Rendering

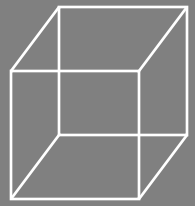
Illumination Model

Wireframe rendering

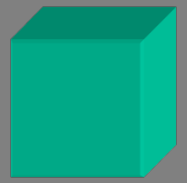
simple, ambiguous

Color filling

flat without any
3D information



Requires modeling interaction of light with the object/surface to have a different color (shade) in 3D



Rendering

Illumination Model

Light on a surface is
- Absorbed
- Reflected
- Transmitted

The amount reflected determines the color and brightness of the object

light material (surface) interaction

Rendering

Illumination Model

The reflected light is scattered depending upon the surface properties and incident light

Ambient light comes from all directions, is scattered in all directions

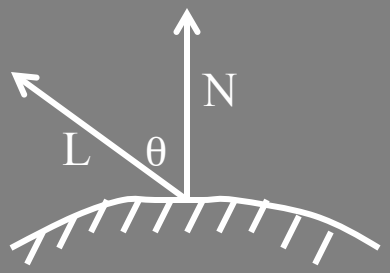
Diffuse light comes from one direction and is scattered in all directions

Specular light comes from one direction and is scattered in preferred direction

Rendering

Illumination Model

Diffuse Reflection



Lambert's Law

$$I_{diffuse} \alpha \cos\theta$$
$$I_d = k_d I_l \cos\theta$$
$$I_d = k_d I_l (L \bullet N)$$

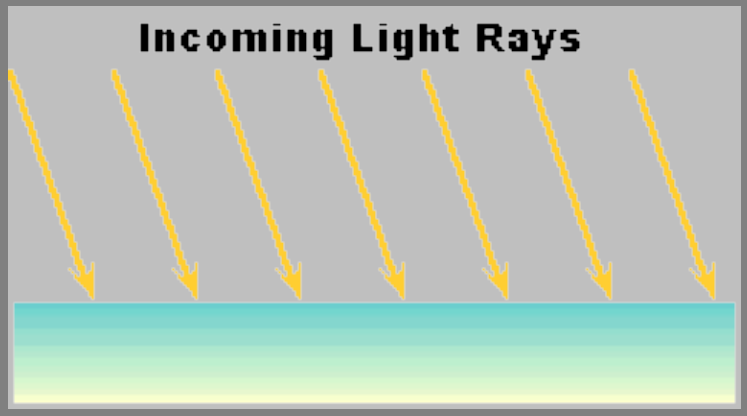
L: Light vector
N: Normal
θ: Angle between L and n

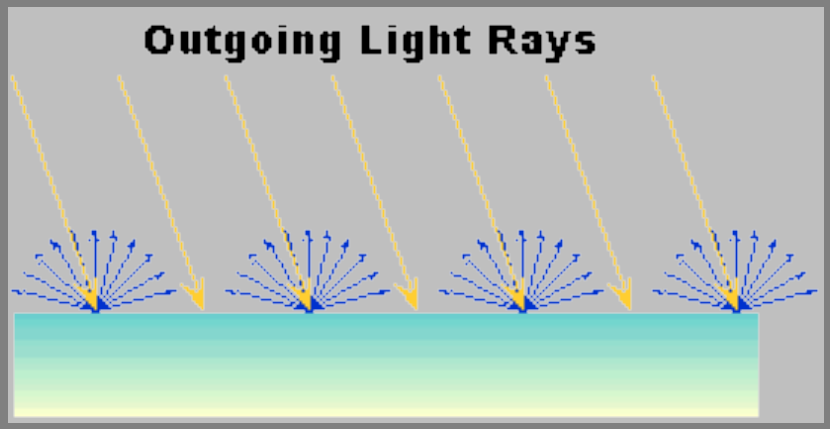
k_d diffuse reflection coefficient

Rendering

Illumination Model

Diffuse Reflection

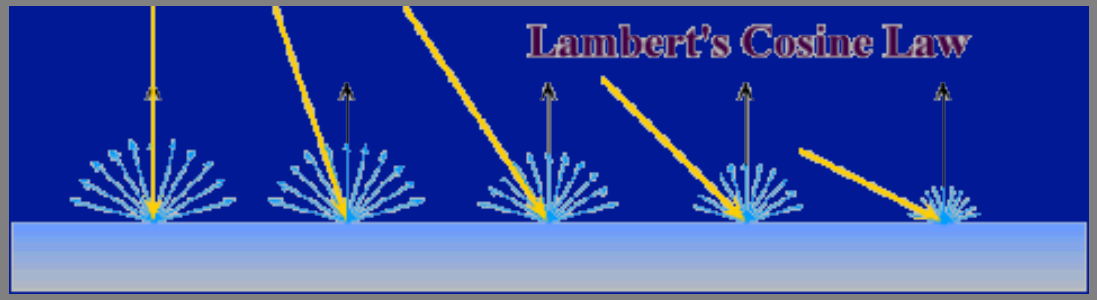


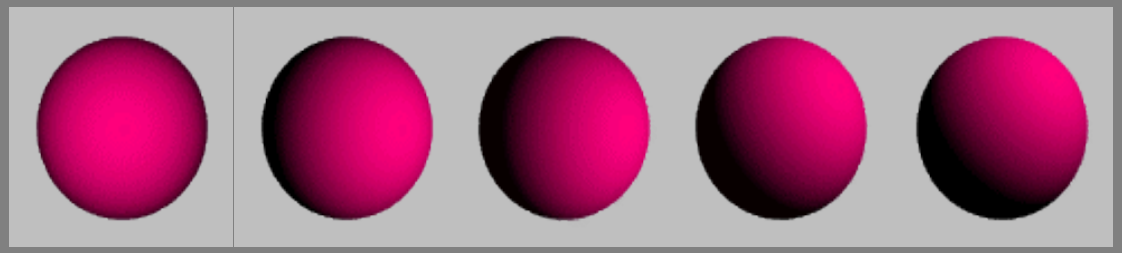


Rendering

Illumination Model

Diffuse Reflection





Rendering

Illumination Model

Diffuse Reflection

Amount of light reflected depends on the direction to the light source and not on the direction to the viewer

Viewer independent

Distance from light source *q* can also be incorporated

$$I_d = k_d I_l (L \bullet N)$$

$$= \frac{k_d}{a + bq + cq^2} I_l (L \bullet N)$$

Rendering

Illumination Model

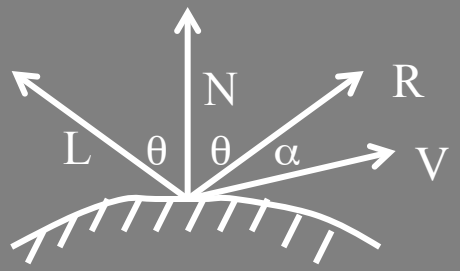
Specular Reflection

- Highlights / Shininess
- Viewing Direction

Rendering

Illumination Model

Specular Reflection



L: Light vector
N: Normal
θ: Angle between L and N
α: Angle between R and V

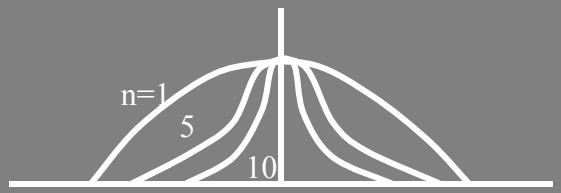
$$I_s = k_s I_l \cos^n \alpha$$
$$I_s = k_s I_l (R \bullet V)^n$$

k_s specular reflection coefficient
n specular reflection exponent

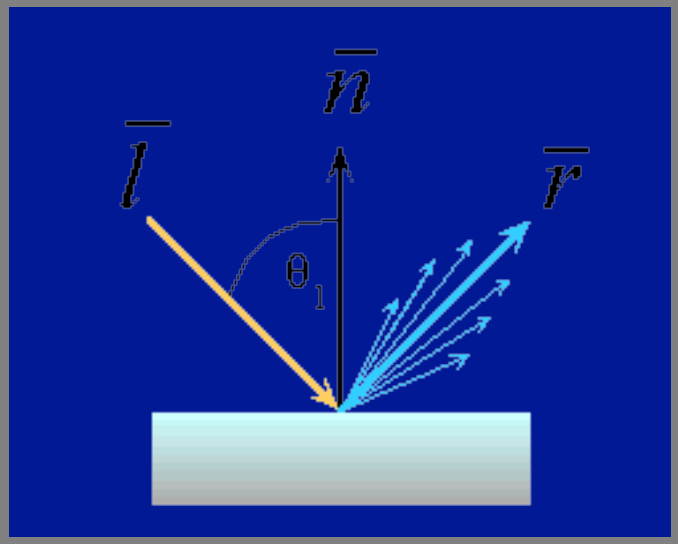
Rendering

Illumination Model

Specular Reflection



large n: metals
small n: paper

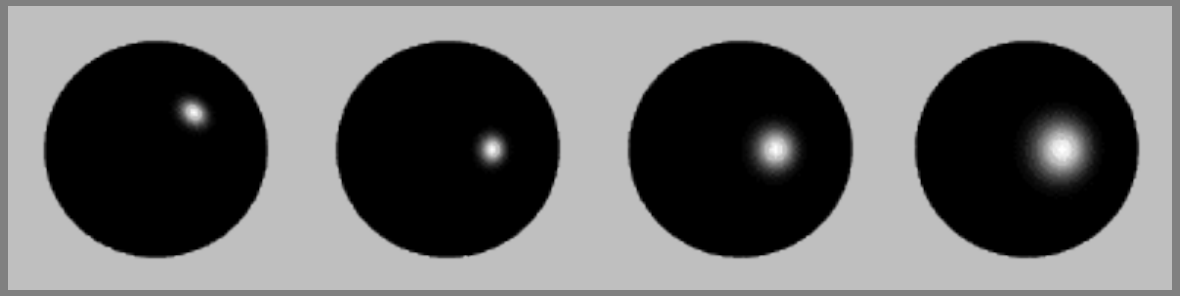


Rendering

Illumination Model

Specular Reflection

Example



Rendering

Illumination Model

Ambient Reflection

Light from distributed light sources (and surroundings)

Also approximates effects of diffusely reflected light from outer bodies / objects.

$$I_{ambient} = k_a I_a$$

k_a ambient reflection coefficient
I_a ambient incident light

Rendering

Illumination Model

Phong Illumination Model

$$
\begin{aligned}
I_{total} &= \textit{ambient reflection} + \textit{diffeuse reflection} + \textit{specular reflection} \\
&= k_a I_a + k_d I_l \cos\theta + k_s I_l \cos^n \alpha \\
&= k_a I_a + k_d I_l (L \bullet N) + k_s I_l (R \bullet V)^n \\
&= k_a I_a + \sum_{i=1}^{m} k_d I_i (L_i \bullet N) + k_s I_i (R_i \bullet V)^n
\end{aligned}
$$

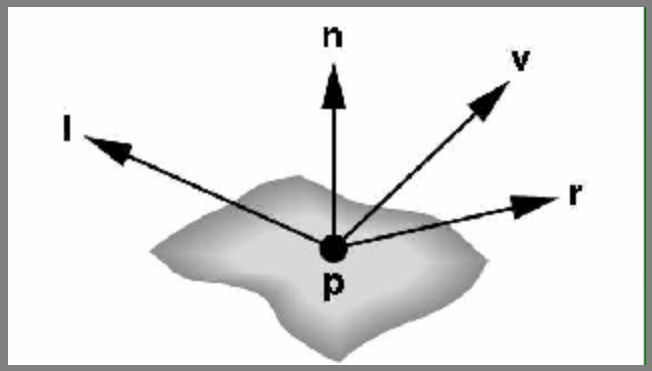
Rendering

Illumination Model

Phong Illumination Model

Local computation for obtaining color (intensity) at a point of the surface

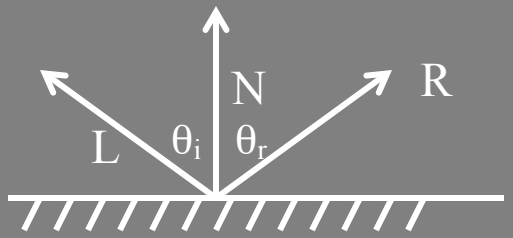
Basic inputs are light(s), material properties

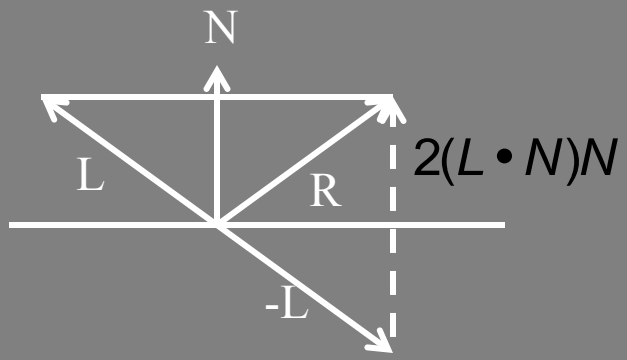


Rendering

Illumination Model

Reflection Vector



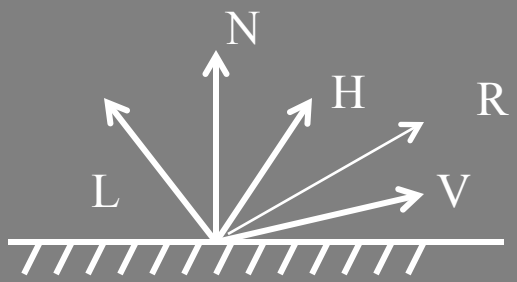


$$R = 2(L \bullet N)N - L$$

Rendering

Illumination Model

Half Way Vector



$$H = \frac{L + V}{|L + V|}$$

Can use $\mathrm{N} \cdot \mathrm{H}$ in place of $\mathrm{R} \cdot \mathrm{V}$

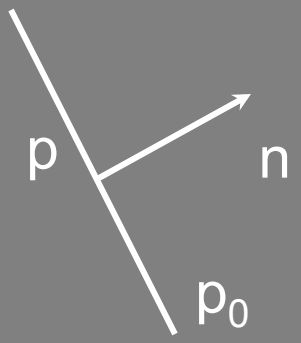
Rendering

Illumination Model

Normal Vector

Plane

$$ax + by + cz + d = 0$$



$$n \bullet (p - p_0) = 0$$

$$n = [a \;\; b \;\; c]$$

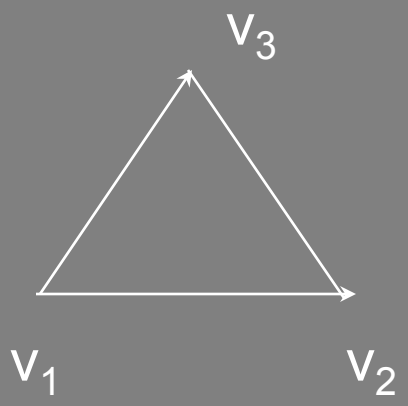
Normalize

Rendering

Illumination Model

Normal Vector

Plane



$$n = (v_3 - v_1) \times (v_2 - v_1)$$

Normalize

Rendering

Illumination Model

Normal Vector

Sphere

Implicit Equation

$$f(x,y,z) = x^2 + y^2 + z^2 - 1 = 0$$

$$n = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}\right]$$

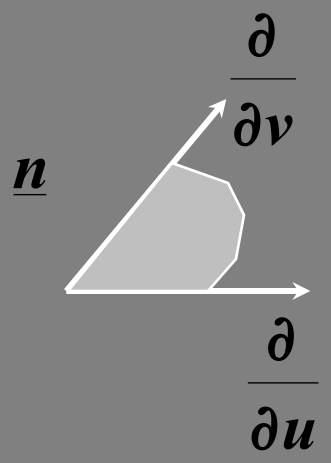
Rendering

Illumination Model

Normal Vector

Parametric Surface

$$\underline{n}(u,v) = \frac{\frac{\partial}{\partial u} b^{m,n}(u,v) \times \frac{\partial}{\partial v} b^{m,n}(u,v)}{\left| \frac{\partial}{\partial u} b^{m,n}(u,v) \times \frac{\partial}{\partial v} b^{m,n}(u,v) \right|}$$



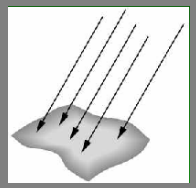
Rendering

Illumination Model

Light Sources

Point light source
- Given by a point
- Light emitted in all directions

Direction light source
- Given by a vector



Spotlight light
- Given by a cone