

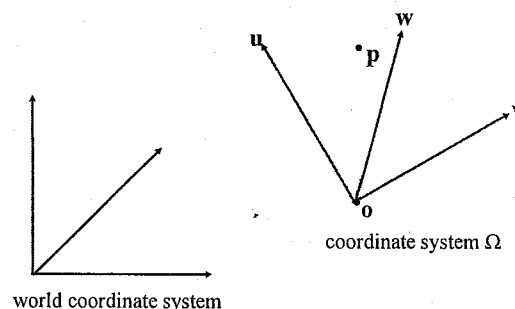
Computer Graphics Ph.D. Qualifying Exam, March 2012

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%) Given a point  $\mathbf{p}$  whose coordinate is  $(x, y, z)$  in the coordinate system  $\Omega$  defined by the origin  $\mathbf{o} = (o_x, o_y, o_z)$  and three axes  $\mathbf{v} = (v_x, v_y, v_z)$ ,  $\mathbf{u} = (u_x, u_y, u_z)$  and  $\mathbf{w} = (w_x, w_y, w_z)$ . Here,  $\mathbf{v}$ ,  $\mathbf{u}$  and  $\mathbf{w}$  are orthonormal vectors and play the roles of x-axis, y-axis and z-axis respectively. What is  $\mathbf{p}$ 's coordinate in the world coordinate system? You can write it in a matrix-vector form without expressing it out.



3. (20%) Consider a unit square. Assume that the texture coordinates are  $(u_{00}, v_{00})$ ,  $(u_{10}, v_{10})$ ,  $(u_{01}, v_{01})$ ,  $(u_{11}, v_{11})$  for its four vertices  $(0, 0)$ ,  $(1, 0)$ ,  $(0, 1)$ ,  $(1, 1)$ . Given a point  $(x, y)$  within the square, what is its texture coordinate using bilinear interpolation?
4. (20%) Given a ray with its origin  $\mathbf{o} = (o_x, o_y, o_z)$  and direction  $\mathbf{d} = (d_x, d_y, d_z)$ , what is its intersection with the plane  $y = y_0$ ?
5. (20%) Describe a method for accelerating ray scene intersection for ray tracing.