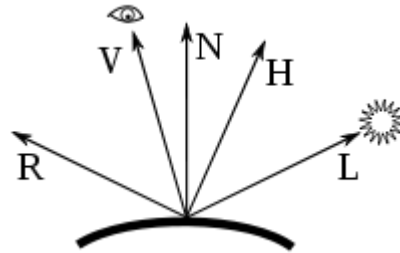


## Shading and the Phong Reflection Model



$$I_p = k_a i_a + \sum_{m \in \text{lights}} (k_d (\hat{L}_m \cdot \hat{N}) i_{m,d} + k_s (\hat{R}_m \cdot \hat{V})^\alpha i_{m,s})$$

This equation models the reflection of light from a specific point on a surface. All of the vectors used in the model are unit length vectors pointing outward from the point.

What does the N vector tell you?

What does the L vector tell you?

What does the V vector tell you?

What does the R vector tell you?

The H vector is the *halfway vector* between L and V. It is used in the Blinn-Phong reflection model...but not the Phong reflection model.

$I_p$  is the total illumination in three different wavelengths Red, Green, and Blue. The illumination in each wavelength, or channel, is described by a number in the range  $[0,1]$ . It is composed of a sum of three terms:

### The Ambient Term

The ambient term is a component-wise product of two RGB values  $k_a i_a$ . The value  $i_a$  is the incoming light to the surface and  $k_a$  describes how much light reflected.

What is the source of the light in this term?

What would we see if the incoming light was blue and the surface green?

## The Diffuse Term

The diffuse term is  $k_d(\hat{L}_m \cdot \hat{N})i_{m,d}$

What does the term  $\hat{L}_m \cdot \hat{N}$  measure?

Under what conditions is diffuse reflection strongest?

What kind of material does this term model?

## The Specular Term

The specular term is  $k_s(\hat{R}_m \cdot \hat{V})^\alpha i_{m,s}$

What does the term  $\hat{R}_m \cdot \hat{V}$  measure?

Under what conditions is specular reflection strongest?

What happens to specular highlights when the shininess exponent  $\alpha$  increases?

If you wanted a surface to look rougher, how would you change the values of the parameters in the specular term?

What kind of material does the specular term model?

## Open Questions

How could you change the equation so that the model includes attenuation (the reduction in illumination as the distance to the light increases)?

Suppose you had a scene with no specular surfaces...and no moving lights. How could you use pre-processing to achieve a higher frame-rate?

Why is modeling 3 wavelengths sufficient to produce realistic images?