Fall 2005 Written Assignment 1
CS 4160 - Computer Graphics
Columbia University

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Instructions:
Read each question carefully.
State all assumptions and show all work to get partial credit.
Include your answers on a separate sheet.
Attach all additional scratch paper.

Question	Points	Score
1 Reflection Models	12	
2 Basic Illumination	18	
Total	30	

1. Reflection Models

OpenGL implements two basic reflection models, Lambertian and Phong. We ask for a brief description for each of these (in general terms, not necessarily specific to OpenGL).

a. What is the Diffuse or Lambertian reflection model? Briefly state the assumptions and give a formula for the reflected light in terms of the Lighting direction L, surface normal N and viewing direction V? What is an example of a surface that is (approximately) Lambertian? (4 points)

b. What is the Phong reflection or illumination model? Similarly, state the assumptions and give a formula for the reflected light in terms of L, N and V. What is a surface that is (approximately) Phong? (4 points)

c. The Phong reflection model was introduced in two ways, using either the reflected direction or the half-angle direction (Blinn-Phong). Explain the differences between these briefly and give the formula for the other version, besides what you described in part b. Which version does OpenGL implement? (4 points)

2. Basic Illumination Concepts

a. Define the terms Radiance, Irradiance and BRDF, and give the units for each. (3 points)

b. Write down the local reflectance equation, i.e. express the net reflected radiance in a given direction as an integral over the incident illumination. Prominently label the main terms of the equation such as the BRDF. (4 points)

c. Now, consider a Lambertian surface with albedo 1 (this means the energy of the reflected light is the same as that of the incident light). What is the BRDF of the surface? (3 points)

d. Use your answers from parts b and c to answer the following question, by explicitly doing an integral for the reflected light. If the radiance from every point in the upper hemisphere is $1\frac{W}{m^2 sr}$, what is the reflected radiance from this Lambertian surface of albedo 1? Does your answer agree with intuition? (4 points)

e. Now, consider the same question, where the upper hemisphere has an incident radiance of $1\frac{W}{m^2 sr}$. However, the surface is now a Phong material, with a Phong exponent (or shininess) s. Use the reflected direction (not half-angle) form of the Phong model. What is the reflected radiance, for viewing the surface from head-on (that is, along the normal direction). Use proper units in your answer (4 points)