XCS40521

UNIVERSITY OF DUBLIN

TRINITY COLLEGE

Faculty of Engineering, Mathematics and Science
School of Computer Science and Statistics

B.A.(Mod.) Computer Science **Trinity Term 2010**
B.A. (Mod.) CSLL
Senior Sophister Examination

Computer Graphics

12-05-2010 **GOLDHALL** **14:00-17:00**

Dr. Veronica Sundstedt

Instructions to Candidates:

- Answer 4 out of the 6 questions
- All questions carry equal marks (they are marked out of 25)
- You may not start this examination, until you are instructed to do so by the Invigilator.

Materials permitted for this examination:

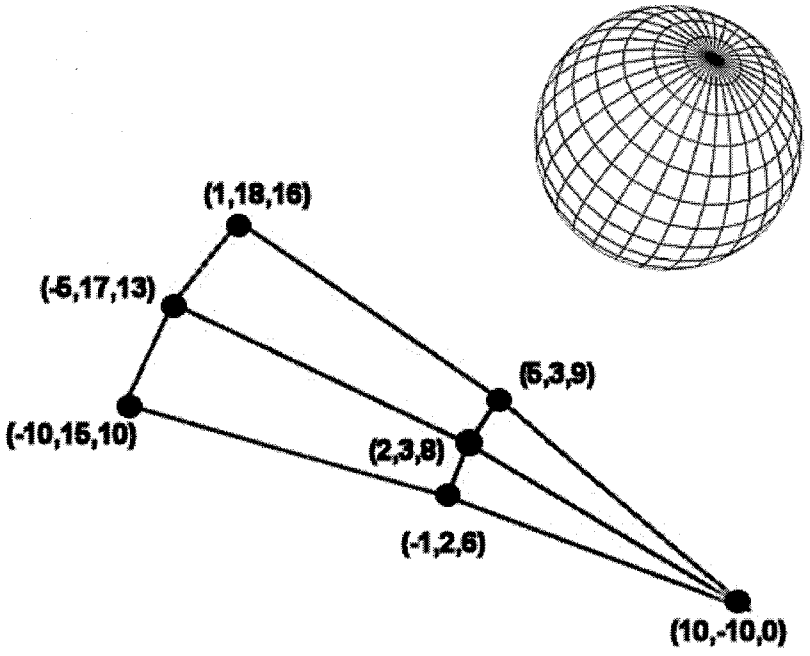
- Non-programmable calculators are permitted for this examination – please indicate the make and model of your calculator on each answer book used.

1.

a) Discuss briefly the following terms in relation to computer graphics. Use figures where appropriate.

- Irradiance
- Cell-shading
- Dominant wavelength theory
- Supersampling
- Half-toning
- Free-form deformation (FFD) **[12 marks]**

b) Consider the sphere below. The figure on the left shows a subset of the surface polygons. Calculate the vertex normal at vertex (2,3,8). **[7 marks]**



c) Describe two applications in which visual perception is used to advance the technologies of computer graphics.

[6 marks]

2.

a) Explain the Gouraud shading technique and discuss it in detail. Use pseudocode to describe the algorithm and show how to draw with it in OpenGL. **[10 marks]**

b) What does the following equation represent? Explain all terms in detail.

$$I = I_a k_a + I_i(k_d(L \cdot N) + k_s(R \cdot V)^n)$$

[12 marks]

c) Blinn suggested a more efficient scheme to the above equation in 1977. What did he suggest and why?

[3 marks]

3.

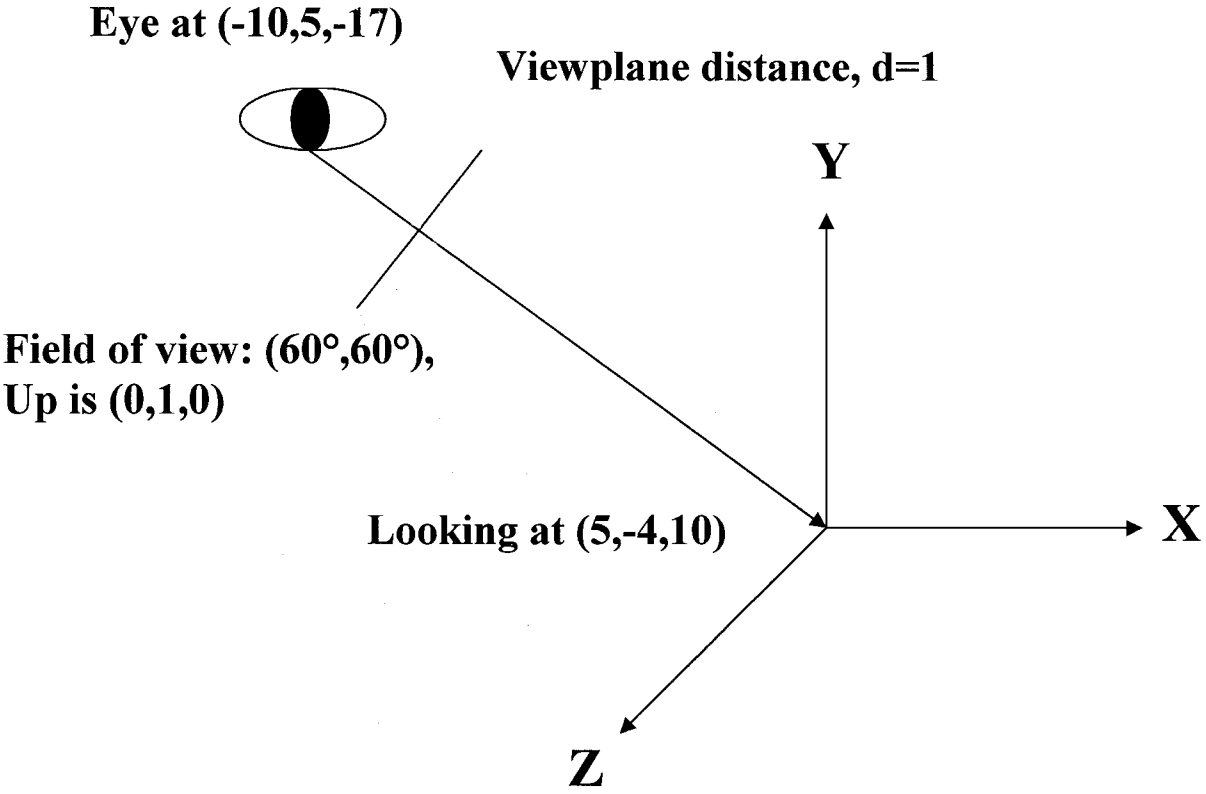
a) Quote three visual phenomena that global illumination can produce but local illumination cannot. **[3 marks]**

b) Outline an algorithm to find the intersection between a ray and a plane. **[8 marks]**

c) We wish to ray-trace an image of size 200x200 pixels, using the setup below. Construct the following:

- The gaze vector
- The camera coordinate system
- The viewport origin
- The viewport coordinate system

Next, find the point P in the scene that corresponds to pixel (178, 43), and thus construct the ray that goes through the centre of this pixel. **[14 marks]**



4.

a) Explain what are *linearly independent vectors* and why they are important in computer graphics. Explain what *basis vectors* are. Are the following three vectors linearly independent? Would they be good basis vectors?

(1,0,1),

(0,0,1),

(0,1,0)

[7 marks]

b) Explain how transformations can be composed and give the 4x4 homogenous matrix for a:

- Translation by (2,4,6)
- Scaling by a factor of 7
- A 45 degree rotation about the Y axis

[8 marks]

c) What is the difference between parallel and perspective projections? Describe an application where each type of projection would be preferable. How would you create parallel and perspective projections in OpenGL (specify code examples). **[10 marks]**

5.

a) What is meant by *multi-phase* collision detection?

[3 marks]

b) In which order do the following terms appear in the graphics pipeline? Explain each term in relation to the pipeline.

- lighting
- 3D camera coordinates
- modelling transformation
- 3d object coordinates
- scan conversion
- 2D screen coordinates
- 3D world coordinates
- projection transformation
- viewing transformations
- clipping

[10 marks]

b) Describe how you would implement a hierarchical model in OpenGL. **[12 marks]**

6.

a) Bézier curves are widely used in computer graphics to model smooth curves. Give the definition of the cubic Bezier curve and derive the conditions necessary to ensure that two cubic Bezier curves join with C1-continuity.

[6 marks]

a) Discuss the following principles with respect to computer animation. In each case, describe an example where you might use them:

- Exaggeration
- Follow through
- Secondary action
- Slow in and slow out
- Staging

[10 marks]

b) Why are Ordinary Differential Equations (ODEs) important in Computer Animation? Outline the ways they are used to describe motion and how they are typically solved in practice. **[9 marks]**