Ahsanullah University of Science and Technology

Department: Computer Science and Engineering
Program: Bachelor of Science in Computer Science and Engineering
Semester Final Examination: Fall 2021
Year: 4th Semester: 2nd
Course Number: CSE4203
Course Title: Computer Graphics
Time: 03 (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 margin.*

Question 1. [Marks: 14]

a) Consider the following parameters for an orthographic ray-tracing: **[10]**

Camera frame: $E = [4, 4, 6]^T$, $U = [1, 0, 0]^T$, $V = [0, 1, 0]^T$, $W = [0, 0, 1]^T$
Viewing Ray: ray origin = $E + 2U + 2V$, ray end = $[6, 6, 0]^T$
Sphere: $(x-1)^2 + (y+2)^2 + z^2 - 100 = 0$

Determine the ray-sphere intersection point(s) if there exists any.

b) State the differences between raster and vector images. **[4]**

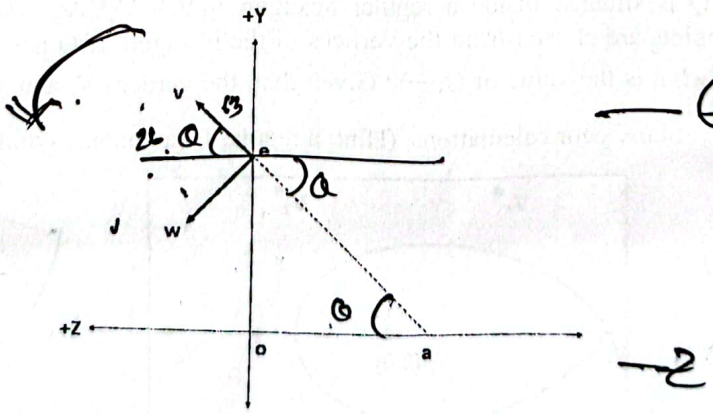
Question 2. [Marks: 14]

a) AB is a line and P is a point in 3D space; where the points A, B and P are (5,-2,3), (10,3,3) and (6,4,2) respectively. We want to rotate P along AB by -90°. Determine the composite transformation matrix to do the task and calculate the rotated point P'. **[10]**

b) What are the properties of affine transformation? Mention an example of non-affine transformation operation. **[4]**

Question 3. [Marks: 14]

a) Origin **O** and basis vectors **{z, y}** construct a 2D canonical coordinate system where –z is the viewing direction and y is the up vector. Consider a frame coordinate with origin **e** and basis **{w, v}**. Here **e** is located on the y-axis and edge **oe** and **oa** of the triangle *oea* has a length of 1 and 2 unit respectively. Determine the position of the point **a** w.r.t the frame coordinate. **[8]**

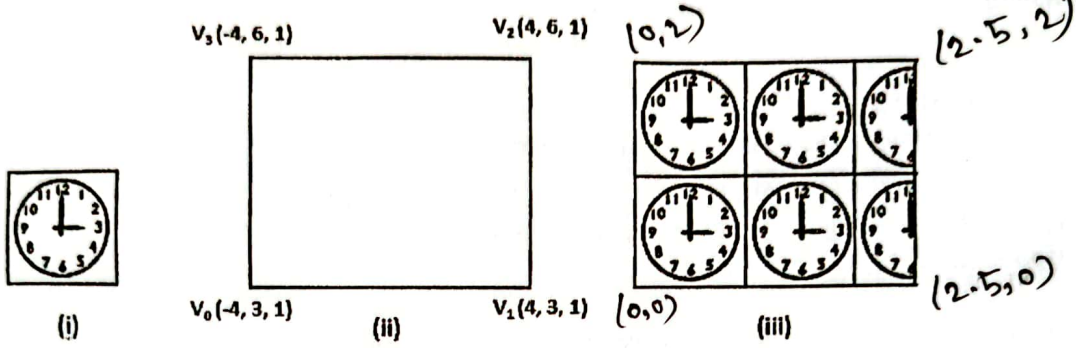


b) Construct the viewport matrix required for a system in which pixel coordinates count down from the top of the image, rather than up from the bottom. [6]

Question 4. [Marks: 14]

(a) Apply the midpoint algorithm to draw a circle's portions of circumference centered at (-5,-1) on the 5th, 6th, 7th and 8th octant with radius 6. Plot the obtained points. For each step, show the values of the decision variables and the points (in a tabular format). [9]

(b) In the following figure, (i) is a texture, (ii) is a rectangular face $V_0V_1V_2V_3$ to be mapped with the texture, and (iii) is the output after texture mapping. List the texture coordinates for corresponding xyz-coordinates to perform texture lookup. (assume any data if necessary) [5]



Question 5. [Marks: 14]

(a) Consider a clipping rectangle defined by the vertices (3,3), (13,3),(13,13) and (3,13). Also, consider a line which has starting and ending points of (10,1) and (2,9) respectively. Find the line-edge intersecting points with respect to all four edges of the clipping rectangle using the Cyrus-Beck clipping algorithm and determine the true clipping points. Show the steps and calculations for your solution. [8]

(3,8)

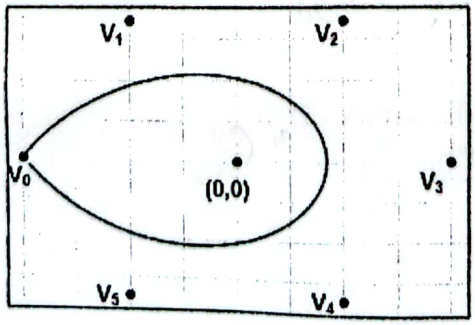
(b) State the drawbacks of vertex-based diffuse shading. Propose a solution to overcome the issue. [3]

(c) Differentiate between orthographic and oblique projections. [3]

Question 6. [Marks: 14]

(a) Consider a pentagon ABCDE with vertices A(1,3), B(5,3), C(8,5.5), D(4,7) and E(1,7). Using the concept of barycentric coordinate, determine if a point P(6, 3.5) is inside the pentagon or not. Describe your approach and show your calculations. [7]

(b) 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 value of $Q(\frac{1}{5})$? Given that, the vertices V_0 and V_1 are (-1,0) and $(-\frac{1}{2},\frac{\sqrt{3}}{2})$ respectively. Show your calculations. (Hint: a regular hexagon has symmetric property) [7]



(-0.376, 0.526)

E → d = d + 2x + 3

SE → d = d + 2x - 2y + 5

[6]

Question 7. [Marks: 14]

(a) Consider a rectangle with vertices A(1,1), B(6,1), C(6,5) and D(1,5). Reflect the rectangle along the line $y = \frac{1}{\sqrt{3}} x - 3$ using 2D transformation. Determine the composite transformation matrix and find the final vertices. **[8]**

(b) How does a transmissive device work? Explain with appropriate diagrams. **[4]**

(c) State the disadvantages of the Lambertian shading model. **[2]**