Date of Examination: 21/04/2022

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Spring 2021

Year: 4th Semester: 2nd

Course Number: CSE4203

Course Name: Computer Graphics

Time: 3 (Three) hours **Full Marks: 70**

Instruction: *There are seven questions carrying a total of 14 marks each. Answer any five questions. Marks allotted are indicated in the right margin.*

Question 1. [Marks: 14]

a) Apply the midpoint algorithm to draw a line from $(2, 1)$ to $(-8, -6)$ and plot the obtained points. Show step-wise values of the decision variables and the points (in a tabular format). [11]

b) Given that, $C_f = 1.0$, $C_b = 0.2$ and $C = 0.8$, where C_f, C_b and C are the foreground, background and composite intensities respectively. What is the alpha value to perform this composition? [3]

Question 2. [Marks: 14]

a) AB is a line and P is a point in 3D space; where the points A, B and P are $(1, 1, 1)$, $(3, 3, 3)$ and $(2, 2, 4)$ respectively. We want to rotate a point P with respect to AB by 90^o. Determine the composite transformation matrix to perform the task. [12]

b) Discuss the limitations of Bezier curve. [2]

Question 3. [Marks: 14]

a) Suppose we have a 2D quad $OABC$ with the vertices $O(0,0)$, $A(1, 0.5)$, $B(2, 1.5)$ and $C(0.75, 3)$. Using the concept of barycentric coordinate, determine if a point $P(1.5, 2.5)$ is inside the quad. Describe your approach and show your calculations. [6]

b) Assume, $ABCD$ is a 2D rectangle and the vertices are $A(2, 2), B(8, 2), C(8, 8)$, and $D(2, 8)$. Apply shear to obtain $A'B'C'D'$ such that $A'D'$ and $B'C'$ both create 30 degree with X-axis after the transformation. Design the steps to perform the task and determine the composite transformation matrix. Plot $A'B'C'D'$. [8]

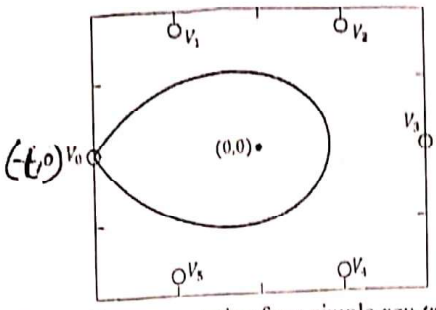
Question 4. [Marks: 14]

a) Apply the midpoint algorithm to draw a circle's portions of circumference centered at $(2, 0)$ on the 3rd, 4th, 5th and 6th octant with radius 7. Plot the obtained points. For each step, show values of the decision variables and the points (in a tabular format). [8]

b) Suppose we want to reflect a 2D point $P(4, 5)$ against a line that goes through $(-1, -3)$ and $(3, 2)$. Determine the composite transformation to perform this task. What is the final position of P? [6]

Question 5. [Marks: 14]

a) A 2D Bezier curve Q is situated inside a regular hexagon $V_0V_1V_2V_3V_4V_5$ (see the following figure). The control points are chosen from the vertices of the hexagon. If Q has the same starting and ending point V_0, what is the Euclidean distance between $Q\left(\frac{1}{2}\right)$ and $Q\left(\frac{1}{6}\right)$? Given that, the vertices V_0 and V_1 are $(-1,0)$ and $(-1,\frac{\sqrt{3}}{2})$ respectively. Show your calculations. [10]

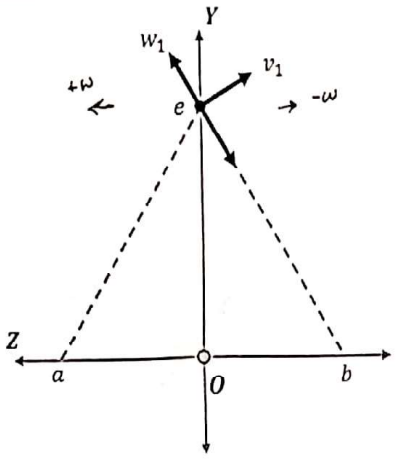


b) With an example, explain the shading computation for a simple *ray-tracing* algorithm. [4]

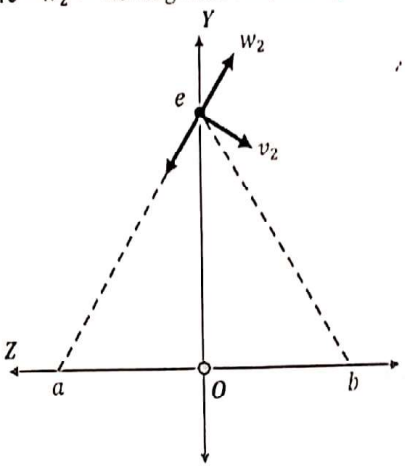
Question 6. [Marks: 14]

a) Consider a 2D canonical camera coordinate system with origin O and basis vectors $\{y, z\}$; where $-z$ is the viewing direction and y is the up vector. Also consider 2 frame coordinate system inside the canonical (see the following figures), which are – [11]

- Frame-1: Origin e and basis vectors $\{v_1, w_1\}$; where $-w_1$ = viewing direction, and v_1 = up
- Frame-2: Origin e and basis vectors $\{v_2, w_2\}$; where $-w_2$ = viewing direction, and v_2 = up



Frame-1



Frame-2

Here e is located on y axis and is a vertex of an equilateral Δeab. where each edge has a length of *one* unit for both the frames. Determine the positions of the O w.r.t *Frame-1* and *Frame-2*.

b) Show that, in case of Phong Shading model, $r = 2(l \cdot n)n - l$, where symbol holds the conventional meaning. [3]

Question 7. [Marks: 14]

a) Consider a clipping rectangle which has width and height of 10 units. Its lower left corner is located at $(3, 3)$. Also consider a line which has a starting point at $(1, 1)$, length = 20 units, and *slope* = 2. Perform the line-edge intersecting points with respect to *all four edges* of the clipping rectangle using Cyrus-Beck algorithm and determine the true clipping points. Show your steps and calculations for your solution (assume any data if necessary). [8]

b) Consider a 3D line AB that needs to be transformed from an orthographic view volume to a viewport with 64×64 resolution. Vertices of the line are $A(-1, -3, -6)$ and $B(2, 4, -7)$. The orthographic view volume has the following setup: [6]

$$l = -5, \quad r = 5, \quad b = -5, \quad t = 5, \quad n = -3, \quad f = -10$$

Determine the matrix M to transform the vertices of the line to viewport. Determine the transformed vertices.