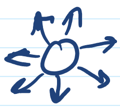
Color filling
flat without any 3D information.

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

Light Sources :-

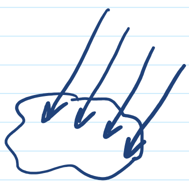
① Point light source



Given by a point
Light emitted in all directions

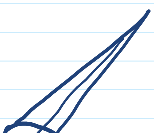
② Direction light source

Given by a vector.

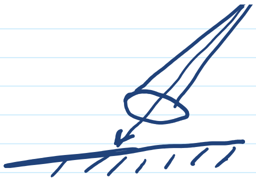


③ Spotlight Light

Given by a cone



Given by a cone



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

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

① **Ambient** light comes from all directions, is scattered in all directions.

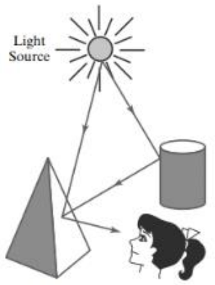


FIGURE 8
Surface lighting effects are produced by a combination of illumination from light sources and reflections from other surfaces.

② **Diffuse** light comes from one direction and is scattered in all directions.

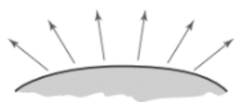


FIGURE 6
Diffuse reflections from a surface.

③ **Specular** light comes from one direction and is scattered in preferred direction.

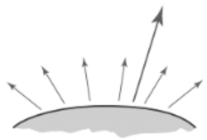
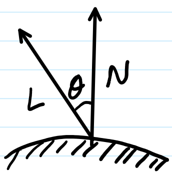


FIGURE 7
Specular reflection superimposed on diffuse reflection vectors.

Diffuse Reflection: —



L: Light vector

N: Normal Vector

θ: Angle between L and N

"Lambert's Cosine Law"

Amount of radiant energy coming from any small surface area in a direction θ relative to the surface normal is proportional to cos θ.

$$\boxed{I_{incident} \propto \cos\theta} \longrightarrow \text{Lambert's Cosine Law.}$$

$$I_{incident} = I_e \cos\theta \quad \text{— (1)}$$

where I_e is the intensity of the source

⇒ Diffuse reflection (I_d) with I_e as the intensity of source light,

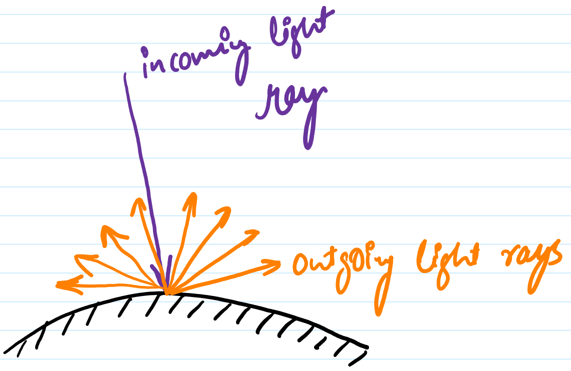
$$I_d = K_d I_{incident}$$

$$\boxed{I_d = k_d I_e \cos\theta}$$

k_d diffuse reflection coefficient.

$$I_d = \begin{cases} K_d I_e (L \cdot N), & \text{if } N \cdot L > 0 \\ 0, & \text{if } N \cdot L \leq 0 \end{cases}$$

⇒ A surface is illuminated by a point source only if the angle of incident is in the range 0° to 90°. When cos θ is negative, The light source is behind the surface.



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

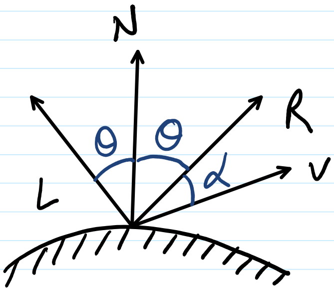
"Viewer independent"

Specular Reflection :—

⇒ Highlights /Shininess (polished metal, apple)

⇒ It is the result of total reflection of the incident light in a concentrated region around the specular reflection angle.

⇒ Depends on viewing direction



L: Light Vector

N: Normal Vector

R: vector in the direction of specular reflection

V: vector pointing to the viewer

θ: Angle between L and N

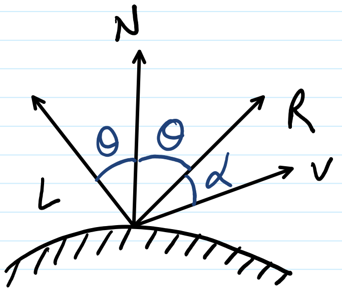
α: Angle between R and V

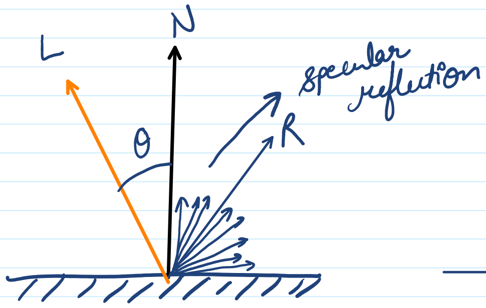
k_s: specular reflection coefficient

n: specular reflection exponent

$$\boxed{I_s = k_s I_e \cos^n \alpha}$$

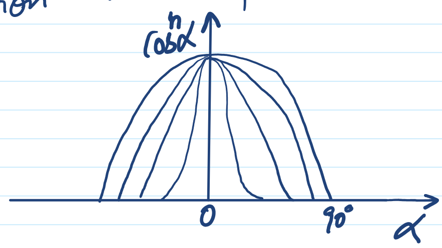
$$I_s = k_s I_e (R \cdot V)^n$$

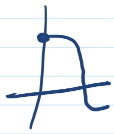




large n: metals (shiny)

small n: paper (dull / matt)





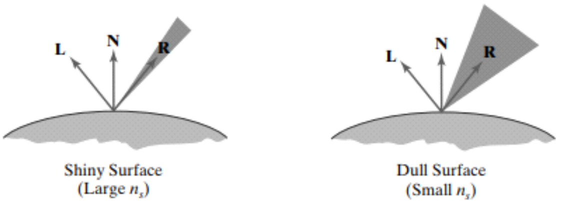


FIGURE 14
Modeling specular reflections (shaded area) with parameter n_s.

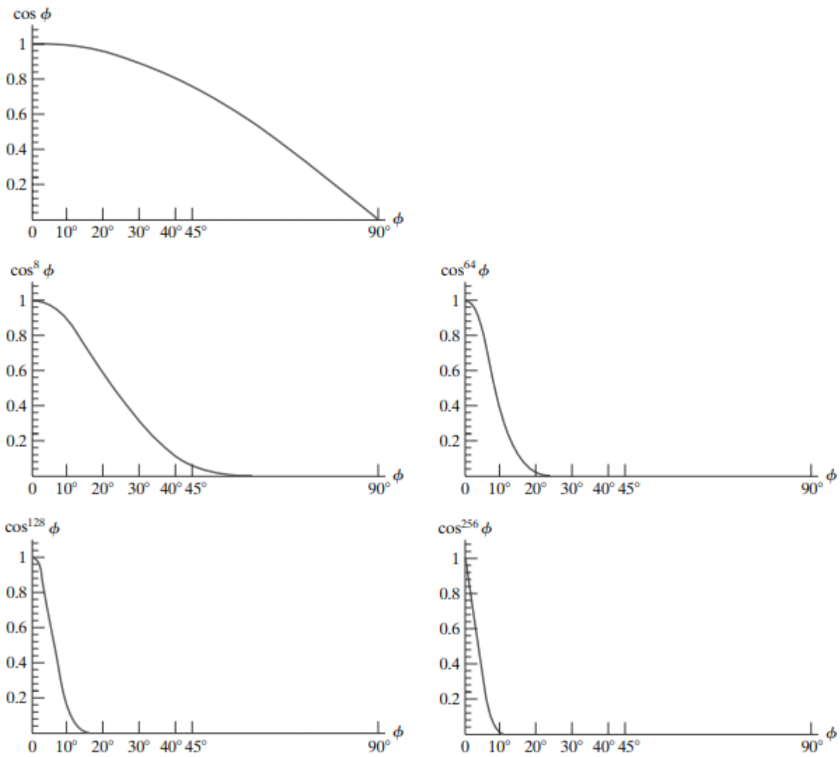


FIGURE 15
Plots of $\cos^{n_s} \phi$ using five different values for the specular exponent n_s.

Ambient Reflection :-

Light from distributed light sources (and surroundings)

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

$I_{ambient} = K_a I_a$ $\quad$ K_a ambient reflection coefficient

I_a ambient incident light

PHONG ILLUMINATION MODEL

$I_{\dots} =$ ambient reflection +

—total

diffuse reflection +
specular reflection

$$= k_a I_a + k_d I_e (L.N) + k_s I_e (R.V)^n$$

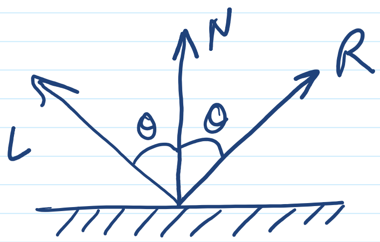
↑

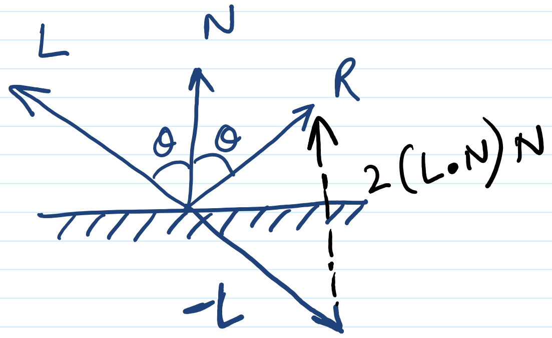
Local Illumination Model :—

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

Basic inputs are light(s), material properties

Vector "R"





$$R = 2(L.N)N - L$$