***Date of Examination: 26.10.2021***

# AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

**Department: Computer Science and Engineering**
**Program: B.Sc. in Computer Science and Engineering**
**Semester Final Examination: Fall 2020**
**Year: 4th Semester: 2nd**
**Course Number: CSE4203**
**Course Name: Computer Graphics**

**Time: 2 (Two) Hours** **Full Marks: 50**

**Use single answer script**

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|---|---|---|
| **Instructions:** | i) | Answer script should be hand written and should be written in A4 white paper. You must submit the hard copy of this answer script to the Department when the university reopens. |
| | ii) | You must write the following information at the top page of each answer script:<br>**Department:** **Program:**<br>**Course no:** **Course Title:**<br>**Examination:** **Semester (Session):**<br>**Student ID:** **Signature and Date:** |
| | iii) | Write down Student ID, Course number and put your signature on top of every single page of the answer script. |
| | iv) | Write down page number at the bottom of every page of the answer script. |
| | v) | Upload the scan copy of your answer script in PDF format through provided **google form** at the respective course site (i.e., **google classroom)** using institutional email within the allocated time. Uploading clear and readable scan copy (uncorrupted) is your responsibility and must cover the full page of your answer script. However, for clear and readable scan copy of the answer script student should use only one side of a page for answering the questions. |
| | vi) | You must avoid **plagiarism,** maintain **academic integrity, and ethics**. You are not allowed to take any help from another individual and if taken so can result in stern disciplinary actions from the university authority. |
| | vii) | Marks allotted are indicated in the **right margin.** |
| | viii) | Assume any reasonable data if needed. |
| | ix) | Symbols and characters have their usual meaning. |
| | x) | Before uploading rename the PDF file as **CourseNo_StudentID.pdf**<br>For example, CSE4203_170104001.pdf |
| | xi) | The answer script **(one single pdf file)** must be uploaded at designated location in the provided **google form link** available in the google classroom. |

**There are 06 (seven) Questions. Answer any 04 (four).**

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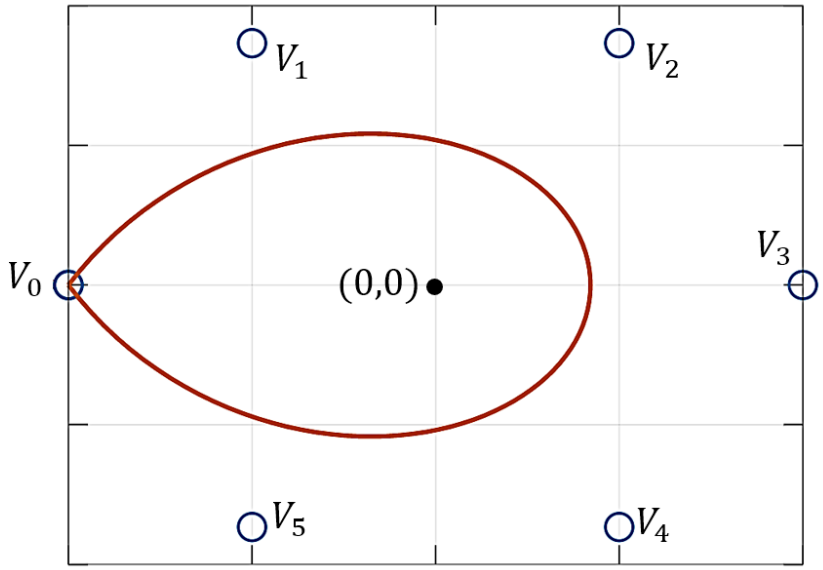
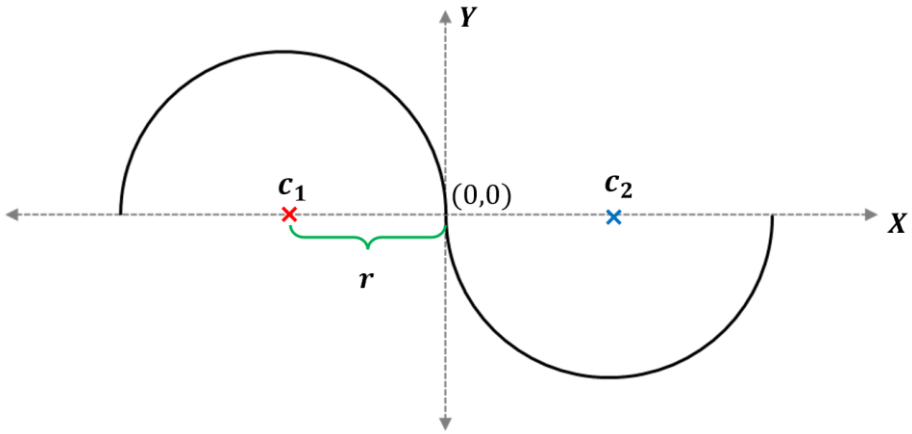
| **Question 1. [Marks: 12.5]** | | |
| **a)** | $AB$ is a line and $P$ is a point in 3D space; where the points $A, B$ and $P$ are $(1,1,1)$, $(3,3,3)$ and $(2,2,4)$ respectively. We want to rotate $P$ with respect to $AB$ by $-90^o$. Determine the composite transformation matrix to do the task. | **[9]** |
| **b)** | Show that, in case of 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. | **[3.5]** |
| **Question 2. [Marks: 12.5]** | | |
| **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 $Q\left(\frac{1}{3}\right)$ and $Q\left(\frac{1}{5}\right)$? Given that, the vertices $V_0$ and $V_1$ are $(-1,0)$ and $(-1,\frac{\sqrt{3}}{2})$ respectively. Hint: a regular hexagon has symmetric property.   | **[8]** |
| **b)** | In OpenGL, which form of the perspective matrix is implemented? Show that, it can be expressed in terms of field of view, aspect ratio, near and far plane. | **[4.5]** |
| **Question 3. [Marks: 12.5]** | | |
| **a)** | Consider a clipping rectangle that has a width and height of 10 units. Its lower left corner is located at $(3,3)$. Also consider a line that has a starting point at $(1,1)$, *length* = 20 units, and *slope* = 2. Determine all the line-edge intersecting points (if any) with respect to the clipping rectangle using the Cyrus-Beck algorithm. Show your steps and calculations (assume any data if necessary). | **[8]** |
| **b)** | Show that, in case of Phong Shading model, $r = 2\,(l \,.\, n)\,n - l$, where symbol holds the conventional meaning. | **[4.5]** |

**Question 4. [Marks: 12.5]**

**a)** Draw the following pattern using Bresenham's circle drawing algorithm. The pattern is constituted of two half circles with the centers $C_1$ and $C_2$ respectively having the same radius of $r = 4$. Both of the circumferences go through $(0,0)$. Show the steps to determine the points' positions and plot them. **[7.5]**



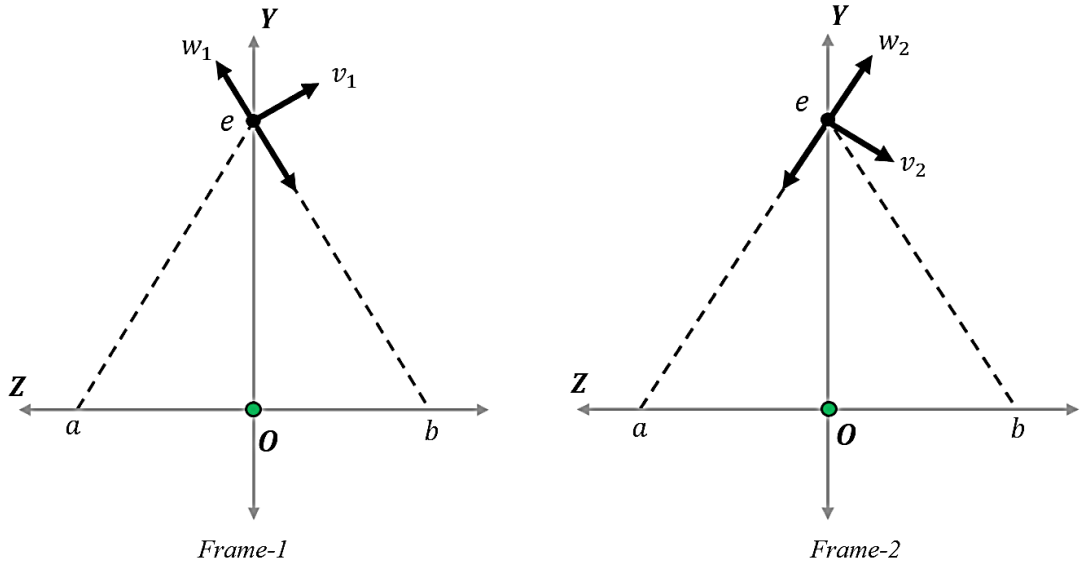

**b)** Derive the viewport transformation matrix with necessary explanations and diagrams. **5**

**Question 5. [Marks: 12.5]**

**a)** Suppose we have a 2D quad $OABC$ with the vertices $O(0,0)$, $A(1,1)$, $B(2,0)$ and $C(1,-1)$. Using the concept of barycentric coordinate, determine if a point $P(1,0)$ is inside the quad. Describe your approach and show your calculations. **[2+5]**

**b)** Assume, $ABCD$ is a 2D rectangle and the vertices are $A(1,1), B(7,1), C(7,7)$, and $D(1,7)$. Introduce shear on $ABCD$ to obtain $A'B'C'D'$ such that $A'D'$ and $B'C'$ both create 45 degree with $X$-axis after the transformation. Determine the composite transformation matrix to perform this task. Perform all the multiplications and plot $A'B'C'D'$. **[5.5]**

**Question 6. [Marks: 12.5]** **[12.5]**



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| | 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 above figure), which are –<br><br>a) *Frame-1:* Origin $e$ and basis vectors $\{v_1, w_1\}$; where $-w_1$ is the viewing direction and $v_1$ is the up vector.<br>b) *Frame-2:* Origin $e$ and basis vectors $\{v_2, w_2\}$; where $-w_2$ is the viewing direction and $v_2$ is the up vector.<br><br>Here $e$ is located on $y$ axis and is a vertex of an equilateral triangle $\Delta eab$. where each edge has a length of 1 unit for both the frames. Determine the position of the $\boldsymbol{O}$ w.r.t *Frame-1* and *Frame-2*. | |