BACHELOR OF COMPUTER SCIENCE & ENGG. EXAMINATION, 2017

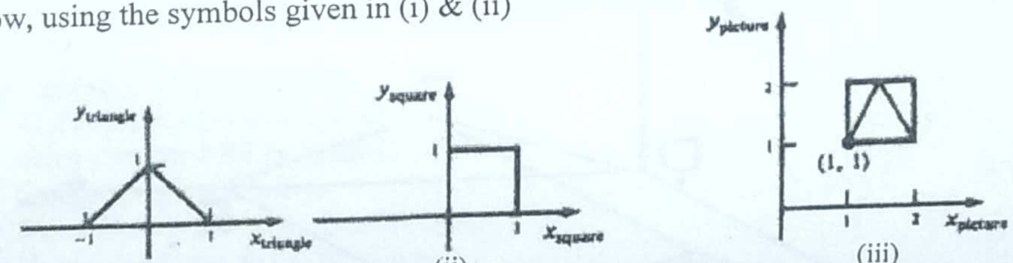
(3^{rd} year, 1st Semester)

COMPUTER GRAPHICS

Time: 3 hours | Full Marks: 100

Answer any FIVE questions.
(Parts of a question must be answered contiguously)

1. a) Obtain the complete transformation matrix needed to create the picture given in (iii) below, using the symbols given in (i) & (ii)



(i) (ii) (iii)

b) Derive the general conditions necessary to keep the enclosed area of a 2D object invariant under arbitrary 2D transformation **[10+10]**

2. a) Develop the Mid Point Subdivision clipping technique for clipping lines against regular windows. Present the technique as a formal algorithm

b) Rasterise 1^{st} quadrant of an ellipse centered at (3, 4) with axes aligned to the coordinate axes and a = 8, b = 5. Your results must be presented in precise tabular form with values of all rasterisation related parameters given in all steps. **[(6+4)+10]**

3. a) A polygon is defined by vertices (1, 1), (8, 1), (8, 6), (5, 3) and (1, 7) in that order. Fill this using active-edge-list (ordered) scan conversion technique; give details of all steps i.e., Y-bucket contents, AEL etc., scan line wise, in neat tabular form. Avoid over/under filling.

b) Using the Liang-Barsky algorithm, clip line $P_1(-1, 1)$ to $P_2(9, 3)$ against the regular window with lower left & upper right corners at (0, 0) & (8, 4) respectively. Present your clipping steps in precise tabular form giving values of all related parameters in each step. **[10+10]**

4. a) Develop the Sutherland & Cohen's algorithm for clipping lines against regular windows.

b) Can this algorithm be extended to clip lines against regular 3D volumes? If so how? Give specific details and explain your answer.

c) Prove that for $x = p^2$ & $y = p$, $p > 0$, transforming the position vector [x y 1] using transformation matrix:

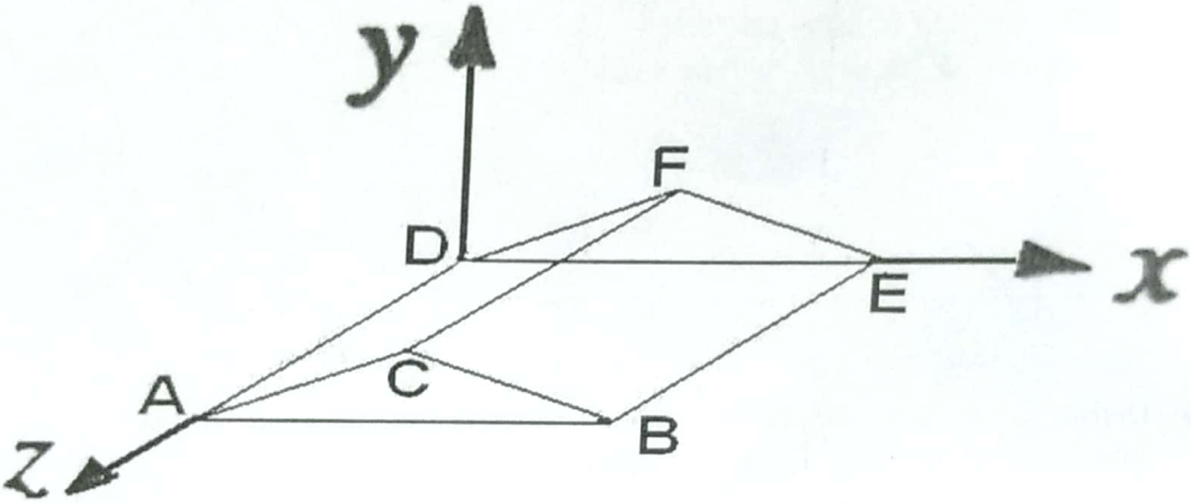
.. . ..

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

yields position vectors of the form [x* y* 1] that represent points lying on an unit circle.

[8+6+6]

5. a) A simple triangular prism is placed so that one of its triangular face lies on the x-y plane with one vertex coincident with the origin and one of its rectangular face lies on the x-z plane. This is shown in the figure below:



Vertices are A(0, 0, 1), B(1, 0, 1), C(0.5, 0.5, 1), D(0, 0, 0), E(1, 0, 0) & F(0.5, 0.5, 0). This prism is rotated about y-axis by angle $\Phi = -30°$, about x-axis by angle $\theta = 45°$ and projected on to the z = 0 plane from centre of projection at (0, 0, 2.5). Generate transformation matrix needed to do this and find position vectors of the projected prism vertices.

b) A cube with sides of length S is placed such that one of its vertices is at the origin and three mutually perpendicular edges connected to this vertex are coincident with the positive coordinate – axes. Derive the transformation matrix needed to rotate this cube CCW by angle θ about the straight line passing through top right corner of the cube-face lying on the x – y plane and bottom left corner of the cube face parallel to but not coincident with the x – y plane.

[10+10]

6. a) Consider a hyperbola with a=2 & b=1. Approximate a segment of this hyperbola in the first quadrant with $4 \le x \le 8$, using 7 linear segments/ 8 points. Use hyperbolic functions for better approximation. Give full numerical details of all your steps, preferably in tabular form

b) A cubic Bezier curve segment is described by control points $P_0(2, 2)$, $P_1(4, 8)$, $P_2(8, 8)$, $P_3(9, 5)$. Another curve segment is defined by $Q_0(a, b)$, $Q_1(c, 2)$, $Q_2(15, 2)$ & $Q_3(18, 2)$. Determine values of a, b & c so that two curves join smoothly. Explain your answer.

[10+10]

7. a) Consider four 2D points $P_1[0,0]$, $P_2[1,1]$, $P_3[2.-1]$ and $P_4[3,0]$, with tangent vectors at

the beginning and end given by $P_1'[1\ 1]$ and $P_4'[1\ 1]$ respectively. Determine the first segment of piece-wise normalized cubic spline through these four points. Calculate intermediate points at $t = 1/3$ and $t = 2/3$ for the segment. Explain properly.

b) Show that for a Bezier curve, the Bernstein basis $J_{n,i}(t)$ is maximised at $t = (i / n)$ for $0 \le i \le n$; Hence sketch variations of $J_{3,i}(t)$ as t increases from 0 to 1 for $0 \le i \le 3$

c) For the Bernstein basis, it is known that

$$\sum_{i=0}^{n} J_{n,i}(t) = 1,\ 0 \le t \le 1$$

Show formally, that this is indeed true for a cubic Bezier curve. [8+6+6]

8. a) Write detailed notes on any four
   i) Cyrus Beck 2D line clipping.
   ii) Scan-line seed fill technique.
   iii) Splitting a Bezier curve.
   iv) C_2 continuity between Bezier curves
   v) Vanishing point & its derivation.
   vi) Parametric representation of conic sections.
   vii) Sutherland Hodgman clipping.
   viii) Frame buffer polygon filling techniques. [5+5+5+5]