

CARDIFF UNIVERSITY EXAMINATION PAPER

Academic Year:	2009/2010
Examination Period:	Autumn
Examination Paper Number:	CM0304
Examination Paper Title:	Graphics
Duration:	2 hours

Do not turn this page over until instructed to do so by the Senior Invigilator.

Structure of Examination Paper:

There are 3 pages.

There are 4 questions in total.

There are no appendices.

The maximum mark for the examination paper is 75 and the mark obtainable for a question or part of a question is shown in brackets alongside the question.

Students to be provided with:

The following items of stationery are to be provided:

ONE answer book.

Instructions to Students:

Answer THREE questions.

The use of a translation dictionary between English or Welsh and another language, provided that it bears an appropriate school stamp, is permitted in this examination.

1. Illumination

- (a) Using Phong's illumination model, we wish to render a scene containing a single directional light source with direction d , which emits monochromatic light. For the ambient, diffuse and specular light components, explain in detail how to compute the intensity of the light observed by a viewer at position v , which is reflected at a point p on a surface with normal n , $\|n\| = 1$. You may assume that the light emitted by the light source is not attenuated.

[10]

- (b) Describe the differences between Gouraud shading and Phong shading. What are the advantages and disadvantages of Phong shading compared to Gouraud shading?

[9]

- (c) Consider a flat surface with tiny parallel scratches across the surface in direction t . It is lit from a directional light source with direction d . The intensity of specular light reflected by this surface depends on the angle between d and t : it is maximal if d is orthogonal to t and minimal if d is parallel to t . Why is Phong's illumination model insufficient to render such surfaces with one polygon? Suggest a modification of the illumination model to handle such surfaces.

[6]

Total: [25]

2. Spatial Data Structures

- (a) Describe (i) an octree and (ii) a k D-tree data structure, for a set of 3D points. Discuss the differences between these data structures and indicate for which types of point sets each data structure is more suitable.

[9]

- (b) Outline how a k D-tree can be constructed for a set of flat, simple, convex polygons in 3D. Describe all necessary operations (there is no need to give any mathematical equations).

[8]

- (c) Let T be a k D-tree of a 3D point set $P = \{p_1, p_2, \dots, p_n\}$. Devise an efficient algorithm which uses T to find a point in P closest to a given point $q \in \mathbb{R}^3$.

[8]

Total: [25]

3. Polygons

- (a) What does it mean for a polygon to be simple, flat and convex? Devise a simple data structure to represent such a polygon and explain how this representation can be used to distinguish between the polygon's front and back when viewed in 3D.

[8]

- (b) Let P be a 3D OpenGL polygon primitive with n consecutive vertices v_0, v_1, \dots, v_{n-1} . Describe in detail the mathematical steps needed to determine whether a viewer at position p sees the front or the back of the polygon (or is looking at the polygon edge on) using the convention from question 3(a).

[9]

- (c) Devise a method to clip a line through the points p_1 and p_2 against a simple polygon given by n consecutive vertices w_0, w_1, \dots, w_{n-1} in 2D. You may assume that none of the polygon's vertices lie on the line. Outline all necessary equations.

[8]

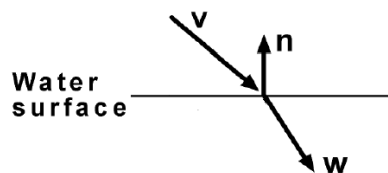
Total: [25]

4. Ray Tracing

- (a) Describe a basic ray tracing algorithm which handles reflections and transparency. There is no need to provide any mathematical formulae, but clearly state what has to be computed.

[12]

- (b) A light vector v passing from air into water is refracted on the water surface (see figure below). Given v , and the *unit* normal n of the water surface, compute the resulting vector w . Assume that the projections of v and w onto n have the same length and that the projection of w onto the water surface has half the length of the projection of v onto the surface.



[6]

- (c) An extended light source is a light source which emits light from a surface, e.g. a sphere, rather than from a single point. With the help of a simple diagram explain how extended light sources create soft shadows. Briefly describe how you might extend the basic ray tracing algorithm to handle extended light sources to give soft shadows.

[7]

Total: [25]