Date of Examination: 15/05/2019

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Fall 2018

Year: 4th 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) Why are the graphics pipelines usually optimized for processing triangles? [2]

   b) Derive the 2D rotation matrix. [3]

   c) Explain the *box filtering technique by supersampling* technique for antialiasing using an example. [4]

   d) Given that, $C_f = 1.0$, $C_b = 0.2$ and $C = 0.8$, where C_f, C_b and C are the foreground, background and composite intensities respectively. Determine the *alpha* (α) *value* to perform this composition. [5]

2. a) 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]

   b) Explain *affine transformation*. What is the advantage of using homogeneous coordinates in case of composite transformation? [4]

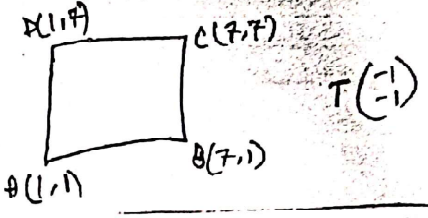
   c) Consider a 3D line AB that needs to be transformed from an orthographic view volume to a viewport with 64×64 resolution. Vertices of the line are A(−1, −3, −6) and B(2, 4, −7). The orthographic view volume has the following setup: [4+2=6]

   $$l = -5,\ r = 5,\ b = -5,\ t = 5,\ n = -3,\ f = -10$$

   Determine the matrix M to transform the vertices of the line to viewport. Apply M on the vertices and determine their positions on the viewport.

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). We introduce shear on the rectangle to obtain $A'B'C'D'$ such that $A'D'$ and $B'C'$ individually creates 75° with X-axis after the transformation. Determine the composite transformation matrix to perform this task. Perform multiplication and plot $A'B'C'D'$. [10]

   b) Explain the reason behind occurring faceted appearance of a model after rendering with *Lambertian shading*. Propose a solution to overcome the issue. [4]



4. Consider the following parameters for an orthographic ray-tracing:

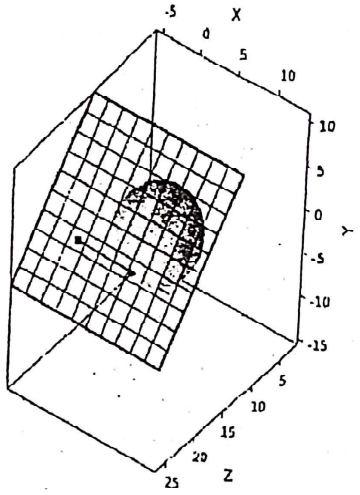
Camera frame: $E = [4, 4, 20]^T$, $U = [1, 0, 0]^T$, $V = [0, 0.7, -0.7]^T$, $W = [0, 0.7, 0.7]^T$

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

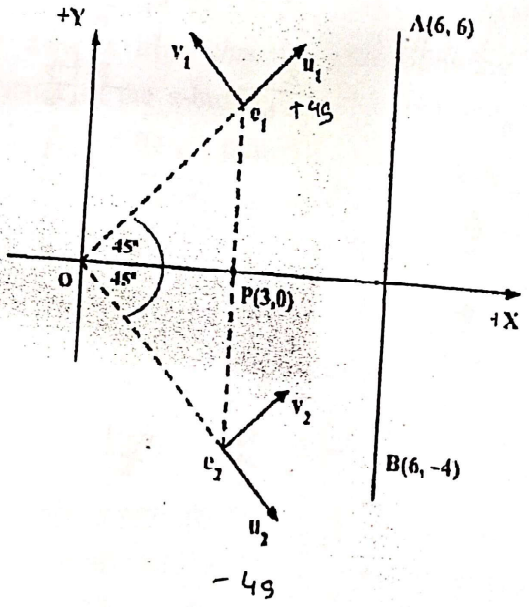
Raster image resolution: 10×10

Sphere: $(x+1)^2 + (y+7)^2 + (z-7)^2 = 25$

Determine the ray-sphere intersection point(s) for a ray (with length = 25) starting at (2, 3) on the image plane. Which intersection point will be closer to the camera?



5. Consider the following figure, where AB is our model P_{xy}. We have two camera frames with camera positions e_1 and e_2, and basis vectors $\{u_1, v_1\}$ and $\{u_2, v_2\}$ respectively. Assume, u_i is *viewing direction* and v_i is *up vector*. Individually for both camera frames, determine *canonical-to-basis* matrices, calculate P_{uv} and plot. [14]

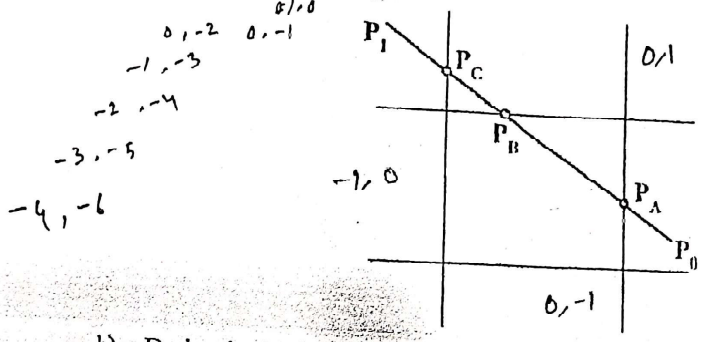


[14]

6. a) Apply the midpoint line drawing algorithm to draw a 2D line from (2, 2) to (−4, −6) and plot obtained points. For each step, show values of the decision variable. [8]

b) Determine the barycentric coordinates of a 2D point P(2.5, 2.25) with respect to a 2D triangle with vertices A(1, 1), B(5, 1) and C(2.5, 2.5). [6]

7. a) Using the concepts of the *Cyrus-Beck* parametric line clipping algorithm, show that P_A and P_D are the true clipping intersection points of a line P_0P_1 with the clipping rectangle. [7]



b) Derive the following formula for the *Phong shading* model. Here, symbols hold conventional meaning. How do you determine the r vector? [5·2 = 7]

$$c = c_e(c_a + c_l \max(0, n \cdot l)) + c_l \max(0, e \cdot r)^p$$