CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 1 | Marks 20 | **SET A**

Date: 15/5/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[6 marks]** Explain how an emissive device works with an example.

2. **[6 marks]** Consider 3 images img1, img2 and img3 (see the image below) overlapping each other where img1 is the foreground of img2 and img2 is the foreground of img3. Both img1 and img2 have an alpha mask α. Determine the pixel values of the resulting output image.

130	20
50	85
230	9

img1

15	20
200	20
110	99

img2

130	20
50	85
230	9

img3

0.2	0.39
0	0.3
0.45	0.5

α

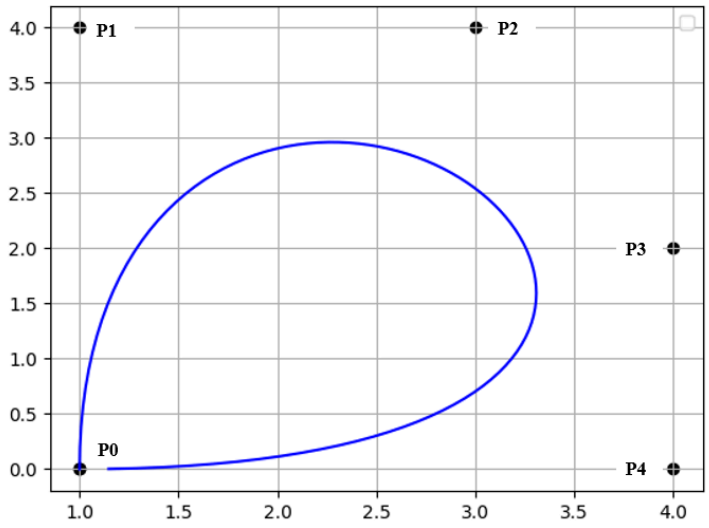
3. **[8 marks]** An uniform quadratic B-Spline curve S is defined by 7 control points P_0 (-3, 1), P_1 (-1, 2), P_2 (1, 3), P_3 (3, 4), P_4 (4, 5), P_5 (6, 7) and P_6 (7, 8). Determine how many curve segments are required. Also, find the point on the last two curve segments for t = 0.3

CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 1 | Marks 20 | **SET B**

Date: 15/5/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[6 marks]** Explain why triangles are commonly used as the primary primitive in computer graphics.
2. **[6 marks]** Derive the equation of a Bezier curve of degree 4 using de Casteljau's Algorithm.
3. **[8 marks]** Consider a Bezier curve Q defined by the points P_0, P_1, P_2, P_3 and P_4 (see the image below). Find the mid-point on the curve if the curve is started and ended on the same point.



CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 1 | Marks 20 | **SET C**

Date: 15/5/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[6 marks]** State the differences between lossless and lossy compression.

2. **[6 marks]** Consider an image IMG with the pixel values shown in the figure. Each pixel in the image can hold up to 8 bits of data. Find the file size of the image in KB. Also, determine the compression ratio of the image, if the image is compressed by applying run-length compression.

0	0	0	1	1	1	2
0	0	0	0	0	1	1
2	2	2	2	0	1	1
2	2	3	3	3	3	3
3	3	3	3	3	1	1
3	3	3	2	2	0	0

IMG

3. **[8 marks]** Consider a curve S defined by 6 control points P_0 (1, 10), P_1 (3, 15), P_2 (5, 20), P_3 (7, 15), P_4 (9, 13) and P_5 (11, 10). The curve is generated by both uniform quadratic B-spline and open Uniform B-spline curves. Determine the midpoint of the first curve segments for both curves.

CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 1 | Marks 20 | **SET D**

Date: 15/5/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[6 marks]** Explain different stages of the graphics pipeline.

2. **[6 marks]** Propose an alpha compositing formula for blending the colors of four objects C_1, C_2, C_3 and C_4. Where C_1 is the foreground of C_2, C_2 is the foreground of C_3 and C_3 is the foreground of C_4 .

3. **[8 marks]** 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 $Q(1) = [5, 1]^T$

CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 1 | Marks 20 | **SET E**

Date: 15/5/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[6 marks]** State the differences between raster and vector images.

2. **[6 marks]** Consider 2 images IMG1 and IMG2 with the pixel values shown in the figure below. Each pixel in the images can hold up to 8 bits of data. Determine which image has the better compression, if the images are compressed by applying run-length compression. (Show necessary calculations to compare the compression)

0	0	0	1	1
0	0	0	0	0
2	2	2	2	0
2	2	3	3	3
3	3	3	3	3

IMG1

0	1	0	1	0
0	1	0	2	2
2	1	0	2	2
3	1	0	3	3
3	1	0	3	3

IMG2

3. **[8 marks]** Consider a curve S defined by 6 control points P_0 (1, 10), P_1 (3, 15), P_2 (5, 20), P_3 (7, 15), P_4 (9, 13) and P_5 (11, 10). The curve is generated by both uniform quadratic B-spline and open Uniform B-spline curves. Determine the final point of the curve for both techniques.

CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 1 | Marks 20 | **SET F**

Date: 15/5/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[6 marks]** State the properties of the Bezier curve.
2. **[6 marks]** Consider 3 images img1, img2 and img3 (see the image below) overlapping each other where img1 is the foreground of img2 and img2 is the foreground of img3. Both img1 and img2 have an alpha mask α. Given the resulting output image is img, find the values of α.

130	20
50	85
230	9

img1

15	20
200	20
110	99

img2

130	20
50	85
230	9

img3

102	20
74	85
201	27

img

3. **[8 marks]** 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 $Q(0.5) = [0.9, 3.28]^T$ and $Q(1) = [7, 2]^T$

CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 2 | Marks 20 | **SET A**

Date: 5/6/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[8 marks]** Determine the composite transformation matrix to convert a canonical view volume of size 3x3x3 to a viewport of size n_x x n_y.
2. **[12 marks]** Consider a rectangle with vertices A(1,1), B(6,1), C(6,5) and D(1,5). Apply appropriate transformation to the rectangle so that point C and D move 8 units to the right and point A and B remain fixed. You must -

    a. Mention the steps.
    b. Determine the composite transformation matrix.
    c. Calculate and plot the final vertices

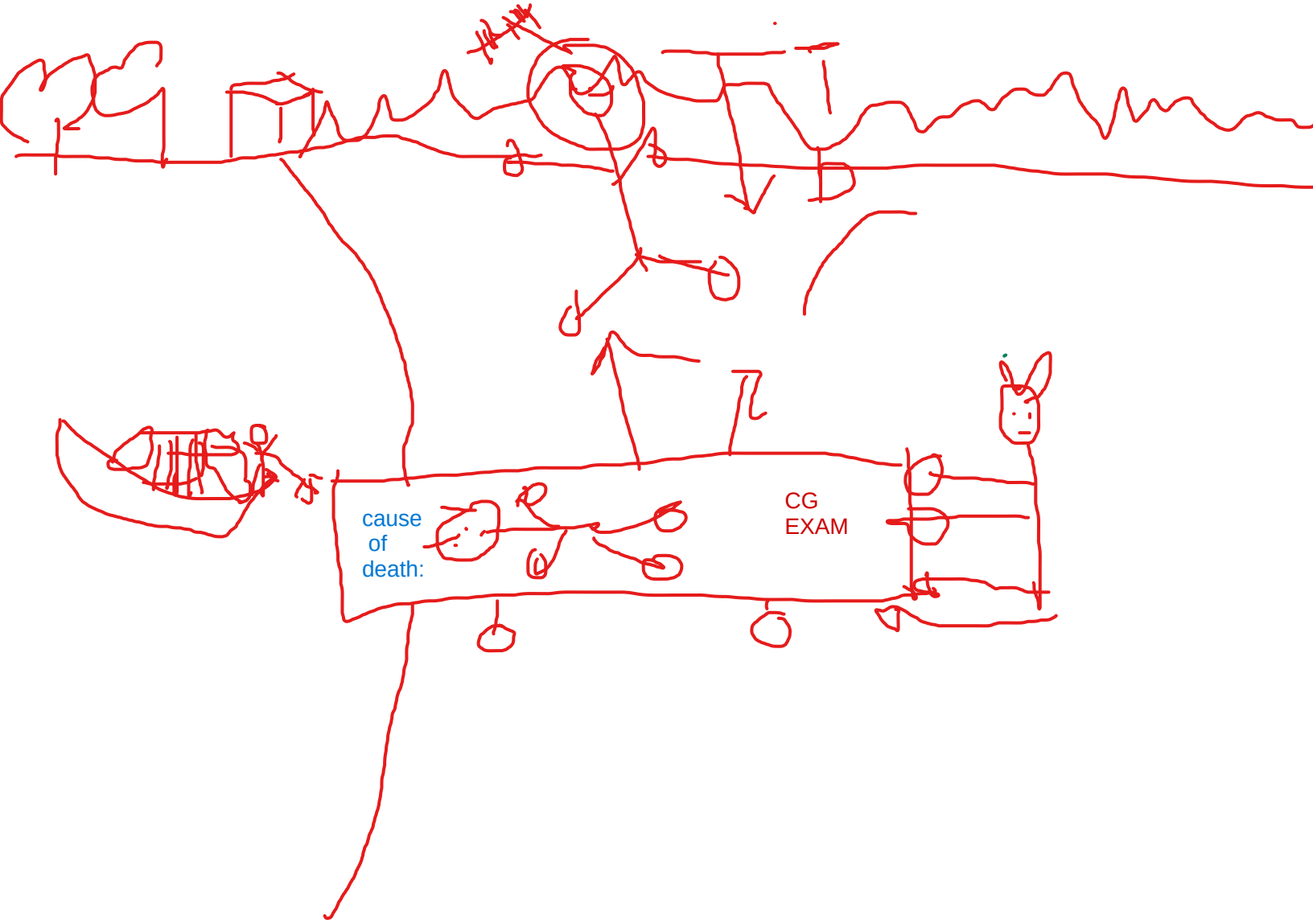
CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 2 | Marks 20 | **SET B**

Date: 5/6/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[8 marks]** Construct the viewport matrix for a viewport of size m_x x m_y in which the pixel coordinates count down from the top of the image, rather than up from the bottom.

2. **[12 marks]** Consider a line AB in a 3D space, where point A and B are (1, 1, -1) and (9, 7, 2) respectively. Apply appropriate transformations to align the line AB to the z-axis so that point A stays at the origin. Calculate and determine the new point A' and B' after the transformation.



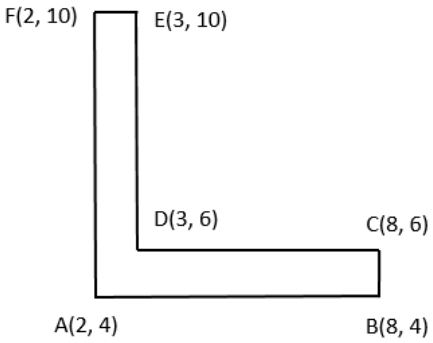
CSE 4203 | Computer Graphics |Fall 2023 | Quiz - 2 | Marks 20 | **SET C**

Date: 5/6/2024 | Time: 30 minutes

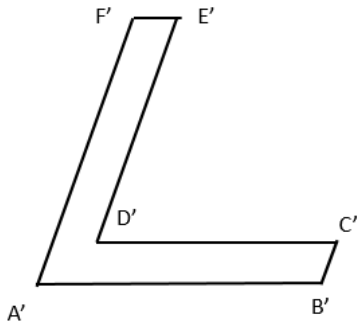
ID:..... Name:..... Section:.....

1. **[8 marks]** Determine the composite transformation matrix to convert an orthographic view volume to a canonical view volume of size 3x3x3.

2. **[12 marks]** Consider a L-shaped object with vertices A(2, 4), B(8, 4), C(8, 6), D(3, 6), E(3, 10) and F(2, 10). Apply appropriate transformations on the object so that the vertices move 3 units to the right while keeping point A and B fixed. (Assume that two edges of the L-shaped object are detachable).



(a) Initial State



(b) Transformed State

CSE 4203 | Computer Graphics |Fall 2023 | Quiz - 2 | Marks 20 | **SET D**

Date: 5/6/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[8 marks]** Show that the composite transformation of two rotations $R(\theta_1)$ and $R^{-1}(\theta_2)$ can be obtained with a single rotation of $R(\theta_1 - \theta_2)$.

2. **[12 marks]** Consider a line AB in a 3D space, where point A and B are (2, 1, 1) and (8, 7, 2) respectively. Apply appropriate transformations to align the line AB to the y-axis so that point A stays at the origin. Calculate and determine the new point A' and B' after the transformation.

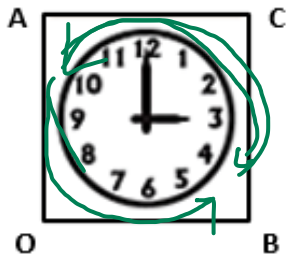
CSE 4203 | Computer Graphics |Fall 2023 | Quiz - 2 | Marks 20 | **SET E**

Date: 5/6/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[8 marks]** Show that reflection about the line y = x in two-dimensional space is equivalent to a rotation of 90 degrees followed by a reflection about the y-axis.

2. **[12 marks]** Stretch the clock OACB (shown in the figure) by 150% along one of its diagonals so that 10:00 through 4:00 move to the northeast, and 9:00 through 5:00 move to the southwest keeping the center of the clock fixed. The four vertices of the clock are O(2,2), A(2,6), C(6,6), and B(6,2). Perform all the transformations and find the final vertices.



CSE 4203 | Computer Graphics |Fall 2023 | Quiz - 2 | Marks 20 | **SET F**

Date: 5/6/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1. **[8 marks]** Prove that two successive reflections across perpendicular lines are equivalent to a single rotation.

2. **[12 marks]** Consider a rectangle with vertices A(10, 12), B(16, 12), C(16, 16) and D(10, 16). Reflect the rectangle along the line 2y - 6x + 2 = 0 using 2D transformation. You must -

   a. Mention the steps.
   b. Determine the composite transformation matrix.
   c. Calculate and plot the final vertices

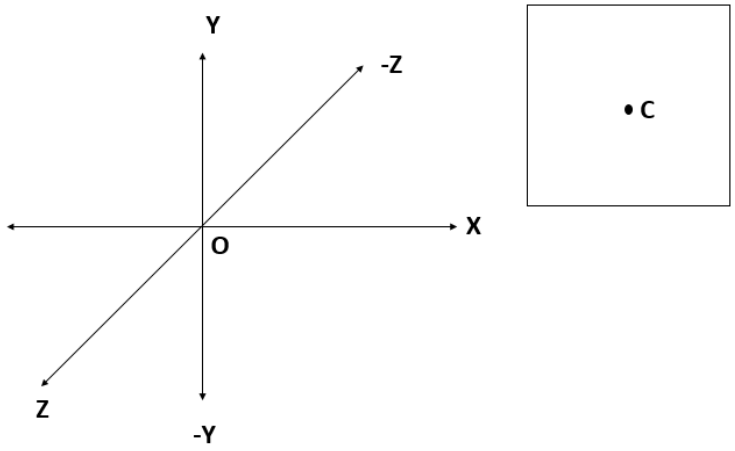
CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 3 | Marks 20 | **SET A**

Date: 3/7/2024 | Time: 30 minutes

ID:..... Name:..... Section:.....

1) Consider a square in a 3D canonical coordinate system (see the following figure). The square has a side of 10 units with a center at C(0, 0, -20). Also, consider a camera coordinate with origin e and basis {u, v, w}. The eye of the camera frame is placed in the upper right corner of the square. The goal is to point the camera viewing direction at point **C** and capture it.

   a) **[10 Marks]** Determine the basis and eye matrix
   b) **[10 Marks]** Determine the position of point **C** w.r.t the camera coordinate.



CSE 4203 | Computer Graphics | Fall 2023 | Quiz - 4 | Marks 20 | Time: 120 minutes | **SET A**

ID:..... Name:..... Section:.....

1. Apply the midpoint line drawing algorithm to draw a line from (1, p) to (-3, p + 9) and plot the points.

Here, $p = (-1)^n \times n$
[n = last 2 digits of your ID]

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)

a) [15 marks] Show the values of the decision variables and the points for each step (in a tabular format).

b) [5 marks] Plot the final points

DECIPHER

Date of Examination: 10.3.2024

Ahsanullah University of Science and Technology
Department: Computer Science and Engineering
Program: Bachelor of Science in Computer Science and Engineering
Semester Final Examination: Spring 2023
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) Briefly explain different stages of viewing transformation. [3]

b) Explain why the degree of a B-spline curve remains unaffected by the number of control points used in the curve. [3]

c) State the differences between lossless and lossy compression. [3]

d) Describe how emissive display device produces colored images. [3]

e) Explain the mathematical equation of the Lambertian shading model. [3]

f) State the differences between hardware and software pipelines. [3]

g) Explain why triangles are commonly used as the primary primitive in computer graphics. [3]

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

a) Consider a screen of size n x m in which the origin coordinate is in the center of the screen and pixel coordinates can have negative values. Apply the necessary transformation to construct the viewport matrix for this screen. [5]

b) Find the dimension of a fractal generated by the following steps below: [5]
Step 1: Start with an unfilled equilateral triangle at stage 0
Step 2: For each unfilled triangle, make a filled copy
Step 3: Scale the copy by half and invert it
Step 4: Place the copy in the center of the unfilled triangle

c) Show that canonical-to-frame transformation is a translation followed by a rotation. [5]

d) A curve is characterized by the following rules: [5]
variables: X, F
constants: +, −

CamScanner

axiom: F+XF+F+XF
rules: X -> XF-F+F-XF+F+XF-F+F-X
Angle: 90 degrees

Here, X means "do nothing", F means "draw a line forward", + means "rotate clockwise by 90 degrees" and − means "rotate counter-clockwise by 90 degrees". Apply the concept of L-systems to draw the curve for the second iteration.

e) Construct an algorithm to create a half circle given the radius and the center using the Bresenham's Circle drawing algorithm. [5]

f) Consider a triangle with vertices A(1, 1), B(9, 1) and C(5, 5) and color values of (1, 0, 0), (1, 1, 0) and (0, 1, 0) at each respective vertex. Find the color of the point P(2, 2) inside the triangle using the concept of barycentric interpolation. [5]

g) Consider 3 primitives p1, p2 and p3 with a uniform color of red (1, 0, 0), green (0, 1, 0) and blue (0, 0, 1) respectively. These primitives are overlapped with each other at different positions. Here (i), (ii) and (iii) show the pixel-wise z-coordinates for p1, p2 and p3. Simulate the z-buffer algorithm and find the final z-buffer and frame-buffer information. [5]

5	5	7	8	8	8
4	7	8	8	8	8
3	7	7	7	∞	∞
2	5	5	5	∞	∞
1	2	2	2	∞	∞
∞	∞	∞	∞	∞	∞

(i)

∞	∞	∞	∞	9	9
∞	∞	∞	∞	9	9
∞	9	9	9	10	10
∞	9	9	9	10	10
∞	8	8	8	8	8
∞	∞	∞	∞	∞	∞

(ii)

2	2	2	1	1	1
3	4	4	5	5	5
7	6	6	6	6	6
8	8	8	9	10	10
8	9	9	9	9	9
10	10	11	12	11	11

(iii)

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

a) Suppose we have a circle created using two Bézier curves, Q1 and Q2. Q1 is defined by four control points: (0, 0), (0, 5), (5, 5), and (5, 0). The control points of Q2 are the reflections of those of Q1. Find the Bézier curve value of Q1(0.6) and Q2(0.8). [6]

b) Consider a clipping rectangle which has width and height of 10 and 8 units respectively. Its lower left corner is located at (2, 2). Also, consider a line which has starting and ending points of (1, 1) and (15, 15) respectively. 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 the steps and calculations for your solution (assume any data if necessary). [6]

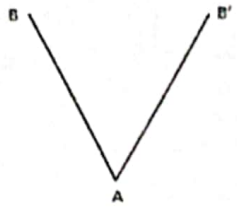
c) Consider a line AB in a 3D space, where point A and B are (1, 1, -1) and (9, 7, 2) respectively. Apply appropriate transformations to align the line AB to the z-axis so that point A stays at the origin. Calculate and determine the new point A' and B' after the transformation. [6]

CamScanner

d) Using the iterative scheme of the Mandelbrot Set for a maximum iteration up to 10 steps, determine whether the complex number c = -0.771 - 0.326i is a member of the Mandelbrot set or not. Also determine the color of the point using the following criteria: [6]

Number of iterations to divergence	Color
less than 5	Red
5 to 8	Yellow
more than 8	Blue

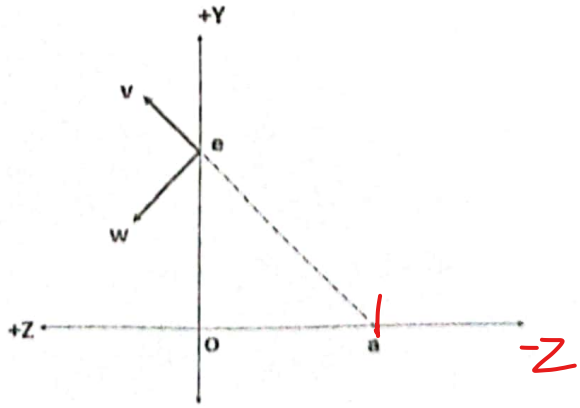
c) Consider an English letter V created by joining 2 lines. The pixel coordinates on the first line AB is obtained using the midpoint line drawing algorithm along the points A(0, 0) and B(-3, 6). Second line AB' is obtained by applying reflection on the obtained coordinates of the first line. Apply necessary transformations and determine the points on the letter V. [6]



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

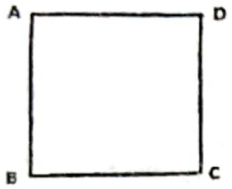
(1) plot(x, y)	(2) swap(x, y); plot(y, x)	(3) x=−x; swap(x, y); plot(−y, x)	(4) x=−x; plot(−x, y)
(5) x=−x; y=−y; plot(−x, −y)	(6) x=−x; y=−y; swap(x, y); plot(−y, −x)	(7) y=−y; swap(x, y); plot(y, −x)	(8) y=−y; plot(x, −y)

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. [6]

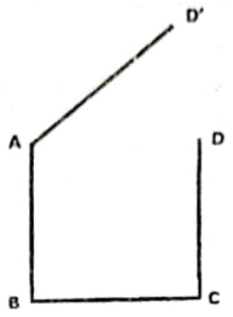


CamScanner

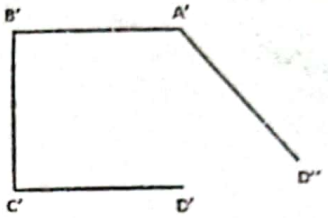
Suppose we have a 2D box ABCD where the vertices are A(-0.5, 0.5), B(-0.5, -0.5), C(0.5, -0.5) and D(0.5, 0.5). The box consists of two parts: the body ABCD and the lid AD. You need to perform appropriate transformations so that the lid AD opens by creating a +45 degree angle with respect to the point A and its final position becomes AD'. Additionally, rotate both the body and lid clockwise by 90 degrees with respect to the origin. Find the final position of the body A'B'C'D' and the lid A'D" after the transformations. [6]



(i) The box



(ii) Output after opening the lid



(iii) Output rotating the body and the lid

CamScanner

INTEGER

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 α1 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

α1

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]

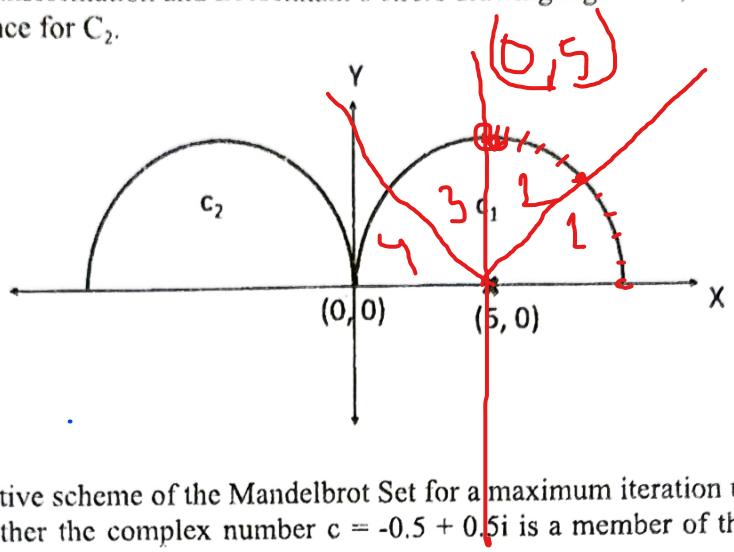
a) Consider a Bezier curve Q, defined by 6 control points (-3, 3), (-1, 4), (0, 5), (1, 3), P_4 and P_5. Find the control points P_4 and P_5, if $Q(0.5) = [0.68, 3.56]^T$ and $Q(1) = [5, 1]^T$ [6]

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]