SOS Graphics Problems Week 5 Name(s) _SOLUTIONS

Hand these in Lab Week 5, or in Class Week 6; just do them paper and pencil….

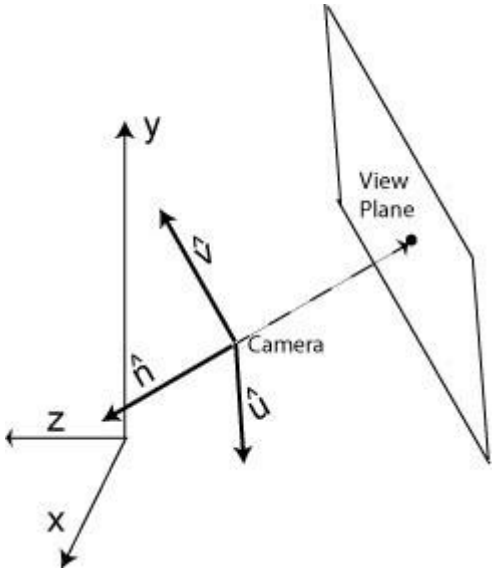
1) (12 pts) Ray Tracing: Suppose you are given:
   - VPN = a vector that points in a direction *opposite* the way the camera looks
   - VUP = the up direction vector

$u = VUP \times n \,/\, \| VUP \times n \|$ How does one calculate the normalized eye coordinate basis vectors: u , n (see picture). Assume you are using a right handed coordinate system as shown

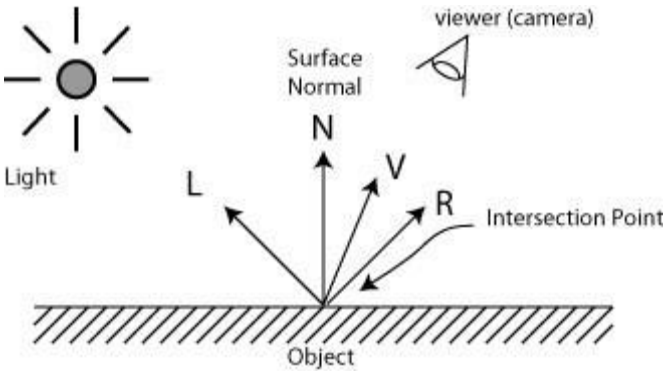
u = VUP x n / || VUP X n ||

v = n x u

n = VPN / ||VPN ||



2) Phong Lighting. Suppose you are given the parameters as shown in the picture: L (unit vector in direction of light), R (unit vector in direction of reflected light), N (unit normal), and V (unit vector in direction of viewer).
You are also given the reflection coefficients k_d and k_s, the specularity n, the surface color C_{surf} (which is the same for both diffuse and specular), and light color C_{Light}.



a) What is R in terms of L, N, and V? $R = 2 (N \cdot L) N - L$

b) What is the color contribution of diffuse light to the pixel color at the intersection point?

$$\text{Diffuse color} = k_d C_{surf} C_{Light} (N \cdot L)$$

c) What is the color contribution of specular light to the pixel color at the intersection point?

$$\text{specular color} = k_s C_{Light} (V \cdot R)^n$$

3) Rays

a) What is the parametric equation of a ray? Besides giving the formula, please explain in words what each of the terms in the formula represents. Include a picture.

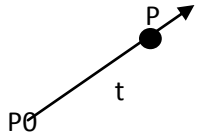
Points P on a ray must satisfy: $P = P_0 + t\ dir$

Where

P_0 = the starting point of the ray

dir = vector pointing along the ray direction

t = positive scalar parameter indicating the distance P is along the ray



b) Given an arbitrary point Q, explain (using words and equations) how you determine if Q is a point on the ray.

A point Q is on the ray if it satisfies the equation $Q = P_0 + t\ dir$ for some positive value of t.

Writing it another way, we have

$$(Q - P_0) - t\ dir = 0$$

This is a vector equation which says that dir must be parallel to $(Q - P_0)$.

There are several ways to check for this.

If we define $w = Q - P_0$, then we must satisfy:

$$(w_x - t\ dir_x,\ w_y - t\ dir_y,\ w_y - t\ dir_y) = (0,0,0)$$

Or, there must exist a <u>single</u> positive t such that

$$t = w_x / dir_x = w_y / dir_y = w_z / dir_z$$

If no such t exists, then Q is not on the ray.