Fall 2008 Written Assignment 1
CS 4160 - Computer Graphics
Columbia University

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Instructions:
You need to do the assignment individually
There are two questions.
You may use any notes, slides or printed materials.
State all assumptions and show all work to get partial credit.

1. OpenGL Illumination and Shading

OpenGL implements a number of basic shading models. This question asks about some of the key components.

(a) What is the Lambertian or Diffuse Illumination Model? What is the version/formula that OpenGL implements? Is the shading computed at vertices or pixels?

(b) What is the Phong Illumination Model? What is the version/formula that OpenGL implements? Is the shading computed at vertices or pixels?

(c) There are 3 basic shading modes in OpenGL: Flat Shading, Gouraud Shading and Phong Shading. Briefly explain these and the differences between them. In particular, please explain the differences of Gouraud and Phong shading and the advantages and disadvantages of each.

(d) Which of the 3 shading modes does basic OpenGL implement and why?

(e) Which of the 3 shading modes can be implemented with modern programmable shaders and how?

2. Basic illumination and radiometry concepts

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

(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.

(c) If the radiance from every point in the upper hemisphere is $1\frac{W}{m^2\ \text{sr}}$, what is the irradiance at a point? (use correct units)

(d) 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?

(e) In part (d), what is the reflected radiance if the incident radiance is as in question c, i.e. $1\frac{W}{m^2\ \text{sr}}$ from every point in the upper hemisphere. Does your answer agree with intuition?

(f) Finally, consider the same question, where the upper hemisphere has an incident radiance of $1\frac{W}{m^2\ \text{sr}}$. 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.