NEWCASTLE UNIVERSITY

SEMESTER 1 2009/10

GRAPHICS

Time allowed - 1½ Hours

Instructions to candidates:

Answer TWO questions

Marks shown for subsections are indicative only

Question 1.

a) Light is a section of the electromagnetic spectrum, including all wavelengths from about 400 to about 700 nanometres. Explain, with reference to the human visual system, how in Computer Graphics the light calculations in a computer and generation of light on a display can be simplified (i.e. not all wavelengths need to be simulated). [5 marks]

b) In low light conditions humans perceive colour in the world differently. Explain how and why this occurs. [3 marks]

c) Simon has written a computer graphics application displaying some simple 3d shapes – a sphere, a cube, and a tetrahedron – and some 2d shapes – a quad and a triangle. Using the keyboard he can move each of these shapes around independently and can rotate the view of them. He observes a number of visual effects. For each, explain how or why it occurs and how it may be resolved.

   i) The screen flickers a lot. [2 marks]

   ii) When viewed from the back Simon can see through the cube (the sides are visible). [2 marks]

   iii) When moved closer to the viewer the sphere seems to have the front sliced off it. [2 marks]

d) Using any appropriate method, describe a procedure for generating a polyhedron to approximate a sphere. You should only generate polygons for the surface of the sphere. [5 marks]

e) Write pseudo-code using OpenGL calls to implement your method (as described in d) as a function with one or more parameters to represent the "quality" of the approximation. The sphere should be centred at the origin. [6 marks]

Question 2.

a) In order for polygons to display correctly in computer graphics (specifically in OpenGL), the polygons must be simple.

i) Describe what is meant by "simple" and also state the other two constraints that should be maintained for polygons in OpenGL. [4 marks]

ii) Devise a test to determine whether a two-dimensional polygon as defined by a series of vertices - A, B, C, D, ... is simple. [4 marks]

b) A games company has been asked to write a football game. The client wants the game player to be able to see the action in detail. This functionality has already been implemented. Describe how this could be extended using OpenGL to add a real-time top-down view map of the pitch to the scene without creating additional geometry. Make sure you mention any factors that should be given special attention. [7 marks]

c) Solids of rotation are formed by rotating a 2-dimensional shape around a given axis. An approximate representation of such a solid can be formed by rotating the cross-section in a fixed number of angular steps. Outline how you would generate a representation of such a solid by considering the case of generating an approximation to a hollow cylinder formed by rotating a rectangle (in the x-y plane) around the z-axis in a series of steps. Suggest how the plane equations of each face might be computed efficiently. [10 marks]

Question 3.

a) Outline the principles of the z-buffer algorithm and explain why it is important. Support your arguments with a counter example of what could happen if the z-buffer algorithm wasn't used. In addition, explain some cases where the z-buffer algorithm may not have the desired effect. [8 marks]

b)

i) Describe what is meant in computer graphics by "picking" and when it might be used. [3 marks]

ii) Give an overview of two different approaches to picking, and explain the advantages and disadvantages of each. [5 marks]

c) In a typical application the programmer must decide whether or not to use display lists.

i) Describe a case where display lists could be useful and why. [2 marks]

ii) Give two factors in favour and two against using display lists in your above case. [3 marks]

d) Jimmy wants to write code to make a red cube spin while moving towards a blue cube. Explain the various errors in the pseudocode fragment below and how they may be changed to achieve the desired effect. [4 marks]

```
render()
{
        glTranslate3f(0.0f,5.0f,0.0f);
        glColor3f(0.0f,0.0f,1.0f);
        drawCube();
        glRotate(angle,0.0f,0.0f,0.0f);
        glTranslate3f(0.0f,distance,0.0f );
        drawCube ();
        glColor3f(1.0f,0.0f,0.0f);
}
```

Question 4.

a) State the correspondence between homogenous coordinates and Cartesian coordinates. Explain why homogeneous coordinates are used to implement geometric transformations such as scaling, rotation and translation. [3 marks]

b) An interesting class of 3-dimensional objects can be created by extruding 2-dimensional objects in a third dimension. For example, a circle becomes a cylinder, a line becomes a quadrilateral, and a triangle becomes a triangular prism.

i) Describe a procedure for generating the extrusion of a two-dimensional polygon where the (2D) vertices of the polygon and the depth of the extrusion are parameters. There should be polygons for all sides of the 3D shape. Assume the polygon is simple, flat and convex. [4 marks]

ii) Using OpenGL calls write pseudocode for a function with two parameters to implement your answer for b) i). The parameters should be the depth of the extrusion, and the array of 2-dimensional vertices of the polygon. The function should generate polygons for all sides of the extruded shape. [3 marks]

iii) Modify your solution to b) ii) to scale the cross-section linearly along the length of the extrusion. [3 marks]

iv) Modify your solution to b) ii) to twist the object around the axis of the extrusion, such that one end of the 3-dimensional object is rotated X degrees in relation to the other end and this twisting occurs as a sequence of rotations. The number of sections in the twist sequence and the degree of rotation (in degrees) should be additional parameters. The rotation should occur along an axis passing through the centre of the polygon. An example of an extruded square with a 45 degree twist and 9 sections is shown below: [7 marks]

v) Modify the code from b) iv) to include the scaling described in b) iii). [5 marks]