The University of Calgary

Department of Computer Science

ENEL/CPSC 555 Computer Graphics

Final Exam December 1997 Time Allowed 2 hours. The exam is open book and calculators may be used.

Instructions: Attempt all the questions. The questions continue on the other side of the paper.

Question 1 (Ray Tracing 25%)

1. A ray, origin $E = (0, 0, 0)$ is fired in the direction of the unit vector $\mathbf{d} = (0.6, 0.8, 0)$ at a triangle, $(3, 0, -3)(3, 0, 3)(3, 3, 0)$ What is the point of intersection of the ray and the plane of the triangle? Is this point inside the triangle?

2. The ray origin E fired in the direction of the unit vector $\mathbf{v} = (0, 0.8, 0.6)$ is parallel to the triangle. What simple test can eliminate such a ray?

3. The SLOW-tracer uses 9 jittered rays per pixel but does not use space subdivision or a bounding box scheme to improve its performance. The scene to be traced contains 1000 randomly distributed spheres and the image size is 600 by 400 pixels. If ray tracing is stopped after the 3rd reflection or refraction (therefore count 1 primary ray, and 3 secondary rays) estimate how many rays will be fired to produce the final image. You may assume that any ray will have a 20% chance of hitting a sphere, 25% of the spheres are reflective or refractive and that there are two light sources.

Question 2 (Shading 25%)

1. A single triangle is rendered using Phong shading and the Phong light model. What conditions will make a specular highlight visible? Maximum?

2. The triangle, $(3, 0, -3)(3, 0, 3)(3, 3, 0)$ is rendered using the Phong light model and the normals are calculated from

3. The same triangle is rendered using Gouraud shading and the Phong light model under ideal conditions to obtain a specular highlight. Is it visible? If not, why not?

Question 3 (Implicit Modelling 25%)

1. Two point (sphere) primitives $A and B$ are placed 2.5 units apart. The zero contours of the primitives are at distances of $R_A = 1$ and $R_B = 2$. The field function used is the cubic (also known as the *Geoff function*) given in the notes. Sketch a diagram showing a slice through the field which shows the zero contour and the 0.5 of the spheres taken independently as if they do not influence each other. Also show the two contours of the combined model.

Question 4 (Short Answer 25%)

1. What does the term *ray signature* refer to?

2. A sphere is rendered with the standard shading equation given in the notes. A single light source is used to illuminate the scene yet a bright diffuse reflection is seen on both the side of the sphere toward the light source and the side which faces away from the source. What is the most likely cause of this problem in the implementation of the shading equation?

3. Explain what is meant by Phong Shading.

4. Explain what is meant by the Phong Light model?

5. In a shading model the intensity at some point P is made inversly proportional to the square of the distance from the light source to P.