Current state of intro students graphic's ability

Know how to draw polygons

Know about cameras

Know how to map 3D polygons onto the screen

Know how to draw the bits closest to the cameras

Issues

- Should we live in a polygonal world?
- How do you get polygons for complex objects?
- What color should each pixel be?

Coloring pixels

Need to model light and surface

Simplest model

Point light source and Lambertian (diffuse) reflection. Gives basic shader--makes things look 3D

Point light source

Modeled by single light direction (key attribute, more than "point-like"--e.g., the sun is essentially a point source

Lambertian Reflection

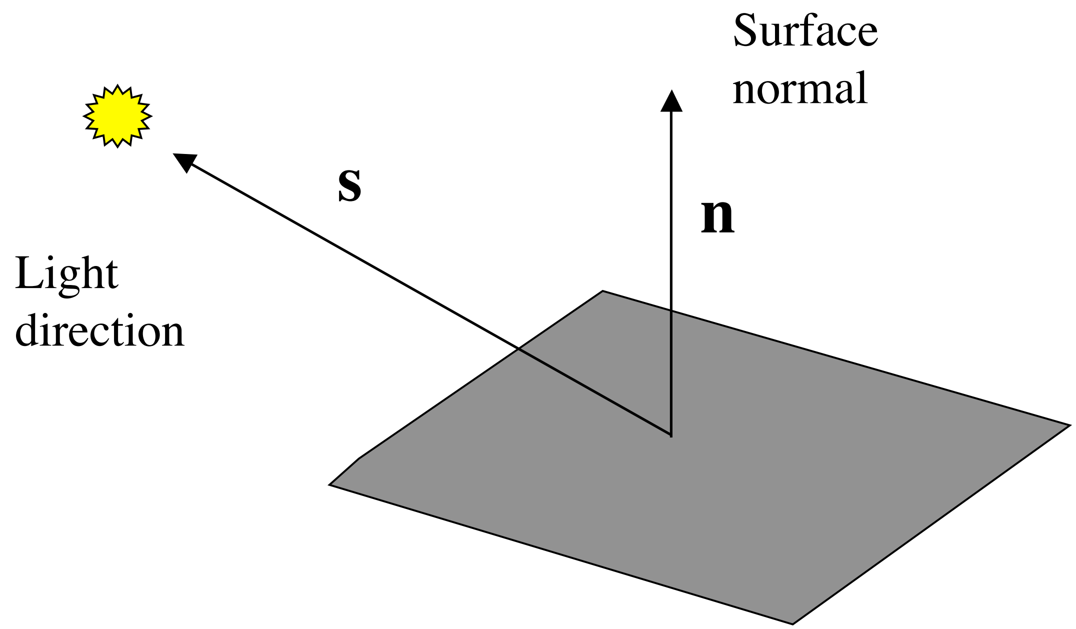
- Light is scattered equally in all directions
- Brightness is independent of viewing direction
- Example--non-shiny paper
- Simple rule--attenuate brightness by

$$\mathbf{n} \cdot \mathbf{s}$$

Surface normal

Light source direction

Lambertian Reflection



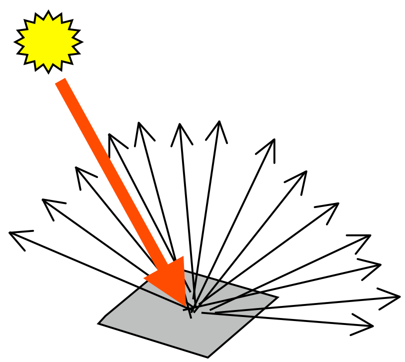
Why is brightness proportional to **n•s** ?

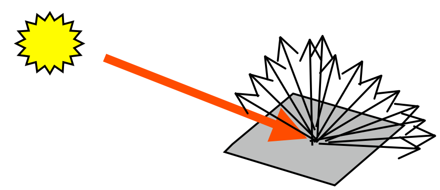
What about more than one light?

Lambertian Reflection

Why is brightness proportional to **n•s** ?

Intuitive argument: The surface scatters light in all directions equally, but as the angle of the light becomes oblique, the amount of light per unit area is reduced (foreshortening) by a factor of the cosine of the angle.





Lambertian Reflection

What about more lights?

If they are point sources, just add them up. Note that this means that extended sources can be approximated by multiple point sources and/or integration.

Applies to non-Lambertian surfaces also.

Special cases to be handled later: Very long thin source and large, planer source.

Lambertian Reflection

Most the world is not Lambertian

Lambertian assumption failures

Lambertian Reflection

Most the world is not Lambertian

Lambertian assumption failures

- Rough surfaces--important example--the moon is not Lambertian
- Dielectrics (plastics, many paints)
- Metallic surfaces
- Skin

More General Reflection

- Many effects when light strikes a surface -- could be:
  - absorbed (could depend on incoming angle)
  - transmitted
  - reflected
  - scattered (in a variety of directions!)
- Typically assume that
  - surfaces don't fluoresce
  - surfaces don't emit light (i.e., they are not sources)
  - all the light leaving a point is due to that arriving at that point

More General Reflection

- Can model this situation with the Bidirectional Reflectance Distribution Function (BRDF)
- This is the ratio of what comes out to what came in
- What comes out <--> “radiance”
- What goes in <--> “irradiance”
- Both are characterized by two angles
- Thus BRDF is a function of four angles
- Technical discussion included in notes for interest only

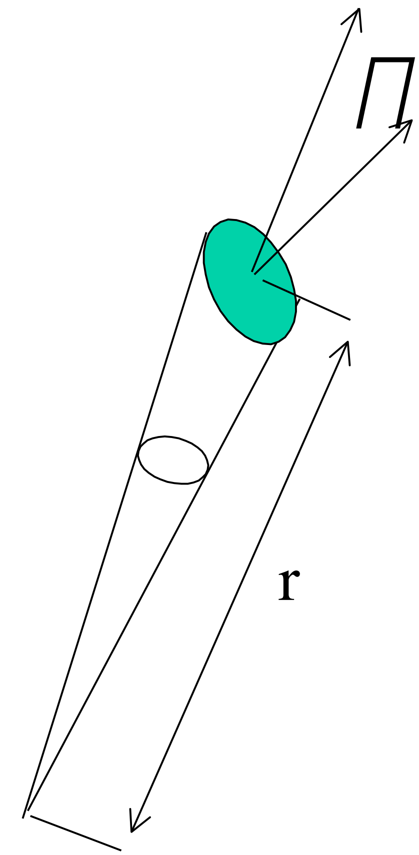
Optional

Solid Angle

- Analogous to measuring angles radians
- The solid angle subtended by a patch area dA is given by

$$d\omega = \frac{dA \cos\theta}{r^2}$$

- Units are steradians (sr)

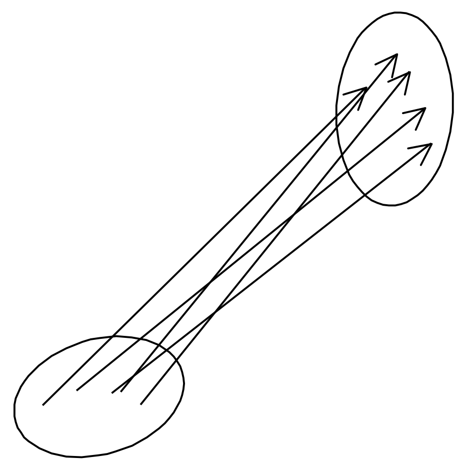


Optional

Radiance

- Amount of light at a point in a particular direction
- Think of a small area either emitting or collecting the light
- Property is: *Radiant power per unit foreshortened area per unit solid angle*
- Units: watts per square meter per steradian ($wm^{-2}sr^{-1}$)
- Usually written as:

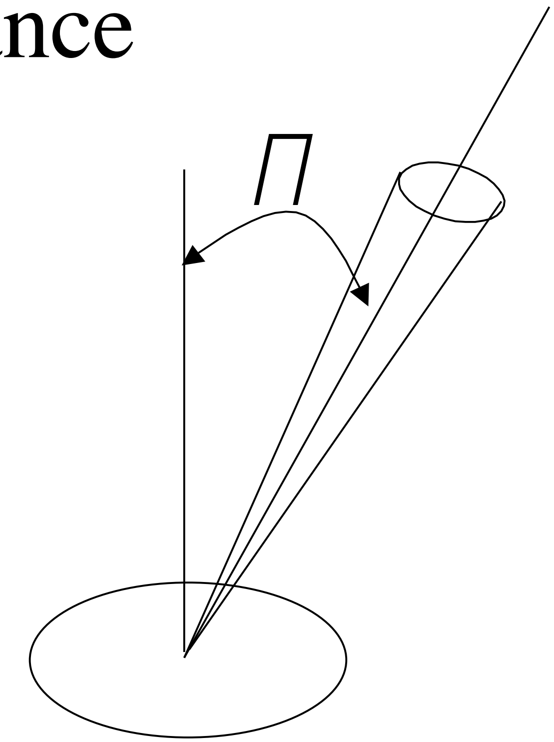
$$L(\underline{x},\square,\square)$$



Optional

Radiance

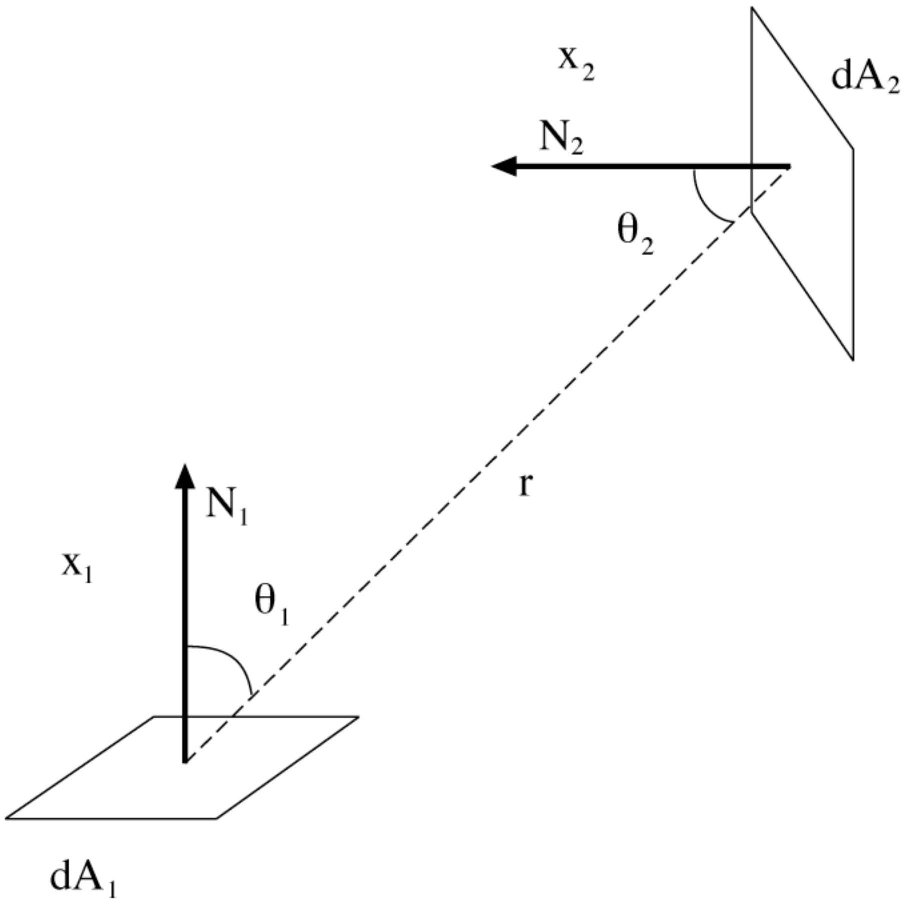
$$L(\underline{x},\theta,\phi) = \frac{d^2P(\underline{x})}{(d\omega)(dA\cos\theta)}$$



- Crucial property: In a vacuum, radiance leaving p in the direction of q is the same as radiance arriving at q from p

Optional

Radiance is constant along straight lines



- Power 1->2, leaving 1:

$$L(\underline{x}_1,\theta,\phi)(dA_1\cos\theta_1)\left(\frac{dA_2\cos\theta_2}{r^2}\right)$$

- Power 1->2, arriving at 2:

$$L(\underline{x}_2,\theta,\phi)(dA_2\cos\theta_2)\left(\frac{dA_1\cos\theta_1}{r^2}\right)$$