Date of Examination :26/11/2019

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Spring 2019

Year: 4rth Semester: 2nd

Course Number: **CSE4203**

Course Name: **Computer Graphics**

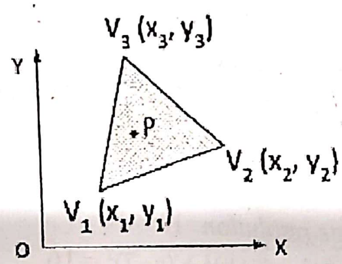
Time: 3 (Three) hours Full Marks: 70

[*There are seven questions carrying a total of 14 marks each. Answer any five questions. Marks allotted are indicated in the right margin.*]

1. a) What is *Level-of-Detail* (LoD) in computer graphics? How does it help in optimizing rendering speed? Ch-2 [1+2=3]

b) Discuss the mechanism to determine point P's *barycentric* coordinates (α, β, γ) based on the triangle $V_1V_2V_3$ in the following scenario. [6]

Slide



c) Simulate the *z-buffer algorithm* for the following setup and show the intermediate states of the z-buffer. Here (i), (ii) and (iii) are the pixel-wise z-coordinates for three different primitives. And, (iv) is the initial z-buffer. [5]

(i)

5	5	7	8
5	6	7	
5	7		
5			

(ii)

6	6	6	6
7	7	6	6
8	8	8	8
	8	8	8

(iii)

4	5	5	6
4	4	5	6
		4	7
			4

(iv)

∞	∞	∞	∞
∞	∞	∞	∞
∞	∞	∞	∞
∞	∞	∞	∞

2. a) Derive the perspective matrix for 2D and 3D cases with appropriate diagrams. Also, show that the matrix can be expressed as follows (P) for 3D, where n and f are the near and far clipping planes' distances respectively. [4+4=8]

$$P = \begin{pmatrix} n & 0 & 0 & 0 \\ 0 & n & 0 & 0 \\ 0 & 0 & n+f & -nf \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

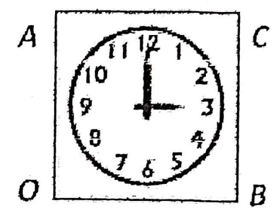
b) In OpenGL, which form of the perspective matrix is implemented? Show that it can be expressed in terms of *field of view, aspect ratio, near* and *far* plane. [3]

c) Explain the reason behind the faceted appearance of a model after rendering with *Lambertian shading*. Propose a solution. [3]

3. a) Assume, $ABCD$ is a 2D rectangle and the coordinates of its 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° with X-axis after the transformation. Determine the composite transformation matrix to perform this task. Perform all the multiplications and plot $A'B'C'D'$. [8]

Fall 19

b) Stretch the clock $OACB$ (shown in the figure) by 50% along one of its diagonals so that 8:00 through 1:00 move to the northwest, and 2:00 through 7:00 move to the southeast. The four vertices of the clock are O(2,2), A(2,6), C(6,6) and B(6,2). Perform all the multiplication and find the final vertices. [6]



4. a) Consider the following parameters for an orthographic ray-tracing: [10]

Camera frame: $E = [5, 5, 20]^T$, $U = [1, 0, 0]^T$, $V = [0, 0.7, -0.7]^T$,
$W = [0, 0.7, 0.7]^T$

Image plane: $l = -10$, $r = 10$, $t = 10$, $b = -10$

Raster image resolution: 10×10

Sphere: $(x+1)^2 + (y+8)^2 + (z-7)^2 = 16$

Determine the ray-sphere intersection points (if any) for a ray (with length = 10) starting from (2, 3) pixel on the raster screen.

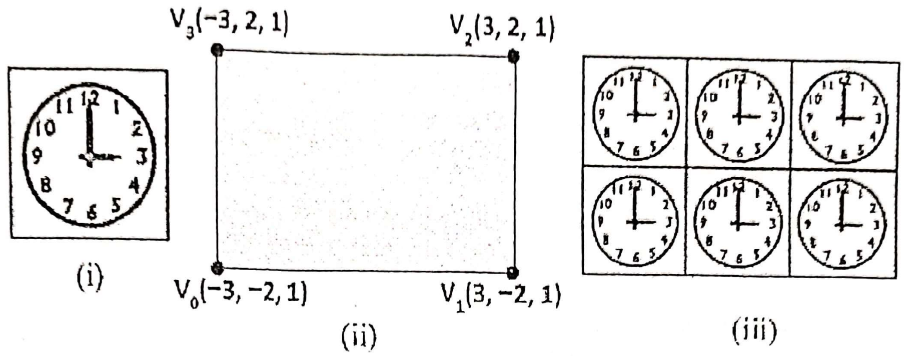
b) Derive the matrix for *window-to-viewport* transformation. Explain the steps for your derivation. [4]

5. a) Derive *frame-to-canonical* matrix for 2D coordinate transformation. [6]

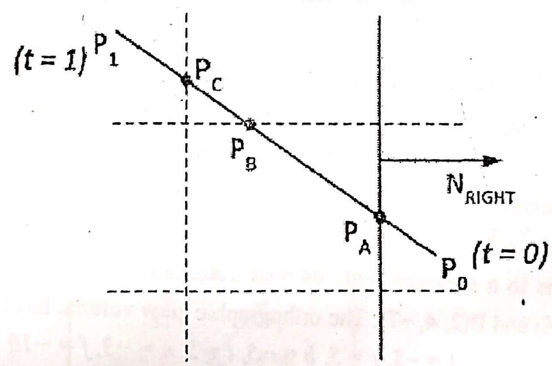
b) Origin $\boldsymbol{O}$ and basis $\{x, y\}$ construct a 2D canonical coordinate system where $-x$ is the viewing direction. Within this, a line $\boldsymbol{bc}$ is a model ($\mathbf{P}_{\text{CANONICAL}}$) where vertices $\boldsymbol{b}$ and $\boldsymbol{c}$ are (−4, 2) and (−8, −2) respectively. Implement a different 2D camera frame which is looking upward with an origin $\boldsymbol{e}$ (−6, −6). Determine the *canonical-to- basis* matrix. Calculate and plot $\mathbf{P}_{\text{FRAME}}$. [5+3=8]

6. a) Apply the *midpoint* line drawing algorithm to draw a line from (1, 1) to (−4, −7). Plot points and for each step show values of the decision variables. [10]

b) 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. [4]



7. a) Consider the line P_0P_1 with a clipping rectangle (shown in the following figure) where N_{RIGHT} is normal to the right clipping edge. Answer the questions from (i) to (iii) based on the *Cyrus-Beck* line clipping algorithm.



i. Derive the formula to determine parameter t for finding P_0P_1's intersection point with the right edge (P_A). [3]

ii. How to decide if the line P_0P_1 is parallel to the right edge? [2]

iii. How to determine potentially entering and potentially leaving interaction points? How can we select the true intersection points? [5]

b) Prove that $r = -l + 2\ (l.n)\ n$ in the context of *Phong* shading model. Here, l, n, and r are the direction to the light, normal on the surface and direction of the reflection respectively at point P (shown in the figure). [4]