Xi'an Jiaotong-Liverpool University
西交利物浦大学

Paper CODE	EXAMINER	DEPARTMENT	TEL
CPT205		Computing	

1st SEMESTER 2023/24 FINAL EXAMINATION

Undergraduate – Year 3

COMPUTER GRAPHICS

TIME ALLOWED: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. **This is a closed-book examination, which is to be written without books or notes.**
2. **Total marks available are 100.**
3. **Answer ALL questions in this examination. It is not necessary to copy the questions into the answer booklet.**
4. **Answers should be written in the answer booklet(s) provided. There is NO penalty for providing a wrong answer.**
5. **Only solutions in English are accepted.**
6. **All materials must be returned to the exam invigilator upon completion of the exam. Failure to do so will be deemed academic misconduct and will be dealt with accordingly.**

Question 1. Fundamentals [Total 20 marks]

1.1. Briefly describe OpenGL. [2 marks]

open graphics library, api programming

1.2. List 4 items of hardware included in a typical graphics system. [2 marks]

Input Device.

LCD, CRT display, GPU, CPU, Framework

1-0

1.3. For a screen with a resolution of 1920*1080 pixels what size of a framebuffer is needed for storing 8-bit RGBA colours? [2 marks]

$1920 * 1080 \times 32/8$ B

1.4. Work out the angle between the two vectors, $\mathbf{V_1} = 3\mathbf{i} - 2\mathbf{j}$ and $\mathbf{V_2} = 2\mathbf{i} + 3\mathbf{j}$. [2 marks]

$\cos\theta = \frac{3\times2 - 2\times3}{\sqrt{\cdots}} = 0 \quad \theta = 90^\circ$

1.5. Calculate the unit vector of $\mathbf{V} = 3\mathbf{i} + 6\mathbf{j} - 2\mathbf{k}$. [2 marks]

$V_0 = \frac{V}{\sqrt{9+36+4}} = \left(\frac{3}{7}, \frac{6}{7}, -\frac{2}{7}\right)$

1-1

1.6. What is an identity matrix and what is it used for in computer graphics? [2 marks]

$I = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ main diagonal 1 square matrix Default transformation

1.7. Given two lines AB specified by A(-6,10) and B(12,6), and CD specified by C(6,8) and D(42,0), determine if they are parallel to each other. [2 marks]

$k_{CD} = \frac{0-8}{42-6} = \frac{-8}{36} = \frac{-4}{18} \qquad k_{AB} = \frac{6-10}{12-(-6)} = \frac{-4}{18}$ ✓

1.8. Given a point in a 3D space represented in the homogeneous co-ordinates P(8, 6, 4, 2), what is the normalised co-ordinate value? [2 marks]

$y = \frac{6}{2} = 3$

3

1.9. How could a 2D rectangle be scaled by a factor of 5 while its centre remains unchanged? [2 marks]

scaling

set translate to orignal

C_x, C_y

$x, y \Rightarrow x-C_x, y-C_y$

$\times 5 \quad \times 5 \Rightarrow +C_x, +C_y$

false

lock translate.

1.10. There are different matrix modes in OpenGL. Which one of **GL_MODELVIEW** and **GL_PROJECTION** should be used in conjunction with a **glRotate ()** function call and why? [2 marks]

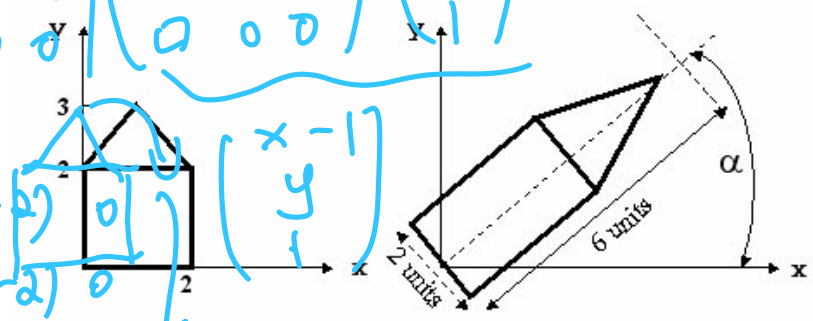
GLModelView → used for transformation

3D to 2D.

2 → 点、线 多边

Question 2. Transformations and viewing [Total 20 marks]

2.1. For the 2D object shown in the figures below, work out the 2D homogeneous transformation matrix **M** which transforms the 2D object in the left into the 2D object in the right (where $\alpha=45^{o}$). You can write the transformation matrix as a product of several simpler matrices (i.e., you do not have to multiply the matrices). A diagram can be used to aid your answer. [8 marks]

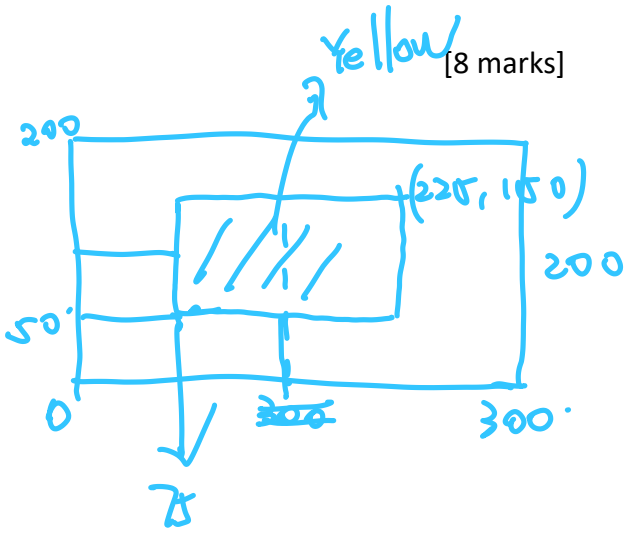


2.2. Given the following fragment of code in OpenGL: [8 marks]

```
void myDisply(void) {
        glViewport(0,0,300,200);

        glMatrixMode(GL_PROJECTION);
        glLoadIndentity();
        gluOrtho2D(-1,1,-1,1);

        glBegin(GL_QUADS);
                glColor3f(1,1,0);
                glVertex2f(-0.5,-0.5);
                glVertex2f(+0.5,-0.5);
                glVertex2f(+0.5,+0.5);
                glVertex2f(-0.5,+0.5);
        glEnd();
}
```



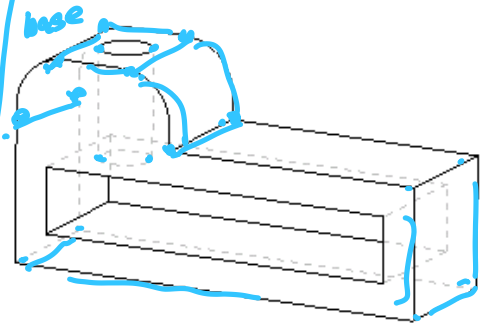
a) Draw a diagram to illustrate the content generated on the screen.
b) Calculate the area of the displayed quad in pixels.

2.3. Explain the frustum volume and its implementation with OpenGL **glFrustum()**. A diagram can be used to aid your answer. [4 marks]

Question 3. Geometric creation and modelling [Total 20 marks]

3.1. A straight line is defined by $P_1(3,12)$ and $P_2(7,2)$. Determine the pixel positions with the DDA (Digital Differential Analyser) algorithm. A diagram can be plotted to demonstrate the result. [8 marks]

3.2. Identify if the following object is a manifold object using Eula's law. You can interpret the object by decomposing it into smaller units, based on which calculations are made. [8 marks]



3.3. Briefly discuss the concept of hierarchical modelling with an example. A diagram can be used to aid your answer. [4 marks]

Question 4. Lighting, materials and texture mapping [Total 20 marks]

4.1. The Phong lighting model can be written (without the distance terms) as

$$I = k_d I_d \mathbf{l} \cdot \mathbf{n} + k_s I_s (\mathbf{v} \cdot \mathbf{r})^{\alpha} + k_a I_a$$

Explain, with a diagram where necessary, each term of the model. [8 marks]

4.2. The following OpenGL code defines a light source: [4 marks]

```
GLfloat light_position[] = {1.0, 1.0, 1.0, 0.0};
glLightfv(GL_LIGHT0, GL_POSITION, light_position);
```

a) What type of light source is specified?
b) Should distance attenuation be applied to this light and why?

4.3. Mipmapping can be applied in texture mapping and it is implemented in graphic systems such as OpenGL. [8 marks]

a) Briefly explain the need and concept for mipmapping.
b) Given a texture map of 32*64 pixels at the highest level, work out the total number of levels for the maps and the size of each map.

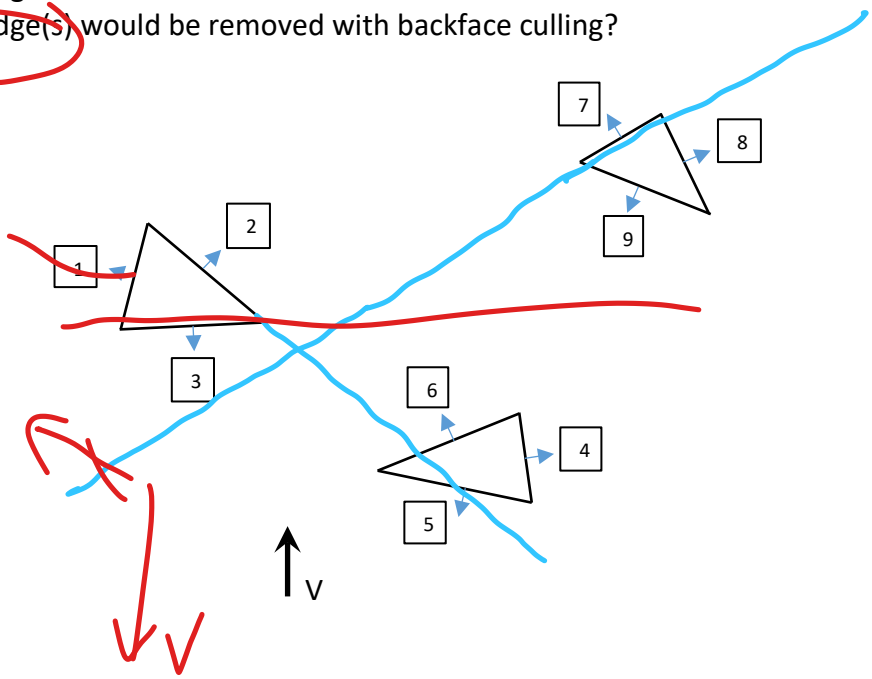
Question 5. Clipping and hidden surface removal [Total 20 marks]

5.1. Briefly discuss object space and image space algorithms for hidden surface removal. [6 marks]

5.2. Describe Brute force clipping of 2D lines (similar triangles) and its computational efficiency. A diagram can be used to aid your answer. [6 marks]

5.3. In the 2D figure below, each edge is a planar face in the triangle with its outward normal shown. You can assume that, if extended, no edge intersects another triangle. [8 marks]

a) Build a BSP (Binary Spatial Partition) tree which uses the lines containing the edges to partition the 2-D space, and insert the edges into the tree.
b) Which edge would be drawn first if the viewer is at the location marked V?
c) Which edge would be drawn last if the viewer is at the location marked V?
d) Which edge(s) would be removed with backface culling?



THIS IS THE END OF THE EXAM.