Roll No. ______________________ **Deadline: July 16, 2024 Tue 08:00 IST**

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

Faculty: RGB

Thapar Institute of Engineering & Technology

Computer Science & Engineering Department

SESSIONAL ASSIGNMENT 2 (SUMMER 2024)

Instructions:

1. Attempt **all** five questions. Attempt all the sub-parts of a question **in one** place.
2. It is advisable to close the notes, while attempting the questions, for better retention;
3. Use only blank A4 sheets to create an answer booklet; The front page of an answer booklet should contain the header here (i.e. everything above Instructions) as is;
4. The submission will be a PDF scan of answer booklet uploaded to the submission form (max 10 MB);
5. **Notation:** $\mathbb{A}, \mathbb{B}, \dots$ are sets; $A, B, \dots$ are matrices; $\mathbf{a}, \mathbf{b}, \dots$ are column vectors; and $a, \alpha, b, \beta, \dots$ are scalars.

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1. Compute augmented transformation matrices for the following, [1+2+2+4 marks]
   a) Translation by affine vector $\mathbf{x}_0 : \mathbf{x}_0^T = \begin{bmatrix} 1 & 1 \end{bmatrix}$ in Euclidean plane.
   b) Rotation by $\theta : \tan\theta = 3/4$, then followed by scaling $\sigma = 5$ times, and then finally a translation by affine vector $\mathbf{x}_0 : \mathbf{x}_0^T = \begin{bmatrix} 5 & 5 \end{bmatrix}$ in Euclidean plane.
   c) Rotation about axis $\mathbf{a} : \mathbf{a}^T = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$ positioned at origin, by an angle $\theta = 45°$.
   d) Scaling along three mutually orthogonal vectors, $\mathbf{a}, \mathbf{b}, \mathbf{c}$ (not necessarily unit vectors) by a factor of $\sigma_a, \sigma_b, \sigma_c$ respectively; $\mathbf{a}^T = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$; $\mathbf{b}^T = \begin{bmatrix} 1 & 1 & -1 \end{bmatrix}$; $\mathbf{c}^T = \begin{bmatrix} 1 & -1 & 1 \end{bmatrix}$; $\begin{bmatrix} \sigma_a & \sigma_b & \sigma_c \end{bmatrix} = \begin{bmatrix} 2 & 0.5 & 1.5 \end{bmatrix}$.

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2. Explain the difference in principle between the Sutherland-Cohen and the Liang-Barsky line-clipping algorithms, and describe for each, an efficient formulation for a fixed-point computer. [3+3+3 marks]

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3. Write the pseudo-code for and compute using the depth-buffer algorithm: RGB colour value at pixel $P(4, 2)$ when the following scene is projected on to $Z = 0$ using an identity matrix for transformation, and looking at $-Z$. The scene consists of two infinite planes A and B. A is defined by incident points $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ and bearing RGB colour $\mathbf{c}_a$; and similarly, B is defined by $\mathbf{b}_1, \mathbf{b}_2, \mathbf{b}_3, \mathbf{c}_b$. [3+6 marks]

$$\begin{bmatrix} \mathbf{a}_1 & \mathbf{a}_2 & \mathbf{a}_3 & \mathbf{c}_a \end{bmatrix} = \begin{bmatrix} 1 & 4 & 8 & 0 \\ 1 & 8 & 1 & 1 \\ -1 & -8 & -1 & 0 \end{bmatrix} \qquad \begin{bmatrix} \mathbf{b}_1 & \mathbf{b}_2 & \mathbf{b}_3 & \mathbf{c}_b \end{bmatrix} = \begin{bmatrix} 8 & 4 & 1 & 0 \\ 8 & 1 & 8 & 0 \\ -1 & -8 & -1 & 1 \end{bmatrix}$$

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4. a) Write the complete pseudo-code for **one** of the following, [6 marks]
      i. Sutherland-Hodgman Clipping Algorithm, **or,**
      ii. Weiler-Atherton Clipping Algorithm
   b) Thus using **the same** algorithm, compute the intersection of rectangles $A \cap B$ [3 marks]

$$A \equiv \begin{bmatrix} -1 & 1 & 1 & -1 \\ -1 & -1 & 1 & 1 \end{bmatrix} \qquad B \equiv \begin{bmatrix} 0 & 2 & 2 & 0 \\ 0 & 0 & 2 & 2 \end{bmatrix}$$

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5. a) Formally define a B-Spline Curve. [5 marks]
   b) Formally define the following continuities for a spline: G^0, C^0, C^1, C^2. [4 marks]
