205 19-20

2023年1月7日 16:38

Question 1. Fundamentals [Total 20 marks]

1.1. Briefly describe OpenGL. [2 marks]

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

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]

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]

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

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

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), show that the two lines are parallel to each other. [2 marks]

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

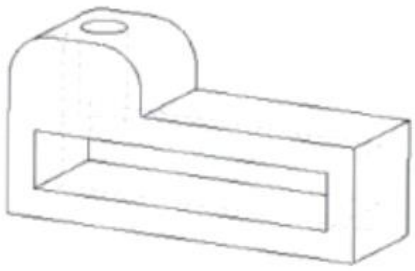
1.9. How could a 2D rectangle be scaled by a factor of 3 while its centre remains unchanged? [2 marks]

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

Question 2. Generation of geometry and modelling [Total 20 marks]

2.1. 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). Alternatively, a diagram can be plotted to demonstrate the result. [8 marks]

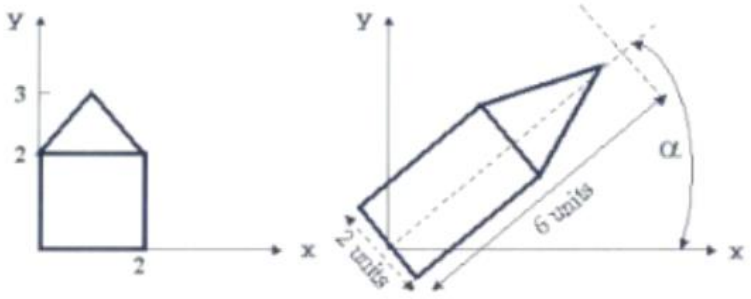
2.2. Identify if the following object is a manifold object using Eula's law. You are required to interpret the object by decomposing it into smaller units, based on which calculations are made. [8 marks]



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

Question 3. Transformations and viewing [Total 20 marks]

3.1. 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 $\alpha=45°$). You can write the transformation matrix as a product of several simpler matrices (i.e., you do not have to multiply the matrices). [8 marks]



3.2. The following is a piece of OpenGL code for drawing a quad in a viewport: [8 marks]

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

        glMatrixMode(GL_PROJECTION);
        glLoadIndentity();
        glOrtho2D(-1,1,-1,1);

        glBegin(GL_QUADS);
                glColor3f(1,0,0);
                glVertex2i(-0.5,-0.5);
                glVertex2i(+0.5,-0.5);
                glVertex2i(+0.5,+0.5);
                glVertex2i(-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.

3.3. Explain the frustum volume and its implementation with OpenGL **glFrustum()**. [4 marks]

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

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

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

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

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

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

a) What kind of light source is specified?
b) If transformations are applied to the light source, will the model-view matrix or projection matrix be used and why?

4.3. Briefly explain the concepts of texture mapping, and second mapping. [8 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.
[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?