



JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF INFORMATICS AND INNOVATIVE SYSTEMS

DEPARTMENT OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

**UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR SCIENCE IN
SECURITY AND FORENICS**

4TH YEAR 1ST SEMESTER 2021/2022 ACADEMIC YEAR

MAIN CAMPUS

COURSE CODE: ICB 1411

COURSE TITLE: COMPUTER GRAPHICS

EXAM VENUE:

STREAM: BSC COMP SECURITY

DATE: DECEMBER 2022

EXAM SESSION:

TIME: 2.00 HOURS

INSTRUCTIONS:

- 1. Answer Question One (Compulsory) and ANY other two questions**
- 2. Candidates are advised not to write on the question paper**
- 3. Candidates must hand in their answer booklets to the invigilator while in the examination room**

QUESTION ONE**[30 MARKS]**

- (a) Explain the use of the following scan algorithms in computer graphics:
- (i) Gupta-Sproull Algorithm [2 Marks]
 - (ii) Digital Differential Analyzer Algorithm [2 Marks]
 - (iii) Fill-Area Algorithms [2 Marks]
- (b) Describe three coordinate systems (spaces) that may be encountered in a rendering pipeline. [6 Marks]
- (c) Differentiate between *random scan system* and *raster scan system*. [4 Marks]
- (d) Name three basic methods that can be used to generate characters on a computer screen. [3 Marks]
- (e) Describe the structure of a typical ray tracer by using the functions *main()*, *trace()*, *shade()*, and *findClosestIntersection()*. [5 Marks]
- (f) Develop an algorithm to draw a thick line from point $P(x_1, y_1)$ to $Q(x_2, y_2)$ of thickness w pixels. [6 Marks]

QUESTION TWO**[20 MARKS]**

- (a) Give three differences between *real-time graphics* and *offline (photorealistic) computer graphics*. [6 Marks]
- (b) Using a well labelled diagram, explain the architecture of a raster display. [6 Marks]
- (c) Assume a raster scan display system supports a frame buffer size of $256 \times 256 \times 2$ bits. Two bits/pixel are used to look up a 4×2 colour table. The entries in the colour table are writable once per raster scan only during the vertical retrace period. The actual colour codes are given as follows.
- | | | | |
|----------|--------|-----------|----------|
| 00 Black | 01 Red | 10 Yellow | 11 White |
|----------|--------|-----------|----------|
- (i) Give a scheme for using the frame buffer if it consists of two separate image planes of size $256 \times 256 \times 1$ each. Plane 1 is to be displayed as yellow on red image. Plane 2 is to be displayed as white on black. [4 Marks]
- (ii) Explain how you will turn on a pixel in either plane. [2 Marks]
- (iii) Explain how you will delete a pixel in either plane. [2 Marks]

QUESTION THREE**[20 MARKS]**

- (a) Consider a case where a line is drawn from (x_1, y_1) to (x_2, y_2) . Scan conversions is started from both (x_1, y_1) to (x_2, y_2) and also from (x_2, y_2) to (x_1, y_1) simultaneously following Bresenham's algorithm.
- (i) Write algorithms steps for such implementations. [7 Marks]
 - (ii) With a supporting reason, give the advantage of this technique. [3 Marks]
- (b) A cube with side of length 4 is placed so that a corner lies on the origin and three manually perpendicular edges from this corner lie on the three positive coordinates axes.
- (i) Translate the cube along the XY plane so that the cube is centered on the origin. [4 Marks]
 - (ii) Perform three-point perspective projection on the translated cube on the $z = 0$ plane with centers of projection $x = -10$ and $z = -10$ on the respective coordinate axes. Draw the projected cube. [6 Marks]

QUESTION FOUR**[20 MARKS]**

It takes three points to define an affine transformation in 2D. Say that the point (1, 1) goes to (4, 4), that (1, -1) goes to $(4 + \sqrt{2}, 4 - \sqrt{2})$, and that the point (-1, 1) goes to $(4 - \sqrt{2}, 4 + \sqrt{2})$. Assume that the affine transformation is described by the following homogeneous matrix equation:

$$\begin{pmatrix} x' \\ y' \\ 1 \end{pmatrix} = \begin{pmatrix} a_{xx} & a_{xy} & b_x \\ a_{yx} & a_{yy} & b_y \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

- Describe an *affine transformation* in your own words. [2 Marks]
- Consider the points to be the corners of a triangle. Draw a picture showing the initial and final positions of the triangle, and give a matrix that transforms the initial triangle to the final one. [6 Marks]
- Write out six linear equations involving the unknowns in the matrix equation above and the coordinates of the given points. [6 Marks]
- Solve the equations to find the unknowns and hence write out the transformation matrix. [6 Marks]

QUESTION FIVE

[20 MARKS]

- Describe the *shadow buffer algorithm*. [3 Marks]
- Given a circle radius = 10, use mid circle algorithm while determining the circle octant in the first quadrant from x=0 to x=y. [8 Marks]
- The Phong shading model can be summarized by the following equation:

$$I_{phong} = k_e + k_a I_a + \sum_i \left[I_{li} \left[k_d (\mathbf{N} \cdot \mathbf{L}_i)_+ + k_s (\mathbf{V} \cdot \mathbf{R}_i)_{+}^{n_s} \right] \min \left\{ 1, \frac{1}{a_0 + a_1 d_i + a_2 d_i^2} \right\} \right]$$

where the summation i is taken over all light sources. The variables used in the Phong shading equation are summarized below:

$I \quad a_0 \quad a_1 \quad a_2 \quad d_i \quad k_e \quad k_a \quad k_d \quad k_s \quad n_s \quad I_a \quad I_{li} \quad \mathbf{L}_i \quad \mathbf{R}_i \quad \mathbf{N} \quad \mathbf{V}$

Explain which of the quantities above are affected when;

- the viewing direction changes. [3 Marks]
- the position of the i^{th} light changes [3 Marks]
- the orientation of the surface changes [3 Marks]

- END -