

UNIVERSITY OF DUBLIN

TRINITY COLLEGE

Faculty of Engineering, Mathematics and Science

School of Computer Science and Statistics

BA (Mod.) Computer Science

Hilary Term 2012

Senior Sophister Examination

CS4052 – Computer Graphics

Friday 13th January

Regent House

09.30 – 11.30

Prof Carol O'Sullivan

Instructions to Candidates:

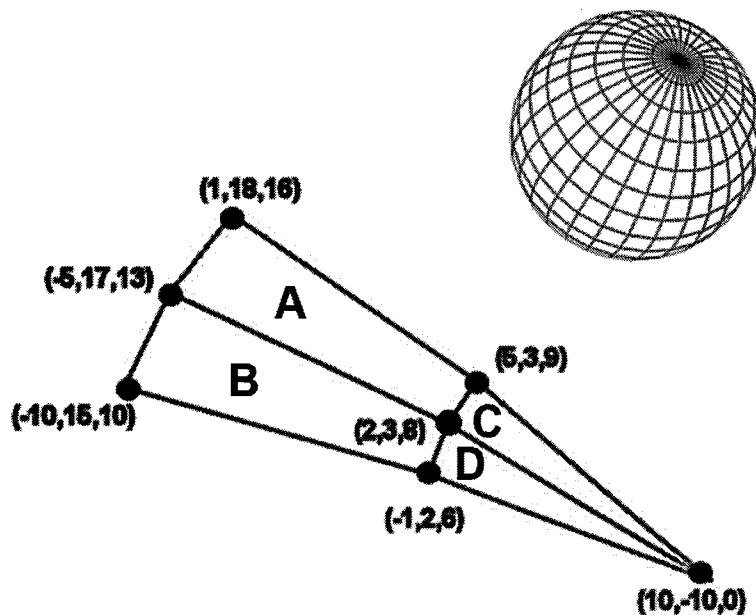
ANSWER ANY FIVE QUESTIONS (20 marks each)

Question 1

- (a) What is “procedural modelling”? Describe three examples of potential application areas of procedural modelling. **(8 marks)**
- (b) Explain what L-systems are, and demonstrate using an example how they can be used to create a model. **(12 marks)**

Question 2

- (a) Explain why normal vectors are important in graphics and give two examples of how they are used. **(8 marks)**
- (b) Consider the sphere below. The figure also shows a subset of the surface polygons. The normal vectors of polygons A and B are $(-0.33, -0.47, 0.82)$ and $(-0.32, -0.46, 0.83)$ respectively. Calculate the unit vertex normal at vertex $(2, 3, 8)$. **(12 marks)**



Question 3

(a) What does this equation represent? Explain all terms in detail. (8 marks)

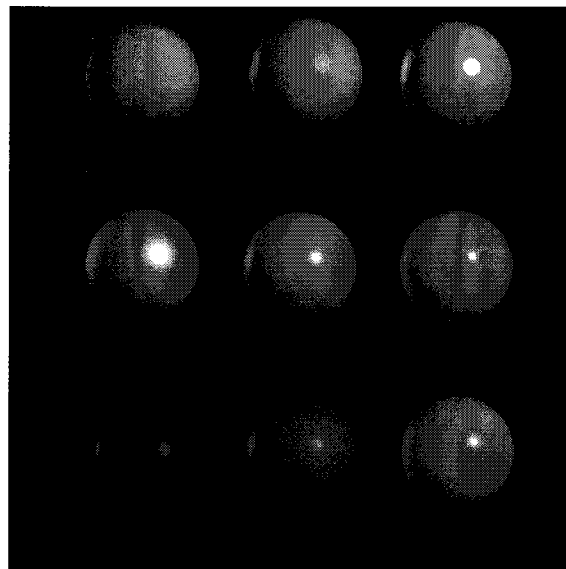
$$L_{r,d}(x, \cdot) = \frac{\rho_d}{\pi} \cos \theta \frac{\Phi_s}{4\pi d^2}$$

(b) Explain light attenuation, and describe how it is implemented in OpenGL. To demonstrate your answer, give sample OpenGL code for simulating a spot light source. (12 marks)

Question 4:

(a) What factors can influence the colour of a point in a rendered scene? (5 marks)

(b) Look at the following picture of spheres. Explain the illumination that is being used to create these images and give estimates for the material properties of each sphere. In each case, provide the OpenGL (or similar API) statements that would be used to create these material properties. (15 marks)



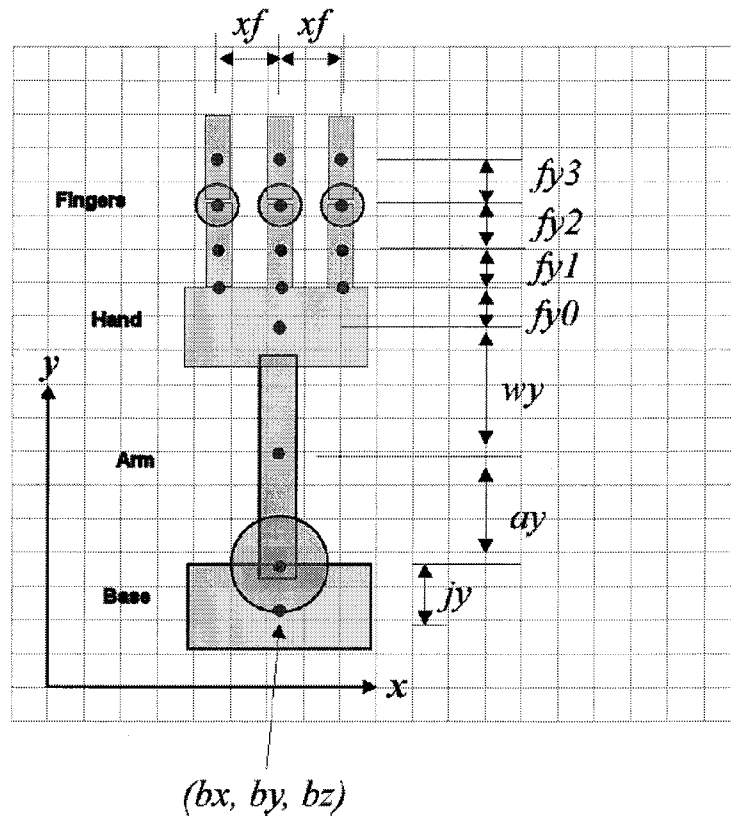
Question 5:

(a) What does each of these matrices represent? Explain how each is derived. **(6 marks)**

(b) In each case, for your own choice of values of the matrix elements, calculate and explain (using diagrams) its effect on a triangle represented by the vertices (3,3,7), (6,4,9), (5,7,8). Provide the OpenGL (or similar API) code that would achieve the transformations you describe. **(14 marks)**

i)	$\begin{bmatrix} 1/s_x & 0 & 0 & 0 \\ 0 & 1/s_y & 0 & 0 \\ 0 & 0 & 1/s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
ii)	$\begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
iii)	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 1/d & 0 \end{bmatrix}$

Question 6



For the above object – provide the OpenGL (or similar API) code necessary to:

- Move the whole assembly to the right by 5 units (**1 mark**)
- Bend the arm unit by 45 degrees to the left (**1 mark**)
- Bend the hand unit by 10 degrees away from you (Right handed system) (**2 marks**)
- Uniformly scale the hand and the fingers by a factor of 3 (**2 marks**)
- Spread the right and left fingers so that there is an angle of 15 degrees between them and the middle one (**4 marks**)
- Bend the top digit of the middle finger inwards towards the palm by 15 degrees (**2 marks**)

(Additional 8 marks for overall structure and accuracy of code)

Question 7:

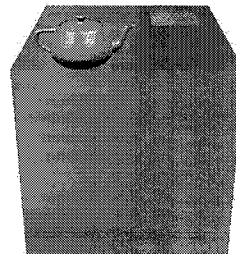
Both of the images (i)-(ii) below show a perspective view, rendered using OpenGL, of exactly the same scene. The scene consists of: a teapot, radius 0.7, and a cube, edge-length 1.0, both sitting on a cube of edge-length 5.0. However, the images look different.

- (a) Explain in detail what is causing this difference. **(6 marks)**
- (b) Give rough estimates of the viewing parameters that are being used to create each image and provide the OpenGL (or similar API) code that would be used to setup and render the scene and both views. **(14 marks)**

(i)



(ii)

**Question 8**

- (a) Describe, using examples, what the implicit or parametric representation of an object is. Discuss their relative merits, and the situations in which each might be used. Give two examples each of both types of surface and how they would be rendered. **(10 marks)**

- (b) Explain each of the following in the context of Parametric Cubic curves, giving examples of how they can be implemented in OpenGL (or similar API) where appropriate **(10 marks)**:

- Curve Continuity
- Geometric and parametric continuity
- Basis matrix
- Geometry matrix
- Blending functions