NEWCASTLE UNIVERSITY

SEMESTER 1 2010/11

GRAPHICS

Time allowed - 1½ Hours

Instructions to candidates:

Answer TWO questions

Marks shown for subsections are indicative only

Question 1.

a) Explain the terms window and viewport as used in graphics software and the appropriate coordinate systems for each. [3 marks]

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

   i) Describe what is meant by "convex" 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 convex. [4 marks]

c) In the development of the Phong reflection model, why do we not consider light sources being obscured from the surface by other surfaces in our reflection model? Provide two reasons for this and explain each. [4 marks]

d) Assume that you have an algorithm that can fill 3D triangles with a constant colour. Explain what additional information and modifications to the algorithm are required to Gouraud shade the triangles. [6 marks]

e) Calculate the approximate maximum resolution needed by a movie projector in a movie theatre above which a higher resolution would provide no visual benefit to the viewer. Clearly state any assumptions that you make. [4 marks]

Question 2.

a) Outline the principles of the z-buffer algorithm and explain what it is used for. Support your arguments with a counter example of what could happen if the z-buffer algorithm wasn't used. Also explain one case 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 explain 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 around itself while moving towards a blue cube. Explain the various errors in the pseudocode fragment below, and how they might be changed to achieve the desired effect.

```
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);
}
```

[4 marks]

Question 3.

a) Explain why homogeneous coordinates are used to implement geometric transformations such as scaling, rotation and translation. Further, state the correspondence between the homogenous coordinates and the Cartesian coordinates of a point in three-dimensional space. [5 marks]

b) An interesting class of three-dimensional objects can be created by extruding two-dimensional objects into 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 general two-dimensional polygon where the (2D) vertices of the polygon and the depth of the extrusion are specified. There should be a polygon representing each side of the 3D shape, and the 3D shape should be centered on the x-y plane in the z-dimension. Assume the polygon is simple, flat, and convex. [6 marks]

ii) Using OpenGL calls, write pseudo-code to implement your procedure as a function with one parameter to represent the depth of the extrusion and a second parameter which is an array of two-dimensional vertices of the polygon. Again, there should be a polygon representing each side the 3D shape, and the 3D shape should be centered around the x-y plane in the z-dimension. [4 marks]

iii) Modify the code from part ii) to make the extruded object half the size of the original polygon at one end (in both the x and y direction, centered on the origin), and twice the size at the opposite end. [3 marks]

iv) Modify the original (non-scaled) code to twist the object through the extrusion, so that one end of the three-dimensional object is rotated X degrees in relation to the other end and this rotation occurs as a sequence of rotations from one end to the other. The number of sections in the twist sequence and the amount of rotation (in degrees) should be additional parameters to the pseudo-code. The rotation should occur around the origin. An example of an extruded square with a 45 degree twist with 9 sections is shown overleaf:

[7 marks]