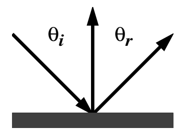
Types of Reflection Functions

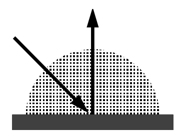
Ideal Specular

- **Reflection Law**
- **Mirror**



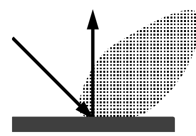
Ideal Diffuse

- **Lambert's Law**
- **Matte**



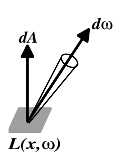
Specular

- **Phong and Blinn Models**
- **Glossiness and Highlights**



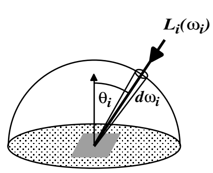
Radiometry

Radiometry **is the science of light energy measurement**



Radiance

The energy carried by a ray
energy/(area solidangle)



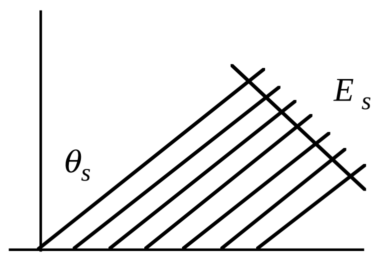
Irradiance

The energy per unit area falling on a surface

Radiosity

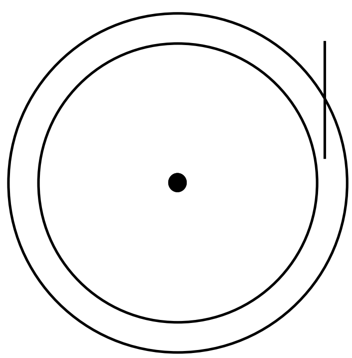
The energy per unit area leaving a surface

Irradiance: Distant Source



$$E = E_s \cos\theta_s$$

Irradiance: Point Source



- Note inverse square law fall off.
- Still has cosine dependency

Ideal Diffuse Reflection

Assume light is equally likely to be reflected in any output direction (independent of input direction).

Lambert's Cosine Law

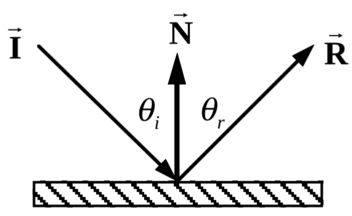
L =

Matte surfaces

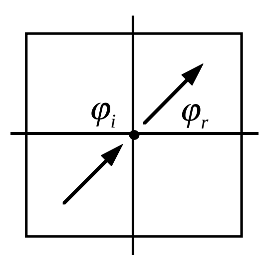
Diffuse Reflection is difficult to explain on first principles

- **Subsurface scattering**
- **Multiple surface reflections**

Law of Reflection



$$\theta_r = \theta_i$$

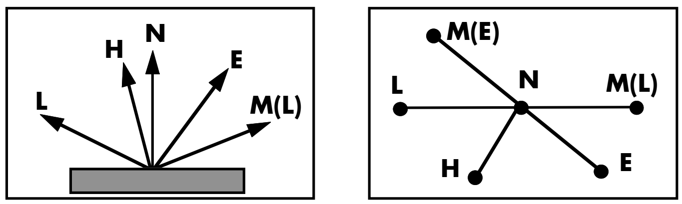


$$\varphi_r = \varphi_i \pm \pi$$

$$\vec{\mathbf{R}} + (-\vec{\mathbf{I}}) = 2\cos\theta\,\vec{\mathbf{N}} = -(\vec{\mathbf{I}} \bullet \vec{\mathbf{N}})\vec{\mathbf{N}}$$

$$\vec{\mathbf{R}} = \vec{\mathbf{I}} - (\vec{\mathbf{I}} \bullet \vec{\mathbf{N}})\vec{\mathbf{N}}$$

Reflection Geometry

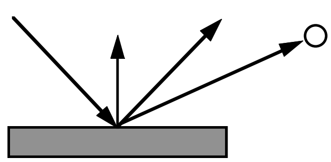


$$\cos\theta_i = \mathbf{L} \bullet \mathbf{N} \qquad \cos\theta_g = \mathbf{E} \bullet \mathbf{N}$$

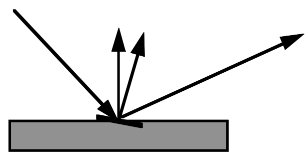
$$\cos\theta_r = \mathbf{E} \bullet \mathbf{N} \qquad \cos\theta_s = \mathbf{R}(\mathbf{L}) \bullet \mathbf{E} = \mathbf{L} \bullet \mathbf{R}(\mathbf{E})$$

$$\cos\theta_{s'} = \mathbf{H} \bullet \mathbf{N}$$

Phong Model: Distributed Light Source



Rough Surface: Microfacet Distribution



Blinn $D_1(\alpha) = \cos^{c_1} \alpha$ $c_1 = \frac{\ln 2}{\ln \cos \beta}$

Torrance-Sparrow $D_2(\alpha) = e^{-(c_2 \alpha)^2}$ $c_2 = \frac{\sqrt{2}}{\beta}$

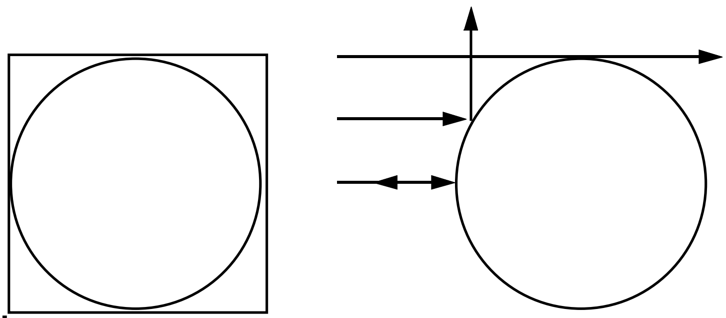
Beckmann $D_4(\alpha) = \frac{1}{\pi^{1/2} m^2 \cos^2 \alpha} e^{-\frac{\tan^2 \alpha}{m^2}}$

Cubical Environment Map

Note:

- **Easy to produce with rendering system**
- **Possible to produce from photographs**
- **Resolution roughly the same in all directions**
- **Texture coordinates simple function of direction**
- **Lines map to lines**

Gazing Ball



Note:

- **Photograph of reflective ball**
- **Reflection indexed by normal**
- **Maps entire field of view to circle**
- **Resolution function of orientation; maximum head-on**
- **Fish eye camera lens similar**

Computer Graphics Models

For example, SGI shading model

$$L_r = k_a L_a + \sum \left(k_d (\mathbf{N} \bullet \mathbf{L}_i) + k_s (\mathbf{N} \bullet \mathbf{H}_i)^s \right) L_i$$

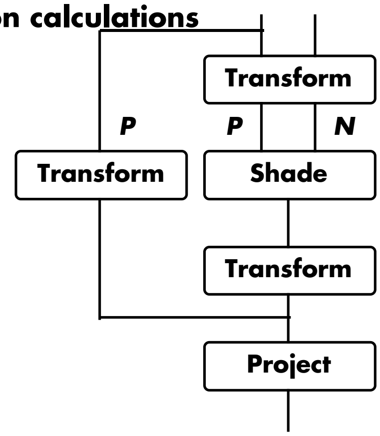
Terms:

- **Ambient - Hack!**
- **Diffuse**
- **Specular**

Lighting

Illumination and reflection calculations

- **Normals**
- **Coordinate systems**
  Lighting calculations are derived from laws of physics must be done in cs isometric to world

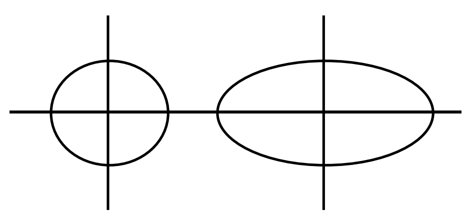


Transformation of Normals

Normals remain perpendicular to tangents

$$N \bullet V = 0$$

$$N' \bullet V' = 0$$



Rotations special case!