The University of Calgary

Department of Computer Science

Final Examination, December 1999

ENEL/CPSC 555 Computer Graphics

Time: 2 Hours

Instructions: Answer any four questions. Open Book, Calculators are permitted.

1 Question 1 (20%) Shading

1. A raft floats in the Indian ocean 600m off the coast of Africa at the Equator. On the raft is a shiny gold coin. A pirate stands on top of a 300m high cliff. Assuming it is mid-june, at what time of day will the Pirate see the gold coin. State any assumptions that you make and show all your working. (Hint) The pirate will only see the coin by its specular reflection.

2. In a simulation of the above example the Phong illumination model is used. Describe the visible difference between rendering the scene using Gouraud shading and Phong Shading.

3. A unit square lies in the $y = 0$ plane, the centre of the square is at the origin. A light source, is placed at a large distance along the positive x-axis, and rotated about the z-axis counter clockwise. Sketch a graph showing how the illumination at the centre of the square changes as the light source is rotated around the centre of the square by 2π radians.

2 Question 2 (20%) Ray Tracing

1. A three units long cylinder, radius 0.5 is modelled with its long axis aligned with the y-axis, and the x and z-axes intersect the cylinder half way up its long axis. It is transformed into the world space by rotating it by $pi/4$ radians around the z-axis, and translating it to the point $(1, 1, 5)$. A ray is fired from the origin in the direction $(0.138675, 0.138675, 0.980581)$.

   In pseudo-code, describe an algorithm for finding the ray cylinder intersection. Write down any transformation matrices that you use. How general is your algorithm?

3 Question 3 (20%) Implicit Modelling

1. Two sphere primitives, A and B are defined by skeletal points whose field contributions falls to zero at distances 2 and 3 respectively. The two spheres are placed with their centres at a distance 3 units apart. Make a 2D sketch showing the plane through the centre of the two spheres. Sketch the 0.5 contour and the 0.0 contour using the field function: $F(r) = (1 - r^2)^2$

2. Explain the ambiguity in the polygonization of cubic voxels defined in the uniform space subdivison algorithm (given in the notes), when diagonal vertices have the same sign and are oppositely signed to the other diaganols on the same face? What larger problem is indicated by this discrepency? How can the above problem be solved using tetrahedra? What are the advantages and disadvantages of using tetrahedra?

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4 Question 4 (20%) Rendering and Ray Tracing

1. How would you extend Warnocks algorithm to produce anti-aliased images?
2. Make brief notes comparing uniform space subdivision and bounding spheres as methods for speeding up ray tracing.
3. In a ray tracer using uniform space subdivision, a bug occurs so that objects are often clipped along vertical planes. What is a likely cause of the bug?
4. What is meant by a *ray signature*?
5. In a ray tracer, some objects have dark speckles in areas which should be bright. What is a likely cause of the bug?

5 Question 5 (20%) HCI

1. Why is it a good idea to involve the user directly with the design of a user interface?
2. Why can this be difficult?