

Thapar Institute of Engineering & Technology

Computer Science & Engineering Department

ASSIGNMENT 1

**Instructions:**

1. Attempt all questions;
2. Attempt all the subparts of a question at one place;
3. Advisable to close the notes, while attempting the questions, for better retention;
4. Use only blank A4 sheets to create an answer booklet;
5. The front page of an answer booklet should contain the header here (i.e. everything above Instructions) as is; followed by candidate details, i.e. Roll No, Name and Submission Date.
6. The submission will be a scan copy of answer booklet uploaded to the submission form. (Max 10 MB)

1. a) Given the control polygon $\mathbf{b}_0, \mathbf{b}_1, \mathbf{b}_2, \mathbf{b}_3$ of a Cubic Bezier curve; determine the vertex coordinates for parameter values $\forall t \in T$. [7 marks]

$$T \equiv \{0, 0.15, 0.35, 0.5, 0.65, 0.85, 1\}$$

$$[\mathbf{b}_0 \quad \mathbf{b}_1 \quad \mathbf{b}_2 \quad \mathbf{b}_3] \equiv \begin{bmatrix} 1 & 2 & 4 & 3 \\ 1 & 3 & 3 & 1 \end{bmatrix}$$

- b) Explain the role of convex hull in curves. [2 marks]

2. a) Describe the continuity conditions for curvilinear geometry. [5 marks]
- b) Define formally, a B-Spline curve. [2 marks]
- c) How is a Bezier curve different from a B-Spline curve? [2 marks]

3. a) Given a triangle, with vertices defined by column vectors of P ; find its vertices after reflection across XZ plane. [3 marks]

$$P \equiv \begin{bmatrix} 3 & 6 & 5 \\ 4 & 4 & 6 \\ 1 & 2 & 3 \end{bmatrix}$$

- b) Given a pyramid with vertices defined by the column vectors of P , and an axis of rotation A with direction \mathbf{v} and passing through \mathbf{p} . Find the coordinates of the vertices after rotation about A by an angle of $\theta = \pi/4$. [6 marks]

$$P \equiv \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$[\mathbf{v} \quad \mathbf{p}] \equiv \begin{bmatrix} 0 & 0 \\ 1 & 1 \\ 1 & 0 \end{bmatrix}$$

4. a) Explain the two winding number rules for inside outside tests. [4 marks]

b) Explain the working principle of a CRT.

[5 marks]

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5. a) Given a projection plane P defined by normal \mathbf{n} and a reference point \mathbf{a} ; and the centre of projection as \mathbf{p}_0 ; find the perspective projection of the point \mathbf{x} on P . [5 marks]

$$[\mathbf{a} \quad \mathbf{n} \quad \mathbf{p}_0 \quad \mathbf{x}] \equiv \begin{bmatrix} 3 & -1 & 1 & 8 \\ 4 & 2 & 1 & 10 \\ 5 & -1 & 3 & 6 \end{bmatrix}$$

- b) Given a geometry G , which is a standard unit cube scaled uniformly by half and viewed through a Cavalier projection bearing $\theta = \pi/4$ wrt. X axis. [2 marks]
- c) Given a view coordinate system (VCS) with origin at \mathbf{p}_v and euler angles ZYX as θ wrt. the world coordinate system (WCS); find the location \mathbf{x}_v in VCS, corresponding to \mathbf{x}_w in WCS. [2 marks]

$$[\mathbf{p}_v \quad \theta \quad \mathbf{x}_w] \equiv \begin{bmatrix} 5 & \pi/3 & 10 \\ 5 & 0 & 10 \\ 0 & 0 & 0 \end{bmatrix}$$

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6. a) Describe the visible surface detection problem in about 25 words. [1 mark]
- b) To render a scene with N polygons into a display with height H ; what are the space and time complexities respectively of a typical image-space method. [2 marks]
- c) Given a 3D space bounded within $[0 \ 0 \ 0]$ and $[7 \ 7 \ -7]$, containing two infinite planes each defined by 3 incident points $\mathbf{a}_0, \mathbf{a}_1, \mathbf{a}_2$ and $\mathbf{b}_0, \mathbf{b}_1, \mathbf{b}_2$ respectively bearing colours (RGB) as \mathbf{c}_a and \mathbf{c}_b respectively.

$$[\mathbf{a}_0 \quad \mathbf{a}_1 \quad \mathbf{a}_2 \quad \mathbf{b}_0 \quad \mathbf{b}_1 \quad \mathbf{b}_2 \quad \mathbf{c}_a \quad \mathbf{c}_b] \equiv \begin{bmatrix} 1 & 6 & 1 & 6 & 1 & 6 & 1 & 0 \\ 1 & 3 & 6 & 6 & 3 & 1 & 0 & 0 \\ -1 & -6 & -1 & -1 & -6 & -1 & 0 & 1 \end{bmatrix}$$

Compute and/ or determine using the depth-buffer method, the colour at pixel $\mathbf{x} = (2, 4)$ on a display resolved into 7×7 pixels. The projection plane is at $Z = 0$, looking at $-Z$. [6 marks]
