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 $\boldsymbol{w}$ 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:

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

a) Describe an *affine transformation* in your own words. [2 Marks]

b) 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]

c) Write out six linear equations involving the unknowns in the matrix equation above and the coordinates of the given points.
[6 Marks]

d) Solve the equations to find the unknowns and hence write out the transformation matrix. [6 Marks]

QUESTION FIVE **[20 MARKS]**

(a) Describe the *shadow buffer algorithm*. [3 Marks]
(b) 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]
(c) The Phong shading model can be summarized by the following equation:

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

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

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

Explain which of the quantities above are affected when;

(i) the viewing direction changes. [3 Marks]
(ii) the position of the i^{th} light changes [3 Marks]
(iii) the orientation of the surface changes [3 Marks]

\- **END –**