Date of Examination: **1.10.2023**

Ahsanullah University of Science and Technology

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Fall 2022

Year: 4th **Semester: 2nd**

Course Number: CSE4203

Course Title: Computer Graphics

Time: 03 (Three) hours **Full Marks: 70**

Instruction: *There are three sets of questions. Answer* ***any five questions from each set.*** *Marks allotted are indicated in the margin.*

Question 1: Answer any 5 questions. [3x5 = 15]

a) Explain how a transmissive device works with an example. [3]

b) Describe how the angle between the e and r vector in the following equation of the Phong shading model affects the highlight of a model. Here, symbols hold the conventional meaning. [3]

$$c = c_l \, max\,(0, e\,.\,r)^{p}$$

c) Explain with appropriate example that the frame-to-canonical transformation can be expressed as a rotation followed by a translation. [3]

d) State the problems associated with the higher degree Bezier Curve. Explain how this problem can be solved. [3]

e) State the differences between image-order and object-order rendering. [3]

f) Explain how a polygon can be colored using Gouraud interpolation. [3]

g) Describe why perspective projection is considered a non-affine transformation. [3]

Question 2: Answer any 5 questions. [5x5 = 25]

a) Apply appropriate transformations to construct the orthographic transformation matrix. [5]

b) Show that the transformation matrix for the reflection about the line y = -x is equivalent to a reflection relative to the y-axis followed by a counter-clockwise rotation of 90 degrees. [5]

c) A curve is characterized by the following rules: [5]
variables: F
constants: +, −
axiom: F
rules: (F → F+F−F−F+F)
Angle: 90 degrees

Here, F means "draw a line forward", + means "turn left 90 degrees", and – means "turn right 90 degrees". Apply the concept of L-systems to draw the curve for the second iteration.

d) Consider 3 images img1, img2 and img3 (see the image below) overlapping each other where img2 is the foreground of img1 and img1 is the foreground of img3. Additionally, img2 has an alpha mask $\alpha 1$ given below and img1 is fully transparent. Find the pixel values for the output image. [5]

30	21	140
27	78	200
222	25	224

img1

50	22	152
55	85	20
230	19	100

img2

150	20	1
90	25	70
112	99	165

img3

0.2	0.39	1
0	0.5	0.82
0.45	0.5	0.7

$\alpha 1$

e) A uniform quadratic B-Spline curve S is defined by 7 control points $P_0(-3, -1)$, $P_1(-2, 0)$, $P_2(-1, 1)$, $P_3(0, 2)$, $P_4(1, 3)$, $P_5(2, 4)$ and $P_6(3, 5)$. Find the midpoint and endpoint of the first 2 curve segments of the quadratic B-Spline curve. [5]

f) Show that, in case of the midpoint line drawing algorithm, we can successively update the decision variable by adding $(y_1 - x_1) - (y_0 - x_0)$ for each selection of a northeast pixel. Here, (x_0, y_0) and (x_1, y_1) are two endpoints of the line. [5]

g) Consider the following parameters for an orthographic ray-tracing: [5]
Camera frame: $E = [2, 6, 10]^T$, $U = [1, 0, 0]^T$, $V = [0, 0.6, -0.6]^T$, $W = [0, 0.6, 0.6]^T$
Image plane: $l = -12$, $r = 12$, $t = 12$, $b = -12$
Raster image resolution: 12×10
A ray (with length = 20) is generated from the lower left corner pixel of the raster image. Find the position of the ray start and end point on the image plane.

Question 3: Answer any 5 questions. [6x5 = 30]

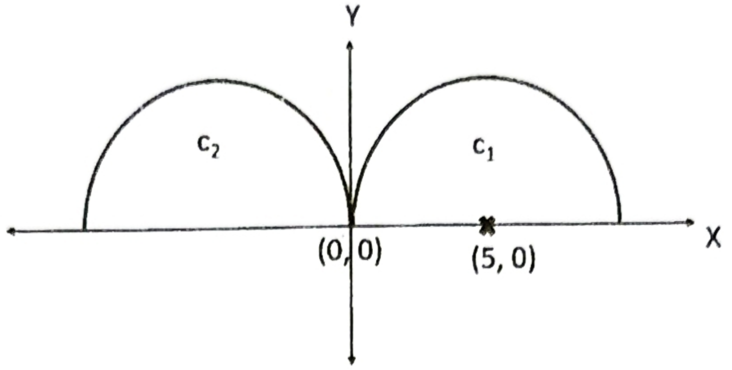
a) Consider a Bezier curve Q, defined by 6 control points (-3, 3), (-1, 4), (0, 5), (1, 3), P_4 and P_5. Find the control points P_4 and P_5, if $Q(0.5) = [0.68, 3.56]^T$ and $Q(1) = [5, 1]^T$ [6]

b) Consider a line AB in a 3D space, where point A and B are (5, -2, 3) and (10, 3, 2) respectively. Apply appropriate transformations to align the line AB to y-axis so that point A stays at origin. Calculate and determine the new point A' and B' after the transformation. [6]

c) Consider a rectangle with vertices A(1, 1), B(5, 1), C(5, 5) and D(1, 5) and color values of (1, 0, 0), (0, 1, 0), (1, 1, 0) and (0, 0, 1) at each respective vertex. Find the color of the point P(4, 2) inside the rectangle using the concept of barycentric interpolation. [6]

d) Assume, ABCD is a 2D rectangle and the vertices are A(2, 2), B(7, 2), C(7, 7) and D(2,7). Apply appropriate transformation on ABCD to obtain A'B'C'D' such that A'D' and B'C' both create 45 degrees with X-axis after the transformation. Determine the composite transformation matrix to perform this task and plot A'B'C'D'. [6]

e) In the following figure, there are 2 half circles C_1 and C_2 where C_2 is the reflection of C_1. Here C_1 has a center at (5, 0) and both share the same point (0, 0) in their circumference. Using affine transformation and Bresenham's circle drawing algorithm, find the points in the circumference for C_2. [6]



f) Using the iterative scheme of the Mandelbrot Set for a maximum iteration up to 10 steps, determine whether the complex number c = -0.5 + 0.5i is a member of the Mandelbrot set or not. [6]

g) Here (in the figure), origin O and basis {x,y} construct a 2D canonical coordinate system. Within this, line ab is our model (P_{xy}). Now, we want to view it from a new 2D camera with eye e and basis {u,v}; which is rotated by θ degrees from its' default orientation. Assume that, u is the viewing direction and b is the center of the circle. [6]