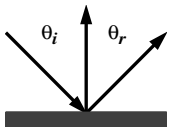
Types of Reflection Functions

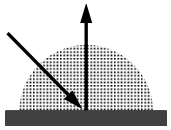
Ideal Specular

- Mirror
- Reflection Law



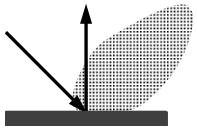
Ideal Diffuse

- Matte
- Lambert's Law



Specular

- Glossiness and Highlights
- Phong and Blinn Models



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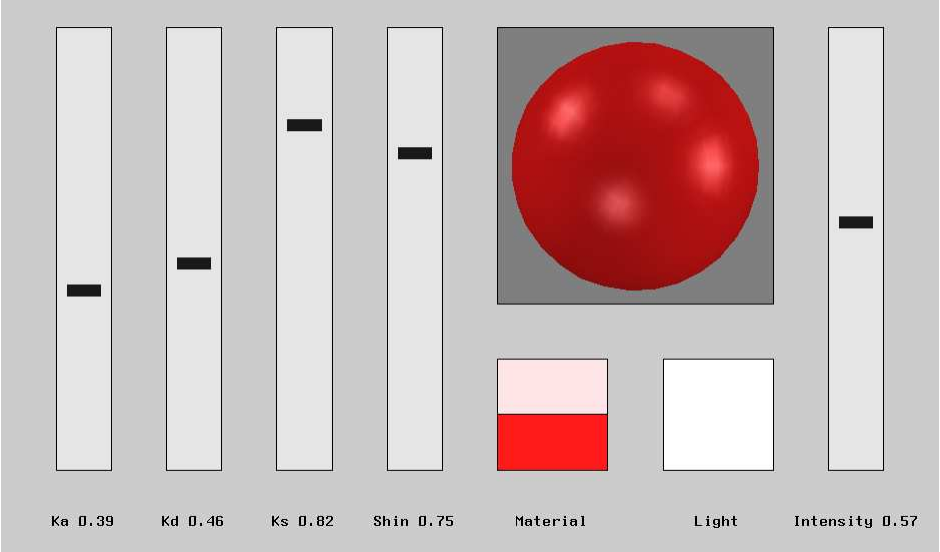

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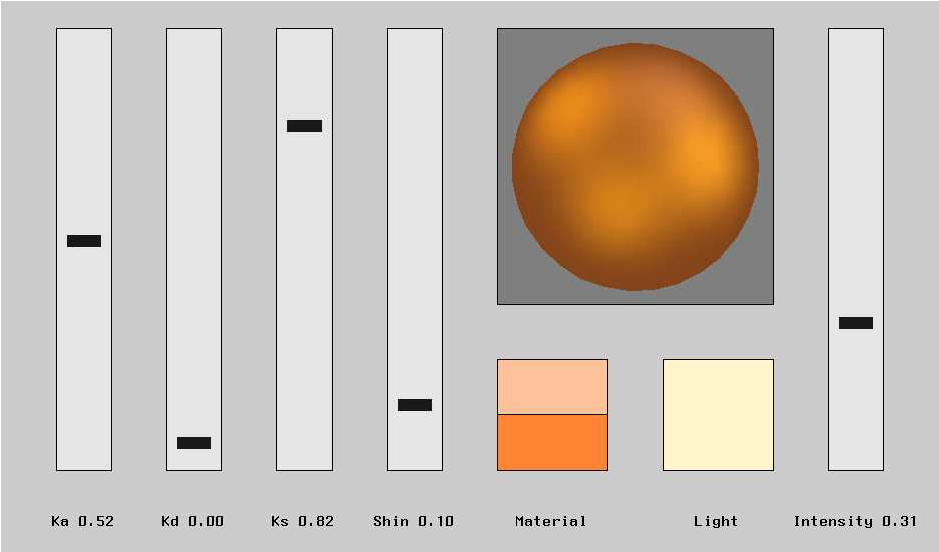

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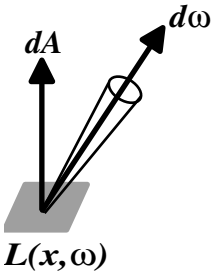
Radiometry: Radiance

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

Definition: The *radiance* (*luminance*) is the power per unit area per unit solid angle.



$$L(x,w) \quad \left[\frac{W}{m^2 sr}\right]\left[Nit = \frac{Lumen}{m^2 sr}\right]$$

Properties:

1. **Fundamental quantity**
2. **Stays constant along a ray**
3. **Response of a sensor proportional to radiance**

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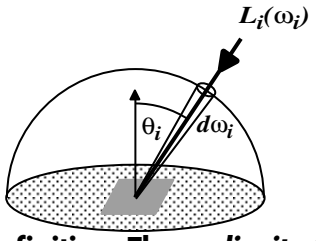
Radiometry: Irradiance and Radiosity

Definition: The *irradiance* (*illuminance*) is the power per unit area incident on a surface.



$$E = \int_{\Omega_i} L_i \cos\theta_i \, d\omega_i$$

$E(x)$ $\left[\frac{W}{m^2}\right]\left[Lux = \frac{lm}{m^2}\right]$

Definition: The *radiosity* (*luminosity*) is the power per unit area leaving a surface.

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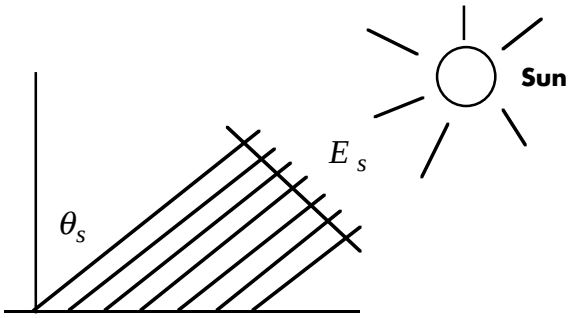
Irradiance: Distant Source



$$E = E_s \cos\theta_s$$

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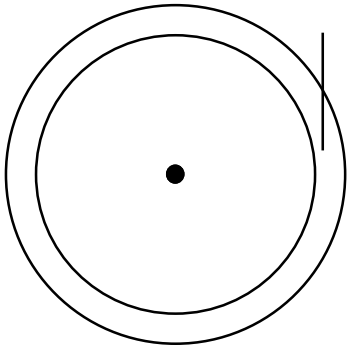
Irradiance: Point Source



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

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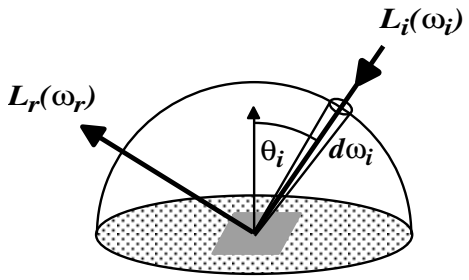
The Reflection Equation



$$L_r(x,\omega_r) = \int_{2\pi} f_r(x,\omega_i \rightarrow \omega_r) L_i(x,\omega_i) \cos\theta_i \, d\omega_i$$

1. Linear response

2. Bidirectional reflectance distribution function (BRDF)

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Matte: Ideal Diffuse Reflection

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

Lambert's Cosine Law

L =

Diffuse Reflection is difficult to explain on first principles

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

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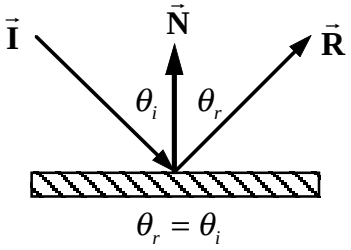
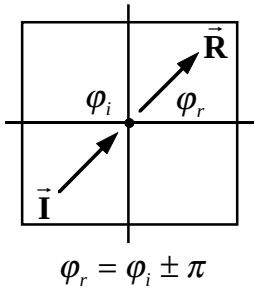
Mirror: Ideal Specular Surface

Law of Reflection





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

$$\vec{\mathbf{R}} = \vec{\mathbf{I}} - 2(\vec{\mathbf{I}} \bullet \vec{\mathbf{N}})\vec{\mathbf{N}} = \vec{\mathbf{M}}(\vec{\mathbf{I}})$$

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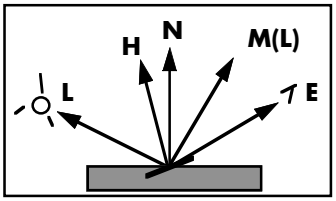
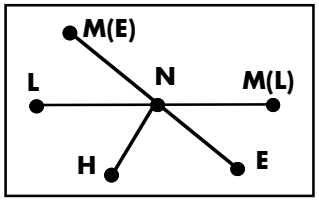
Reflection Geometry

$$\mathbf{H} = \frac{\mathbf{L} + \mathbf{E}}{|\mathbf{L} + \mathbf{E}|}$$





$\cos\theta_i = \mathbf{L} \bullet \mathbf{N}$

$\cos\theta_r = \mathbf{E} \bullet \mathbf{N}$

$\cos\theta_g = \mathbf{E} \bullet \mathbf{N}$

$\cos\theta_s = \mathbf{M(L)} \bullet \mathbf{E} = \mathbf{L} \bullet \mathbf{M(E)}$

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

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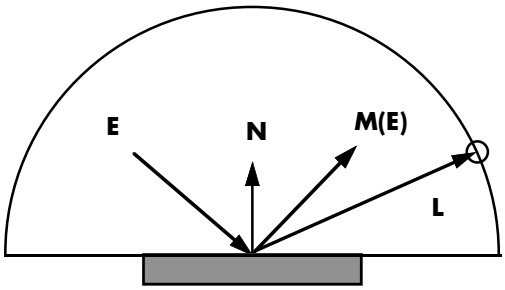
Phong Model: Distributed Light Source



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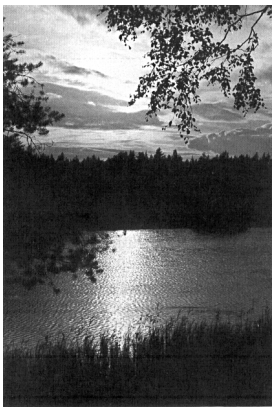
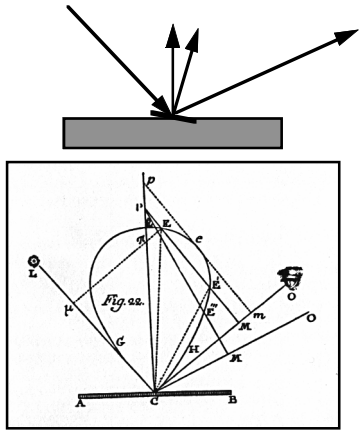
Rough Surface: Microfacet Distribution



Minnaert p. 28



Bouguer's Treatise on Optics

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