Roll No. ______________________ **June 21, 2024**

UCS505: Computer Graphics Time: **3 hours** MM:**45**

Faculty: ANG,AMK,HPS,YDS,RGB

Thapar Institute of Engineering & Technology

Computer Science & Engineering Department

END SEMESTER EXAMINATION

Instructions:

1. Attempt any 5 questions;
2. Attempt all the subparts of a question at one place.

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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]

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

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

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

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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]

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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]

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

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

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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]

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

b) Given a geometry G, which is a standard unit cube scaled uniformly by half and viewed through a Cavelier 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 $\boldsymbol{\theta}$ wrt. the world coordinate system (WCS); find the location $\mathbf{x}_v$ in VCS, corresponding to $\mathbf{x}_w$ in WCS. [2 marks]

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

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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 $[0 \quad 0 \quad 0]$ and $[7 \quad 7 \quad -7]$, 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.

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

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]
