6.837 Introduction to Computer Graphics
Quiz 1: Ray Tracing
Tuesday October 7, 2003 2:40-4pm
One hand-written sheet allowed
Total is 50 points

Name:

1 Ray Tracing [/14]

1.1 Complexity [/3]

We want to render a scene of N objects with one single light source onto an image of M pixels (the image resolution is $\sqrt{M} * \sqrt{M}$). Any object can be reflective and refractive, but we enforce a maximum recursion depth of K.

What is the worst-case complexity of ray tracing for the total image?

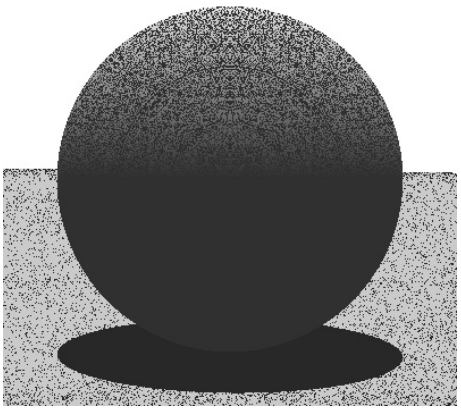
1.2 Light sources [/2]

How is this complexity changed when we have L light sources?

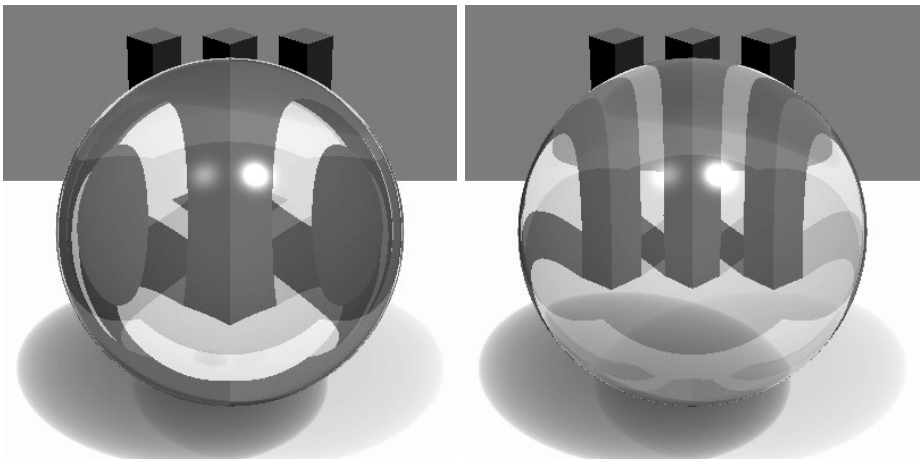
1.3 Forward ray tracing [/3]

Give a 1-to-2-sentence explanation of why forward ray tracing is not directly practical.

1.4 What is the bug that caused the artifacts in this image? [/3]



1.5 Which sphere has the bigger index of refraction? [/3]



2 Transformations [/6]

2.1 Matrix form [/3]

What is the 4×4 matrix in homogeneous coordinate form corresponding to a 3D translation by (a, b, c)?

2.2 Normal transform [/3]

In a ray tracer, when an object is transformed by a linear transformation described by matrix M, how must we transform the surface normal after ray intersection? Give both a one- or two-sentence explanation and a formula.

3 Local shading [/8]

3.1 Coefficients [/3]

Describe what the image will look like if the scene contains no real light source but the ambient light color is (1,1,1).

3.2 Give a one-sentence description of the Fresnel effect. [/3]

3.3 Dimensionality of BRDFs [/2]

How many dimensions does an anisotropic BRDF have?

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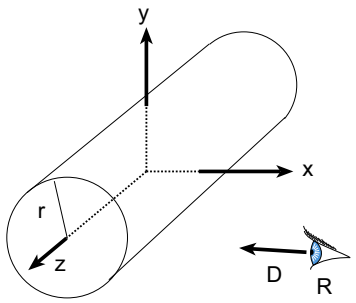
4 Ray-Cylinder Intersection [/22]



4.1 Implicit cylinder [/2]

Give the implicit equation for an infinite cylinder centered on the z axis and with radius r.

4.2 Explicit ray [/2]

Give the explicit (parametric) equation for a ray with origin **R** and direction **D**.

4.3 Ray-cylinder intersection equation [/4]

Write the quadratic equation for the intersection of a ray with an infinite cylinder centered on the z axis. Solve your equation for t.

4.4 Ray-cylinder intersection pseudo code [/8]

Using the result from the previous question, write the pseudocode for the intersection method
`bool Cylinder::intersect(const Ray &r, Hit &h, float tmin);`
Don't forget to compute the surface normal, but don't worry about the material.

4.5 General cylinder [/3]

In your ray tracer, without writing additional code, how would you use the code from question 4.4 to render arbitrary infinite cylinders (arbitrary position and arbitrary orientation)?

4.6 Non-infinite cylinders [/3]

How would you modify the code from question 4.4 to render non-infinite cylinders. That is, the cylinder only goes from z_1 to z_2. You do not need to render the caps of the cylinder. You can assume that $z_2 \geq z_1$.