Date of Examination: 24.05.2021

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

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

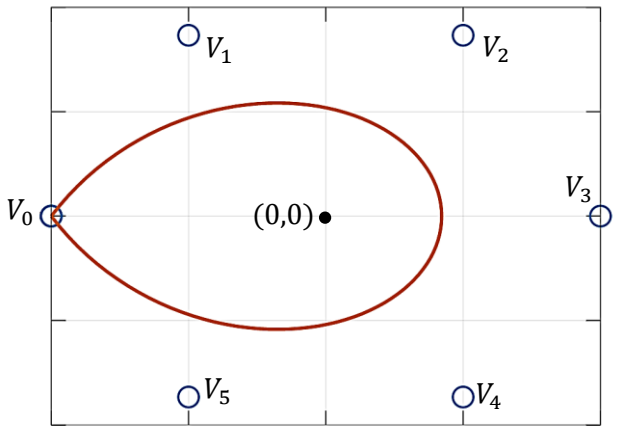
Time: 3 (Three) Hours **Full Marks: 60**

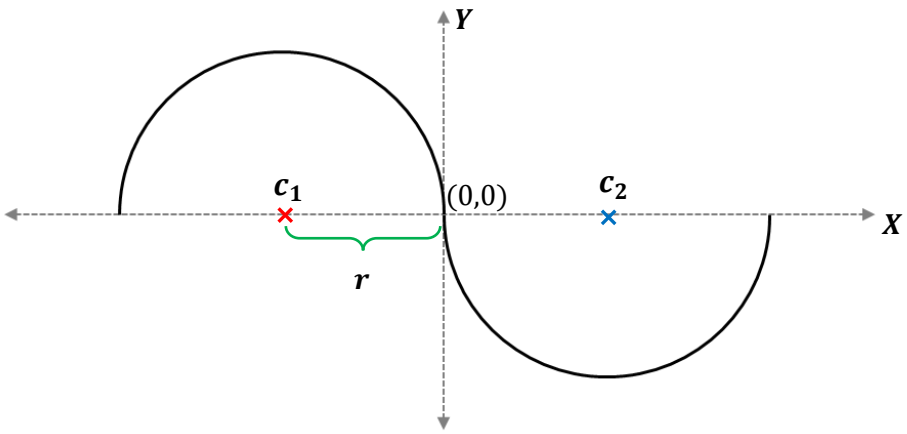
Use single answer script

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: **Department:** **Program:** **Course no:** **Course Title:** **Examination:** **Semester (Session):** **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)	Necessary **charts/tables** are attached at the end of the question paper. You may use graph papers where necessary.
	ix)	Assume any reasonable data if needed.
	x)	Symbols and characters have their usual meaning.
	xi)	Before uploading rename the PDF file as **CourseNo_StudentID.pdf** e.g., CSE4203_160204001.pdf

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 07 (seven) Questions. Answer any 05 (five).

Question 1. [Marks: 12]		
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 along AB by $+90^o$. Determine the composite transformation matrix to do the task and calculate the rotated point P'.	**[6+4]**
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.	**[2]**
Question 2. [Marks: 12]		
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 are the coordinates at $Q\left(\frac{1}{3}\right)$ and $Q\left(\frac{1}{4}\right)$? 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. 	**[6]**
b)	Differentiate between *Painter's* algorithm and *Z-buffer* algorithm with appropriate examples.	**[4]**
c)	Explain the super-sampling technique for antialiasing using example.	**[2]**
Question 3. [Marks: 12]		
a)	Consider the following parameters for an orthographic ray-tracing. *Camera frame:* the viewpoint $\boldsymbol{e}$ is $(-5,0,0)$, and the viewing direction is upward. *Image plane:* $l = -10, r = 10, t = 10, b = -10$ *Raster image resolution:* 10×10 *Sphere:* centered at $\boldsymbol{e}$ with a radius of 6 units. Determine the ray-sphere intersection points (if any) for a ray (with length=10 units) originated at $(4,4)$ pixel on the raster screen.	**[6]**

b)	Why do we need to transform a vertex from its orthographic view volume setup to canonical view volume setup?	**[3]**
c)	Consider the following image. Can we store it as a vector image? Justify your answer. 	**[3]**
Question 4. [Marks: 12]		
a)	Consider a clipping rectangle which has width and height of 10 units. Its lower left corner is located at $(3, 3)$. Also consider a line which 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 Cyrus-Beck algorithm. Show your steps and calculations (assume any necessary data).	**[6]**
b)	What is the significance of $max()$ function in Lambertian Shading model formula?	**[3]**
c)	Show that, in case of Phong Shading model, $r = -l + 2(l.n)n$; where symbol holds the conventional meaning.	**[3]**
Question 5. [Marks: 12]		
	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 same radius of $r = 3$. Both of the circumferences go through $(0,0)$. i. Describe necessary modification of the original algorithm to perform the task. **[3]** ii. Show the steps to determine the points' positions and plot them. **[7+2]** 	

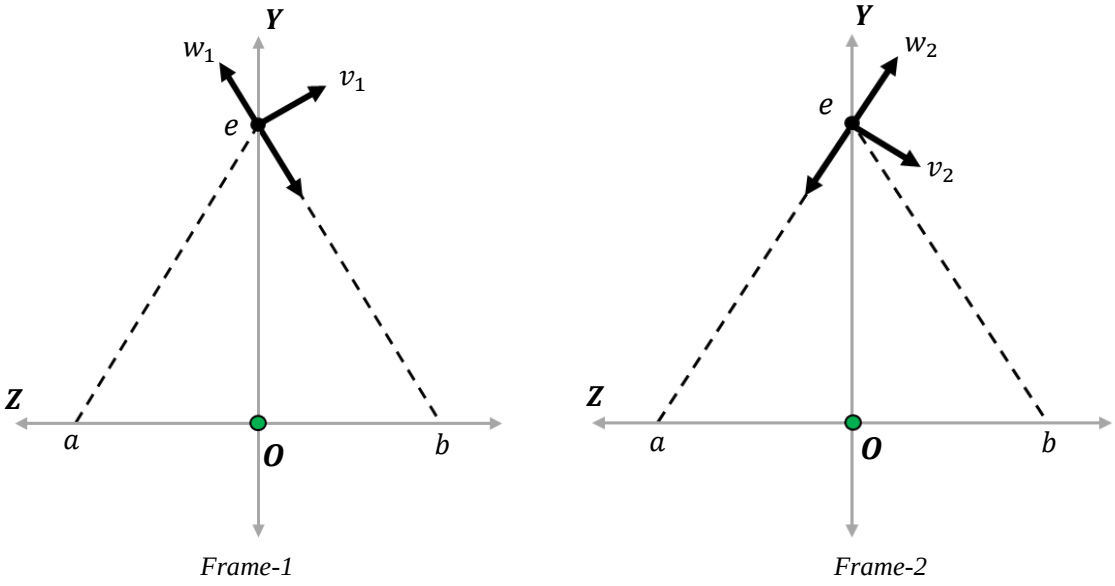
Question 6. [Marks: 12]

a)	Suppose we have a 2D quad $OABC$ with the vertices $O(0,0)$, $A(1, 0.5)$, $B(2, 1.5)$ and $C(0.75, 3)$. Using the concept of barycentric coordinate, determine if a point $P(1.5, 2.5)$ is inside the quad. Describe your approach and show your calculations.	**[2+5]**
b)	What are the properties of *affine* transformation? Mention an example of *non-affine* transformation operation.	**[2+1]**
c)	What is the *level-of-detail* rendering? Why do we use this technique?	**[1+1]**

Question 7. [Marks: 12]

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 following figure), which are –

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.
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.



Frame-1 *Frame-2*

Here e is located on y axis and is a vertex of an equilateral triangle Δeab. 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*. **[6+6]**