**UNIVERSITY OF EDINBURGH**

**FACULTY OF SCIENCE AND ENGINEERING**

**COMPUTER SCIENCE FOUR**

# COMPUTER GRAPHICS

**Monday 22 April 2002**

**14:00 to 15:30**

**Examiners:**

**Prof. K. Turner (External)**

**Prof. C. Stirling (Chairman)**

## INSTRUCTIONS TO CANDIDATES

**Answer any TWO questions.**

**All questions carry equal weight.**

1. (a) Explain how you would generate a Bézier surface patch and how these are combined to create a larger arbitrary shaped surface. Define any terms used in generating expressions for surface coordinates. [*10 marks* ]

(b) What is the convex hull property of a space curve or surface and how might you make use of this property? [*3 marks* ]

(c) Derive the B-spline matrix for the standard, cubic, uniform, non-rational B-spline. Show all of your working. [*12 marks* ]

2. (a) Describe the Bresenham line-drawing algorithm for straight lines using the example of a line drawn from (0,0) to (X,Y) in the first octant. Show how, with minor modification, the algorithm can be computed using only integer arithmetic. What would you do differently if the line was drawn in any other octant? *[8 marks ]*

(b) Why do we require antialiasing for lines, what do we require to implement it and how in principle is it applied? *[3 marks ]*

(c) Briefly explain why triangles are often the preferred primitive in 3D modelling and rendering. Give examples where appropriate to support your answer. *[4 marks ]*

(d) Derive an expression in matrix form defining a rotation about an arbitrary axis in $R^3$. Hence define the matrix expression denoting a rotation by $\alpha$ clockwise about the axis $(\frac{\sqrt{3}}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}, \frac{1}{\sqrt{2}})$. You will need to know the premultiply matrices for anticlockwise rotation about the major axes, and these are:

$$R_x(\theta) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{pmatrix};$$

$$R_y(\theta) = \begin{pmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{pmatrix};$$

$$R_z(\theta) = \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}.$$

*[10 marks ]*

3. (a) Briefly describe the principles of the *radiosity* method for rendering scenes. [*8 marks*]

   (b) With the aid of diagrams briefly describe the operation of Gouraud and Phong smooth shading algorithms. [*6 marks*]

   (c) Briefly describe the following texture mapping techniques and give examples of each:

      i. environment mapping [*4 marks*]
      ii. illumination mapping [*2 marks*]
      iii. shadow mapping [*3 marks*]
      iv. bump mapping [*2 marks*]