

Computer Graphics Ph.D. Qualifying Exam, September 2010

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

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

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. (30%) (a) Describe the rendering equation proposed by Kajiya in his classic SIGGRAPH 1986 paper. (12%) (b) Describe Whitted's ray tracing shading model. (12%) Describe the relationship between Whitted's ray tracing model and rendering equation? (6%)
3. (15%) (a) A mipmap is a data structure for texture map anti-aliasing. Explain how it works and estimate its memory consumption compared to the initial image alone. (10%) (b) Suggest another way for anti-aliasing. (5%)
4. (15%) A point \mathbf{p} on a surface has an associated unit normal \mathbf{n} , and tangent vectors \mathbf{t}_1 and \mathbf{t}_2 . If the surface is transformed by the matrix \mathbf{M} and the transformed point of \mathbf{p} is $\mathbf{M}\mathbf{p}$, what is the transformed normal vector? (Hint: by definition, the normal vector is orthogonal to tangent vectors. The transformed normal should maintain this property.)
5. (20%) (a) Avatar is a stereoscopic 3D film. Explain the main idea of displaying stereoscopic media on a flat screen. (10%) (b) Show that, in the following figure, disparity $d = x - (-x')$ is proportional to the inverse of the depth Z . (10%)

