Written Assignment #3
Ray Tracing
15-462 Computer Graphics, Fall 2004

DUE: Tuesday, November 4, just before class

NOTE: If you want to use late days on the homework, please let me know 24 hours in advance and I will hold off on going through solutions. **Otherwise late homeworks will not be accepted.**

The work must be your own. Please use any resources available to you (the book, the web, etc.), but write up the answers in your own words, explaining all of the steps. Also please cite any external references you use (other than the textbook) to come up with your answers.

Total: 40 points

1. **(10 points) Ray-sphere intersection.** Assume an eye point of (1, 1, 1), a pixel location at (-1, -1, -1), and a sphere centered at the origin with radius 1. Compute the intersection point between the ray and the sphere. Include all of the following steps:
    a. Write an equation for the ray from the eye through the pixel location.
    b. Write an equation for the sphere.
    c. Use these equations to solve for the intersection point.

2. **(10 points) Ray-triangle intersection.** Assume an eye point of (1, 1, 1), a pixel location at (-1, -1, -1), and a triangle with vertices (1, 0, 0), (0, 1, 0), and (0, 0, 1). Compute the intersection between the ray and the triangle. Include all of the following steps:
    a. Write an equation for the ray from the eye through the pixel location.
    b. Write an equation for the plane containing the triangle.
    c. Use these equations to solve for the ray-plane intersection point.
    d. Compute the barycentric coordinates of that intersection point using one of the general techniques described in the book and lectures (e.g., using the ratio of areas or the implicit equations for lines).

3. **(5 points) Attenuation.** In lecture 12, we saw the following equation for lighting with attenuation:

$$I = k_a I_a + k_d (l \bullet n) \frac{I_d}{(a + br + cr^2)} + k_s (r \bullet v)^\alpha \frac{I_s}{(a + br + cr^2)}$$

The ray tracing equation without attenuation is:

$$I = k_a I_a + k_d (l \bullet n) I_d + k_s (r \bullet v)^\alpha I_s + k_r I_r + k_t I_t$$

Work out how to add attenuation properly to this equation. Start by drawing a diagram of all the rays, because it is trickier than it looks at first glance to get this right!

4. **(15 points) Ray tracing vs. Phong illumination**. For each of the following effects,
    a. Describe how it is achieved in the Phong illumination model discussed in the first half of the course (the model supported by OpenGL).
    b. Describe how it is achieved using the ray tracing model we are now discussing in class.
    c. Compare the two approaches. For example, if the ray tracing approach is more accurate, state that this is true and explain why.

        i. Phong shading (i.e., shading using normal interpolation)
        ii. Shadows
        iii. Reflections (e.g., a mirror or reflective ball)
        iv. Translucency
        v. Hidden surface removal