Computer Graphics Ph.D. Qualifying Exam, March 2015

1. (20%) (a) The Phong illumination model can be summarized by the following equation:

$$I = k_e + k_a I_a + \sum_i \left[I_{l_i} \left(k_d (\mathbf{N} \cdot \mathbf{L}_i)_+ + k_s (\mathbf{V} \cdot \mathbf{R}_i)_+^{n_s} \right) \min \left(1, \frac{1}{a_0 + a_1 d_i + a_2 d_i^2} \right) \right]$$

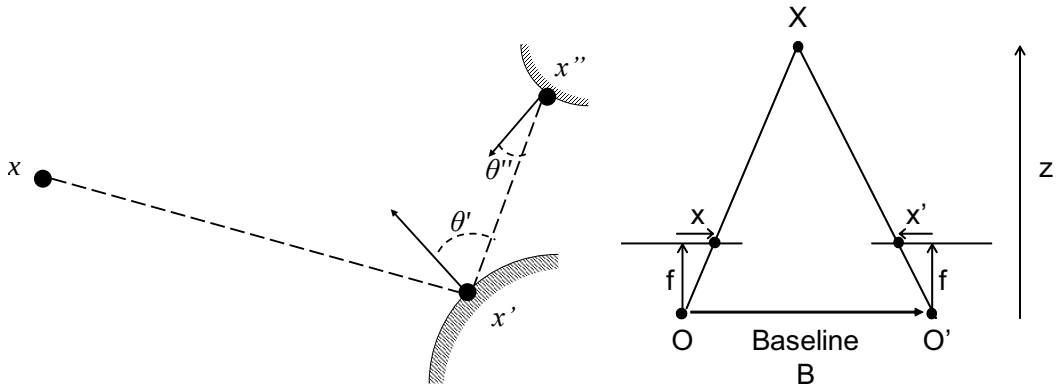
   Draw a diagram to explain the main variables in the above formulation. What effects do the terms of the above formulation intend to model? (b) Describe how to shade a triangle using flat shading, Gouraud shading and Phong shading. Discuss their visual differences.

2. (20%) What is the 4×4 transformation matrix that maps a point in the world coordinate system to the coordinate system whose origin is (o_0, o_1, o_2) and the three axes are (u_0, u_1, u_2), (v_0, v_1, v_2) and (w_0, w_1, w_2)?

3. (20%) Does the line formed by connecting the points $(1, 2, 3)$ and $(9, 12, 13)$ intersect with the plane $x = 5$? If so, what is the intersection?

4. (20%) Consider the following equation and diagram in Figure (a):

$$L(x, x') = \delta(x, x') \left[E(x, x') + \int_S \rho_{x'}(x, x'') L(x', x'') \frac{\cos(\theta') \cos(\theta'')}{\|x' - x''\|^2} dx'' \right]$$



(a) rendering equation (b) stereoscopic setup

   Explain what the terms $\delta(x, x')$, $E(x, x')$, S, $\rho_{x'}(x, x'')$, $\cos(\theta')$ and $\|x' - x''\|^2$ account for. What is the equation for?

5. (20%) (a) Virtual Reality becomes a hot topic again recently as VR headsets, such as Oculus Rift and HTC Vive, hit the market. Explain how they provide stereoscopic perception to human. (10%) (b) Show that, in Figure (b), disparity $d = x - (-x')$ is proportional to the inverse of the depth Z. (10%)