Q.2a. How a raster image is created? Discuss the three principal sources of creating them.

b.Differentiate between line-drawing displays and raster displays.

c.Define color lookup table.
How many different colors can be displayed in a graphic system when the color depth is 8 bits and look up table entry is 12 bits wide?

Q-2 (a) Explanation: Section 1.3.4 Page 47-48 (Text book)

2 (b) Explanation Section 1.4.1 & 1.4.2 Page - 54, 55 (Textbook)

2 (c) Explanation Page 59, 60
Solution: A system with b=8 bit planes and LUT width w=12 can display 4096 colours, any 256 of them at a time.

Q.3a. Give the Open GL code for drawing the dot plot of a function. (8)

b. Define the terms window & Viewport. Find the normalization transformation that maps a window whose lower left corner is at (1,1) and upper right corner is at (3, 5) onto
(i) Viewport that is the entire normalized device screen.
(ii)Viewport that has lower left corner at (0, 0) and upper right corner at (½, ½)

Q-3 (a) Page-84 Textbook (Solution: Figure— Complete Program for draw. "dotplot" of a function)

3 (b) Continued on next page

Soln: 3(b)

(part-a)

The window parameters are

$wx_{min} = 1$, $wy_{min} = 1$, $wx_{max} = 3$, $wy_{max} = 5$

Viewport parameters are

$v_{xmin} = 0$, $v_{ymin} = 0$, $v_{xmax} = 1$, $v_{ymax} = 1$

hence $s_x = 1/2$, $s_y = 1/4$

So N using $= \begin{pmatrix} 1 & 0 & v_{xmin} \\ 0 & 1 & v_{ymin} \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} s_x & 0 & 0 \\ 0 & s_y & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & -w_{xmin} \\ 0 & 1 & -w_{ymin} \\ 0 & 0 & 1 \end{pmatrix}$

$$N = \begin{pmatrix} 1/2 & 0 & -1/2 \\ 0 & 1/4 & -1/4 \\ 0 & 0 & 1 \end{pmatrix}$$

Part-b. Window parameters are same as part a

Viewport parameter are $v_{xmin} = 0$ $v_{ymin} = 0$

$v_{xmax} = 1/2$ hence $s_x = 1/4$

$v_{ymax} = 1/2$ $s_y = 1/8$

$$N = \begin{pmatrix} 1/4 & 0 & -1/4 \\ 0 & 1/8 & -1/8 \\ 0 & 0 & 1 \end{pmatrix}$$

Q.4a.How Cohen Sutherland line clipping algorithm differs from Cyrus-Beck line algorithm? Discuss all cases of line clipping, which arise in Cohen Sutherland algorithm. Draw suitable diagram to discuss the cases.

Q-4(a) Explanation 3.3.2 Page 129, 130 (Textbook)

4.8.3 Page 224

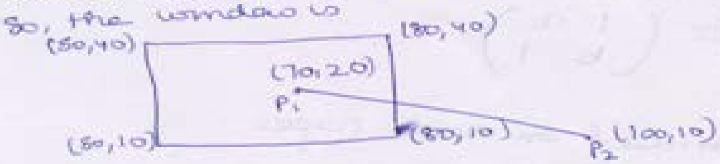
b. Use the Cohen Sutherland algorithm to clip $P_1(70,20)$ and P_2 (100, 10) against a window with lower left hand corner (50, 10) and upper right hand corner (80, 40).

4 (b) Soln: P_1 (70,20) and P_2 (100,10)

Window lower left corner = (50,10)

Window upper right corner = (80,40)

So, the window is



Continued on back side.

4(b) ctd:

Now we assign 4 bit binary outcode.
Point P_1 is inside the window so outcode of $P_1 = (0000)$
and outcode of $P_2 = (0010)$ as P_2 is right of window
And of P_1 & P_2

$$\begin{array}{r} 0000 \\ 0010 \\ \hline 0000 \end{array} \text{(AND)}$$

The result of AND operation is zero so line is partially visible.

Slope of line P_1P_2 is $m = \frac{y_2-y_1}{x_2-x_1} = -1/3$

We have to find intersection of line P_1P_2 with right edge of window i.e Point P_2
let the intersection point be (x,y) here $x=80$, value of

$P_2(x_2,y_2) = P_2(100,10)$

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

$$\frac{-1}{3} = \frac{y-10}{80-100}, \quad y-10 = \frac{20}{3} \Rightarrow y = \frac{20}{3}+10 = 16.66$$

$\therefore \; y = 16.66$

The intersection point $P_3 = (80, 16.66)$

So, after clipping line P_1P_2 against window, new line is P_1P_3 with coordinates $P_1(70,20)$ and $P_3(80,16.66)$

Q.5 a. Prove that simultaneous shearing in both directions (x and y directions) is not equal to the composition of pure shear along x-axis followed by pure shear along y-axis.

Soln 5(a) Simultaneous shearing — (i)

$S_n = \begin{pmatrix} 1 & a \\ b & 1 \end{pmatrix}$.

$S_x = \begin{pmatrix} 1 & a \\ 0 & 1 \end{pmatrix}$. $m\,y = \begin{pmatrix} 1 & 0 \\ b & 1 \end{pmatrix}$

∴ shearing $m\,x$ follow by y direction is

$\begin{pmatrix} 1 & a \\ 0 & 1 \end{pmatrix}\begin{pmatrix} 1 & 0 \\ b & 1 \end{pmatrix} = \begin{pmatrix} 1+ab & a \\ b & 1 \end{pmatrix}$

is $\neq \begin{pmatrix} 1 & a \\ b & 1 \end{pmatrix}$

b.Find the transformation matrix that reduces the square ABCD, whose centre is at (2, 2), to half of its size, with centre still remaining at (2, 2). The coordinates of the square ABCD are A(0,0), B(0,4), C(4, 4) and D(4, 0) Find the coordinates of new square.

5(b) Square ABCD = $\begin{pmatrix} 0 & 0 & 1 \\ 0 & 4 & 1 \\ 4 & 4 & 1 \\ 4 & 0 & 1 \end{pmatrix}$

Square ABCD reduced to half of its size:

$S_x = 1/2$, $S_y = 1/2$

So scaling matrix is $\begin{pmatrix} 1/2 & 0 & 0 \\ 0 & 1/2 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

After scaling we get

$\begin{pmatrix} 0 & 0 & 1 \\ 0 & 4 & 1 \\ 4 & 4 & 1 \\ 4 & 0 & 1 \end{pmatrix}\begin{pmatrix} 1/2 & 0 & 0 \\ 0 & 1/2 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 2 & 1 \\ 2 & 2 & 1 \\ 2 & 0 & 1 \end{pmatrix}$

So coordinates of square ABCD are

$A=(0,0)$, $B=(0,2)$ $C=(2,2)$ $D=(2,0)$

current centre is (1,1) but new centre of ABCD (2,2)

translate ABCD by $T_x=1$, $T_y=1$

after translation we get

$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 1 & 0 \end{pmatrix}\begin{pmatrix} 0 & 0 & 1 \\ 0 & 2 & 1 \\ 2 & 2 & 1 \\ 2 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 3 & 1 \\ 3 & 3 & 1 \\ 3 & 1 & 1 \end{pmatrix}$

$A \to (1,1)$ $B \to (1,3)$ $C \to (3,3)$ $D \to (3,1)$

c. Define and explain Affine transformations.

(c) Soln: 5.2.2 Page 248,249 (Text book)

Q.6a. Discuss and explain the taxonomy of projections. (8)

b.Consider the polygon with vertices (8)

$P_0 = (6, 1, 4)$
$P_1 = (7, 0, 9)$
$P_2 = (1, 1, 2)$
Find the normal to this polygon using Newell's Method.

6(a) 7.6. Page 426, - 434 Textbook

6(b) Solved example 6.2.2 (Text book Page 325)
Ans. Direct use of cross product gives
$((7,0,9) - (6,1,4)) \times ((1,1,2) - (6,1,4)) = (2,-23,-5)$

Q.7 a. What is the need of the concept of "Shading in computer Graphics"? List the merits and demerits of Phong shading. (6)

b.Write the pseudo code for the z-buffer algorithm for visible surface detection. What is the maximum number of objects that can be handled by z-buffer algorithm? Give two advantages and two disadvantages of z-buffer algorithm.

7.(a) Section 8.1, Page 441 (Textbook)
Section 8.3.2 Page 467-468

7(b) Section 13.2 (Text book)
Pseudocode figure 13.7
Page 736-737

Q.8 a. Discuss the different ways to define a region. Also differentiate between them.
b.Define Aliasing. Discuss the different anti-aliasing techniques.

Soln 8(a) Section 10.5.1, Page 593-596 (Textbook)
8(b) Section 10.8 Page 609-612 (Text book)

Q.9 a. Explain the terms "Parametric continuity" and "Geometric continuity" in Bezier curves. (5)

b.Write any three properties of Bezier curve. What are the limitations of Bezier curves?

Soln 9(a) to Page 633-34 Section 11.1.2
9(b) Just give the properties
11.5 Page 646-649

c.A Bezier curve is to be drawn, given the control points P_1(40,40), P_2(10, 40), P_3(10, 60), P_4(60, 0). Calculate the coordinates of the points on the curve corresponding to the parameter t = 0.2, 0.4, 0.6. Draw a graph sketch of the curve and show coordinates of various points on it.

9(c) Polynomial is given by

$$P(t) = \sum_{k=1}^{n+1} P_k \, BEZ_{k,n+1}(t)$$

$$= P_1 BEZ_{1,4}(t) + P_2 BEZ_{2,4}(t) + P_3 BEZ_{3,4}(t) + P_4 BEZ_{4,4}(t)$$

$$BEZ_{1,4}(t) = (1-t)^3$$

$$BEZ_{2,4}(t) = 3t(1-t)^2$$

$$BEZ_{3,4}(t) = 3t^2(1-t)$$

$$BEZ_{4,4}(t) = t^3$$

$$P(t) = P_1(1-t)^3 + P_2 3t(1-t)^2 + P_3 3t^2(1-t) + P_4 t^3$$

At $t=0$, $P_1 = (40, 40)$

$t=1$, $P_4 = (60, 0)$

$t=0.2 = [25.76, 41.6]$

$t=0.4 = [19.68, 43.2]$

$t=0.6 = [22.72, 40]$

TEXT BOOK

I. **Computer Graphics Using OpenGL, F.S. Hill, Jr., Second edition, PHI/Pearson Education, 2005 (TB-I)**