UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2013

COMPUTING AND INFORMATION SYSTEMS

IS53032A Advanced Graphics and Animation

Duration: 2 hours 15 minutes

There are five questions in this paper. You should answer no more than THREE questions. Full marks will be awarded for complete answers to a total of THREE questions. Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [.] *brackets.*

There are 75 marks available on this paper.

No calculators should be used.

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Question 1 Transformations and projections

(a) Explain what is meant by the term *viewing coordinates*. [3]

(b) Explain the difference between position and displacement vectors. Give an example for each. [4]

(c) Describe how, using vectors, you would create an object that moves towards you at a constant speed. [6]

(d) Consider the following classes of elementary 3D transformations:

scale(sx, sy, sz)

rotate-x(θ) – rotate about x axis counterclockwise by θ

rotate-y(θ)

rotate-z(θ)

translate(t_x , t_y , t_z)

Each of the following sequences of transformations happens to reduce to a single transformation from one of these classes. Find the equivalent elementary transformation for each sequence.

i. scale(2, 1, 1), then scale(1, 3, 4) [3]

ii. scale(2, 1, 1), then rotate-y(90°), then scale(3, 1, 1), then rotate-y(-90°) [3]

iii. rotate-x(90°), then rotate-y(90°), then rotate-z(90°) [3]

iv. rotate-z(90°), then translate(1, 0, 0), then rotate-z(-90°) [3]

Question 2 Rasterization

(a) In the graphics pipeline, when a triangle is processed, the (x,y,z) coordinates of the vertices are interpolated across the whole triangle to give the coordinates of each fragment. Name two other things that may commonly be specified at the vertices and then interpolated across the triangle to give a value for each fragment. [2]

(b) What is a depth buffer and how it is used in hidden surface removal? [5]

(c) Sketch a configuration of triangles for which the painter's algorithm fails. How can it be fixed? [6]

(d) Indicate why 3D clipping is needed in a practical renderer. Why is this especially important for video games? [6]

(e) Discuss the reasons for any visual differences between Gouraud shading and per-pixel Phong shading. [6]

Question 3 Rendering

(a) Why is it difficult to correctly model the illumination of materials like skin and marble? [3]

(b) Describe the process of image-based lighting. [6]

(c) Describe the differences between between real-time graphics and offline (photorealistic) computer graphics. In this context, also explain why graphics hardware, e.g. graphics cards, are useful for computer graphics. [6]

(d) The Phong model for specular reflection consists of an ambient, a diffuse and a specular component. Explain the purpose of Phong's model, what each of the three components are, and what real effect each is trying to model. [10]

Question 4 Textures

(a) What is a *texel*? [2]

(b) What shapes are the following texture coordinate functions being projected onto? [3]

i. $u = \text{atan2}(x, z)$; $v = y$

ii. $u = x; v = y$

iii. $u = \text{atan2}(x, z)$; $v = \text{atan2}(y, \sqrt{x2 + z2}\ )$

(c) There are several techniques that can be used to make surfaces look more realistic.

i. Describe the technique of bump mapping. [5]

ii. How is it performed? [5]

iii. How does bump mapping differ from displacement mapping? [3]

(d) Describe the process of environment mapping. Use diagrams where appropriate. [7]

Question 5 Post-processing and display

(a) What is gamma correction and what is its purpose? [4]

(b) Explain the process of creating a photographic high dynamic range (HDR) image. [3]

(c) Describe three existing HDR image formats and state a strength and weakness for each. [6]

(d) Why is a linear scaling not sufficient to compress an HDR image? [3]

(e) Give an overview of the concept of tone mapping. [3]

(f) Explain the difference between global and local tone mapping operators. [6]