Phong Lighting Model

Lighting components:

Surface parameters:

Diffuse color: $K_d = (K_d^R, K_d^G, K_d^B)$ fraction of light reflected diffusely

Specular color: $K_s = (K_s^R, K_s^G, K_s^B)$ fraction of light reflected diffusely

α = shininess (0,1: very rough, 10..20: mid smooth, 100..200: very shiny)

Light parameters:

Ambient light color and brightness: $I_a = (I_a^R, I_a^G, I_a^B)$

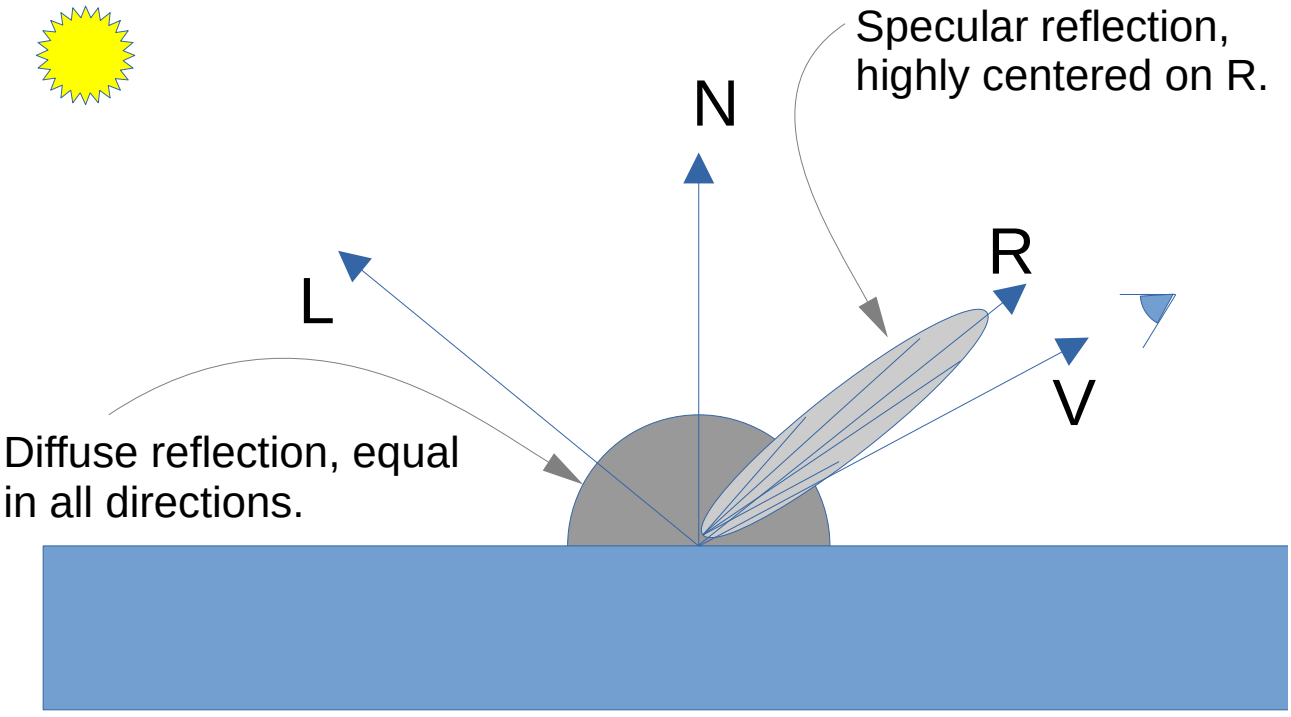
Light I color and brightness: $I_i = (I_i^R, I_i^G, I_i^B)$

Geometry parameters (all normalized to unit length):

Vector towards light: L_i

Normal of surface: N

Direction toward eye: V



Ambient calculation

Light from all directions scattered equally in all directions

$I_a K_a$ which means

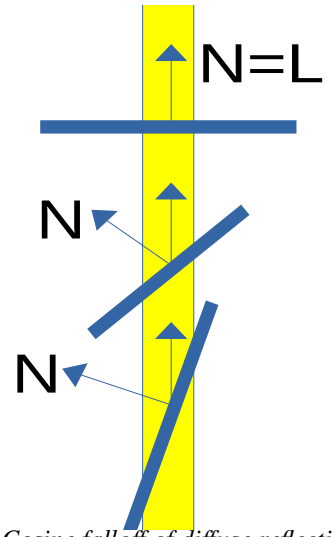
$(I_a^R, I_a^G, I_a^B)(K_a^R, K_a^G, K_a^B) = (I_a^R K_a^R,\ I_a^G K_a^G,\ I_a^B K_a^B)$

Diffuse (sub-surface) calculation

Light from a direction L_i *scattered equally in all directions*

$I_i K_d (N \cdot L_i)_+$

where $(N \cdot L_i)_+$ means clamp negative values to zero: $max(0,\ N \cdot L_i)$



Cosine falloff of diffuse reflection

Specular (surface reflection) calculation

Light reflected mirror-like (or nearly) in a lobe around the reflection direction

$I_i K_s (V \cdot R_i)_+^{\alpha}$

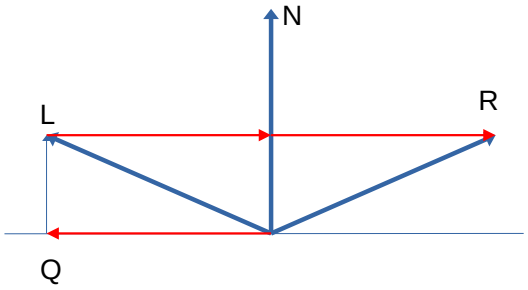
Computing R

Project L to Q to be perpendicular to N:

$$Q = L - \frac{L \cdot N}{N \cdot N} N = L - (L \cdot N) N$$

$$R = L - 2Q$$

$$R = 2(L \cdot N) N - L$$



Phong: Putting it all together

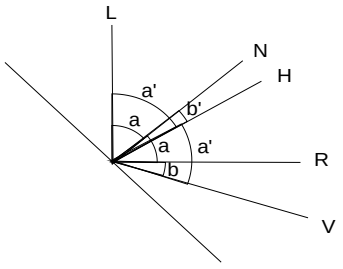
$$I_o = \overbrace{I_a K_a}^{\text{ambient}} + \overbrace{I_i K_d (N \cdot L_i)_+}^{\text{diffuse}} + \overbrace{I_i K_s (V \cdot R_i)_+^n}^{\text{specular}}$$

Blinn-Phong alternative to Phong

The halfway vector $H = (L_i + V) / \left\| L_i + V \right\|$

Use $H \cdot N$ rather than $R \cdot V$

Claim: $H \cdot N$ and $R \cdot V$ have similar behavior because $b' = b/2$



$$I_o = \overbrace{I_a K_a}^{\text{ambient}} + \overbrace{I_i K_d (N \cdot L_i)_+}^{\text{diffuse}} + \overbrace{I_i K_s (N \cdot H_i)_+^n}^{\text{specular}}$$

Phong problems

$$I_o = I_a K_a + \sum_i I_i \left(K_d (N \cdot L_i)_+ + K_s (N \cdot H_I)_+^n \right)$$

Ambient:

Constant for all surfaces and directions.

Solution: None! We have no good solution for this (in low level real-time graphics).

Diffuse:

Diffuse is far too bright! Diffuse reflection is spread over a whole hemisphere – the eye sees only some of it.

Solution: K_d / π

Specular:

K_s is constant

Solution: Any of several micro-facet lighting models.