Date of Examination: 20.3.2023

Ahsanullah University of Science and Technology

Department: Computer Science and Engineering
Program: Bachelor of Science in Computer Science and Engineering
Semester Final Examination: Spring 2022
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) Explain the level-of-detail rendering. [3]

b) What is a vanishing point? Give an example scenario of multiple vanishing points. [3]

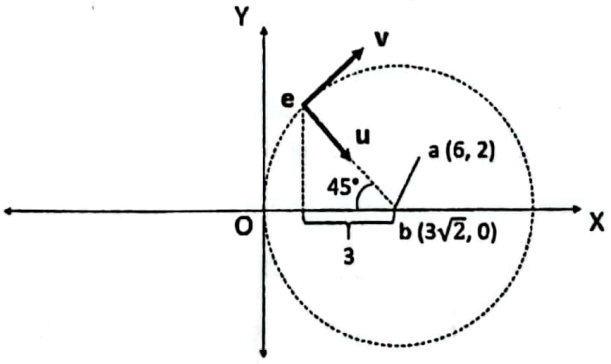
c) Consider a sphere centered at (0, 4, 0) with a radius of 5. A viewing ray is generated with an origin (4, 4, 2) and end-point (4, 10, 2). Determine the ray-sphere intersection point(s) if there exists any using the concept of orthographic ray tracing. [8]

Question 2. [Marks: 14]

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

b) Explain the problems associated with it if homogeneous coordinates were not used in matrix transformation. [4]

c) Here (in the figure), origin O and basis {x,y} construct a 2D canonical coordinate system. Within this, line ab is our model (Pxy). Now, we want to view it from a new 2D camera with eye e and basis {u,v}; which is rotated by −45 degrees around b. Determine the position of a and b w.r.t camera coordinate. [8]
Assume that, u is the viewing direction and b is the center of the circle.



Question 3. [Marks: 14]

a) Consider a rectangle with vertices A(1, 1), B(6, 1), C(6, 5) and D(1, 5). Apply appropriate transformation to the rectangle to obtain a parallelogram in such a way that point C and D move 4 units to its right from the original position and point A and B remain unchanged. [8]

b) Write down the algorithm to create a half circle given the radius and the center using Bresenham's Circle drawing algorithm. [6]

Question 4. [Marks: 14]

(a) Consider a line with a start and end point of (0, 0) and (-1, -2) respectively. Apply the necessary transformation to increase the size of the line by 100% and find the final vertices after the transformation. Also, determine the coordinates of each pixel along the transformed line segment using the midpoint line drawing algorithm. [10]

Necessary adjustments of the original algorithm for different octants are provided below:

(1) plot(x, y)	(2) swap(x, y); plot(y, x)	(3) x=−x; swap(x, y); plot(−y, x)	(4) x=−x; plot(−x, y)
(5) x=−x; y=−y; plot(−x, −y)	(6) x=−x; y=−y; swap(x, y); plot(−y, −x)	(7) y=−y; swap(x, y); plot(y, −x)	(8) y=−y; plot(x, −y)

(b) Derive 2D perspective projection matrix. [4]

Question 5. [Marks: 14]

(a) Consider a triangle with vertices A(1, 1), B(5, 1), and C(3, 3) and color values of red(1, 0, 0), green(0, 0.9, 0), and blue(0, 0, 0.8) at each vertex of the triangle. Find the color of the point P(3, 2) inside the triangle using the concept of barycentric interpolation. [7]

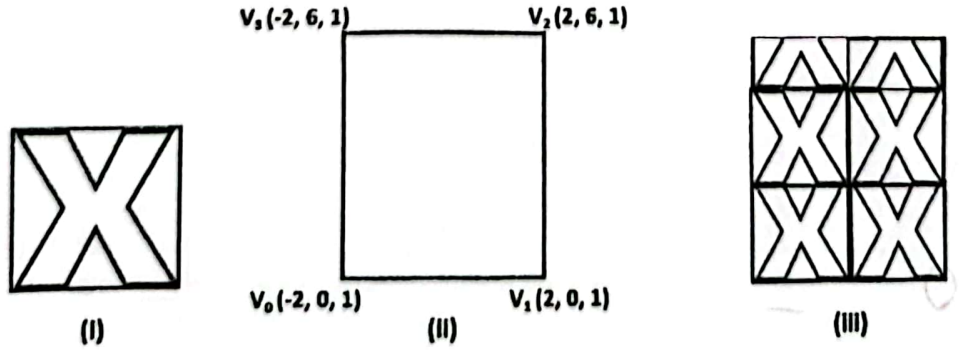
(b) Consider a square OACB with vertices O(3, 2), A(3, 6), C(7, 6) and B(7, 2). Reflect the square along a line x = -1 using 2D transformation. Determine the composite transformation matrix and find the final vertices. [7]

Question 6. [Marks: 14]

(a) Suppose we have a cubic Bézier curve defined by the control points $P_0 = (0, 0)$, $P_1 = (2, 5)$, $P_2 = (5, 5)$, and $P_3 = (8, 0)$. Find the mid-point and end-point of the cubic curve. [7]

(b) State the limitations of the Lambertian shading model. [3]

(c) 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) [4]



[10]

A'(84.83, 26.928, 1.33)
B'(148.83, 107.21, 0)

Question 7. [Marks: 14]

(a) Transform a 3D line AB from an orthographic view volume to the viewport of size 256 x 128. Consider the vertices of the line are A(-2, -4, -1), B(1, 5, -5) and the orthographic view volume has the following setup: [7]

$$l = -6, r = 6, b = -7, t = 7, n = -2, f = -8$$

(b) Consider there are two objects overlapping each other, where C_1 is the color of the foreground object and C_2 is the color of the background object. Construct an alpha compositing formula if the foreground object has 30% transparency and the background object is fully opaque. [4]

(c) Explain how to determine whether a polygon is facing towards or away from the camera. [3]