Computer Graphics Ph.D. Qualifying Exam, March 2016

1. (20%) Given a coordinate system whose origin is $(3, -1, 2)$ and three axes are $(0, 1, 0)$, $(0, 0, -1)$ and $(-1, 0, 0)$ in the order, what is the matrix for transforming points from this coordinate system to the world coordinate system?

2. (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.

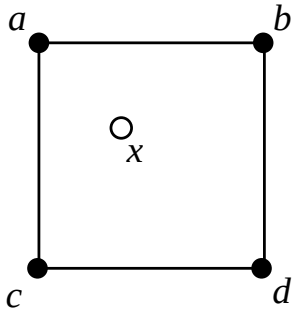
3. (20%) The above model does not account for shadows. Assume that V_{l_i} denotes the visibility to the i-th light source. (a) How to incorporate V_{l_i} into the above equation so that it accounts for shadows? (8%) (b) Describe a method for determine V_{l_i}. (12%)

4. (20%) Consider the square in Figure (a). The four corners a, b, c, d have coordinates $(0, 0)$, $(1, 0)$, $(0, 1)$ and $(1, 1)$. Assume that a, b, c, d hold values 3, 6, 9, 12 in the order. What is the value of x with coordinate $(1/3, 1/3)$ using bilinear interpolation?

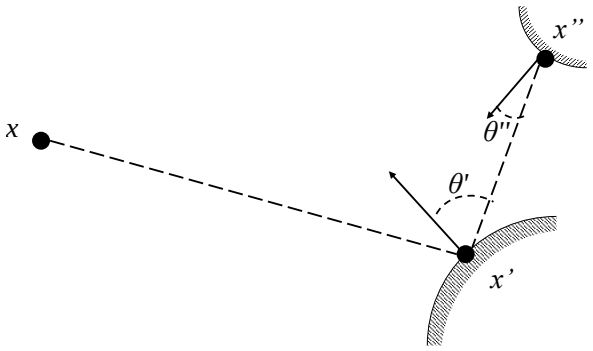
5. (20%) Consider the following equation and diagram in Figure (b):

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

   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?



(a) bilinear interpolation



(b) rendering equation