of the picture that lie outside the viewport are clipped, and the contents of the viewport are transferred to device coordinates.

SIGNIFICANCE:

Changing the position of the viewport, we can view objects at different positions on the display area of an output device.

1.6.CLIPPING OPERATION

CONCEPT

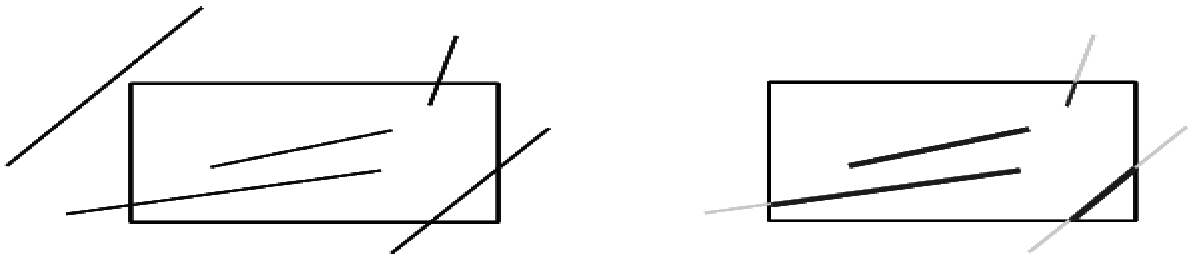
Point clipping
Line clipping (Straight-line segment)
Area clipping
Curve clipping
Text clipping

Point Clipping

Clip window is a rectangle in standard position. A point P=(x,y) for display, if following inequalities are satisfied: xwmin <= x <= xwmax
ywmin <= y <= ywmax

Line Clipping

A line clipping procedure involves several parts. First we test a given line segment 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 perform intersection calculations with one or more clipping boundaries.

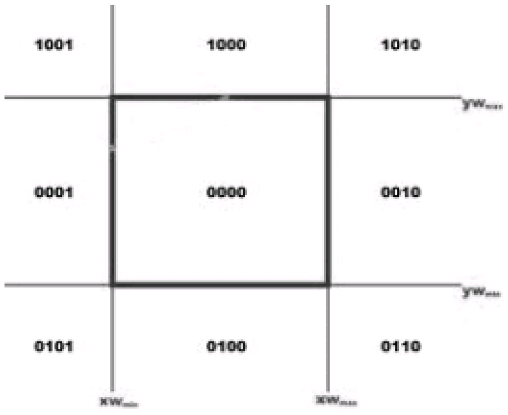


All other lines cross one or more clipping boundaries. For a line segment with end points (x1,y1) and (x2,y2) one or both end points outside clipping rectangle, the parametric representation could be used to determine values of u for an intersection with the clipping boundary coordinates.

If the value of u for an intersection with a rectangle boundary edge is outside the range of 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. This method can be applied to each clipping boundary edge in to determined whether any part of line segment is to displayed.

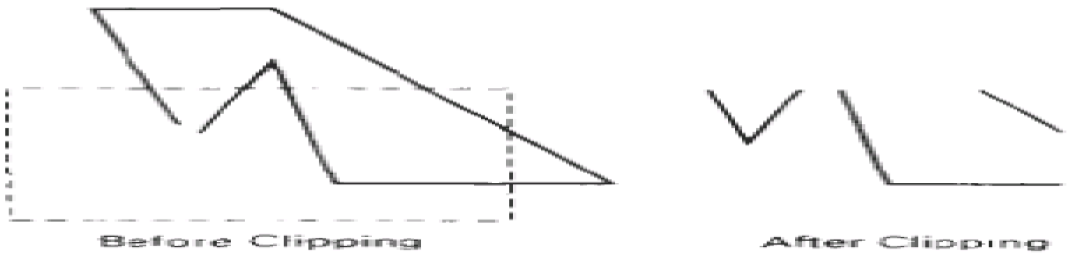
Cohen-Sutherland Line Clipping

This is one of the oldest and most popular line-clipping procedures. The method speeds up the processing of line segments by performing initial tests that reduce the number of intersections that must be calculated. Every line endpoint in a picture is assigned a four digit binary code called a **region code** that identifies the location of the point relative to the boundaries of the clipping rectangle.



POLYGON CLIPPING

To clip polygons, we need to modify the line-clipping procedures. A polygon boundary processed with a line clipper may be displayed as a series of unconnected line segments (Fig.), depending on the orientation of the polygon to the clipping window.



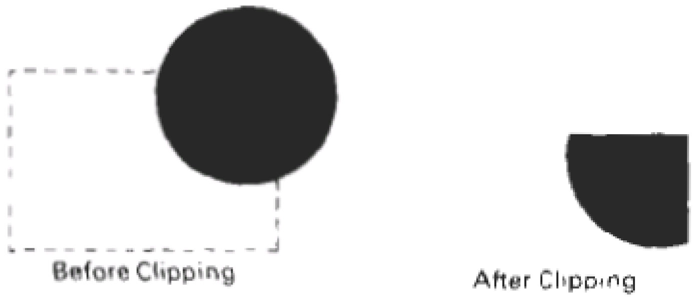
Sutherland – Hodgeman polygon clipping:

A polygon can be clipped by processing the polygon boundary as a whole against each window edge. This could be accomplished by processing all polygon vertices against each clip rectangle boundary. There are four possible cases when processing vertices in sequence around the perimeter of a polygon. As each point of adjacent polygon vertices is passed to a window boundary clipper, make the following tests:

1. If the first vertex is outside the window boundary and second vertex is inside, both the intersection point of the polygon edge with window boundary and second vertex are added to output vertex list.
2. If both input vertices are inside the window boundary, only the second vertex is added to the output vertex list.
3. If first vertex is inside the window boundary and second vertex is outside only the edge intersection with window boundary is added to output vertex list.
4. If both input vertices are outside the window boundary nothing is added to the output list.

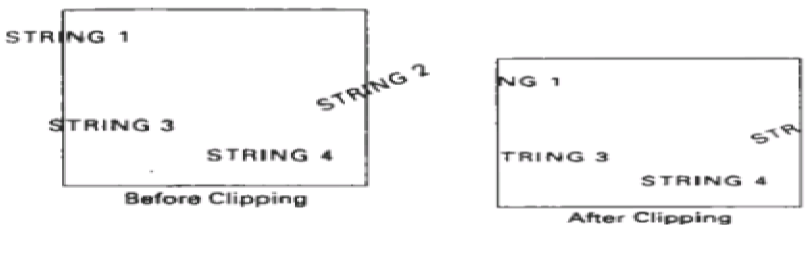
Curve Clipping

Curve-clipping procedures will involve nonlinear equations, and this requires more processing than for objects with linear boundaries. The bounding rectangle for a circle or other curved object can be used first to test for overlap with a rectangular clip window



TEXT CLIPPING

An alternative to rejecting an entire character string that overlaps a window boundary is to use the **all-or-none character-clipping** strategy. Here we discard only those characters that are not completely inside the window .In this case, the boundary limits of individual characters are compared to the window. Any character that either overlaps or is outside a window boundary is clipped.



Exterior clipping:

Procedure for clipping a picture to the interior of a region by eliminating everything outside the clipping region. By these procedures the inside region of the picture is saved. To clip a picture to the exterior of a specified region. The picture parts to be saved are those that are outside the region. This is called as exterior clipping.

SIGNIFICANCE:

A line clipping procedure involves several parts. First we test a given line segment whether it lies completely inside the clipping window.

APPLICATIONS:

1.Implement Line,circle,ellipse drawing algorithm.
2.Implement clipping algorithms.
3.Implementation of Transformations

UNIT - II THREE-DIMENSIONAL CONCEPTS

Parallel and Perspective projections-Three-Dimensional Object Representations – Polygons, Curved lines,Splines, Quadric Surfaces- Visualization of data sets- Three- Transformations – Three-Dimensional Viewing –Visible surface identification.

PREREQUISITE DISCUSSION:

This we discuss about three dimensional concepts and object design.

2.1.PARALLEL AND PERSPECTIVE PROJECTIONS

CONCEPT:

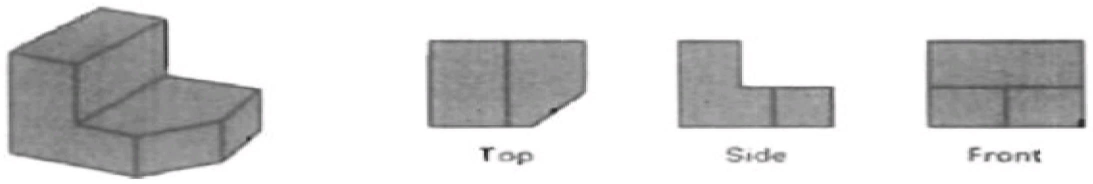
Parallel Projection:

Parallel projection is a method for generating a view of a solid object is to project points on the object surface along parallel lines onto the display plane.

In parallel projection, parallel lines in the world coordinate scene project into parallel lines on the two dimensional display planes.

This technique is used in engineering and architectural drawings to represent an object with a set of views that maintain relative proportions of the object.

The appearance of the solid object can be reconstructed from the major views.



Perspective Projection:

It is a method for generating a view of a three dimensional scene is to project points to the display plane alone converging paths.

This makes objects further from the viewing position be displayed smaller than objects of the same size that are nearer to the viewing position.

In a perspective projection, parallel lines in a scene that are not parallel to the display plane are projected into converging lines.

SIGNIFICANCE:

Scenes displayed using perspective projections appear more realistic, since this is the way that our eyes and a camera lens form images.

2.2.THREE-DIMENSIONAL OBJECT REPRESENTATIONS

CONCEPT

Three Dimensional Object Representations

Representation schemes for solid objects are divided into two categories as follows:
1. Boundary Representation (B-reps)
It describes a three dimensional object as a set of surfaces that separate the object interior from the environment. Examples are polygon facets and spline patches.
2. Space Partitioning representation

Eg: Octree Representation

SIGNIFICANCE:

It Describes The Interior Properties, By Partitioning The Spatial Region Containing An Object Into A Set Of Small, Nonoverlapping, Contiguous Solids(Usually Cubes).

2.3.POLYGON SURFACES

CONCEPT

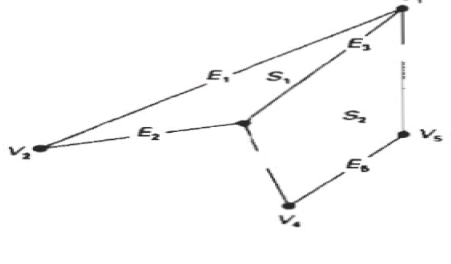
Polygon surfaces are boundary representations for a 3D graphics object is a set of polygons that enclose the object interior. **Polygon Tables**
The polygon surface is specified with a set of vertex coordinates and associated attribute parameters.

For each polygon input, the data are placed into tables that are to be used in the subsequent processing.

Polygon data tables can be organized into two groups: Geometric tables and attribute tables.

Geometric Tables

Contain vertex coordinates and parameters to identify the spatial orientation of the polygon surfaces. **Attribute tables** Contain attribute information for an object such as parameters specifying the degree of transparency of the object and its surface reflectivity and texture characteristics.



Vertex table Edge Table Polygon surface table V1 : X1, Y1, Z1 E1 : V1, V2 S1 : E1, E2, E3 V2 : X2, Y2, Z2 E2 : V2, V3 S2 : E3, E4, E5, E6 V3 : X3, Y3, Z3 E3 : V3, V1 V4 : X4, Y4, Z4 E4 : V3, V4 V5 : X5, Y5, Z5 E5 : V4, V5 E6 : V5, V1
Listing the geometric data in three tables provides a convenient reference to the individual components (vertices, edges and polygons) of each object.

The object can be displayed efficiently by using data from the edge table to draw the component lines.

Extra information can be added to the data tables for faster information extraction. For instance, edge table can be expanded to include forward points into the polygon table so that common edges between polygons can be identified more rapidly.

vertices are input, we can calculate edge slopes and we can scan the coordinate values to identify the minimum and maximum x, y and z values for individual polygons.

The more information included in the data tables will be easier to check for errors.

Some of the tests that could be performed by a graphics package are:

1. That every vertex is listed as an endpoint for at least two edges.

2. That every edge is part of at least one polygon.

3. That every polygon is closed.

4. That each polygon has at least one shared edge.

5. That if the edge table contains pointers to polygons, every edge referenced by a polygon pointer has a reciprocal pointer back to the polygon.

Plane Equations:

To produce a display of a 3D object, we must process the input data representation for the object through several procedures such as,
- Transformation of the modeling and world coordinate descriptions to viewing coordinates.

- Then to device coordinates:

- Identification of visible surfaces

- The application of surface-rendering procedures.

For these processes, we need information about the spatial orientation of the individual surface components of the object. This information is obtained from the vertex coordinate value and the equations that describe the polygon planes.

The equation for a plane surface is $Ax + By+ Cz + D = 0$ ----(1) Where (x, y, z) is any point on the plane, and the coefficients A,B,C and D are constants describing the spatial properties of the plane.

Polygon Meshes

A single plane surface can be specified with a function such as **fillArea**. But when object surfaces are to be tiled, it is more convenient to specify the surface facets with a mesh function.

One type of polygon mesh is the **triangle strip**.A triangle strip formed with 11 triangles connecting 13 vertices.

This function produces n-2 connected triangles given the coordinates for n vertices.

Curved Lines and Surfaces

Displays of three dimensional curved lines and surface can be generated from an input set of mathematical functions defining the objects or from a set of user specified data points.

When functions are specified, a package can project the defining equations for a curve to the display plane and plot pixel positions along the path of the projected function.

For surfaces, a functional description in decorated to produce a polygon-mesh approximation to the surface.

Quadric Surfaces

The quadric surfaces are described with second degree equations (quadratics).

They include spheres, ellipsoids, tori, parabolids, and hyperboloids.

Sphere

In Cartesian coordinates, a spherical surface with radius r centered on the coordinates origin is defined as the set of points (x, y, z) that satisfy the equation.

x2 + y2 + z2 = r2

Ellipsoid

Ellipsoid surface is an extension of a spherical surface where the radius in three mutually perpendicular directions can have different values

Spline Representations

A Spline is a flexible strip used to produce a smooth curve through a designated set of points.

Several small weights are distributed along the length of the strip to hold it in position on the drafting table as the curve is drawn.

The **Spline curve** refers to any sections curve formed with polynomial sections satisfying specified continuity conditions at the boundary of the pieces.

A **Spline surface** can be described with two sets of orthogonal spline curves.

Splines are used in graphics applications to design curve and surface shapes, to digitize drawings for computer storage, and to specify animation paths for the objects or the camera in the scene. CAD applications for splines include the design of automobiles bodies, aircraft and spacecraft surfaces, and ship hulls.

Interpolation and Approximation Splines

Spline curve can be specified by a set of coordinate positions called **control points** which indicates the general shape of the curve.
These control points are fitted with piecewise continuous parametric polynomial functions in one of the two ways.
When polynomial sections are fitted so that the curve passes through each control point the resulting curve is said to **interpolate** the set of control points.

A set of six control points interpolated with piecewise continuous polynomial sections

When the polynomials are fitted to the general control point path without necessarily passing through any control points, the resulting curve is said to **approximate** the set of control points.

A set of six control points approximated with piecewise continuous polynomial sections

Interpolation curves are used to digitize drawings or to specify animation paths.

Approximation curves are used as design tools to structure object surfaces.

A spline curve is designed , modified and manipulated with operations on the control points.The curve can be translated, rotated or scaled with transformation applied to the control points.

The convex polygon boundary that encloses a set of control points is called the **convex hull**.

The shape of the convex hull is to imagine a rubber band stretched around the position of the control points so that each control point is either on the perimeter of the hull or inside it.

Parametric Continuity Conditions

For a smooth transition from one section of a piecewise parametric curve to the next various **continuity conditions** are needed at the connection points.

If each section of a spline in described with a set of parametric coordinate functions or the form

$x = x(u), y = y(u), z = z(u), u1 <= u <= u2$

Zero order parametric continuity referred to as C0 continuity, means that the curves meet. (i.e) the values of x,y, and z evaluated at u2 for the first curve section are equal. Respectively, to the value of x,y, and z evaluated at u1 for the next curve section.

First order parametric continuity referred to as C1 continuity means that the first parametric derivatives of the coordinate functions in equation (a) for two successive curve sections are equal at their joining point.

Second order parametric continuity, or C2 continuity means that both the first and second parametric derivatives of the two curve sections are equal at their intersection.

Geometric Continuity Conditions

To specify conditions for geometric continuity is an alternate method for joining two successive curve sections.

The parametric derivatives of the two sections should be proportional to each other at their common boundary instead of equal to each other.

Zero order Geometric continuity referred as G0 continuity means that the two curves sections must have the same coordinate position at the boundary point.

First order Geometric Continuity referred as G1 continuity means that the parametric first derivatives are proportional at the interaction of two successive sections.

Second order Geometric continuity referred as G2 continuity means that both the first and second parametric derivatives of the two curve sections are proportional at their boundary. Here the curvatures of two sections will match at the joining position.

SIGNIFICANCE:

A spline curve is designed , modified and manipulated with operations on the control points.The curve can be translated, rotated or scaled with transformation applied to the control points.

2.4.VISUALIZATION OF DATA SETS

CONCEPT:

The use of graphical methods as an aid in scientific and engineering analysis is commonly referred to as **scientific visualization**.

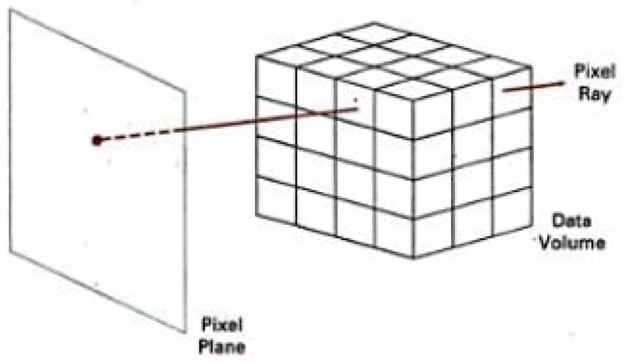
This involves the visualization of data sets and processes that may be difficult or impossible to analyze without graphical methods. Example medical scanners, satellite and spacecraft scanners.

Visualization techniques are useful for analyzing process that occur over a long period of time or that cannot observed directly. Example quantum mechanical phenomena and special relativity effects produced by objects traveling near the speed of light.

Scientific visualization is used to visually display , enhance and manipulate information to allow better understanding of the data.

Similar methods employed by commerce , industry and other nonscientific areas are sometimes referred to as business visualization.

Data sets are classified according to their spatial distribution (2D or 3D) and according to data type (scalars , vectors , tensors and multivariate data).

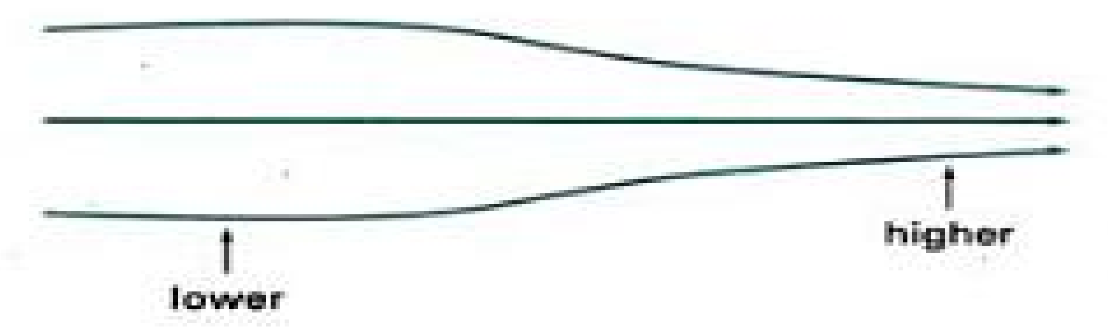


Visual representation for Vector fields

A vector quantity V in three-dimensional space has three scalar values

(Vx , Vy,Vz,) one for each coordinate direction, and a two-dimensional vector has two components **(Vx, Vy,).** Another way to describe a vector quantity is by giving its magnitude I**V** I and its direction as a unit vector **u**. As with scalars, vector quantities may be functions of position, time, and other parameters. Some examples of physical vector quantities are velocity, acceleration, force, electric fields, magnetic fields, gravitational fields, and electric current.

One way to visualize a vector field is to plot each data point as a small arrow that shows the magnitude and direction of the vector. This method is most often used with cross-sectional slices, since it can be difficult to see the trends in a three-dimensional region cluttered with overlapping arrows. Magnitudes for the vector values can be shown by varying the lengths of the arrows. Vector values are also represented by plotting **field lines** or **streamlines .** Field lines are commonly used for electric , magnetic and gravitational fields. The magnitude of the vector values is indicated by spacing between field lines, and the direction is the tangent to the field.



Visual Representations for Tensor Fields

A tensor quantity in three-dimensional space has nine components and can be represented with a 3 by 3 matrix. This representation is used for a **second-order tensor,** and higher-order tensors do occur in some applications. Some examples of physical, second-order tensors are stress and strain in a material subjected to external forces, conductivity of an electrical conductor, and the metric tensor, which gives the properties of a particular coordinate space.

SIGNIFICANCE:

The use of graphical methods as an aid in scientific and engineering analysis is commonly referred to as **scientific visualization**.

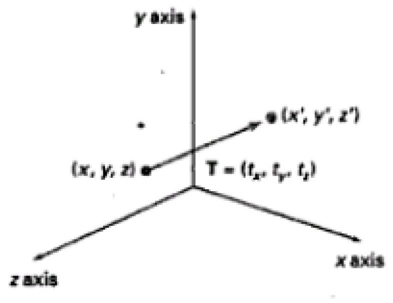
2.5THREE DIMENSIONAL GEOMETRIC AND MODELING TRANSFORMATIONS:

CONCEPT:

Geometric transformations and object modeling in three dimensions are extended from two-dimensional methods by including considerations for the z-coordinate

Translation

In a three dimensional homogeneous coordinate representation, a point or an object is translated from position P = (x,y,z) to position P = (x,y,z) with the matrix operation.



Rotation

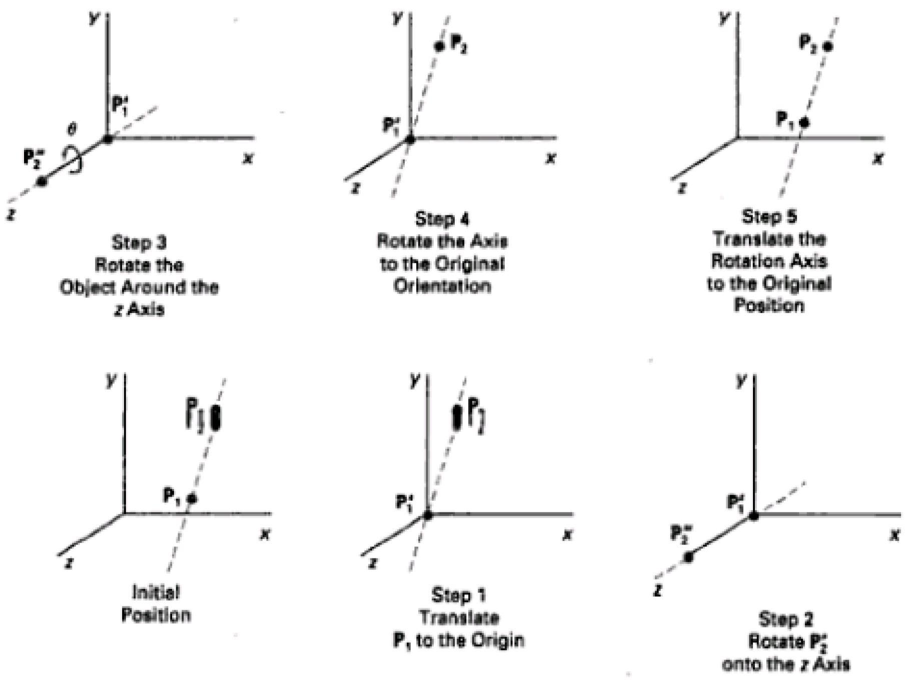
To generate a rotation transformation for an object an axis of rotation must be designed to rotate the object and the amount of angular rotation is also be specified.

Positive rotation angles produce counter clockwise rotations about a coordinate axis.

Co-ordinate Axes Rotations

The 2D z axis rotation equations are easily extended to 3D.

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


Step 3
Rotate the Object Around the z Axis
Step 4
Rotate the Axis to the Original Orientation
Step 5
Translate the Rotation Axis to the Original Position
Initial Position
Step 1
Translate P1 to the Origin
Step 2
Rotate P2' onto the z Axis

Scaling

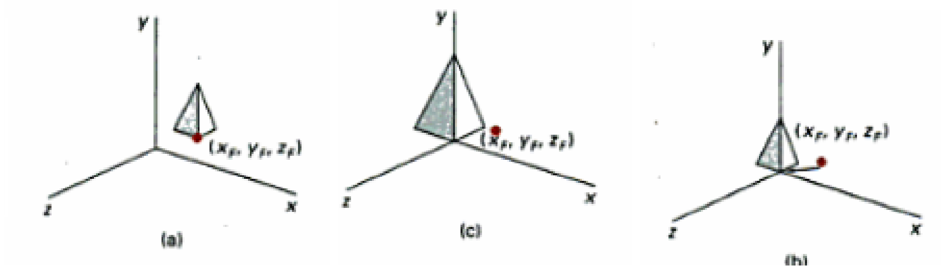
The matrix expression for the scaling transformation of a position P = (x,y,.z)

Scaling an object changes the size of the object and repositions the object relatives to the coordinate origin.

If the transformation parameters are not equal, relative dimensions in the object are changed.

The original shape of the object is preserved with a uniform scaling (sx = sy= sz) .

Scaling with respect to a selected fixed position (x f, yf, zf) can be represented with the following transformation sequence:
1. Translate the fixed point to the origin. 2. Scale the object relative to the coordinate origin



Other Transformations

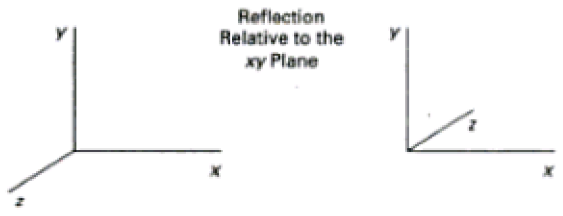
Reflections

A 3D reflection can be performed relative to a selected reflection axis or with respect to a selected reflection plane.

Reflection relative to a given axis are equivalent to 1800 rotations about the axis.

Reflection relative to a plane are equivalent to 1800 rotations in 4D space.

When the reflection plane in a coordinate plane (either xy, xz or yz) then the transformation can be a conversion between left-handed and right-handed systems.

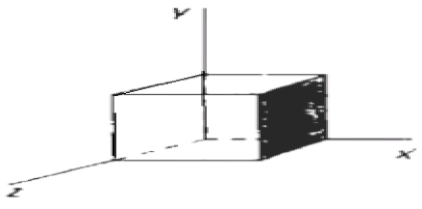


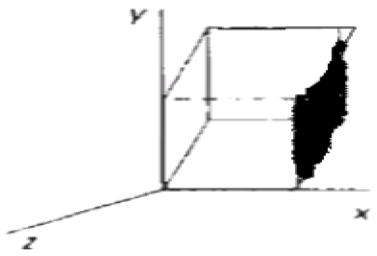
Shears

Shearing transformations are used to modify object shapes.

They are also used in three dimensional viewing for obtaining general projections transformations.

The following transformation produces a z-axis shear.





Composite Transformation

Composite three dimensional transformations can be formed by multiplying the matrix representation for the individual operations in the transformation sequence.

This concatenation is carried out from right to left, where the right most matrixes is the first transformation to be applied to an object and the left most matrix is the last transformation.

A sequence of basic, three-dimensional geometric transformations is combined to produce a single composite transformation which can be applied to the coordinate definition of an object.

Three Dimensional Transformation Functions

Some of the basic 3D transformation functions are: translate (translateVector, matrixTranslate) rotateX(thetaX, xMatrixRotate) rotateY(thetaY, yMatrixRotate) rotateZ(thetaZ, zMatrixRotate) scale3 (scaleVector, matrixScale)
Each of these functions produces a 4 by 4 transformation matrix that can be used to transform coordinate positions expressed as homogeneous column vectors.

Parameter translate Vector is a pointer to list of translation distances tx, ty, and tz.

Parameter scale vector specifies the three scaling parameters sx, sy and sz.

Rotate and scale matrices transform objects with respect to the coordinate origin.

Composite transformation can be constructed with the following functions:

composeMatrix3 buildTransformationMatrix3 composeTransformationMatrix3
The order of the transformation sequence for
the **buildTransformationMarix3** and **composeTransfomationMarix3** functions, is the same as in 2 dimensions:
1. scale

2. rotate

3. translate
Once a transformation matrix is specified, the matrix can be applied to specified points with

transformPoint3 (inPoint, matrix, outpoint)
The transformations for hierarchical construction can be set using structures with the function

setLocalTransformation3 (matrix, type) where parameter matrix specifies the elements of a 4 by 4 transformation matrix and parameter type can be assigned one of the values of: Preconcatenate, Postconcatenate, or replace.

SIGNIFICANCE:

A 3D reflection can be performed relative to a selected reflection axis or with respect to a selected reflection plane.

2.6.THREE-DIMENSIONAL VIEWING

CONCEPT:

In three dimensional graphics applications,
- we can view an object from any spatial position, from the front, from above or from the back.

- We could generate a view of what we could see if we were standing in the middle of a group of objects or inside object, such as a building.

Viewing Pipeline:

In the view of a three dimensional scene, to take a snapshot we need to do the following steps.
1. Positioning the camera at a particular point in space.

2. Deciding the camera orientation (i.e.,) pointing the camera and rotating it around the line of right to set up the direction for the picture.

3. When snap the shutter, the scene is cropped to the size of the „window of the camera and light from the visible surfaces is projected into the camera film.

In such a way the below figure shows the three dimensional transformation pipeline, from modeling coordinates to final device coordinate.

Processing Steps

1. Once the scene has been modeled, world coordinates position is converted to viewing coordinates.

2. The viewing coordinates system is used in graphics packages as a reference for specifying the observer viewing position and the position of the projection plane.

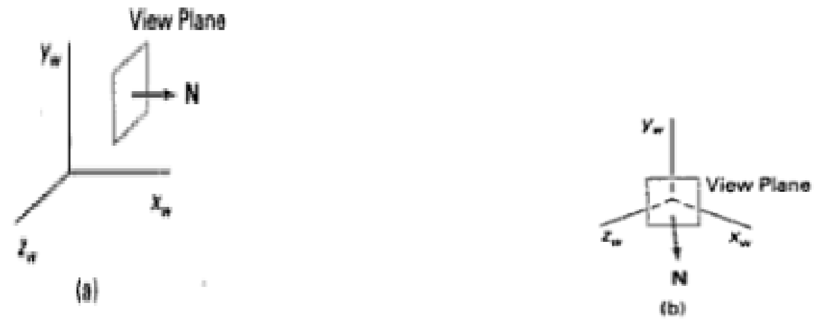
3. Projection operations are performed to convert the viewing coordinate description of the scene to coordinate positions on the projection plane, which will then be mapped to the output device.

A **viewplane** or **projection plane** is set-up perpendicular to the viewing Zv axis.

World coordinate positions in the scene are transformed to viewing coordinates, then viewing coordinates are projected to the view plane.

The **view reference point** is a world coordinate position, which is the origin of the viewing coordinate system. It is chosen to be close to or on the surface of some object in a scene.

Then we select the positive direction for the viewing Zv axis, and the orientation of the view plane by specifying the **view plane normal vector, N**. Here the world coordinate position establishes the direction for N relative either to the world origin or to the viewing coordinate origin.



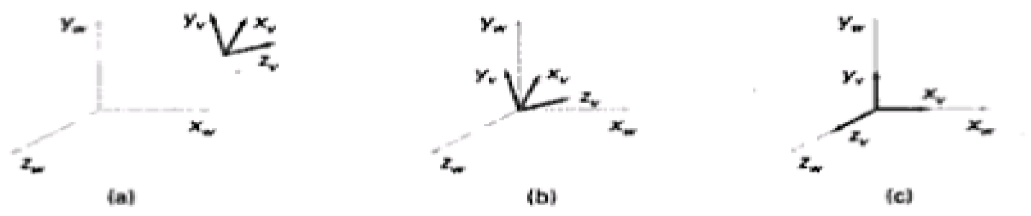
Transformation from world to viewing coordinates

Before object descriptions can be projected to the view plane, they must be transferred to viewing coordinate. This transformation sequence is,

1. Translate the view reference point to the origin of the world coordinate system.

2. Apply rotations to align the xv, yv and zv axes with the world xw,yw and zw axes respectively.

If the view reference point is specified at world position(x0,y0,z0) this point is translated to the world origin with the matrix transformation.



Another method for generation the rotation transformation matrix is to calculate unit uvn vectors and form the composite rotation matrix directly.

Given vectors N and V, these unit vectors are calculated as

n = N / (|N|) = (n1, n2, n3) u = (V*N) / (|V*N|) = (u1, u2, u3) v = n*u = (v1, v2, v3)

This method automatically adjusts the direction for v, so that v is perpendicular to n.

The composite rotation matrix for the viewing transformation is

u1 u2 u3 0 R = v1 v2 v3 0 n1 n2 n3 0 0 0 0 1

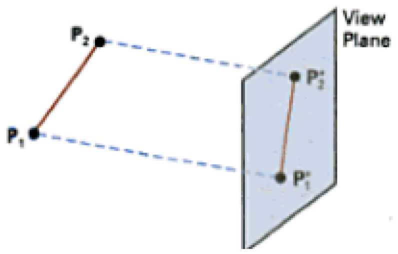
which transforms u into the world xw axis, v onto the yw axis and n onto the zw axis

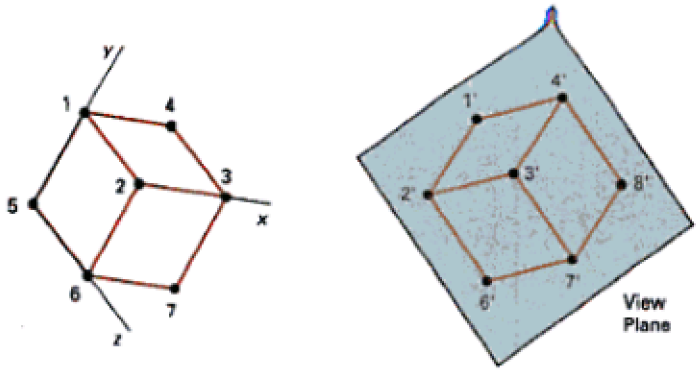
Projections

Once world coordinate descriptions of the objects are converted to viewing coordinates, we can project the 3 dimensional objects onto the two dimensional view planes.

There are two basic types of projection.

1. **Parallel Projection** - Here the coordinate positions are transformed to the view plane along parallel lines.
Parallel projection of an object to the view plan





SIGNIFICANCE:

In three dimensional graphics applications, we can view an object from any spatial position, from the front, from above or from the back.

2.7.VISIBLE SURFACE IDENTIFICATION

CONCEPT

A major consideration in the generation of realistic graphics displays is identifying those parts of a scene that are visible from a chosen viewing position.

Classification of Visible Surface Detection Algorithms

These are classified into two types based on whether they deal with object definitions directly or with their projected images

1. Object Space Methods:

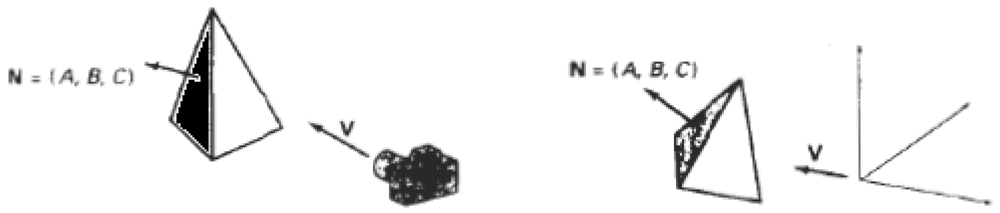
compares objects and parts of objects to each other within the scene definition to determine which surfaces as a whole we should label as visible.

2. Image space methods:

visibility is decided point by point at each pixel position on the projection plane. Most Visible Surface Detection Algorithms use image space methods.

Back Face Detection

A point (x, y,z) is "inside" a polygon surface with plane parameters A, B, C, and D if Ax + By + Cz + D < 0 ----------------(1) When an inside point is along the line of sight to the surface, the polygon must be a back face .

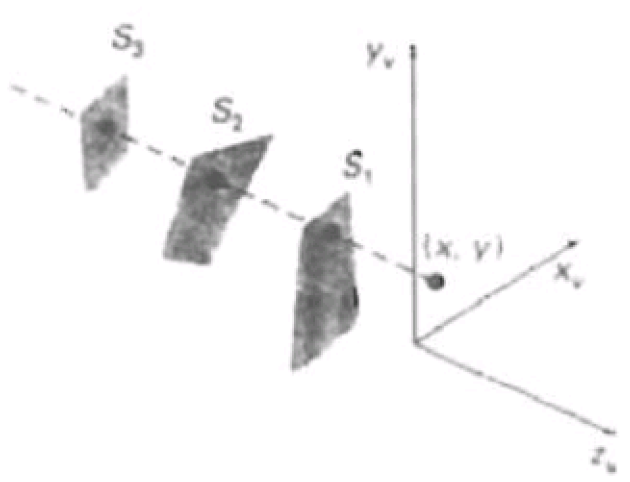


Depth Buffer Method

A 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 also referred to as the z-buffer method. Each surface of a scene is processed separately, one point at a time across the surface. The method is usually applied to scenes containing only polygon surfaces, because depth values can be computed very quickly and the method is easy to implement.

But the mcthod can be applied to nonplanar surfaces. With object descriptions converted to projection coordinates, each (x, y, z) position on a polygon surface corresponds to the orthographic projection point (x, y) on the view plane.



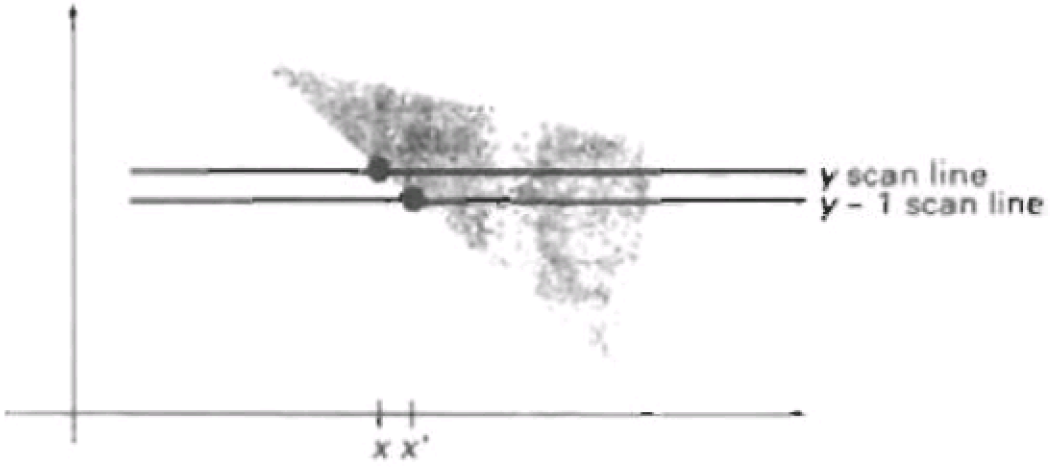
We can implement the depth-buffer algorithm in normalized coordinates, so that ***z*** values range from **0** at the back clipping plane to **Zmax** at the front clipping plane.

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.

Initially,all positions in the depth buffer are set to 0 (minimum depth), and the refresh buffer is initialized to the background intensity. We summarize the **steps of a depth-buffer algorithm as follows**:
1. Initialize the depth buffer and refresh buffer so that for all buffer positions (x, y), depth (x, y)=0, refresh(x , y)=Ibackgnd 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.

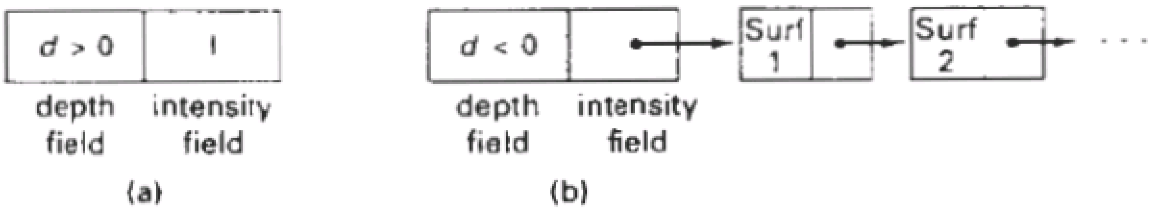
If z > depth(x, y), then set

depth (x, y)=z , refresh(x,y)= Isurf(x, y)



A- BUFFER METHOD

An extension of the ideas in the depth-buffer method is the A-buffer method. The A buffer method represents an **antialiased, area-averaged, accumulation-buffer method** developed by Lucasfilm for implementation in the surface-rendering system called **REYES** (an acronym for "Renders Everything You Ever Saw"). A drawback of the depth-buffer method is that it can only find one visible surface at each pixel position. The A-buffer method expands

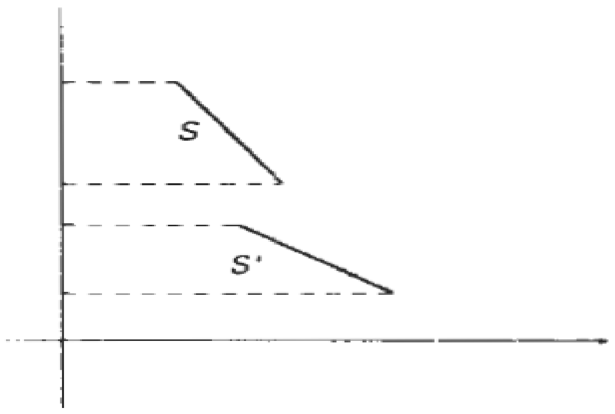


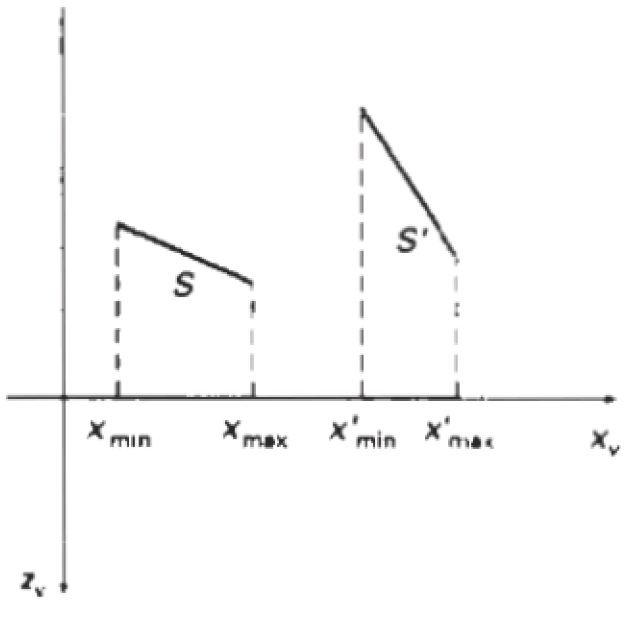
SCAN-LINE METHOD

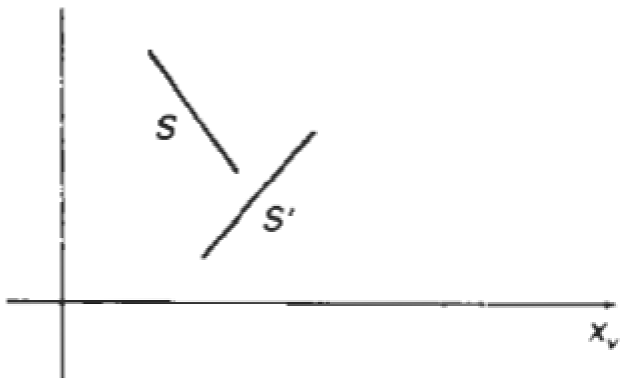
This image-space method for removing hidden surfaces is an extension of the scan-line algorithm for filling polygon interiors. As each scan line is processed, all polygon surfaces intersecting that line are examined to determine which are visible. Across each scan line, depth calculations are made for 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.

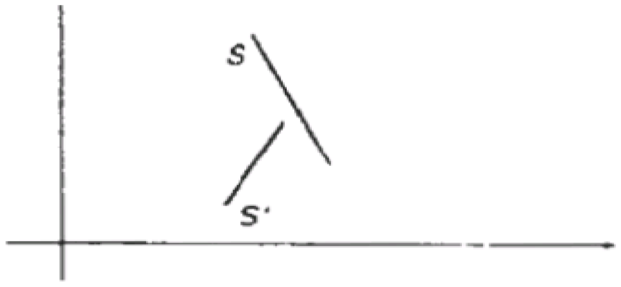
We assume that tables are set up for the various surfaces, which include both an edge table and a polygon table. The **edge table** contains coordinate endpoints for each line in-the scene, the inverse slope of each line, and pointers into the polygon table to identify the surfaces bounded by each line. The **polygon table** contains coefficients of the plane equation for each surface, intensity information for the surfaces, and possibly pointers into the edge table.

To facilitate the search for surfaces crossing a given scan line, we can set up an active list of edges from information in the edge table. This active list will contain only edges that cross the current scan line, sorted in order of increasing x**.** In addition, we define a flag for each surface that is set on or off to indicate whether a position along a scan line is inside or outside of the surface. Scan lines are processed from left to right. At the leftmost boundary of a surface, the surface flag is turned on; and at the rightmost boundary, it is turned off.

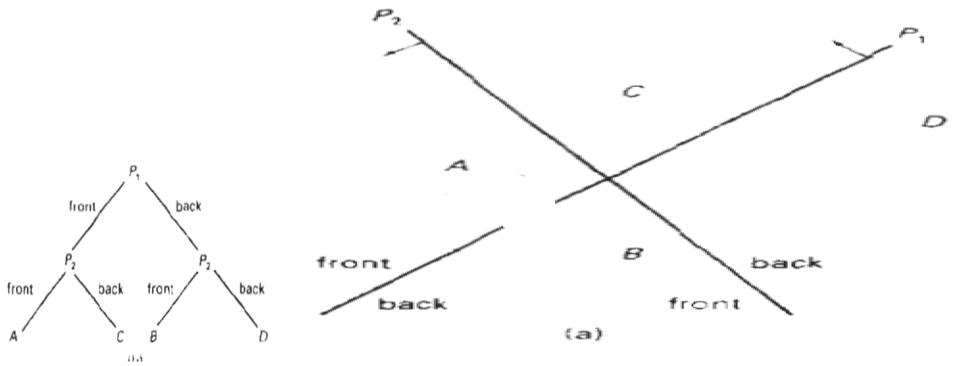








BSP-Tree Method A binary space-partitioning (BSP) tree is an efficient method for determining object visibility by painting surfaces onto the screen from back to front, as in the painter's algorithm. The BSP tree is particularly useful when the view reference point changes, but the objects in a scene are at fixed positions. Applying a BSP tree to visibility testing involves identifying surfaces that are "inside" and "outside" the partitioning plane at each step of the space subdivision, relative to the viewing direction. The figure(a) illustrates the basic concept in this algorithm.



Area – Subdivision Method

This technique for hidden-surface removal is essentially an image-space method ,but object-space operations can be used to accomplish depth ordering of surfaces. The area-subdivision method takes advantage of area coherence in a scene by locating those view areas that represent part of a single surface. We apply this method by successively dividing 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.

octree methods

When an **octree** representation is used for the viewing volume, hidden-surface elimination is accomplished by projecting octree nodes onto the viewing surface in a front-to-back order. In the below Fig. the front face of a region of space (the side toward the viewer) is formed with octants 0, 1**,** 2, and 3. Surfaces in the front of these octants are visible to the viewer. Any surfaces toward the re in the back octants (4,5,6, and 7) may be hidden by the front surfaces.

When an **octree** representation is used for the viewing volume, hidden-surface elimination is accomplished by projecting octree nodes onto the viewing surface in a front-to-back order. In the below Fig. the front face of a region of space (the side toward the viewer) is formed with octants 0, 1**,** 2, and 3. Surfaces in the front of these octants are visible to the viewer. Any surfaces toward the re in the back octants (4,5,6, and 7) may be hidden by the front surfaces.

SIGNIFICANCE:

This technique for hidden-surface removal is essentially an image-space method ,but object-space operations can be used to accomplish depth ordering of surfaces**.**

APPLICATIONS:

1.Real time 3D magic

2.Implement 3D transformations

3.Correct view about 3D

UNIT III - GRAPHICS PROGRAMMING

Color Models – RGB, YIQ, CMY, HSV – Animations – General Computer Animation, Raster, Keyframe - Graphics programming using OPENGL – Basic graphics primitives –Drawing three dimensional objects - Drawing three dimensional scenes

PREREQUISITE DISCUSSION:

In this unit going to discuss about graphics color models and general computer animation and three dimensional object scenes.

3.1.COLOR MODELS

CONCEPTS:

Color Model is a method for explaining the properties or behavior of color within some particular context. No single color model can explain all aspects of color, so we make use of different models to help describe the different perceived characteristics of color.

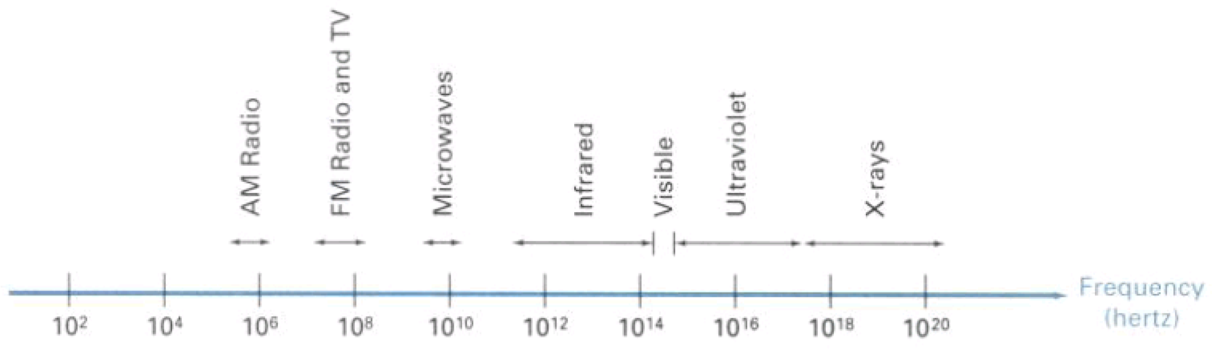
Properties of Light

Light is a narrow frequency band within the electromagnetic system.

Other frequency bands within this spectrum are called radio waves, micro waves, infrared waves and x-rays. The below fig shows the frequency ranges for some of the electromagnetic bands.

Each frequency value within the visible band corresponds to a distinct color.

At the low frequency end is a red color (4.3*104 Hz) and the highest frequency is a violet color (7.5 *10 14Hz)



Spectral colors range from the reds through orange and yellow at the low frequency end to greens, blues and violet at the high end.

Since light is an electro magnetic wave, the various colors are described in terms of either the frequency for the wave length λ of the wave.

The wave length ad frequency of the monochromatic wave are inversely proportional to each other, with the proportionality constants as the speed of light C where $C = \lambda f$

A light source such as the sun or a light bulb emits all frequencies within the visible range to produce white light. When white light is incident upon an object, some frequencies are reflected and some are absorbed by the object. The combination of frequencies present in the reflected light determines what we perceive as the color of the object.

If low frequencies are predominant in the reflected light, the object is described as red. In this case, the perceived light has the dominant frequency at the red end of the spectrum. The dominant frequency is also called the hue, or simply the color of the light.

Brightness is another property, which in the perceived intensity of the light.

Intensity in the radiant energy emitted per limit time, per unit solid angle, and per unit projected area of the source.

Radiant energy is related to the luminance of the source.

The next property in the purity or saturation of the light.
- Purity describes how washed out or how pure the color of the light appears.

- Pastels and Pale colors are described as less pure.
The term chromaticity is used to refer collectively to the two properties, purity and dominant frequency.

SIGNIFICANCE:

Color Model is a method for explaining the properties or behavior of color within some particular context.

3.2.STANDARD PRIMARIES

CONCEPTS

XYZ COLOR MODEL

The set of primaries is generally referred to as the XYZ or (X,Y,Z) color model where X,Y and Z represent vectors in a 3D, additive color space.

Any color Cλ is expressed as
$C\lambda = X\mathbf{X} + Y\mathbf{Y} + Z\mathbf{Z}$ -------------(1) Where X,Y and Z designates the amounts of the standard primaries needed to match Cλ.
It is convenient to normalize the amount in equation (1) against luminance (X + Y+ Z). Normalized amounts are calculated as,

$x = X/(X+Y+Z)$, $y = Y/(X+Y+Z)$, $z = Z/(X+Y+Z)$ with $x + y + z = 1$

Any color can be represented with just the x and y amounts. The parameters x and y are called the chromaticity values because they depend only on hue and purity.

RGB Color Model

Based on the tristimulus theory of our eyes perceive color through the stimulation of three visual pigments in the cones on the retina.

These visual pigments have a peak sensitivity at wavelengths of about 630 nm (red), 530 nm (green) and 450 nm (blue).

By comparing intensities in a light source, we perceive the color of the light.

This is the basis for displaying color output on a video monitor using the 3 color primaries, red, green, and blue referred to as the RGB color model.

The sign represents black, and the vertex with coordinates (1,1,1) in white.

Vertices of the cube on the axes represent the primary colors, the remaining vertices represents the complementary color for each of the primary colors.

The RGB color scheme is an additive model. (i.e.,) Intensities of the primary colors are added to produce other colors.

Each color point within the bounds of the cube can be represented as the triple (R,G,B) where values for R, G and B are assigned in the range from 0 to1.

The color Cλ is expressed in RGB component as
$C\lambda = R\mathbf{R} + G\mathbf{G} + B$

YIQ Color Model

The National Television System Committee (NTSC) color model for forming the composite video signal in the YIQ model.

In the YIQ color model, luminance (brightness) information in contained in the Y parameter, chromaticity information (hue and purity) is contained into the I and Q parameters.

A combination of red, green and blue intensities are chosen for the Y parameter to yield the standard luminosity curve.

Since Y contains the luminance information, black and white TV monitors use only the Y signal.

Parameter I contain orange-cyan hue information that provides the flash-tone shading and occupies a bandwidth of 1.5 MHz.

Parameter Q carries green-magenta hue information in a bandwidth of about 0.6 MHz.

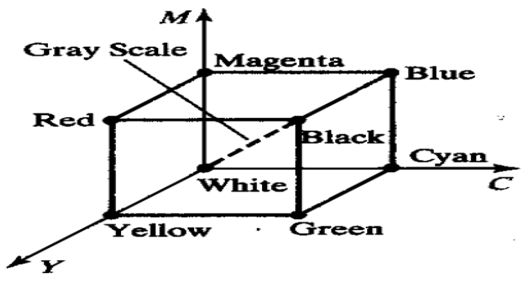
An RGB signal can be converted to a TV signal

CMY Color Model

A color model defined with the primary colors cyan, magenta, and yellow (CMY) in useful for describing color output to hard copy devices.

It is a subtractive color model (i.e.,) cyan can be formed by adding green and blue light. When white light is reflected from cyan-colored ink, the reflected light must have no red component. i.e., red light is absorbed or subtracted by the link.

Magenta ink subtracts the green component from incident light and yellow subtracts the blue component.



In CMY model, point (1,1,1) represents black because all components of the incident light are subtracted.

The origin represents white light.

Equal amounts of each of the primary colors produce grays along the main diagonal of the cube.

A combination of cyan and magenta ink produces blue light because the red and green components of the incident light are absorbed.

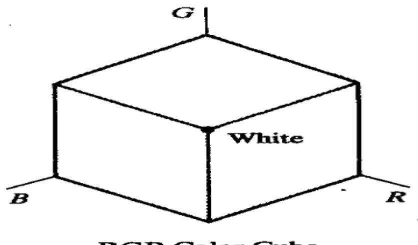
The printing process often used with the CMY model generates a color point with a collection of 4 ink dots; one dot is used for each of the primary colors (cyan, magenta and yellow) and one dot in black.

HSV Color Model

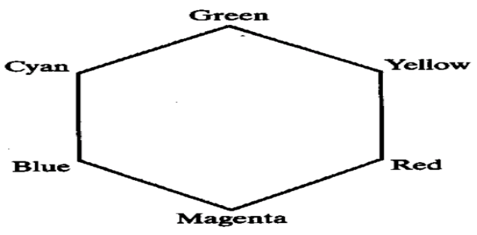
The HSV model uses color descriptions that have a more interactive appeal to a user.

Color parameters in this model are hue (H), saturation (S), and value (V).

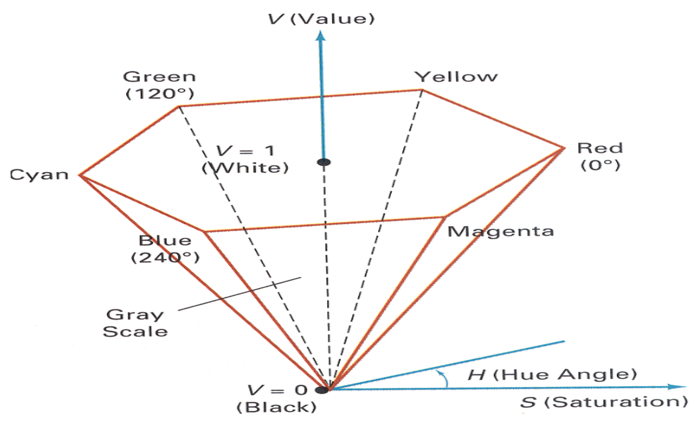
The 3D representation of the HSV model is derived from the RGB cube. The outline of the cube has the hexagon shape.



RGB Color Cube
(a)



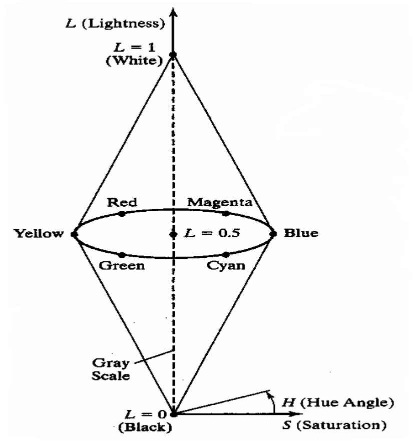
Color Hexagon
(b)



HLS Color Model

HLS model is based on intuitive color parameters used by Tektronix.

It has the double cone representation shown in the below figure. The 3 parameters in this model are called Hue (H), lightness (L) and saturation (s).



SIGNIFICANCE:

Different types of color models provide how the color displays in different form.

3.3.ANIMATION

CONCEPT :

Computer animation refers to any time sequence of visual changes in a scene.

Computer animations can also be generated by changing camera parameters such as position, orientation and focal length.

Applications of computer-generated animation are entertainment, advertising, training and education.

Example : Advertising animations often transition one object shape into another. **Frame-by-Frame animation** Each frame of the scene is separately generated and stored. Later, the frames can be recoded on film or they can be consecutively displayed in "real-time playback" mode **Design of Animation Sequences** An animation sequence in designed with the following steps:
Story board layout

Object definitions

Key-frame specifications

Generation of in-between frames.

Story board

The story board is an outline of the action.

It defines the motion sequences as a set of basic events that are to take place.

Depending on the type of animation to be produced, the story board could consist of a set of rough sketches or a list of the basic ideas for the motion.

Object Definition
An object definition is given for each participant in the action.

Objects can be defined in terms of basic shapes such as polygons or splines.

The associated movements of each object are specified along with the shape.

SIGNIFICANCE:

Computer animation refers to any time sequence of visual changes in a scene.

3.4.KEY FRAME

CONCEPT

A key frame is detailed drawing of the scene at a certain time in the animation sequence.

Within each key frame, each object is positioned according to the time for that frame.

Some key frames are chosen at extreme positions in the action; others are spaced so that the time interval between key frames is not too much.

Computer Animation Languages

Animation functions include a graphics editor, a key frame generator and standard graphics routines.

The graphics editor allows designing and modifying object shapes, using spline surfaces, constructive solid geometry methods or other representation schemes.

Scene description includes the positioning of objects and light sources defining the photometric parameters and setting the camera parameters.

Action specification involves the layout of motion paths for the objects and camera.

Keyframe systems are specialized animation languages designed dimply to generate the in-betweens from the user specified keyframes.

Parameterized systems allow object motion characteristics to be specified as part of the object definitions. The adjustable parameters control such object characteristics as degrees of freedom motion limitations and allowable shape changes.

Scripting systems allow object specifications and animation sequences to be defined with a user input script. From the script, a library of various objects and motions can be constructed.

Keyframe Systems

Each set of in-betweens are generated from the specification of two keyframes.

For complex scenes, we can separate the frames into individual components or objects called cells, an acronym from cartoon animation.

Morphing

Transformation of object shapes from one form to another is called Morphing.

Morphing methods can be applied to any motion or transition involving a change in shape. The example is shown in the below figure.
The general preprocessing rules for equalizing keyframes in terms of either the number of vertices to be added to a keyframe.

Suppose we equalize the edge count and parameters Lk and Lk+1 denote the number of line segments in two consecutive frames. We define,
Lmax = max (Lk, Lk+1) Lmin = min(Lk , Lk+1) Ne = Lmax mod Lmin Ns = int (Lmax/Lmin)
The preprocessing is accomplished by

1. Dividing Ne edges of keyframemin into Ns+1 section.
2. Dividing the remaining lines of keyframemin into Ns sections.

For example, if Lk = 15 and Lk+1 = 11, we divide 4 lines of keyframek+1 into 2 sections each. The remaining lines of keyframek+1 are left infact.

If the vector counts in equalized parameters Vk and Vk+1 are used to denote the number of vertices in the two consecutive frames. In this case we define

Vmax = max(Vk,Vk+1), Vmin = min(Vk,Vk+1) and Nls = (Vmax -1) mod (Vmin – 1) Np = int ((Vmax – 1)/(Vmin – 1))
Preprocessing using vertex count is performed by

1. Adding Np points to Nls line section of keyframemin.

2. Adding Np-1 points to the remaining edges of keyframemin.

Simulating Accelerations

Curve-fitting techniques are often used to specify the animation paths between key frames. Given the vertex positions at the key frames, we can fit the positions with linear or nonlinear paths. Figure illustrates a nonlinear fit of key-frame positions. This determines the trajectories for the in-betweens. To simulate accelerations, we can adjust the time spacing for the in-betweens.

Goal Directed Systems

We can specify the motions that are to take place in general terms that abstractly describe the actions.

These systems are called goal directed. Because they determine specific motion parameters given the goals of the animation.

Eg., To specify an object to „walk or to „run to a particular distance.

Kinematics and Dynamics

With a kinematics description, we specify the animation by motion parameters (position, velocity and acceleration) without reference to the forces that cause the motion.

For constant velocity (zero acceleration) we designate the motions of rigid bodies in a scene by giving an initial position and velocity vector for each object.

We can specify accelerations (rate of change of velocity), speed up, slow downs and curved motion paths.

An alternative approach is to use inverse kinematics; where the initial and final positions of the object are specified at specified times and the motion parameters are computed by the system.

SIGNIFICANCE:

Transformation of object shapes from one form to another

3.5.GRAPHICS PROGRAMMING USING OPENGL

CONCEPT:

OpenGL is a software interface that allows you to access the graphics hardware without taking care of the hardware details or which graphics adapter is in the system.

OpenGL is a low-level graphics library specification. It makes available to the programmer a small set of geomteric primitives - points, lines, polygons, images, and bitmaps.

OpenGL provides a set of commands that allow the specification of geometric objects in two or three dimensions, using the provided primitives, together with commands that control how these objects are rendered (drawn).

Libraries
OpenGL Utility Library (GLU) contains several routines that use lower-level OpenGL commands to perform such tasks as setting up matrices for specific viewing orientations and projections and rendering surfaces.

OpenGL Utility Toolkit (GLUT) is a window-system-independent toolkit, written by Mark Kilgard, to hide the complexities of differing window APIs.

Include Files

For all OpenGL applications, you want to include the gl.h header file in every file. Almost all OpenGL applications use GLU, the aforementioned OpenGL Utility Library, which also requires inclusion of the glu.h header file. So almost every OpenGL source file begins with: #include <GL/gl.h> #include <GL/glu.h> If you are using the OpenGL Utility Toolkit (GLUT) for managing your window manager tasks, you should include: #include <GL/glut.h> The following files must be placed in the proper folder to run a OpenGL Program. Libraries (place in the lib\ subdirectory of Visual C++)
opengl32.lib

glu32.lib

Working with OpenGL Opening a window for Drawing

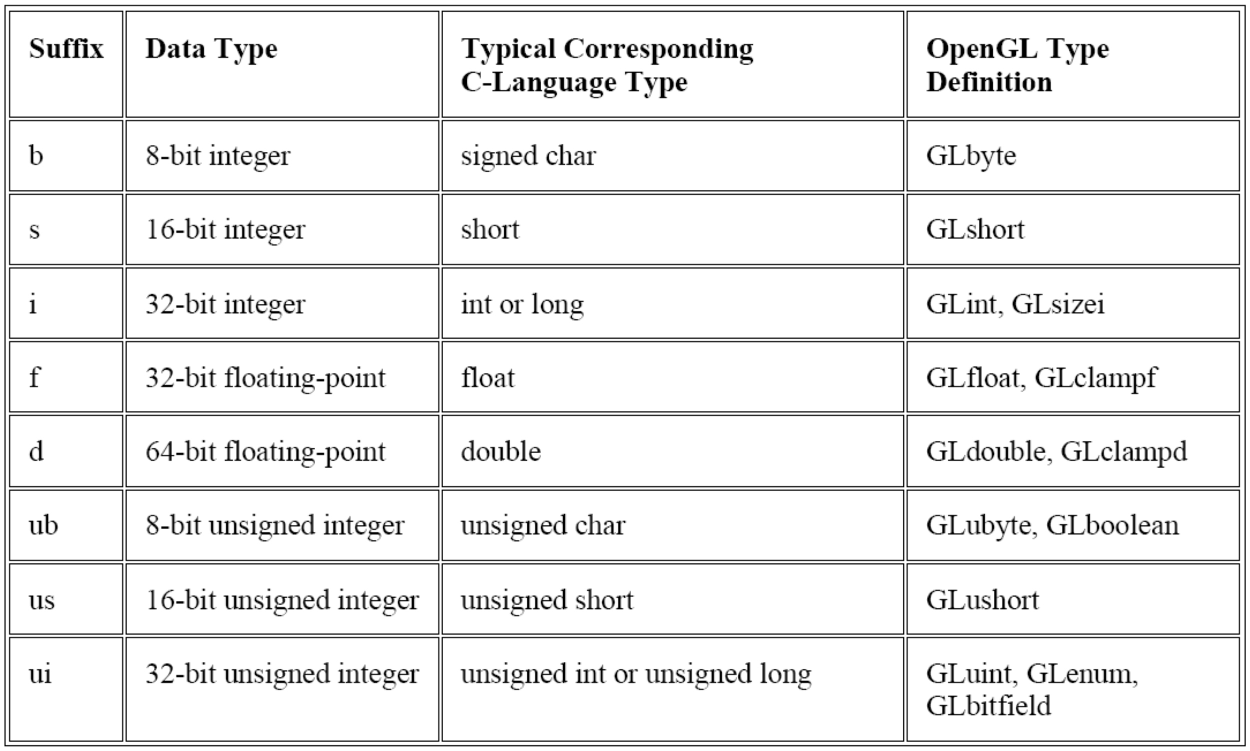
The First task in making pictures is to open a screen window for drawing. The following five functions initialize and display the screen window in our program.
1. glutInit(&argc, argv)
The first thing we need to do is call the glutInit() procedure. It should be called before any other GLUT routine because it initializes the GLUT library. The parameters to glutInit() should be the same as those to main(), specifically main(int argc, char** argv) and glutInit(&argc, argv).
2. glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB)
The next thing we need to do is call the glutInitDisplayMode() procedure to specify the display mode for a window.

We must first decide whether we want to use an RGBA (GLUT_RGB) or color-index (GLUT_INDEX) color model. The RGBA mode stores its color buffers as red, green, blue, and alpha color components. Color-index mode, in contrast, stores color buffers in indicies. And for special effects, such as shading, lighting, and fog, RGBA mode provides more flexibility. In general, use RGBA mode whenever possible. RGBA mode is the default.

Another decision we need to make when setting up the display mode is whether we want to use single buffering (GLUT_SINGLE) or double buffering (GLUT_DOUBLE). If we aren't using annimation, stick with single buffering, which is the default.
3. glutInitWindowSize(640,480)
We need to create the characteristics of our window. A call to glutInitWindowSize() will be used to specify the size, in pixels, of our inital window. The arguments indicate the height and width (in pixels) of the requested window.
4. glutInitWindowPosition(100,15)
Similarly, glutInitWindowPosition() is used to specify the screen location for the upper-left corner of our initial window
. The arguments, x and y, indicate the location of the window relative to the entire display. This function positioned the screen 100 pixels over from the left edge and 150 pixels down from the top.
5. glutCreateWindow("Example")
To create a window, the with the previously set characteristics (display mode, size, location, etc), the programmer uses the glutCreateWindow() command. The command takes a string as a parameter which may appear in the title bar.

6. glutMainLoop()
The window is not actually displayed until the glutMainLoop() is entered.

The very last thing is we have to call this function **Event Driven Programming** The method of associating a call back function with a particular type of event is called as event driven programming. OpenGL provides tools to assist with the event management.



Suffix	Data Type	Typical Corresponding C-Language Type	OpenGL Type Definition
b	8-bit integer	signed char	GLbyte
s	16-bit integer	short	GLshort
i	32-bit integer	int or long	GLint, GLsizei
f	32-bit floating-point	float	GLfloat, GLclampf
d	64-bit floating-point	double	GLdouble, GLclampd
ub	8-bit unsigned integer	unsigned char	GLubyte, GLboolean
us	16-bit unsigned integer	unsigned short	GLushort
ui	32-bit unsigned integer	unsigned int or unsigned long	GLuint, GLenum, GLbitfield

Example

```
//the following code plots three dots
glBegin(GL_POINTS);

glVertex2i(100, 50);

glVertex2i(100, 130);

glVertex2i(150, 130);

glEnd( ); // the following code draws a triangle

glBegin(GL_TRIANGLES);

 glVertex3f(100.0f, 100.0f, 0.0f);

glVertex3f(150.0f, 100.0f, 0.0f);
```

glVertex3f(125.0f, 50.0f, 0.0f); glEnd( ); **// the following code draw a lines**

glBegin(GL_LINES);

glVertex3f(100.0f, 100.0f, 0.0f); // origin of the line

glVertex3f(200.0f, 140.0f, 5.0f); // ending point of the line

glEnd( );

OpenGl State

OpenGl keeps track of many state variables, such as current size of a point, the current color of a drawing, the current background color, etc. The value of a state variable remains active until new value is given. **glPointSize() :** The size of a point can be set with glPointSize(), which takes one floating point argument **Example :** glPointSize(4.0); **glClearColor() :** establishes what color the window will be cleared to. The background color is set with glClearColor(red, green, blue, alpha), where alpha specifies a degree of transparency **Example :** glClearColor (0.0, 0.0, 0.0, 0.0); //set black background color

Drawing Aligned Rectangles.

A special case of a polygon is the **aligned rectangle,** so called because its sides are aligned with the coordinate axes.
OpenGL provides the ready-made function:
glRecti(GLint x1, GLint y1, GLint x2, GLint y2); // draw a rectangle with opposite corners (x1, y1) and (x2, y2); // fill it with the current color;
glClearColor(1.0,1.0,1.0,0.0); // white background
glClear(GL_COLOR_BUFFER_BIT); // clear the window
glColor3f(0.6,0.6,0.6); // bright gray
glRecti(20,20,100,70); glColor3f(0.2,0.2,0.2); //
gray glRecti(70, 50, 150, 130);
ratio = width/height; **Polygons** Polygons are the areas enclosed by single closed loops of line segments, where the line segments are specified by the vertices at their endpoints Polygons are typically drawn by filling in all the pixels enclosed within the boundary, but you can also draw them as outlined polygons or simply as points at the vertices. A filled polygon might be solidly filled, or stippled with a certain pattern OpenGL also supports filling more general polygons with a pattern or color.

The following list explains the function of each of the five constants:
GL_TRIANGLES: takes the listed vertices three at a time, and draws a separate triangle for each; GL_QUADS: takes the vertices four at a time and draws a separate quadrilateral for each GL_TRIANGLE_STRIP: draws a series of triangles based on triplets of vertices: *v*0, *v*1, *v*2, then *v*2, *v*1, *v*3, then *v*2, *v*3, *v*4, etc. (in an order so that all triangles are "traversed" in the same way;e.g. counterclockwise).
GL_TRIANGLE_FAN: draws a series of connected triangles based on triplets of vertices: *v*0, *v*1, *v*2, then *v*0, *v2, v*3, then *v*0, *v*3, *v*4, etc. GL_QUAD_STRIP: draws a series of quadrilaterals based on foursomes of vertices: first v0, v1, v3, v2, then v2, v3, v5, v4, then v4, v5, v7, v6 (in an order so that all quadrilaterals are "traversed" in the same way; e.g. counterclockwise).

Working With Material Properties In OpenGL

The effect of a light source can be seen only when light reflects off an objects surface. OpenGL provides methods for specifying the various reflection coefficients. The coefficients are set with variations of the function glMaterial and they can be specified individually for front and back faces. The code: Glfloat myDiffuse[]={0.8, 0.2, 0.0, 1.0 }; glMaterialfv(GL_FRONT,GL_DIFFUSE,myDiffuse); sets the diffuse reflection coefficients(ρdr , ρdg ,ρdb) equal to (0.8, 0.2, 0.0) for all specified front faces. The first parameter of glMaterialfv() can take the following values: GL_FRONT:Set the reflection coefficient for front faces. GL_BACK:Set the reflection coefficient for back faces. GL_FRONT_AND_BACK:Set the reflection coefficient for both front and back faces. The second parameter can take the following values:
GL_AMBIENT: Set the ambient reflection coefficients. GL_DIFFUSE: Set the diffuse reflection coefficients. GL_SPECULAR: Set the specular reflection coefficients. GL_AMBIENT_AND_DIFFUSE: Set both the ambient and the diffuse reflection coefficients to the same values. GL_EMISSION: Set the emissive color of the surface. The emissive color of a face causes it to “glow” in the specified color, independently of any light source.

Shading of Scenes specified by SDL

The scene description language SDL supports the loading of material properties into objects so that they can be shaded properly. light 3 4 5 .8 .8 ! bright white light at (3,4,5) background 1 1 1 ! white background globalAmbient .2 .2 .2 ! a dark gray global ambient light ambient .2 .6 0 diffuse .8 .2 1 ! red material specular 1 1 1 ! bright specular spots – the color of the source specularExponent 20 !set the phong exponent scale 4 4 4 sphere

SIGNIFICANCE:

OpenGL is a low-level graphics library specification. It makes available to the programmer a small set of geomteric primitives - points, lines, polygons, images, and bitmaps.

3.6.BASIC GRAPHICS PRIMITIVES

CONCEPTS:

OpenGL Provides tools for drawing all the output primitives such as points, lines, triangles, polygons, quads etc and it is defined by one or more vertices.
To draw such objects in OpenGL we pass it a list of vertices. The list occurs between the two OpenGL function calls glBegin() and glEnd(). The argument of glBegin() determine which object is drawn.
These functions are glBegin(int mode); glEnd(void); The parameter mode of the function glBegin can be one of the following:
GL_POINTS GL_LINES

GL_LINE_STRIP

GL_LINE_LOOP

GL_TRIANGLES

GL_TRIANGLE_STRIP

GL_TRIANGLE_FAN GL_QUADS

glFlush() :

ensures that the drawing commands are actually executed rather than stored in a buffer awaiting (ie) Force all issued OpenGL commands to be executed

glMatrixMode(GL_PROJECTION) : For orthographic projection

glLoadIdentity() : To load identity matrix

SIGNIFICANCE:

Different types of graphics OPENGL functions are used to implement line,polygon.

3.7.DRAWING THREE DIMENSIONAL OBJECTS & DRAWING THREE DIMENSIONAL SCENES

CONCEPTS:

OpenGL has separate transformation matrices for different graphics features

glMatrixMode(GLenum mode), where mode is one of:

GL_MODELVIEW - for manipulating model in scene
GL_PROJECTION - perspective orientation
GL_TEXTURE - texture map orientation

glLoadIdentity(): loads a 4-by-4 identity matrix into the current matrix
glPushMatrix() : push current matrix stack
glPopMatrix() : pop the current matrix stack
glMultMatrix () : multiply the current matrix with the specified matrix
glViewport() : set the viewport **Example :** glViewport(0, 0, width, height);
gluPerspective() : function sets up a perspective projection matrix.
Format : gluPerspective(angle, asratio, ZMIN, ZMAX);
Example : gluPerspective(60.0, width/height, 0.1, 100.0);
gluLookAt() - view volume that is centered on a specified eyepoint
Example : gluLookAt(3.0, 2.0, 1.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
glutSwapBuffers () : glutSwapBuffers swaps the buffers of the current window if double buffered.

Example for drawing three dimension Objects glBegin(GL_QUADS);

// Start drawing a quad primitive

glVertex3f(-1.0f, -1.0f, 0.0f); // The bottom left corner glVertex3f(-1.0f, 1.0f, 0.0f); // The top left corner glVertex3f(1.0f, 1.0f, 0.0f); // The top right corner glVertex3f(1.0f, -1.0f, 0.0f); // The bottom right corner glEnd(); **// Triangle**

// Quads in different colours

```
glBegin(GL_QUADS);
 glColor3f(1,0,0); //red
glVertex3f(-0.5, -0.5, 0.0);
glColor3f(0,1,0); //green
glVertex3f(-0.5, 0.5, 0.0);
glColor3f(0,0,1); //blue
glVertex3f(0.5, 0.5, 0.0);
 glColor3f(1,1,1); //white
glVertex3f(0.5, -0.5, 0.0); glEnd();
```

SIGNIFICANCE:

It used to make a realistic scenes and structures

APPLICATIONS:

1.Implement a color models.

2.Implement a realistic scenes and objects

3.OPENGL is a easy way to make a real objects.

UNIT IV – RENDERING

Introduction to shading models – Flat and smooth shading – Adding texture to faces – Adding shadows of objects – Building a camera ina program – Creating shaded objects – Rendering texture – Drawing shadows.

PREREQUISITE DISCUSSION:

This uint give a discussion about shading and textures to a pictures.

4.1 INTRODUCTION TO SHADING MODELS

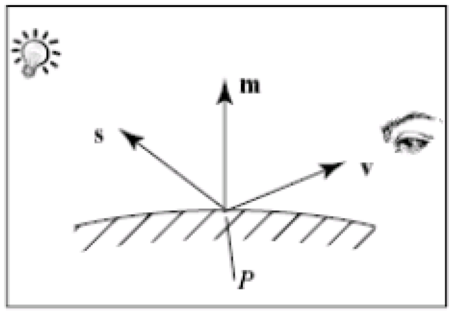
CONCEPTS:

The mechanism of light reflection from an actual surface is very complicated it depends on many factors. Some of these factors are geometric and others are related to the characteristics of the surface. A shading model dictates how light is scattered or reflected from a surface.
The shading models described here focuses on achromatic light.
Achromatic light has brightness and no color, it is a shade of gray so it is described by a single value its intensity.

A shading model uses two types of light source to illuminate the objects in a scene : **point light sources** and **ambient light**. Incident light interacts with the surface in three different ways:

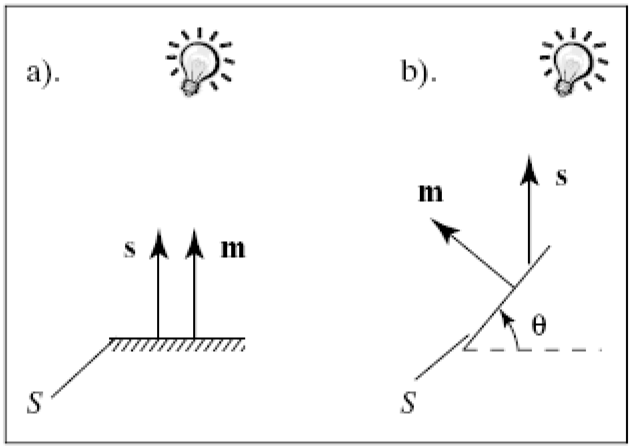
Some is absorbed by the surface and is converted to heat.
Some is reflected from the surface
Some is transmitted into the interior of the object

Geometric Ingredients For Finding Reflected Light We need to find three vectors in order to compute the diffuse and specular components. The below fig. shows three principal vectors (s, m and v) required to find the amount of light that reaches the eye from a point P.



1. The normal vector **, m** , to the surface at P.
2. The vector **v** from P to the viewer□s eye.
3. The vector **s** from P to the light source.

The angles between these three vectors form the basis of computing light intensities. These angles are normally calculated using world coordinates.



Therefore the strength of the diffuse component: Id = Is ρd Is is the intensity of the light source and ρd is the **diffuse reflection coefficient**.

If the facet is aimed away from the eye this dot product is negative so we need to evaluate Id to 0. A more precise computation of the diffuse component is : Id = Is ρd max ms m s.0 , .ms m s
The reflection coefficient ρd depends on the wavelength of the incident light , the angle θ and various physical properties of the surface.

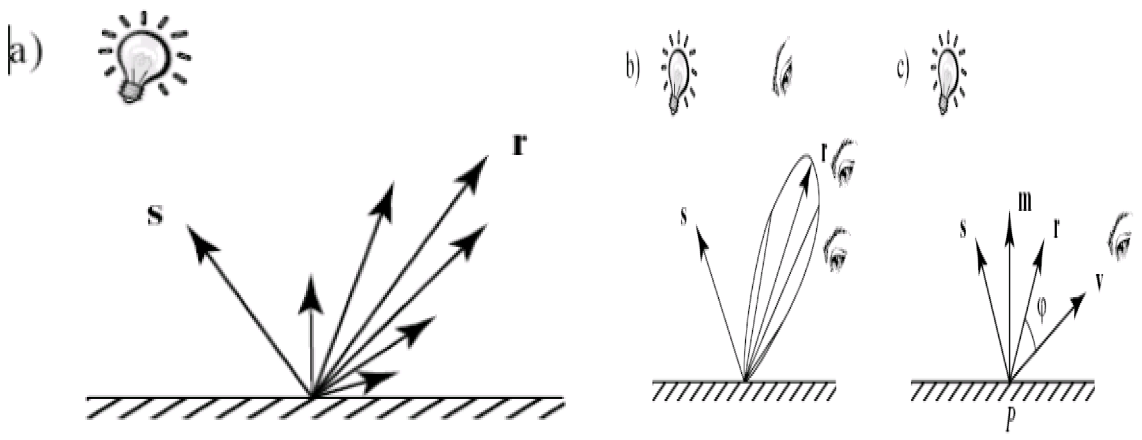
Specular Reflection

Real objects do not scatter light uniformly in all directions and so a specular component is added to the shading model. Specular reflection causes highlights which can add reality to a picture when objects are shinny.

The behavior of specular light can be explained with Phong model. **Phong Model** It is easy to apply and the highlights generated by the phong model given an plasticlike appearance , so the phong model is good when the object is made of shinny plastic or glass.

The Phong model is less successful with objects that have a shinny metallic surface. Fig a) shows a situation where light from a source impinges on a surface and is reflected in different directions.

In this model we discuss the amount of light reflected is greatest in the direction of perfect mirror reflection , r, where the angle of incidence θ equals the angle of reflection. This is the direction in which all light would travel if the surface were a perfect mirror



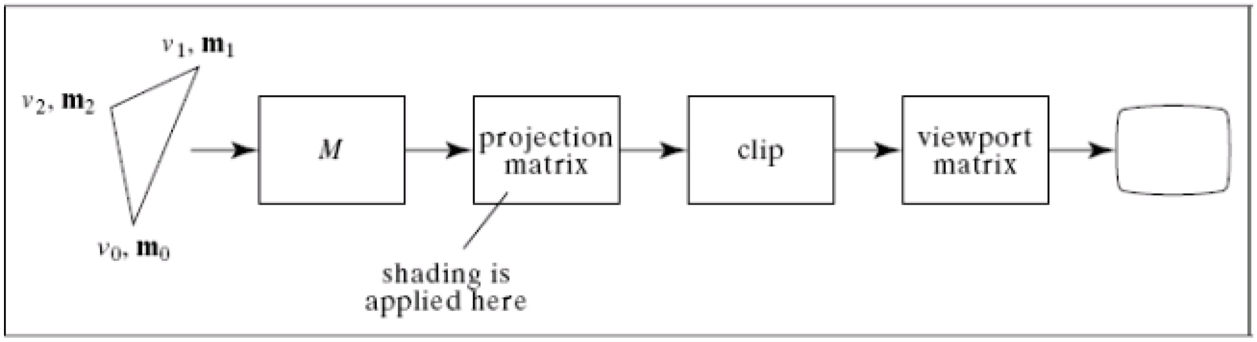
The Role of Ambient Light and Exploiting Human Perception

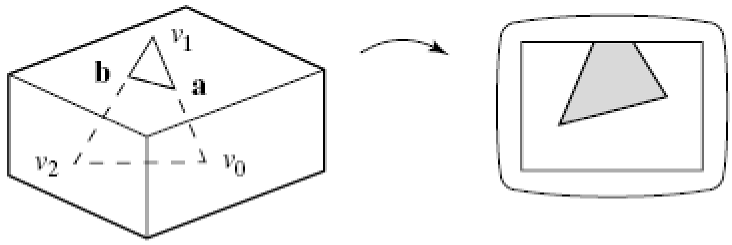
The diffuse and specular components of reflected light are found by simplifying the rules by which physical light reflects from physical surfaces. The dependence of these components on the relative position of the eye , model and light sources greatly improves the reality of a picture. The simple reflection model does not perfectly renders a scene. An example: shadows are unrealistically deep and harsh, to soften these shadows we add a third light component called **ambient light**.

To Add Color

Colored light can be constructed by adding certain amounts of red, green and blue light. When dealing with colored sources and surfaces we calculate each color component individually and simply add them to from the final color of the reflected light.

Shading and the Graphics Pipeline





SIGNIFICANCE:

A shading model uses two types of light source to illuminate the objects in a scene : point light sources and ambient light. Incident light interacts with the surfaces.

4.2.FLAT SHADING AND SMOOTH SHADING

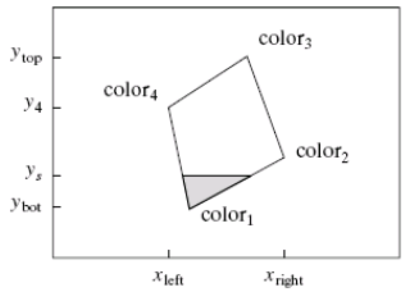
CONCEPTS:

Different objects require different shading effects. In the modeling process we attached a normal vector to each vertex of each face.

If a certain face is to appear as a distinct polygon, we attach the same normal vector to all of its vertices; the normal vector chosen is that indicating the direction normal to the plane of the face. If the face is approximate an underlying surface, we attach to each vertex the normal to the underlying surface at that plane.

The information obtained from the normal vector at each vertex is used to perform different kinds of shading.

The main distinction is between a shading method that accentuates the individual polygons (**flat shading**) and a method that blends the faces to de-emphasize the edges between them (**smooth shading**).



The screen coordinates of each vertex is noted. The lowest and highest points on the face are ybott and ytop. The tiler first fills in the row at y= ybott , then at ybott + 1, etc. At each scan line ys, there is a leftmost pixel xleft and a rightmost pixel xright. The toler moves from xleft to xright, placing the desired color in each pixel. The tiler is implemented as a simple double loop:

Flat Shading

When a face is flat, like a roof and the light sources are distant , the diffuse light component varies little over different points on the roof. In such cases we use the same color for every pixel covered by the face. OpenGL offers a rendering mode in which the entire face is drawn with the same color. In this mode, although a color is passed down the pipeline as part of each vertex of the face, the painting algorithm uses only one color value. So the command

find the color c for this pixel is not inside the loops, but appears before the loop, setting c to the color of one of the vertices. Flat shading is invoked in OpenGL using the command

glShadeModel(GL_FLAT);

Smooth Shading

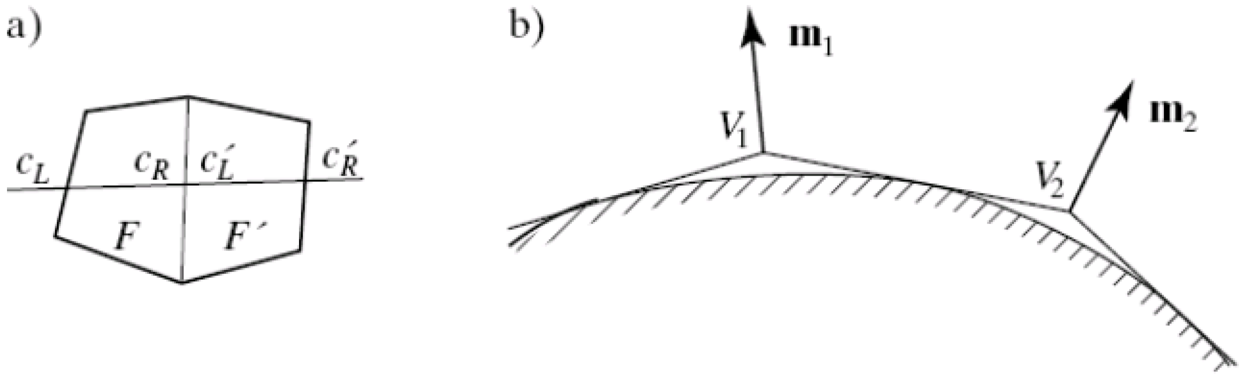
Smooth shading attempts to de-emphasize edges between faces by computing colors at more points on each face. The two types of smooth shading
Gouraud shading
Phong shading

Gouraud Shading

Gouraud shading computes a different value of c for each pixel. For the scan line ys in the fig. , it finds the color at the leftmost pixel, colorleft, by linear interpolation of the colors at the top and bottom of the left edge of the polygon. For the same scan line the color at the top is color4, and that at the bottom is color1, so colorleft will be calculated as

colorleft = lerp(color1, color4,f), ----------(1) where the fraction varies between 0 and 1 as ys varies from ybott to y4.

The eq(1) involves three calculations since each color quantity has a red, green and blue component. Colorright is found by interpolating the colors at the top and bottom of the right edge. The tiler then fills across the scan line , linearly interpolating between colorleft and colorright to obtain the color at pixel x: C(x) = lerp To increase the efficiency of the fill, this color is computed incrementally at each pixel . that is there is a constant difference between c(x+1) and c(x) so that.



Phong Shading

Highlights are better reproduced using Phong Shading. Greater realism can be achieved with regard to highlights on shiny objects by a better approximation of the normal vector to the face at each pixel this type of shading is called as Phong Shading.

SIGNIFICANCE:

Different objects require different shading effects. In the modeling process we attached a normal vector to each vertex of each face.

4.3.ADDING TEXTURE TO FACES

CONCEPTS:

various faces of a mesh object.
The basic technique begins with some texture function, **texture(s,t)** in **texture space** , which has two parameters s and t. The function texture(s,t) produces a color or intensity value for each value of s and t between 0(dark)and 1(light). The two common sources of textures are
Bitmap Textures
Procedural Textures

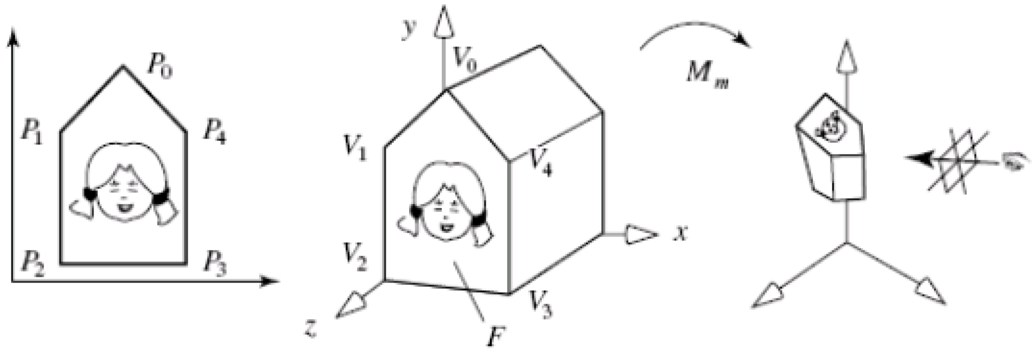
Bitmap Textures

Textures are formed from bitmap representations of images, such as digitized photo.

Such a representation consists of an

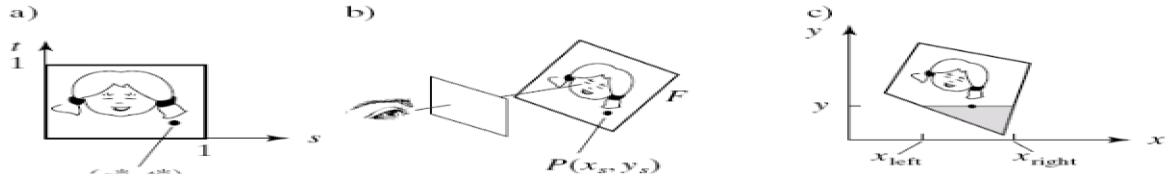
array **txtr[c][r]** of color values. If the array has C columns and R rows, the indices c and r vary from 0 to C-1 and R-1 resp.,.

The function texture(s,t) accesses samples in the array as in the code: Color3 texture (float s, float t) { return txtr[(int) (s * C)][(int) (t * R)]; } Where Color3 holds an RGB triple.



Adding Texture Coordinates to Mesh Objects

A mesh objects has three lists
The vertex list
The normal vector list
The face list



Creating a Glowing Object

This is the simplest method. The visibility intensity I is set equal to the texture value at each spot: I=texture(s,t)

SIGNIFICANCE:

It is used to Textures are formed from bitmap representations of images, such as digitized photo.

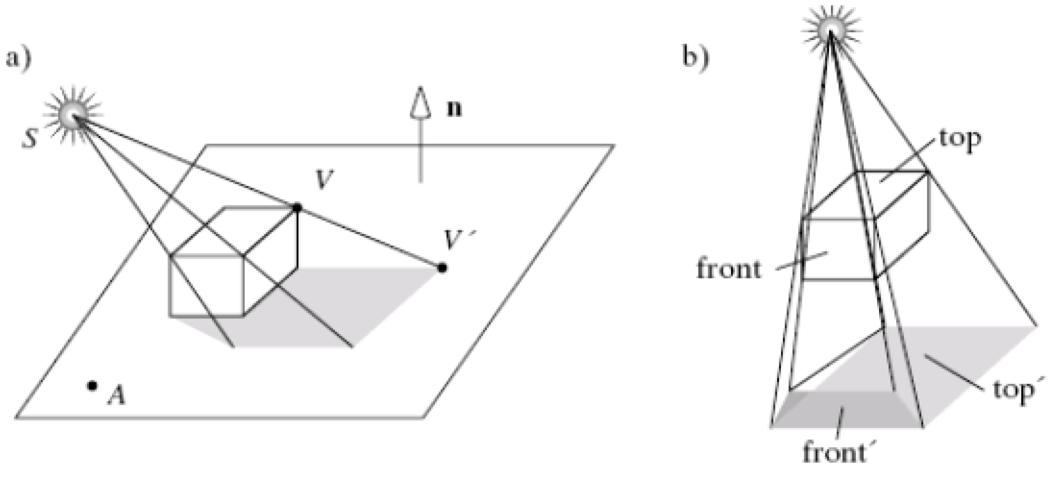
4.4.ADDING SHADOWS OF OBJECTS

CONCEPTS:

Shadows make an image more realistic. The way one object casts a shadow on another object gives important visual clues as to how the two objects are positioned with respect to each other. Shadows conveys lot of information as such, you are getting a second look at the object from the view point of the light source. There are two methods for computing shadows:
Shadows as Texture
Creating shadows with the use of a shadow buffer

Shadows as Texture

The technique of "painting" shadows as a texture works for shadows that are cast onto a flat surface by a point light source. The problem is to compute the shape of the shadow that is cast.



Building the "Projected" Face

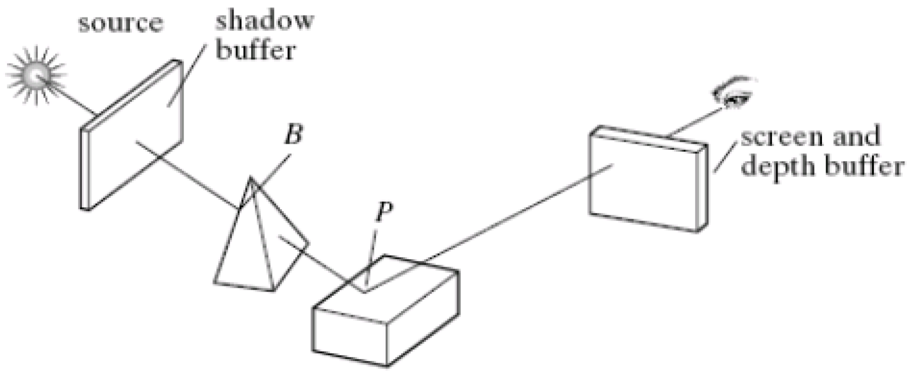
To make the new face F produced by F, we project each of the vertices of F onto the plane. Suppose that the plane passes through point A and has a normal vector n. Consider projecting vertex V, producing V. V is the point where the ray from source at S through V hits the plane, this point is

Creating Shadows with the use of a Shadow buffer

This method uses a variant of the depth buffer that performs the removal of hidden surfaces. An auxiliary second depth buffer called a shadow buffer is used for each light source. This requires lot of memory. This method is based on the principle that any points in a scene that are hidden from the light source must be in shadow. If no object lies between a point and the light source, the point is not in shadow. The shadow buffer contains a depth picture of the scene from the point of view of the light source. Each of the elements of the buffer records the distance from the source to the closest object in the associated direction. Rendering is done in two stages:

1) Loading the shadow buffer

The shadow buffer is initialized with 1.0 in each element, the largest pseudodepth possible. Then through a camera positioned at the light source, each of the scene is rasterized but only the pseudodepth of the point on the face is tested. Each element of the shadow buffer keeps track of the smallest pseudodepth seen so far.).( ) .( ) (' SV n S A n S V S V



2) Rendering the scene

Each face in the scene is rendered using the eye camera. Suppose the eye camera sees point P through pixel p[c][r]. When rendering p[c][r], we need to find
the pseudodepth D from the source to p
the index location [i][j] in the shadow buffer that is to be tested and
the value d[i][j] stored in the shadow buffer

SIGNIFICANCE:

Shadows make an image more realistic. The way one object casts a shadow on another object gives important visual clues as to how the two objects are positioned with respect to each other.

4.5.BUILDING A CAMERA IN A PROGRAM

CONCEPTS:

To have a finite control over camera movements, we create and manipulate our own camera in a program. After each change to this camera is made, the camera tells OpenGL what the new camera is. We create a Camera class that does all things a camera does. In a program we create a Camera object called cam, and adjust it with functions such as the following:

cam.set(eye, look, up); //

initialize the camera cam.slide(-1, 0, -2); //slide the camera forward and to the

left cam.roll(30); // roll it through 30 degree cam.yaw(20); // yaw it through 20 degree

Flying the camera

The user flies the camera through a scene interactively by pressing keys or clicking the mouse. For instance,
pressing u will slide the camera up some amount
pressing y will yaw the camera to the left
pressing f will slide the camera forward
The user can see different views of the scene and then changes the camera to a better view and produce a picture. Or the user can fly around a scene

taking different snapshots. If the snapshots are stored and then played back, an animation is produced of the camera flying around the scene. There are six degrees of freedom for adjusting a camera: It can be slid in three dimensions and it can be rotated about any of three coordinate axes.

Sliding the Camera

Sliding the camera means to move it along one of its own axes that is, in the u, v and n direction without rotating it. Since the camera is looking along the negative n axis, movement along n is forward or back. Movement along u is left or right and along v is up or down. To move the camera a distance D along its u axis, set eye to eye + Du. For convenience ,we can combine the three possible slides in a single function: slide(delU, delV, delN) slides the camera amount delU along u, delV along v and delN along n. The code is as follows:

void Camera : : slide(float delU, float delV, float delN)

{ eye.x += delU * u.x + delV * v.x + delN * n.x; eye.y += delU * u.y + delV * v.y + delN * n.y; eye.z += delU * u.z + delV * v.z + delN * n.z; setModelViewMatrix(); }

Two new axes are formed u and v that lie in the same plane as u and v, and have been rotated through the angle α radians. We form u as the appropriate linear combination of u and v and similarly for v: u = cos (α)u + sin(α)v ; v = -sin (α)u + cos(α)v

SIGNIFICANCE:

we create and manipulate our own camera in a program. After each change to this camera is made, the camera tells OpenGL

4.6.RENDERING TEXTURES

CONCEPTS:

A simple method for adding surface detail is the model structure and patterns with polygon facets. For large scale detail, polygon modeling can give good results. Also we could model an irregular surface with small, randomly oriented polygon facets, provided the facets were not too small.

Surface pattern polygons are generally overlaid on a larger surface polygon and are processed with the parent□s surface.

Only the parent polygon is processed by the visible surface algorithms, but the illumination parameters for the surfac3e detail polygons take precedence over the parent polygon. When fine surface detail is to be modeled, polygon are not practical.

4.7.CREATING SHADED OBJECTS & DRAWING SHADOWS

CONCEPTS:

To find where the ray S + ct intersects the surface, we substitute S + ct for P in F(P) (the explicit form of the shape) d(t) = f(S + ct) This function is
positive at these values of t for which the ray is outside the object.
zero when the ray coincides with the surface of the object and
negative when the ray is inside the surface.

The generic torus has the implicit function as F(P) = (Px2+Py2) - d)2 + Pz2 – 1

Creating An Image By Means of Iterative Function Systems

Another way to approach infinity is to apply a transformation to a picture again and again and examine the results. This technique also provides an another method to create fractal shapes.

An Experimental Copier

We take an initial image I0 and put it through a special photocopier that produces a new image I1. I1 is not a copy of I0 rather it is a superposition of several reduced versions of I0. We then take I1 and feed it back into the copier again, to produce image I2. This process is repeated , obtaining a sequence of images I0, I1, I2,… called the **orbit of I0**. **Making new copies from old**

Underlying Theory of the Copying Process

Each lens in the copier builds an image by transforming every point in the input image and drawing it on the output image. A black and white image I can be described simply as the set of its black points: **I = set of all black points = { (x,y) such that (x,y) is colored black }**

I is the input image to the copier.

Then the ith lens characterized by transformation Ti, builds a new set of points we denote as Ti(I) and adds them to the image being produced at the current iteration. Each added set Ti(I) is the set of all transformed points

I: **Ti(I) = { (x’,y’) such that (x’,y’) = Ti(P) for some point P in I }** Upon superposing the three transformed images, we obtain the output image as the union of the outputs from the three lenses:

Output image = T1(I) U T2(I) U T3(I)

The overall mapping from input image to output image as W(.). It maps one set of points – one image – into another and is given by:

W(.)=T1(.) U T2(.) U T3(.)

For instance the copy of the first image I0 is the set W(I0). Each affine map reduces the size of its image at least slightly, the orbit converge to a unique image called the **attractor** of the IFS. We denote the attractor by the set A, some of its important properties are:

1. The attractor set A is a fixed point of the mapping W(.), which we write as W(A)=A. That is putting A through the copier again produces exactly the same image A.

The iterates have already converged to the set A, so iterating once more makes no difference.

2. Starting with any input image B and iterating the copying process enough times, we find that the orbit of images always converges to the same A.

If Ik = W (k)(B) is the kth iterate of image B, then as k goes to infinity Ik becomes indistinguishable from the attractor A.

Drawing the kth Iterate

We use graphics to display each of the iterates along the orbit. The initial image I0 can be set, but two choices are particularly suited to the tools developed:

I0 is a polyline. Then successive iterates are collections of polylines.

I0 is a single point. Then successive iterates are collections of points.

Using a polyline for I0 has the advantage that you can see how each polyline is reduced in size in each successive iterate. But more memory and time are required to draw each polyline and finally each polyline is so reduced as to be indistinguishable from a point. Using a single point for I0 causes each iterate to be a set of points, so it is straight forward to store these in a list. Then if IFS consists of N affine maps, the first iterate I1 consists of N points, image I2 consists of N2 points, I3 consists of N3 points, etc.

SIGNIFICANCE:

It is used to create a shaded realistic images and objects

APPLICATIONS:

1.To make a camera

2.To implement Real objects

UNIT V FRACTALS

Fractals and Self similarity – Peano curves – Creating image by iterated functions –Mandelbrot sets – Julia Sets – Random Fractals – Overview of Ray Tracing –Intersecting rays with other primitives – Adding Surface texture – Reflections and Transparency – Boolean operations on Objects

PREREQUISITE DISCUSSION:

This unit give brief explanation about fractals, Peanocurves, and ray tracing

5.1.FRACTALS AND SELF-SIMILARITY

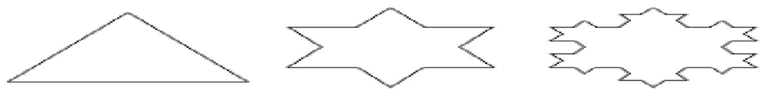
CONCEPTS:

Many of the curves and pictures have a particularly important property called **self-similar**. This means that they appear the same at every scale: No matter how much one enlarges a picture of the curve, it has the same level of detail. Some curves are **exactly self-similar**, whereby if a region is enlarged the enlargement looks exactly like the original. Other curves are **statistically self-similar**, such that the wiggles and irregularities in the curve are the same "on the average", no matter how many times the picture is enlarged. Example: Coastline.

Successive Refinement of Curves

A complex curve can be fashioned recursively by repeatedly "refining" a simple curve. The simplest example is the Koch curve, discovered in1904 by the Swedish mathematician Helge von Koch. The curve produces an infinitely long line within a region of finite area. Successive generations of the Koch curve are denoted K0, K1, K2….The zeroth generation shape K0 is a horizontal line of length unity

To create K1 , divide the line K0 into three equal parts and replace the middle section with a triangular bump having sides of length 1/3. The total length of the line is 4/3. The second order curve K2, is formed by building a bump on each of the four line segments of K1. To form Kn+1 from Kn: Subdivide each segment of Kn into three equal parts and replace the middle part with a bump in the shape of an equilateral triangle.
In this process each segment is increased in length by a factor of 4/3, so the total length of the curve is 4/3 larger than that of the previous generation. Thus Ki has total length of (4/3)i , which increases as i increases. As i tends to infinity, the length of the curve becomes infinite..



SIGNIFICANCE:

It gives the clear view of particular picture.

5.2.PEANO CURVES

CONCEPTS:

UNDERLYING THEORY OF THE COPYING PROCESS :

Each lens in the copier builds an image by transforming every point in the input image and drawing it on the output image. A black and white image I can be described simply as the set of its black points: **I = set of all black points = { (x,y) such that (x,y) is colored black }** I is the input image to the copier. Then the ith lens characterized by transformation Ti, builds a new set of points we denote as Ti(I) and adds them to the image being produced at the current iteration. Each added set Ti(I) is the set of all transformed points I: **Ti(I) = { (x',y') such that (x',y') = Ti(P) for some point P in I }** Upon superposing the three transformed images, we obtain the output image as the union of the outputs from the three lenses: **Output image = T1(I) U T2(I) U T3(I)** The overall mapping from input image to output image as W(.). It maps one set of points – one image – into another and is given by: **W(.)=T1(.) U T2(.) U T3(.)** For instance the copy of the first image I0 is the set W(I0).

1. The attractor set A is a fixed point of the mapping W(.), which we write as W(A)=A. That is putting A through the copier again produces exactly the same image A.
The iterates have already converged to the set A, so iterating once more makes no difference.
2. Starting with any input image B and iterating the copying process enough times, we find that the orbit of images always converges to the same A.

If Ik = W (k)(B) is the kth iterate of image B, then as k goes to infinity Ik becomes indistinguishable from the attractor A.

5.3.CREATING IMAGE BY ITERATED FUNCTIONS

CONCEPTS:

Another way to approach infinity is to apply a transformation to a picture again and again and examine the results. This technique also provides an another method to create fractal shapes.

An Experimental Copier

We take an initial image I0 and put it through a special photocopier that produces a new image I1. I1 is not a copy of I0 rather it is a superposition of several reduced versions of I0. We then take I1 and feed it back into the copier again, to produce image I2. This process is repeated , obtaining a sequence of images I0, I1, I2,… called the **orbit of I0**. **Making new copies from old**

Underlying Theory of the Copying Process

Each lens in the copier builds an image by transforming every point in the input image and drawing it on the output image. A black and white image I can be described simply as the set of its black points: **I = set of all black points = { (x,y) such that (x,y) is colored black }** I is the input image to the copier. Then the ith lens characterized by transformation Ti, builds a new set of points we denote as Ti(I) and adds them to the image being produced at the current iteration. Each added set Ti(I) is the set of all transformed points
I: **Ti(I) = { (x',y') such that (x',y') = Ti(P) for some point P in I }** Upon superposing the three transformed images, we obtain the output image as the union of the outputs from the three lenses:
Output image = T1(I) U T2(I) U T3(I) The overall mapping from input image to output image as W(.). It maps one set of points – one image – into another and is given by: **W(.)=T1(.) U T2(.) U T3(.)** For instance the copy of the first image I0 is the set W(I0). Each affine map reduces the size of its image at least slightly, the orbit converge to a unique image called the **attractor** of the IFS. We denote the attractor by the set A, some of its important properties are:
1. The attractor set A is a fixed point of the mapping W(.), which we write as W(A)=A. That is putting A through the copier again produces exactly the same image A.

The iterates have already converged to the set A, so iterating once more makes no difference.
2. Starting with any input image B and iterating the copying process enough times, we find that the orbit of images always converges to the same A.

If Ik = W (k)(B) is the kth iterate of image B, then as k goes to infinity Ik becomes indistinguishable from the attractor A.

Drawing the kth Iterate

We use graphics to display each of the iterates along the orbit. The initial image I0 can be set, but two choices are particularly suited to the tools developed:
I0 is a polyline. Then successive iterates are collections of polylines.
I0 is a single point. Then successive iterates are collections of points.

Using a polyline for I0 has the advantage that you can see how each polyline is reduced in size in each successive iterate. But more memory and time are required to draw each polyline and finally each polyline is so reduced as to be indistinguishable from a point. Using a single point for I0 causes each iterate to be a set of points, so it is straight forward to store these in a list. Then if IFS consists of N affine maps, the first iterate I1 consists of N points, image I2 consists of N2 points, I3 consists of N3 points, etc.
Copier Operation pseudocode(recursive version)

SIGNIFICANCE:

This technique also provides an another method to create fractal shapes.

5,.4.THE MANDELBROT SET

CONCEPTS:

Graphics provides a powerful tool for studying a fascinating collection of sets that are the most complicated objects in mathematics. Julia and Mandelbrot sets arise from a branch of analysis known as iteration theory, which asks what happens when one iterates a function endlessly. Mandelbrot used computer graphics to perform experiments.

A view of the Mandelbrot set is shown in the below figure. It is the black inner portion, which appears to consist of a cardoid along with a number of wartlike circles glued to it.

The IFS uses the simple function f(z) = z2 + c -------------------------------(1) where c is some constant. The system produces each output by squaring its input and adding c. We assume that the process begins with the starting value s, so the system generates the sequence of values or orbit d1= (s)2 + c d2= ((s)2 + c)2 + c d3= (((s)2 + c)2 + c)2 + c d4= ((((s)2 + c)2 + c)2 + c)2 + c ------------------------------(2) The orbit depends on two ingredients
the starting point s
the given value of c

Given two values of s and c how do points dk along the orbit behaves as k gets larger and larger? Specifically, does the orbit remain finite or explode. Orbits that remain finite lie in their corresponding Julia or Mandelbrot set, whereas those that explode lie outside the set.
When s and c are chosen to be complex numbers , complex arithmetic is used each time the function is applied.

The Mandelbrot and Julia sets live in the complex plane – plane of complex numbers.
The IFS works well with both complex and real numbers.
Both s and c are complex numbers and at each iteration we square the previous result and add c. Squaring a complex number z = x + yi yields the new complex number: (x + yi)2 = (x2 – y2) + (2xy)i ----------------------------------(3) having real part equal to x2 – y2 and imaginary part equal to 2xy.

Some Notes on the Fixed Points of the System It is useful to examine the fixed points of the system f(.) =(.)2 + c . The behavior of the orbits depends on these fixed points that is those complex numbers z that map into themselves, so that z2 + c = z. This gives us the quadratic equation z2 – z + c = 0 and the fixed points of the system are the two solutions of this equation, given by p+, p- = --------------------------------(4) If an orbit reaches a fixed point, p its gets trapped there forever. The fixed point can be characterized as **attracting** or **repelling**. I
f an orbit flies close to a fixed point p, the next point along the orbit will be forced c 41 21
closer to p if p is an attracting fixed point
farther away from p if p is a repelling a fixed point.

If an orbit gets close to an attracting fixed point, it is sucked into the point. In contrast, a repelling fixed point keeps the orbit away from it.

Defining the Mandelbrot Set

The Mandelbrot set considers different values of c, always using the starting point s =0. For each value of c, the set reports on the nature of the orbit of 0, whose first few values are as follows: orbit of 0: 0, c, c2+c, (c2+c)2+c, ((c2+c)2+c)2 +c,…….. For each complex number c, either the orbit is **finite** so that how far along the orbit one goes, the values remain finite or the orbit **explodes** that is the values get larger without limit. The Mandelbrot set denoted by M, contains just those values of c that result in finite orbits:
The point c is in M if 0 has a finite orbit.
The point c is not in M if the orbit of 0 explodes.

5.5.JULIA SETS

CONCEPTS:

Like the Mandelbrot set, Julia sets are extremely complicated sets of points in the complex plane. There is a different Julia set, denoted Jc for each value of c. A closely related variation is the **filled-in Julia set**, denoted by Kc, which is easier to define.

The Filled-In Julia Set Kc

In the IFS we set c to some fixed chosen value and examine what happens for different starting point s. We ask how the orbit of starting point s behaves. Either it explodes or it doesnt. If it is finite , we say the starting point s is in Kc, otherwise s lies outside of Kc. **Definition:** The filled-in Julia set at c, Kc, is the set of all starting points whose orbits are finite. When studying Kc, one chooses a single value for c and considers different starting points. Kc should be always symmetrical about the origin, since the orbits of s and –s become identical after one iteration.

Drawing Filled-in Julia Sets

A starting point s is in Kc, depending on whether its orbit is finite or explodes, the process of drawing a filled-in Julia set is almost similar to Mandelbrot set. We choose a window in the complex plane and associate pixels with points in the window.

The pixels correspond to different values of the starting point s. A single value of c is chosen and then the orbit for each pixel position is examined to see if it explodes and if so, how quickly does it explodes.

Pseudocode for drawing a region of the Filled-in Julia set for(j=0; j<rows; j++) for(i=0; i<cols; i++) { find the corresponding s value in equation (5)

estimate the dwell of the orbit find Color determined by estimated dwell setPixel(j , k, Color); } The dwell() must be passed to the starting point s as well as c.

Making a high-resolution image of a Kc requires a great deal of computer time, since a complex calculation is associated with every pixel. **5.5.3 Notes on Fixed Points and Basins of Attraction**

If an orbit starts close enough to an attracting fixed point, it is sucked into that point. If it starts too far away, it explodes. The set of points that are sucked in forms a so called **basin of attraction** for the fixed point p. The set is the filled-in Julia set Kc.

The fixed point which lies inside the circle $|z|= ½$ is the attracting point. All points inside Kc, have orbits that explode. All points inside Kc, have orbits that spiral or plunge into the attracting fixed point. If the starting point is inside Kc, then all of the points on the orbit must also be inside Kc and they produce a finite orbit. The repelling fixed point is on the boundary of Kc.

Kc for Two Simple Cases

The set Kc is simple for two values of c: 1. **c=0:** Starting at any point s, the orbit is simply s, s2,s4,…….,s2k,…, so the orbit spirals into 0 if $|s|<1$ and explodes if $|s|>1$. Thus K0 is the set of all complex numbers lying inside the unit circle, the circle of radius 1 centered at the origin. 2. **c = -2:** in this case it turns out that the filled-in Julia set consists of all points lying on the real axis between -2 and 2. For all other values of c, the set Kc, is complex. It has been shown that each Kc is one of the two types:
Kc is connected or

Kc is a Cantor set

A theoretical result is that Kc is connected for precisely those values of c that lie in the Mandelbrot set.

The Julia Set Jc Julia Set Jc is for any given value of c; it is the boundary of Kc. Kc is the set of all starting points that have finite orbits and every point outside Kc has an exploding orbit. We say that the points just along the boundary of Kc and “on the fence”.

Inside the boundary all orbits remain finite; just outside it, all orbits goes to infinity.

Preimages and Fixed Points If the process started instead at f(s), the image of s, then the two orbits would be: s, f(s), f2(s), f3(s),…. (orbit of s) or f(s), f2(s), f3(s), f4(s),…. (orbit of f(s)) which have the same value forever. If the orbit of s is finite, then so is the orbit of its image f(s).

All of the points in the orbit , if considered as starting points on their own, have orbits with thew same behavior: They all are finite or they all explode. Any starting point whose orbit passes through s has the same behavior as the orbit that start at s: The two orbits are identical forever. The point “**just before**” s in the sequence is called the **preimage** of s and is the inverse of the function f(.) = (.)2 + c. The inverse of f(.) is , so we have two preimages of z are given by ------------------(6) c z c z

5.6.RANDOM FRACTALS

CONCEPTS:

Fractal is the term associated with randomly generated curves and surfaces that exhibit a degree of self-similarity. These curves are used to provide “naturalistic” shapes for representing objects such as coastlines, rugged mountains, grass and fire.

Fractalizing a Segment

The simplest random fractal is formed by recursively roughening or fractalizing a line segment. At each step, each line segment is replaced with a “random elbow”. The figure shows this process applied to the line segment S having endpoints A and B. S is replaced by the two segments from A to C and from C to B. For a fractal curve, point C is randomly chosen along the perpendicular bisector L of S. The elbow lies randomly on one or the other side of the “parent” segment AB.

Three stages are required in the fractalization of a segment. In the first stage, the midpoint of AB is perturbed to form point C. In the second stage , each of the two segment has its midpoints perturbed to form points D and E. In the third and final stage, the new points F…..I are added.

To perform fractalization in a program Line L passes through the midpoint M of segment S and is perpendicular to it. Any point C along L has the parametric form:

SIGNIFICANCE:

To Generate a fractalizing Segments in a picture.

5.7.INTERSECTING RAYS WITH OTHER PRIMITIVES

CONCEPTS:

First the ray is transformed into the generic coordinates of the object and then the various intersection with the generic object are computed.

1) Intersecting with a Square

The generic square lies in the z=0 plane and extends from -1 to 1 in both x and y. The square can be transformed into any parallelogram positioned in space, so it is often used in scenes to provide this, flat surfaces such as walls and windows. The function hit(1) first finds where the ray hits the generic plane and then test whether this hit spot also lies within the square.

2) Intersecting with a Tapered Cylinder

The side of the cylinder is part of an infinitely long wall with a radius of L at z=0,and a small radius of S at z=1.This wall has the implicit form as F(x, y, z)=x2 + y2- (1 + (S - 1) z)2, for 0 < z < 1 If S=1, the shape becomes the generic cylinder, if S=0 , it becomes the generic cone. We develop a hit () method for the tapered cylinder, which also provides hit() method for the cylinder and cone. **3) Intersecting with a Cube (or any Convex Polyhedron)** The convex polyhedron, the generic cube deserves special attention. It is centered at the origin and has corner at (±1, ±1, ±1) using all right combinations of +1 and -1.Thus,its edges are aligned with coordinates axes, and its six faces lie in the plan. The generic cube is important for two reasons.

A large variety of intersecting boxes can be modeled and placed in a scene by applying an affine transformation to a generic cube. Then, in ray tracing each ray routine. can be inverse transformed into the generic cube□s coordinate system and we can use a ray with generic cube intersection

5.8.ADDING SURFACE TEXTURE

CONCEPTS:

A fast method for approximating global illumination effect is environmental mapping. An environment array is used to store background intensity information for a scene. This array is then mapped to the objects in a scene based on the specified viewing direction.

This is called as environment mapping or reflection mapping. To render the surface of an object, we project pixel areas on to surface and then reflect the projected pixel area on to the environment map to pick up the surface shading attributes for each pixel. If the object is transparent, we can also refract the projected pixel are also the environment map. The environment mapping process for reflection of a projected pixel area is shown in figure.

Pixel intensity is determined by averaging the intensity values within the intersected region of the environment map. A simple method for adding surface detail is the model structure and patterns with polygon facets. For large scale detail, polygon modeling can give good results. Also we could model an irregular surface with small, randomly oriented polygon facets, provided the facets were not too small. Surface pattern polygons are generally overlaid on a larger surface polygon and are processed with the parent□s surface.

Only the parent polygon is processed by the visible surface algorithms, but the illumination parameters for the surfac3e detail polygons take precedence over the parent polygon. When fine surface detail is to be modeled, polygon are not practical.

Texture Mapping

A method for adding surface detail is to map texture patterns onto the surfaces of objects. The texture pattern may either be defined in a rectangular array or as a procedure that modifies surface intensity values. This approach is referred to as texture mapping or pattern mapping.

The texture pattern is defined with a rectangular grid of intensity values in a texture space referenced with (*s,t*) coordinate values. Surface positions in the scene are referenced with UV object space coordinates and pixel positions on the projection plane are referenced in *xy* Cartesian coordinates.

Texture mapping can be accomplished in one of two ways. Either we can map the texture pattern to object surfaces, then to the projection plane, or we can map pixel areas onto object surfaces then to texture space. Mapping a texture pattern to pixel coordinates is sometime called texture scanning, while the mapping from pixel coordinates to texture space is referred to as **pixel order scanning** or **inverse scanning** or **image order scanning**.

often specified with parametric linear functions $U=fu(s,t)=au\ s+ but + cu$ $V=fv(s,t)=av\ s+ bvt + cv$ The object to image space mapping is accomplished with the concatenation of the viewing and projection transformations. A disadvantage of mapping from texture space to pixel space is that a selected texture patch usually does not match up with the pixel boundaries, thus requiring calculation of the fractional area of pixel coverage. Therefore, mapping from pixel space to texture space is the most commonly used texture mapping method. This avoids pixel subdivision calculations, and allows anti aliasing procedures to be easily applied. The mapping from image space to texture space does require calculation of the inverse viewing projection transformation mVP -1 and the inverse texture map transformation mT -1

Procedural Texturing Methods

Next method for adding surface texture is to use procedural definitions of the color variations that are to be applied to the objects in a scene. This approach avoids the transformation calculations involved transferring two dimensional texture patterns to object surfaces. When values are assigned throughout a region of three dimensional space, the object color variations are referred to as solid textures. Values from texture space are transferred to object surfaces using procedural methods, since it is usually impossible to store texture values for all points throughout a region of space (*e.g*) Wood Grains or Marble patterns Bump Mapping. Although texture mapping can be used to add fine surface detail, it is not a good method for modeling the surface roughness that appears on objects such as oranges, strawberries and raisins. The illumination detail in the texture pattern usually does not correspond to the illumination direction in the scene.

A better method for creating surfaces **bumpiness** is to apply a perturbation function to the surface normal and then use the perturbed normal in the illumination model calculations. This technique is called **bump mapping.** If $P(u,v)$ represents a position on a parameter surface, we can obtain the surface normal at that point with the calculation $N = Pu \times Pv$ Where Pu and Pv are the partial derivatives of P with respect to parameters u and v. To obtain a perturbed normal, we modify the surface position vector by adding a small perturbation function called a **bump function**. $P'(u,v) = P(u,v) + b(u,v)\ n$. This adds bumps to the surface in the direction of the unit surface normal n=N/|N|. The perturbed surface normal is then obtained as N'=Pu' + Pv' We calculate the partial derivative with respect to u of the perturbed position vector as Pu' = _∂_(P + bn) ∂u = Pu + bu n + bnu Assuming the bump function b is small, we can neglect the last term and write p u' ≈ pu + bun Similarly p v'= p v + b v n. and the perturbed surface normal is N' = Pu + Pv + b v (Pu x n) + bu (n x Pv) + bu bv (n x n). But n x n =0, so that N' = N + bv (Pu x n) + bu (n x Pv) The final step is to normalize N' for use in the illumination model calculations.

SIGNIFICANCE:

A better method for creating surfaces bumpiness is to apply a perturbation function to the surface normal and then use the perturbed normal in the illumination model calculations

5.9. REFLECTIONS AND TRANSPERENCY

CONCEPTS:

The great strengths of the ray tracing method is the ease with which it can handle both reflection and refraction of light. This allows one to build scenes of exquisite realism, containing mirrors, fishbowls, lenses and the like.

There can be multiple reflections in which light bounces off several shiny surfaces before reaching the eye or elaborate combinations of refraction and reflection. Each of these processes requires the spawnins and tracing of additional rays.
shows a ray emanating, from the eye in the direction dir and hitting a surface at the point Ph. when the surface is mirror like or transparent, the light I that reaches the eye may have 5 components I=Iamb + Idiff + Ispec + Irefl + Itran The first three are the fan=miler ambient, diffuse and specular contributions.

The diffuse and specular part arise from light sources in the environment that are visible at Pn. Iraft is the reflected light component ,arising from the light , Ik that is incident at Pn along the direction –r. This direction is such that the angles of incidence and reflection are equal,so R=dir-2(dir.m)m Where we assume that the normal vector m at Ph has been normalized.

Similarly Itran is the transmitted light components arising from the light IT that is transmitted thorough the transparent material to Ph along the direction –t. A portion of this light passes through the surface and in so doing is bent, continuing its travel along –dir. The refraction direction + depends on several factors.

I is a sum of various light contributions, IR and IT each arise from their own fine components – ambient, diffuse and so on. IR is the light that would be seen by an eye at Ph along a ray from P to Pn. To determine IR, we do in fact spawn a secondary ray from Pn in the direction r, find the first object it hits and then repeat the same computation of light component. Similarly IT is found by casting a ray in the direction t and seeing what surface is hit first, then computing the light contributions.

The Refraction of Light

When a ray of light strikes a transparent object, apportion of the ray penetrates the object. The ray will change direction from dir to + if the speed of light is different in medium 1 than in medium 2. If the angle of incidence of the ray is θ1, Snells law states that the angle of refraction will be
sin(θ2) = sin(θ1) C2 C1 where C1 is the spped of light in medium 1 and C2 is the speed of light in medium 2. Only the ratio C2/C1 is important. It is often called the index of refraction of medium 2 with respect to medium 1. Note that if θ1 ,equals zero so does θ2 .

Light hitting an interface at right angles is not bent. In ray traving scenes that include transparent objects, we must keep track of the medium through which a ray is passing so that we can determine the value C2/C1 at the next intersection where the ray either exists from the current object or enters another one.

This tracking is most easily accomplished by adding a field to the ray that holds a pointer to the object within which the ray is travelling. Several design polices are used,
1) Design Policy 1: No two transparent object may interpenetrate.
2) Design Policy 2: Transparent object may interpenetrate.

5.10.COMPOUND OBJECTS: BOOLEAN OPERATIONS ON OBJECTS

CONCEPTS:

A ray tracing method to combine simple shapes to more complex ones is known as constructive Solid Geometry(CSG). Arbitrarily complex shapes are defined by set operations on simpler shapes in a CSG. Objects such as lenses and hollow fish bowls, as well as objects with holes are easily formed by combining the generic shapes. Such objects are called compound, Boolean or CSG objects. The Boolean operators: union, intersection and difference are shown in the figure 5.17. Two compound objects build from spheres. The intersection of two spheres is shown as a lens shape.

That is a point in the lens if and only if it is in both spheres. L is the intersection of the S1 and S2 is written as L=S1∩S2

sets A and B, denoted A-B,if it is in A and not in B.Applying the difference operation is analogous to removing material to cutting or carrying.The bowl is specified by B=(S1-S2)-C. The solid globe, S1 is hollowed out by removing all the points of the inner sphere, S2,forming a hollow spherical shell.

The top is then opened by removing all points in the cone C. A point is in the union of two sets A and B, denoted AUB, if it is in A or in B or in both. Forming the union of two objects is analogous to gluing them together.

The union of two cones and two cylinders is shown as a rocket. R=C1 U C2 U C3 U C4. Cone C1 resets on cylinder C2.Cone C3 is partially embedded in C2 and resets on the fatter cylinder C4. **5.10.1 Ray Tracing CSC objects** Ray trace objects that are Boolean combinations of simpler objects.

The ray inside lens L from t3 to t2 and the hit time is t3.If the lens is opaque, the familiar shading rules will be applied to find what color the lens is at the hit spot. If the lens is mirror like or transparent spawned rays are generated with the proper directions and are traced as shown in figure 5.18. Ray,first strikes the bowl at t1,the smallest of the times for which it is in S1 but not in either S2 or C. Ray 2 on the other hand,first hits the bowl at t5.

Again this is the smallest time for which the ray is in S1,but in neither the other sphere nor the cone.The hits at earlier times are hits with components parts of the bowl,but not with the bowl itself.

Data Structure for Boolean objects Since a compound object is always the combination of two other objects say obj1 OP Obj2, or binary tree structure provides a natural description. **5.10.3 Intersecting Rays with Boolean Objects** We need to be develop a hit() method to work each type of

Boolean object.The method must form inside set for the ray with the left subtree,the inside set for the ray with the right subtree,and then combine the two sets appropriately. bool Intersection Bool::hit(ray in Intersection & inter)
{ Intersection lftinter,rtinter; if (ray misses the extends)return false; if (C) left −>hit(r,lftinter)||((right−>hit(r,rtinter))) return false; return (inter.numHits > 0); }
Extent tests are first made to see if there is an early out.
Then the proper hit() routing is called for the left subtree and unless the ray misses this subtree,the hit list rinter is formed.If there is a miss,hit() returns the value false immediately because the ray must hit dot subtrees in order to hit their intersection.Then the hit list rtInter is formed. The code is similar for the union Bool and DifferenceBool classes. For UnionBool::hit(),the two hits are formed using if((!left-)hit(r,lftInter))**(|right-)hit(r,rtinter))) return false; which provides an early out only if both hit lists are empty. For differenceBool::hit(),we use the code if((!left−>hit(r,lftInter)) return false; if(!right−>hit(r,rtInter)) { inter=lftInter; return true; } which gives an early out if the ray misses the left subtree,since it must then miss the whole object.

Building and using Extents for CSG object

The creation of projection,sphere and box extend for CSG object. During a preprocessing step,the true for the CSG object is scanned and extents are built for each node and stored within the node itself. During raytracing,the ray can be tested

against each extent encounted,with the potential benefit of an early out in the intersection process if it becomes clear that the ray cannot hit the object.

SIGNIFICANCE:

Ray tracing method to combine simple shapes to more complex ones is known as constructive Solid Geometry(CSG).

APPLICATIONS:

1.Implementing texture to a faces.

2.Implement a ray tracing method

A.GLOSSARY:

DDA-DIGITAL DIFFERANSIAL ALGORITHMS

y=mx+b-Slope equations

SETPIXEL- Set the coordinates of the line

3D-Three Dimensional Transformations

Polygon Meshes -A single plane surface can be specified with a function such as **fillArea**.

octree-used for the viewing volume, hidden-surface elimination is accomplished by projecting

octree nodes onto the viewing surface in a front-to-back order.

edge table - contains coordinate endpoints for each line in-the scene, the inverse slope of each line

Fractals : Another way to approach infinity is to apply a transformation to a picture again and again and examine the results. This technique also provides an another method to create fractal shapes.

B.QUESTION BANK

UNIT I

2D PRIMITIVES

1. Define Computer graphics.

Computer graphics remains one of the most existing and rapidly growing computer fields.Computer graphics may be defined as a pictorial representation or graphical representation of objects in a computer.

2. Define refresh buffer/frame buffer.

The memory area where in picture definition is stored is called Refreshbuffer. This memory area holds the set of intensity values for all the screen points. On a black and white system with one bit per pixel, the frame buffer is called a bitmap.

3. What is pixel?

Each screen point in a monitor is called a pixel/pel. It is also called picture element.

4. Define aspect ratio.
It is a property of video monitors. This number gives the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen.

5. What is Output Primitive?

Basic geometric structures that describe a scene are referred to as Output Primitives. Points and straight lines segments are the simplest geometric components of pictures. Additional output primitives that can be used to construct a picture include circles and other conic sections, quadric surfaces, spline curves and surfaces, polygon color areas, and character strings.

6. What is DDA?

The Digital Differential Analyzer is a scan-conversion line algorithm based on calculating either difference in y-coordinate (dy) or difference in x-coordinate. We sample the line at unit intervals in one coordinate and determine corresponding integer values nearest the line path for the other coordinate.

7.What are the disadvantages of DDA algorithm?

• R
ound-off error in successive additions of the floating-point increment can cause the calculated pixel positions to drift away from the true line path for long line segments.

- R
ounding operations and floating-point arithmetic in procedure are still time-consuming.

8. What is attribute parameter?

Any parameter that affects the way a primitive is to be displayed is referred to as an attribute parameter.

9. What are the basic line attributes?

Basic attributes of a straight line segment are its type, its width, and its color. 10. What is meant by aliasing?

The distortion of information due to low frequency sampling (Under sampling) is called aliasing. We can improve the appearance of displayed raster lines by applying antialiasing methods that compensate for the under sampling process.
11. Define 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, tx and ty, to original coordinate position (x, y) to move the point to a new position (x', y'). x' = x + tx, y' = y + ty. The translation distance pair (tx, ty) is called a translation vector or shift vector.

12. Define Rotation.

A 2-D rotation is applied to an object by repositioning it \along a circular path in the xy plane.

13. Define Scaling.

A scaling transformation alters the size of an object. This operation can be carried out for polygons by multiplying the coordinate values (x,y) of each vertex by scaling factors sx and sy to produce the transformed coordinates (x', y'). x' = x. sx, y' = y. sy.

14. Define Reflection.

A Reflection is a transformation that produces a mirror image of an object. The mirror image for a 2D reflection is generated relative to an axis of reflection by rotating the object 180 degree about the reflection axis.

15. Define Shear.

A transformation that distorts the shape of an object such that the transformed shape appears as if the object were composed of internal layers that had been caused to slide over each other is called a shear.

16. Define Window.

A world-coordinate area selected for display is called a window

17. Define view port.

An area on a display device to which a window is mapped is called a view port.

18. What is viewing transformation?

The mapping of a part of a world-coordinate scene to device coordinates is referred to as viewing transformation.

19. Define Clipping.

Any procedure that identifies those portions of a picture that are either inside or outside of a specified region of space is referred to as a clipping algorithm or simply clipping. The region against which an object is clipped is called a clip window.

20 What are the types of Clipping?

Point clipping

Line clipping

Area clipping

Curve clipping

Text clipping

21.What is the purpose of presentation graphics?

Presentation graphics is used to produce illustrations for reports or to generate 35-mm slides or transparencies for use with projectors. Presentation graphics is commonly used to summarize financial, statical, mathematical, scientific, and economic data for research reports, managerial reports, consumer information bulletins, and other types of reports.

22. What is frame buffer?

Picture definition is stored in a memory area called frame buffer or refresh buffer.

16.MARKS

1. Explain DDA line drawing algorithm with Example
2. Explain about midpoint ellipse drawing algorithm
3.Explain about Bresenham's and mid point circle Drawing Algorithm.
4. Explain about clipping operations.

UNIT II

3D CONCEPTS

1. Categorize the 3D representations?

Boundary representation (B-reps) and space-partitioning representations.

2. What Boundary representation?

It describes a 3D object as a set of surfaces that separate the object interior from the environment. e.g. polygon facets and spline patches.

3. What space-partitioning representation?

This is used to describe interior properties, by partitioning the spatial region containing an object in to a set of small, non-overlapping, contiguous solids. e.g. octree.

4. What is Transformation?

Transformation is the process of introducing changes in the shape size and orientation of the object using scaling rotation reflection shearing & translation etc.

5. What is projection?

The process of displaying 3D objects on a 2D display is called as Projection.

6.What are the types of projection?
Perspective projection Parallel projection

7.What is parallel projection?
In a parallel projection, coordinate positions are transformed to the view plane along parallel lines.

8. What is Perspective projection?
For a perspective projection object positions are transformed to the view plane along lines that converge to a point called the projection reference point

9. Write short notes on active and passive transformations?
In the active transformation the points x and x| represent different coordinates of the same coordinate system. Here all the points are acted upon by the same transformation and hence the shape of the object is not distorted.

In a passive transformation the points x and x| represent same points in the space but in a different coordinate system. Here the change in the coordinates is merely due to the change in the type of the user coordinate system.

10. What is scaling?
The scaling transformations changes the shape of an object and can be carried out by multiplying each vertex (x,y) by scaling factor Sx,Sy where Sx is the scaling factor of x and Sy is the scaling factor of y.

11. What is shearing?
The shearing transformation actually slants the object along the X direction or the Y direction as required.ie; this transformation slants the shape of an object along a required plane.

12. What is reflection?
The reflection is actually the transformation that produces a mirror image of an object. For this use some angles and lines of reflection.

13. Distinguish between window port & view port?
A portion of a picture that is to be displayed by a window is known as window port. The display area of the part selected or the form in which the selected part is viewed is known as view port.
14. Define clipping.

Clipping is the method of cutting a graphics display to neatly fit a predefined graphics region or the view port.

15. What is covering (exterior clipping)?

This is just opposite to clipping. This removes the lines coming inside the windows and displays the remaining. Covering is mainly used to make labels on the complex pictures.

16. What is the need of homogeneous coordinates?
To perform more than one transformation at a time, use homogeneous coordinates or matrixes. They reduce unwanted calculations intermediate steps saves time and memory and produce a sequence of transformations.

17. Distinguish between uniform scaling and differential scaling?
When the scaling factors sx and sy are assigned to the same value, a uniform scaling is produced that maintains relative object proportions. Unequal values for sx and sy result in a differential scaling that is often used in design application

18. What is fixed point scaling?

The location of a scaled object can be controlled by a position called the fixed point that is to remain unchanged after the scaling transformation.

19. List out the various Text clipping?

▪
ll-or-none string clipping - if all of the string is inside a clip window, keep it otherwise discards.

All-or-none character clipping – discard only those characters that are not completely inside the window. Any character that either overlaps or is outside a window boundary is clipped.
Individual characters – if an individual character overlaps a clip window boundary, clip off the parts of the character that are outside the window.

20.What is the various representation schemes used in three dimensional objects?

Boundary representation (B-res) – describe the 3 dimensional objects as a set of surfaces that separate the object interior from the environment.

▪
pace- portioning representation – describe interior properties, by partitioning the spatial region containing an object into a set of small, no overlapping, contiguous solids.

16 MARK QUESTIONS

1.Write a short notes on parallel and perspective projection.

2.What is viewing?Discuss their properties
3.Explain in details about three dimensional Transformation
4.Explain in briefly about viewing

UNIT-III

COLOR MODELS

1. What is color model?

A color model is a method for explaining the properties or behavior of color within some context.

2,List out the properties that are perceive in a light source.

Hue

Brightness(luminance)

Purity(saturation)

3.How is the color expressed in XYZ color model? Any color is expressed as

C1=XX+YY+ZZ

X,Y, and Z represent vectors in 3D

X,Y, and Z designate the amounts of the standard primaries.

4.What is RGB color model?
The RGB color model is an additive color model in which red,green and blue light is added together in various ways to reproduce a broad array of colors.

5.How is RGB model represented?

RGB model is represented by a unit cube. The color is expressed as an RGB triplet, each component of which can vary from 0 to 1.

6.What is YIQ color model?

YIQ is the color space used by the National Television System Committee color TV system. It was designed to separate chrominance from luminance. The Y,I,Q components are assumed to be in the [0,1] or [0,255] range.

7.How is RGB converted to CMY?

The conversion from RGB to CMY representation is done using the following matrix transformation.

[C M Y]=[1 1 1]-[R G B]

Where [1 1 1]represents white.

8.How is CMY converted to RGB?

The conversion from CMY toRGB representation is done using the following matrix transformation.

[R G B]=[1 1 1]-[C M Y]

Where [1 1 1] represents black.

9.What is HSV color model?

HSV stands for Hue,Saturation and Value.
Hue-The color we see(red,green,purple)
Saturation-How far is the color from gray

Values(Luminance)-How bright is the color.

10.What does Computer animation refer?

Computer animation refers to any time sequence of visual changes in

scene. It display time variations in object size,color,transparency & surface texture.

11.What is Frame-by-Frame animation?
Frame-by-Frame animation is an animation in which each frame of the scene is separately generated and stored.
12.What does story board define?
The story board is an outline of the action. It defines the motion sequence as a set of basic events that are to take place.

13.What is Graphics editor?

The graphics editor allows designing and modifying object shapes, using spline surfaces, constructive solid geometry methods,or other representation schemes.

14.What is Morphing?

Transformation of object shapes from one form to another is called morphing.

15.What is OPENGL?

OpenGL stands for Open graphics library. OpenGL provides a set of commands to render a 3D scene i.e., the data is provided in an OpenGL usable form and OpenGL will show this data on the screen.

16.Write down the Skeleton of an event driven program using OpenGL?

Void main()

{

Initialize things

Set the display mode

Create a screen window

Register the call back functions

Perhaps initialize other things

Enter the unending main loop

}

17.Give the format OpenGL vertex command? The OpenGL vertex command contains

The prefix “gl” indicates a function from the OpenGL library.

The basic command root

The number of arguments being sent to the function

The type of argument.

18.What is the use of glPointSize()?

The glPointSize() is used to set the size of a point which takes one floating point argument.

Syntax

glPointSize(Glfloat size)

where

size specifies the diameter of rasterized points the default is 1.0

19.What is the Modelview Matrix?

The modelview matrix is the CT. It combines the following 2 effects

Modelling tranformations on objects

the transformation that orients and positions the camera in space.
20.What is the Viewport Matrix?

The viewport matrix maps the standard cube into a 3D viewport
Whose x and y values extend across the viewport and whose z component extends from 0 to 1.

<u>16 mark Questions:</u>
1.Explain about various color models?
2.What is OpenGL? Discuss about the event driven programming.
3.Explain about computer animation?
4.Explain about the basic graphics primitive of OpenGL?
5.Explain about drawing 3D objects & scenes?

UNIT IV

RENDERING

1.What is the shading model?

The shading model attempts to model how light that emanates from light sources would interact with objects in a scene. The shading model dictates how light is scattered or reflected from a surface

2.What is known as black body?

If all of the incident light is absorbed, the object appears black and is known as a blackbody.

3.State Lamber’s Law?

The relationship between brightness and surface orientation is called lamber’s law.

4.What are the three types of light contributions?

Diffuse

Specular

Ambient

5.What are the two types of smooth shading?

The 2 types of smooth shading are

Gouraud shading

Phone shading

6.What is called Phong shading?
Greater realism can be achieved, to highlights on shiny objects, by a better approximation of the normal vector to the face at each pixel. This type of shading is called phong shading.

7.What is called texels?

Textures are formed bitmap representations of images. Such representation consists of an array, such as texture [c] [r], of color values called texels.

8.What is the use of glGetUniformLocation function?

The glGetUniformLocation function is used to retrieve the locations of some uniform variables that are defined in the shaders.

9.Mention the types of shader?

GL_VERTEX_SHADER

GL_FRAGMENT_SHADER

GL_DELETE_SHADER

GL_ATTACH_SHADER

10.Write down the function of texture(s,t)?

The function texture (s,t) accesses “samples” in the array, as in the code,

```
Color3 texture(float s, float t)

{
```

Return txtr[(int)(s*c)][(int)(t*R)];

}

11.What is the visible intensity?

The visible intensity I is set equal to the texture value at each spot.

I= texture(s,t)

12.What is the use of glTexCoord2f() function?
The function glTexCoord2f() is used to associate a point in texture space, Pi=(si,ti) with each vertex Vi of the face.

13.Write down the OpenGL command to define a quadrilateral face.
glBegin(GL_QUADS);//define a quadrilateral face glTexCoord2f(0.0,0.0);
glVertex3f(1.0,2.5,1.5); glTexCoord2f(0.0,0.6);glVertex3f(1.0,3.7,1.5);
glTexCoord2f(0.8,0.6);glVertex(2.0,3.7,1.5);
glTexCoord2f(0.8,0.0);glVertex3f(2.0,2.5,1.5); glEnd();

14.Give the basic idea of reflection Mapping.
The reflection mapping can significantly improve the realism of pictures especially animations. The basic idea is to see reflections in an object thet suggest the “world” surrounding thet object.

5.What is called a shadow buffer?
An auxiliary second depth buffer,called a shadow buffer,is employed for each light source. It contains depth picture for the scene from the point of view of the light source.

16.What does sliding means?
Sliding means to move the camera along one of its own axes,(ie) in the u,v or n directions,without rotating it.

17.Write down the syntax for glFramebufferRenderbufferEXT().

Void glFramebufferRenderbufferEXT(GLenum target,
GLenum attachmentPoint,

GLenum renderbufferTarget,

GLuint renderbufferId);

18.What is the function of glCheckFramebufferStatusEXT()?
The glCheckFramebufferStatusEXT() validates all its attached images and framebuffer

parameters on the currently bound FBO. And, this function cannot be called within glBegin()/glEnd() pair.

19.Write down the syntax for glGetRenderbufferParameteriveEXT().

Void glGetRenderbufferParameterivEXT(GLenum target, GLenum param, Glint* value);

20.List out some of the rules of FBO completeness.
The width and height of framebuffer-attachable image must be not zero
FBO must have at least one image attached
All images attached a FBO must have the same width and height
All images attached the color attachment points must have the same internal format.

16 mark Questions:

1.Explain about shading models?
2.Explain in detail about Flat and Smooth shading?
3.Explain in detail about adding texture to faces?
4.Explain in detail about adding shadows of objects?
5.Discuss about the process of creating shaded objects?

UNIT V

FRACTALS

1. Define Fractal
A fractal is an image or a geometric object with self-similar properties produced by recursive or iterative algorithmic means .

2.List out some properties of fractal.

Self similar
Formation by iteration
Fractional dimension
Form is extremely irregular or fragmented

3.What are three types of self-similarity found in fractals?
Exactly self-similar
Quasi-self-similarity
Statistically self-similar

4.Give some examples of fractals.
Clouds
Grass

Fore
Modeling mountains(terrain)
Coastline
Branches of a tree
Surface of a sponge
Cracks in the pavement

5.What is Koch Curve?
The Koch curve is a curve that is generated by a simple geometric procedure which can be iterated an infinite number of times by dividing a straight line segment into three equal parts and substituting the intermediate part with two segment of the same length.

6.Give the general procedure to construct Koch curve.
To form Kn+1 from Kn:
Subdivide each segment of Kn into three equal parts and
replace the middle part with a bump in the shape of an equivalent triangle.

Total length of Ki is $(4/3)^I$ which increases as i increases.

7.What is known as L-Systems?
L-systems(also known as Lindenmayer Systems or parallel string-rewrite systems) is a simple approach to generate a large number of complex curves by refining the line segments based on a simple set of rules.

8. What are the instructions to be followed in L-systems?
An L-system works by giving the turtle a string sequence where each symbol in the sequence gives turtle instructions.

‘F’ go forward 1 step
‘+’ turn right by x degrees
‘-‘ turn left by x degrees

Where x is set and predetermined.

9. What is String Production Rules?
String Production Rules is a rule used to generate a simple String in to the longer one that will generate richer curve.

10.What is Iterated Function System(IFS)?
Iterated function systems or IFSs are a method of constructing fractals in which each string is repeatedly fed back into the same function to produce the next higher order object; the resulting constructions are always self-similar
11.Give the rules for Dragon Curves?

The rules that used X and Y for dragon curves F F
X   X+YF+
Y -FX-Y Atom=FX
F means “draw forward”
- means “turn left 90^0”, and
+ means “turn right 90^0”.

12.Give the parameter to represent each curves based on String production The five key ingredients for each curve
Atom
F-string
X-string
Y-string

Angle in degree

13.What is space-filling curve?
A space-filling curves in the 2D plane are commonly called Peano curves.

14.What is called Ray Tracing?
Ray tracing, also called as ray casting, is a technique for generating an image by tracing the path of light through pixels in an image plane and simulating the effects of its encounters with virtual objects.

15.What is the state of a turtle?
A turtle has a position and points in some direction, so its state consists of the values of the current position (CP) and current direction (CD)
State of the turtle={CP,CD}

16. The hit() methods performs the following functions
The ray is first transformed into the generic coordinates of the object
The various intersections with the generic object are computed

17.What is known as Surface texture?
Surface texture, also known as surface finish, is the characteristics of a surface in which computer-generated imaged=s is made more lively and realistic by painting textures on various surfaces.

18.What is total internal reflection?
The internal reflection is an optical phenomenon that happens when a ray of light strikes a medium boundary at an angle larger than a particular critical angle with respect to the normal to the surface

19.What is Constructive solid geometry?
Constructive solid geometry (CSG) is a technique used in solid modeling. Constructive solid geometry allows a modeler to create a complex surface or object by using Boolean operators to combine objects.

20.What is CSG Objects?
CSG objects (also called as compound or Boolean objects) is an object is constructed by combining the primitives by means of allowable operations, which are typically Boolean operation on sets,

Union

Intersection
Difference

<u>16 mark Questions:</u>
1.Define Koch curve? How do you construct the Koch curve?
2.Explain about Mandelbrot sets?
3.Explain about Julia sets?
4.Explain about Intersecting rays with other primitives?
5.Explain about Boolean operation on objects?

Anna University
B.E./B.Tech. DEGREE EXAMINATION, November/December 2012
Seventh Semester
Computer Science and Engineering
CS2401 Computer Graphics
(Regulation 2008)

Semester : 7
Year : 4th yr
Regulation : 2008
Department : B.E CSE, B.Tech IT
Subject Code : CS2401
Subject Name : Computer Graphics
Content : CS2401 Computer Graphics Nov / Dec 2012 Question Paper.

PART A

1.Write down the shear transformation matrix.
2.Define text clipping.
3.Differentiate oblique and orthogonal projections.
4.Define spline curves.
5.State the difference between CMY and HSV color models.
6.What are key frame systems?

7.What is a shadow?
8.Define texture.
9.List down the properties of piano curves.
10.Write down some of boolean operations on objects.

PART B

11.a.Explain the following
i.Line Drawing algorithm.
ii.Line clipping algorithm.
b.With suitable examples, explain the following
i.Rotational transformation.
ii.Curve Clipping Algorithm.
12.a.i.Differentiate parallel and perspective projections.
ii.Write notes on 3D viewing.
b.i.With suitable examples, explain the 3D transformations.
ii.Write notes on quadratic surfaces.
13.a.i.Explain RGB color model in detail.
ii.Explain how 3D scenes are drawn.
b.i.Discuss the computer animation techniques.
ii.Explain how 3D objects are drawn.
14.a.Differentiate flat and smooth shading models.
b.Discuss the methods to draw and add shadow to objects.
15.a.i.Mandelbrot sets. ii.Julia sets.
b.i.Describe the creation of images by iterated functions.
ii.Explain the method for adding surface textures.

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2011.
Seventh Semester
Computer Science and Engineering
CS 2401 — COMPUTER GRAPHICS
(Common to Information Technology)
(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A **(10 × 2 = 20 marks)**

1. Write down any two line attributes.
2. Differentiate window and view port.
3. What are spline curves?
4. Define quadric surfaces.
5. What is animation?
6. Define key frames.
7. What do you mean by shading of objects?
8. What is texture?
9. Define fractals.
10. Differentiate Mandelbrot and Julia sets.

PART B **(5 × 16 = 80 marks)**

11. (a) Write down and explain the midpoint circle drawing algorithm. Assume 10 cm as the radius and co-ordinate origin as the centre of the circle. (16 marks)
Or
(b) Explain in detail the Cohen-Sutherland line clipping algorithm with an example. (16 marks)
12. (a) Differentiate parallel and perspective projections and derive their projection matrices. (16 marks)
Or
(b) With suitable examples, explain all 3D transformations. (16 marks)
13. (a) Write notes on RGB and HSV color models. (16 marks)
Or
(b) Discuss the following:
(i) Methods to draw 3D objects. (8)
(ii) Basic OPENGL operations. (8)
14. (a) Explain the following:
(i) Adding texture to faces. (8)
(ii) Adding shadows of objects. (8)
Or
(b) Write down and explain the details to build a camera in a program. (16 marks)