Radiometry

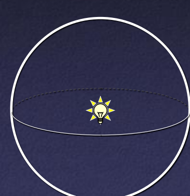
COS 526, Fall 2012

Radiometric Units

- Light is a form of energy
  - Measured in Joules (J)
- Power: energy per unit time
  - Measured in Joules/sec = Watts (W)
  - Also called Radiant Flux (Φ)

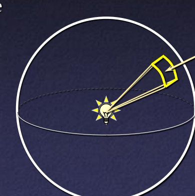
Isotropic Point Source

- Radiant flux leaves point source in all directions
- Flux distributed evenly over sphere



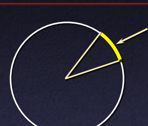
Point Light Source in a Direction

- How to define radiant flux for one direction?
  - Solid angle



Digression – Solid Angle

- Angle in radians



- Solid angle in steradians

Point Light Source in a Direction

- How to define radiant flux for one direction?
  - Solid angle

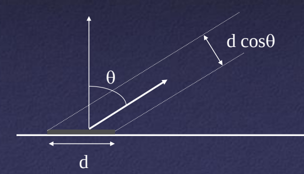
- *Radiant Intensity* (I) = radiant flux per unit solid angle
  - Measured in Watts per steradian (W/sr)

Light Falling on a Surface from a Direction

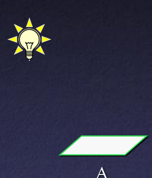
- Power per unit area – *Irradiance* (E)
  - Measured in W/m^2
- Move surface away from light
  - Inverse square law: E ~ 1/r^2
- Tilt surface away from light
  - Cosine law: E ~ $\mathbf{n} \cdot \mathbf{l}$

Why the Cosine Term?

- Foreshortening is by cosine of angle.
- Radiance gives energy by *effective* surface area.

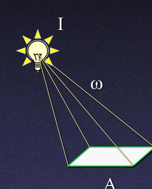


Light Falling on a Surface from a Direction



$$E = \frac{\Phi}{A}$$

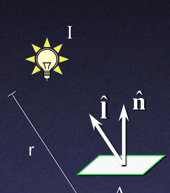
Light Falling on a Surface from a Direction



$$E = \frac{\Phi}{A}$$

$$\Phi = I\omega$$

Light Falling on a Surface from a Direction



$$E = \frac{\Phi}{A}$$

$$\Phi = I\omega$$

$$\omega = \frac{A(\hat{\mathbf{n}} \cdot \hat{\mathbf{l}})}{r^2}$$

$$\Rightarrow E = \frac{I(\hat{\mathbf{n}} \cdot \hat{\mathbf{l}})}{r^2}$$

Light Emitted from a Surface in a Direction

- Power per unit area per unit solid angle – *Radiance* (L)
  - Measured in W/m^2/sr
  - *Projected area* – perpendicular to given direction

$$L = \frac{d\Phi}{dA_p \, d\omega}$$

$$L = \frac{d\Phi}{dA \cos\theta \;\, d\vec{\omega}}$$

Irradiance from Radiance

$$E = \int_{\Omega} L\cos\theta \, d\omega$$

- $\cos\theta \; d\omega$ is projection of a differential area

Radiance as a unit of measure

- Radiance doesn't change with distance
  - Therefore it's the quantity we want to measure in a ray tracer.
- Radiance proportional to what a sensor (camera, eye) measures.
  - Therefore it's what we want to output.

Radiometric and Photometric Units

Radiant energy Joule (J)	Luminous energy Talbot
Radiant flux or power (F) Watt (W) = J / sec	Luminous power Lumen (lm) = talbot / sec = cd · sr
Radiant intensity (I) W / sr	Luminous intensity Candela (cd)
Irradiance (E) W / m^2	Illuminance Lux = lm / m^2
Radiance (L) W / m^2 / sr	Luminance Nit = lm / m^2 / sr
Radiosity (B) W / m^2	Luminosity Lux = lm / m^2