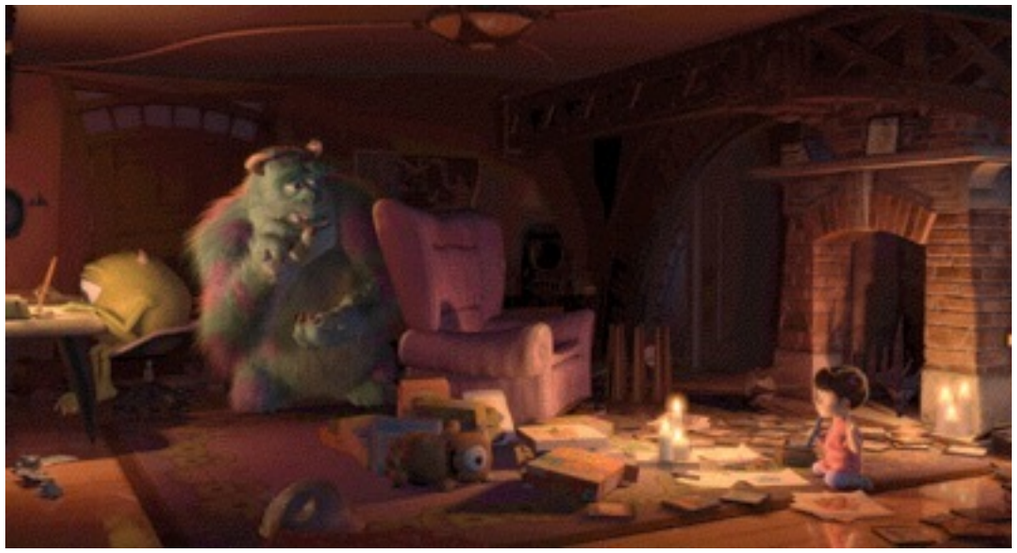
Lighting

CS 355: Interactive Graphics and Image Processing



Kinds of Lighting

- Direct:
  Light falling on an object directly from a light source
- Indirect: ← More in CS 455
  Light falling on an object after being reflected off (or going through) other objects
- Ambient:
  General light bouncing around and scattered enough to be effectively "everywhere"

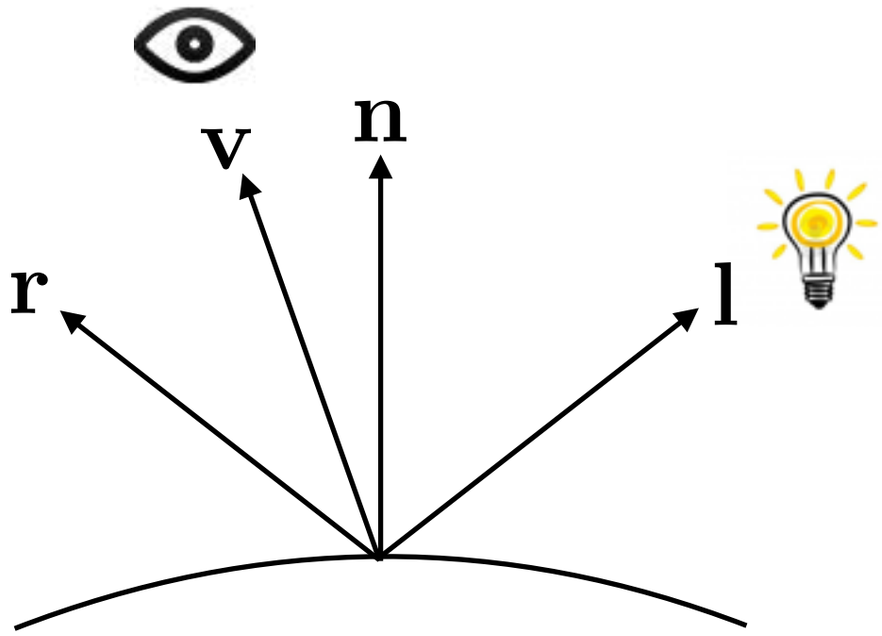
Light Sources

We'll focus on this for now

- Point
- Area
- Spot
- and many other models...

Basic Geometry of Lighting

- The surface **n**ormal
- The **l**ighting direction (to the light)
- The **v**iewing direction (to the eye/camera)
- The **r**eflected light direction



Surface Reflectance

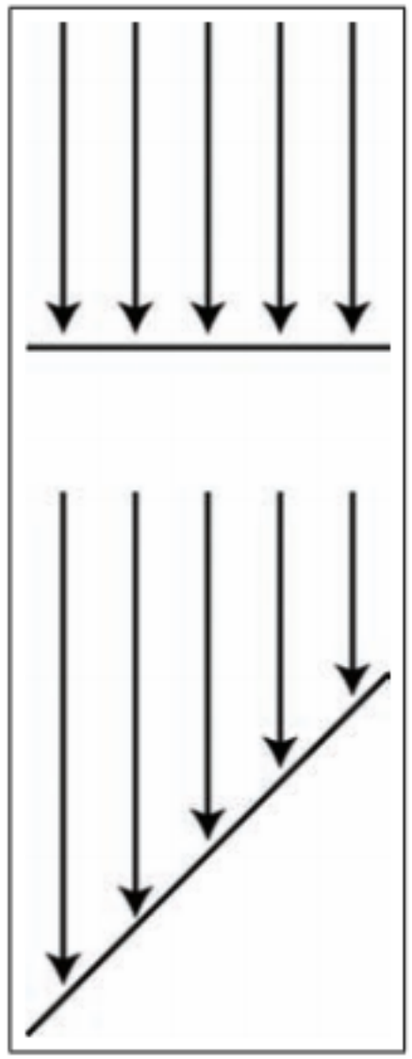
- Most objects don't give off light
  - reflect some of the light that falls on them
  - absorb the rest
- The wavelengths reflected give the object its color
- The effect is multiplicative:
  i.e., "reflects 40% of the green light"
- If we model the light as RGB, we can also model the reflectance as RGB
- Reflectance is also sometimes called *albedo*

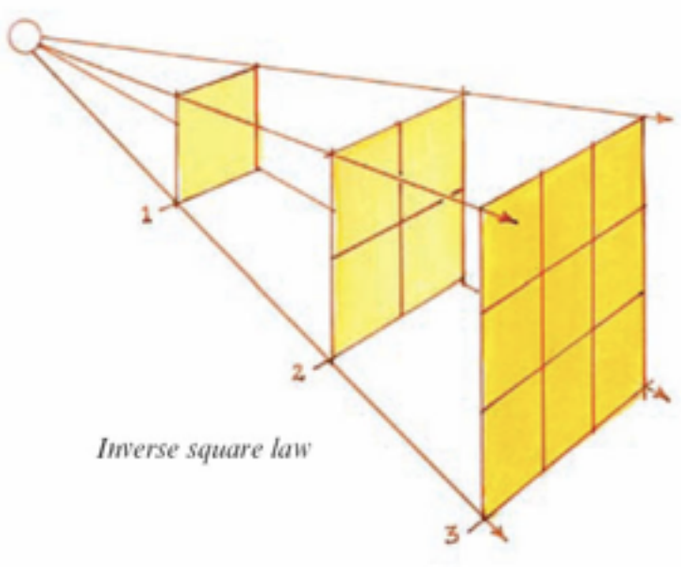
Irradiance

- We sometimes say "the amount of light"
- But it's really how much light *per unit area*
- This quantity is called the *irradiance*

Irradiance

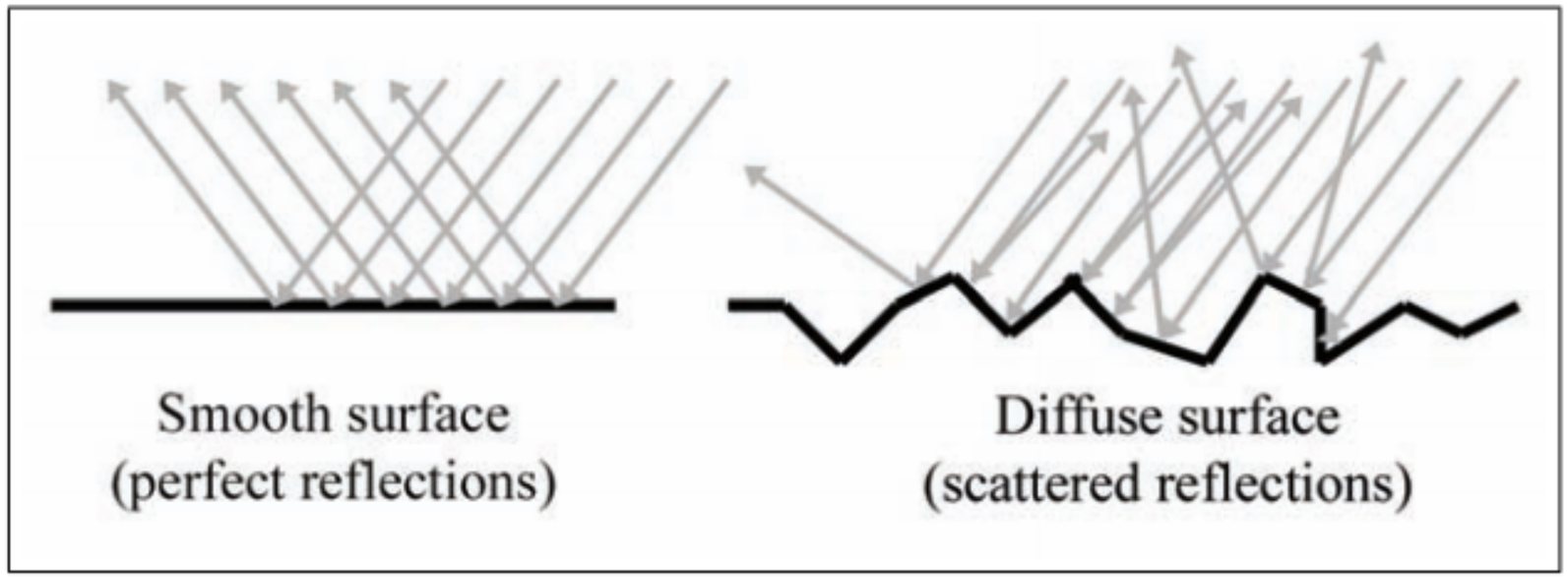
- Two important properties:
  - Irradiance falls of with the square of the distance
  - Irradiance is less when falling on a slanted surface





Inverse square law

Specular vs. Diffuse

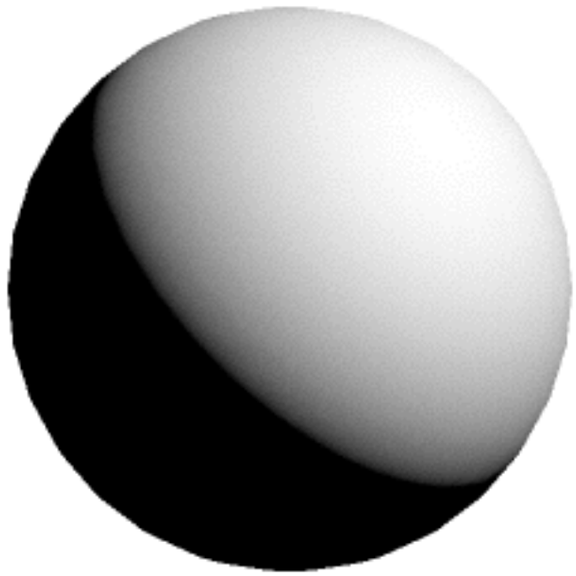


Some light is reflected perfectly (specular)

Some light is scattered (diffuse)

Diffuse Reflection

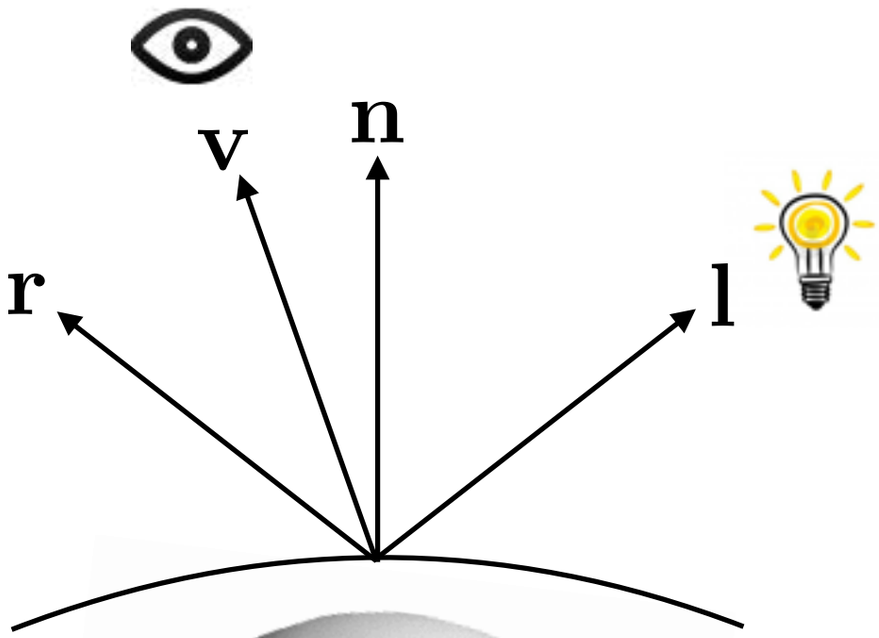
- Light scattered in every direction is called the *diffuse* part of the reflected light
- A perfectly diffuse surface is called *Lambertian*
- Only lighting direction matters
- Viewing direction *does not*



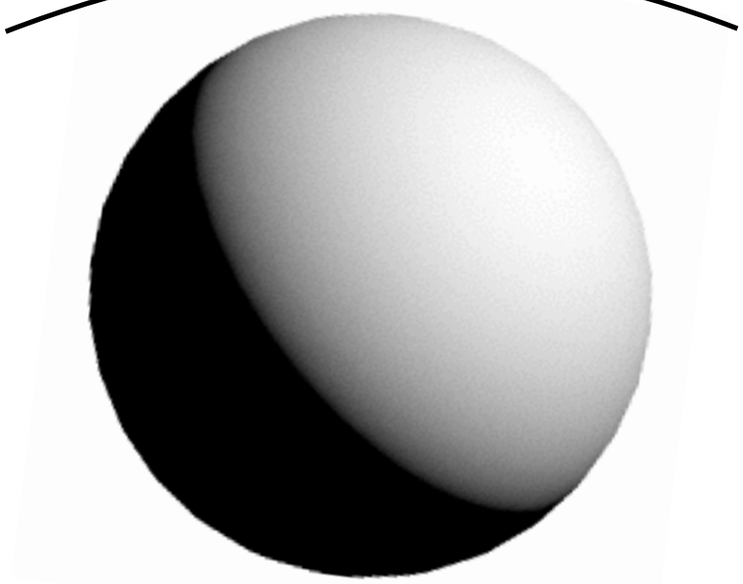
A Simple Diffuse Model

$$\mathbf{c}_{\text{diff}} = (\mathbf{s} \otimes \mathbf{m}_{\text{diff}})(\mathbf{n} \cdot \mathbf{l})$$

- $\mathbf{c}_{\text{diff}}$: diffuse reflected color
- $\mathbf{s}$: source intensity
- $\mathbf{m}_{\text{diff}}$: material diffuse reflectance

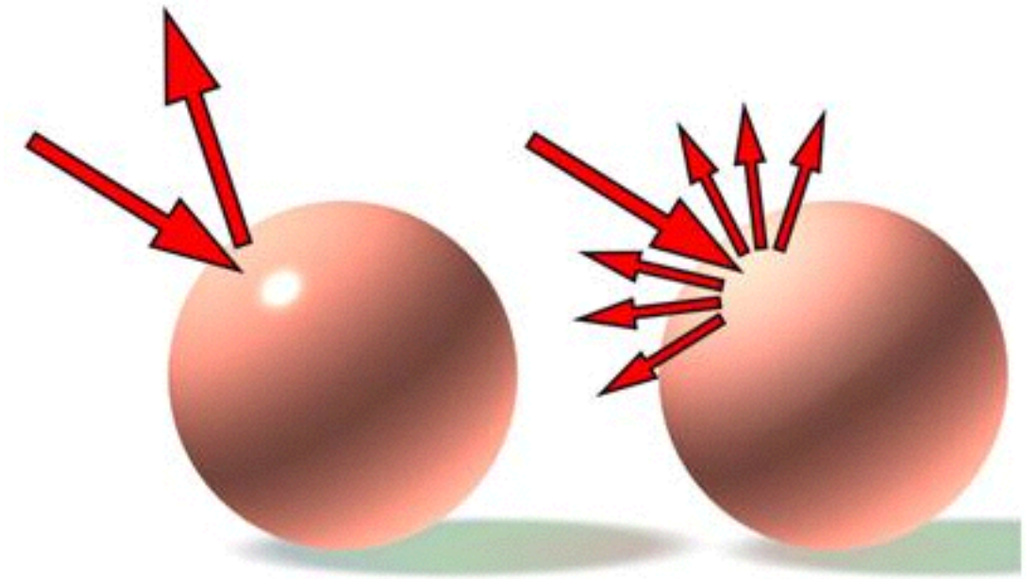


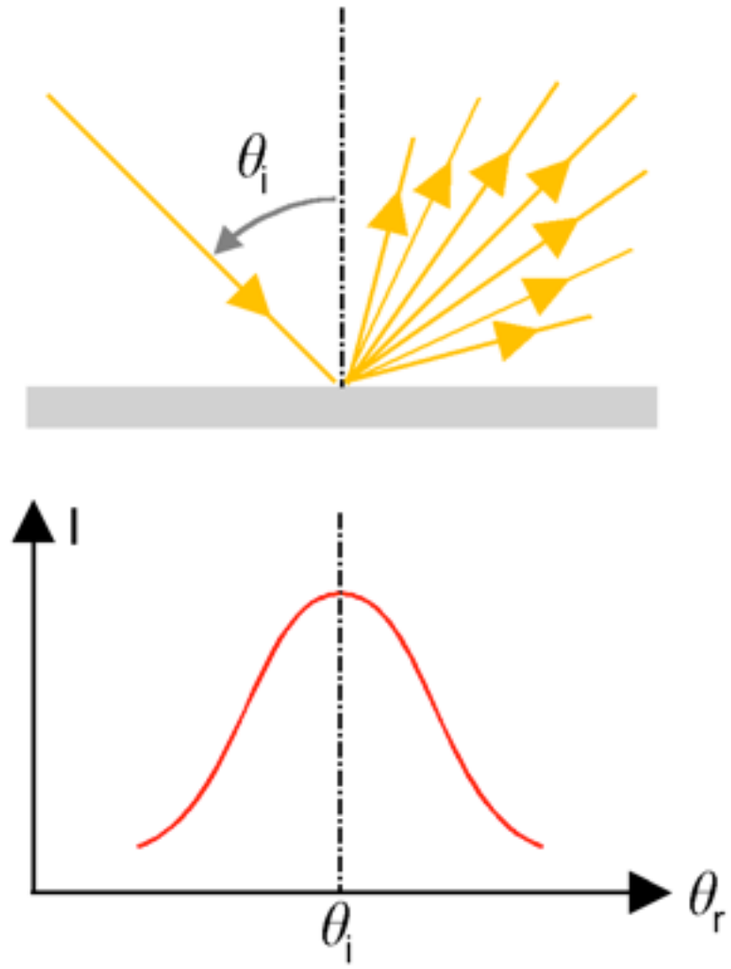
Assumes constant lighting direction and strength



Specular Reflections

Specular Reflections





Angle of reflection = Angle of incidence
(but may be blurred)

Specular Reflections

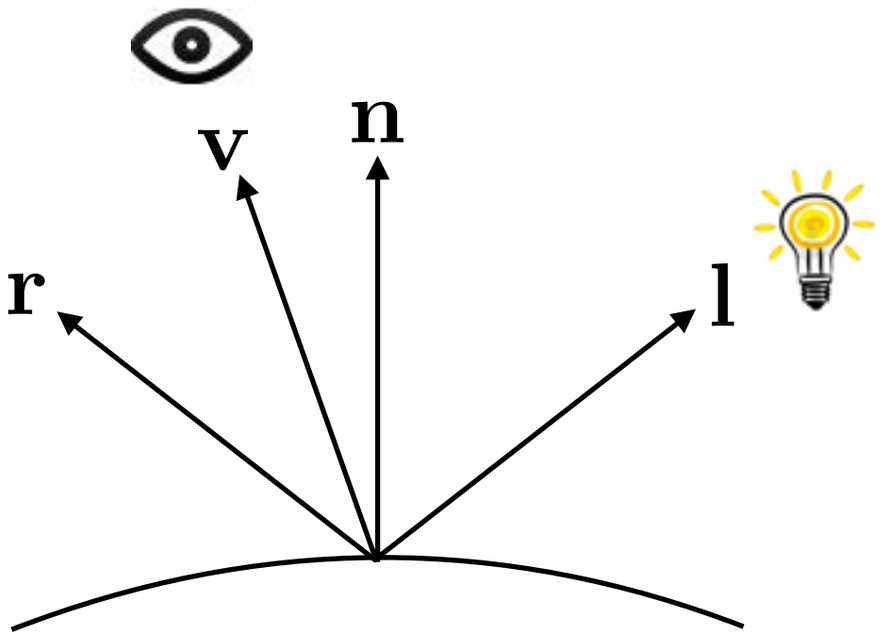
how glossy the surface is

$$\mathbf{c}_{\text{spec}} = (\mathbf{s} \otimes \mathbf{m}_{\text{spec}})(\mathbf{v} \cdot \mathbf{r})^{m_{\text{gls}}}$$

specular reflected color

source intensity

material specular reflectance



Specular Reflections

m_{gls}

$\mathbf{m}_{\mathrm{spec}}$

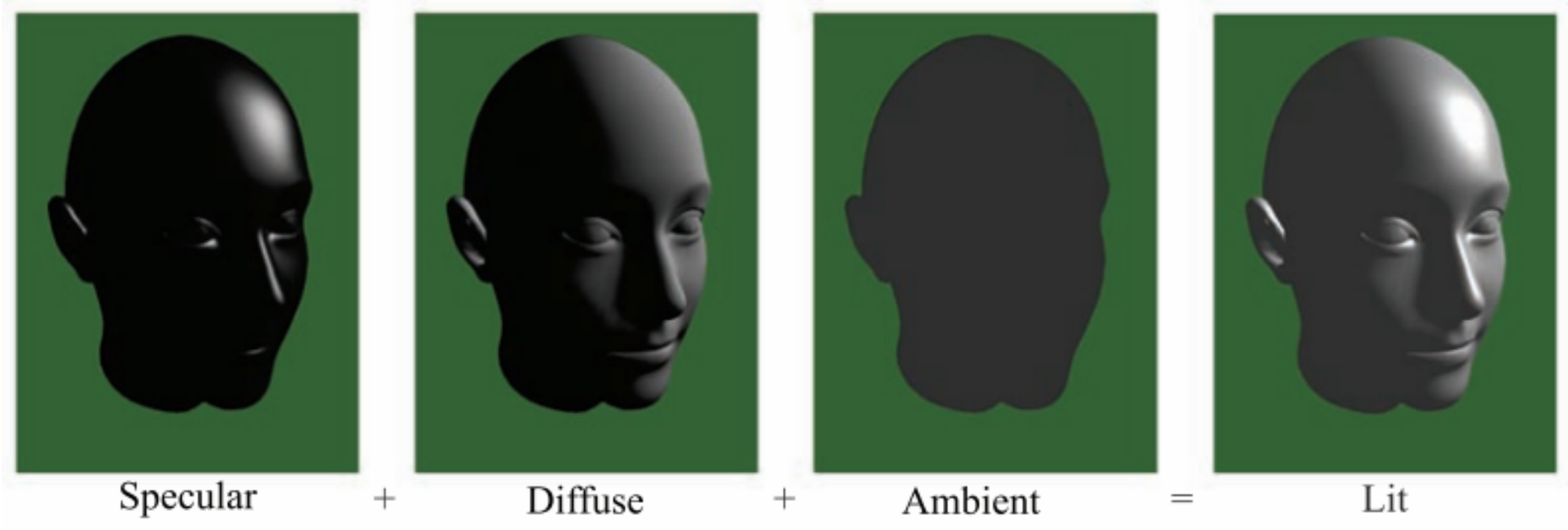
Ambient Reflection

- Ambient light is “all around”, so directions don’t matter

- Just the product of the ambient light and the surface reflectance

$$\mathbf{c}_{\mathrm{amb}} = \mathbf{s}_{\mathrm{amb}} \otimes \mathbf{m}_{\mathrm{amb}}$$

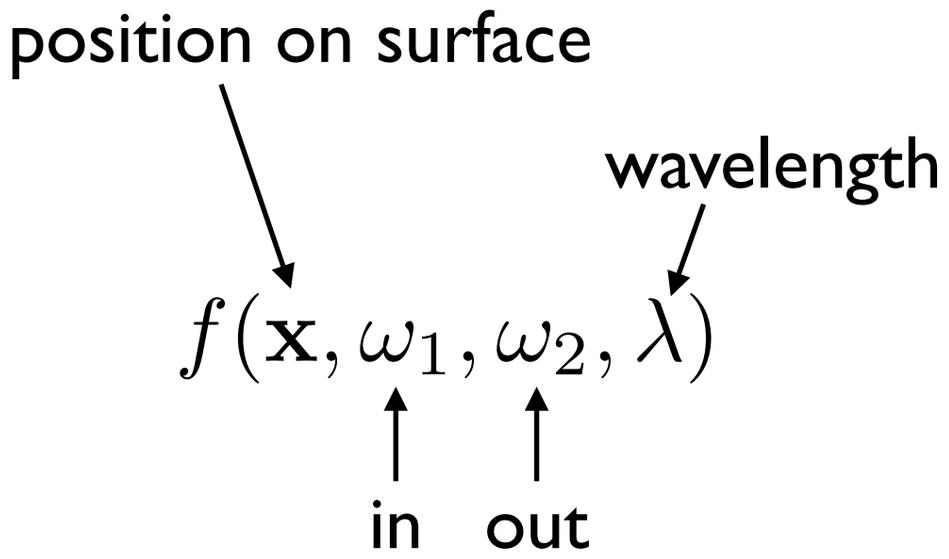
All Together Now…



This is called the *Phong* model
(the *Blinn* model is similar with slightly different specular)

BRDFs

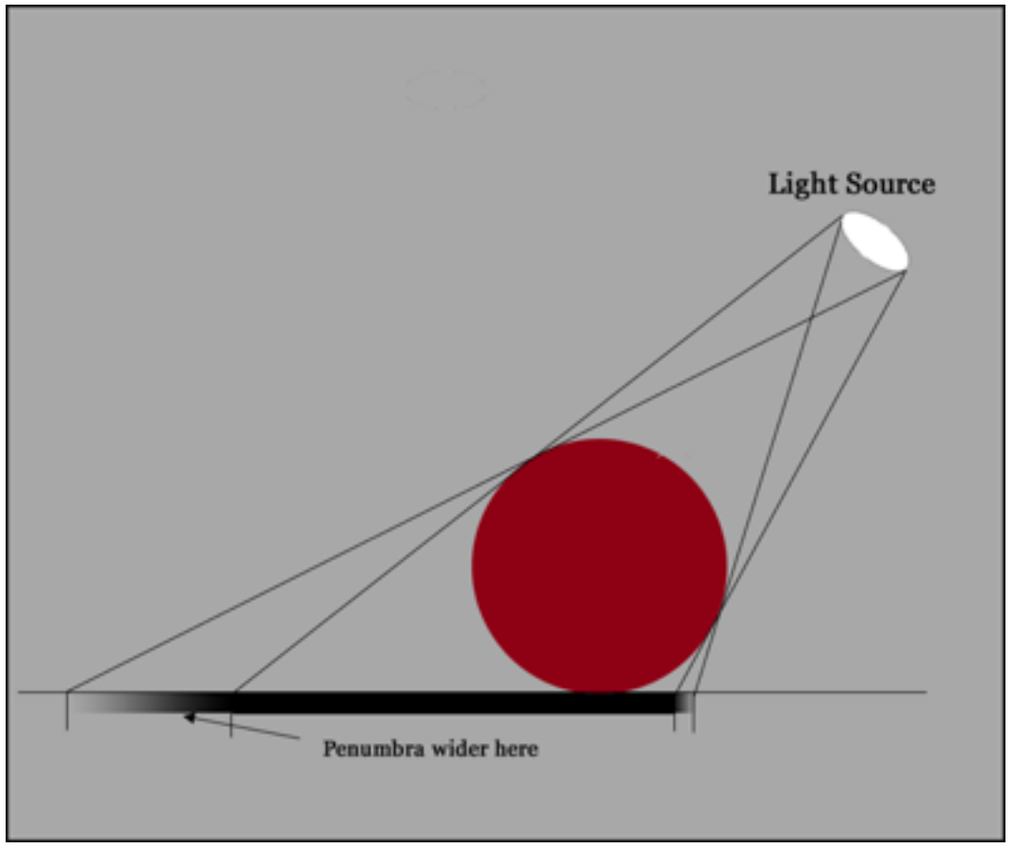
- The Phong model is only an approximation
- Not a simple mix of pure diffuse and pure specular
- Reflectance isn't constant across the surface
- Function of both incoming direction and outgoing direction



Bidirectional Reflectance Distribution Function

What About Shadows?

- Point lights cast hard shadows
- Area lights cast softer shadows
- Umbra = area in full shadow
- Penumbra = area in partial shadow

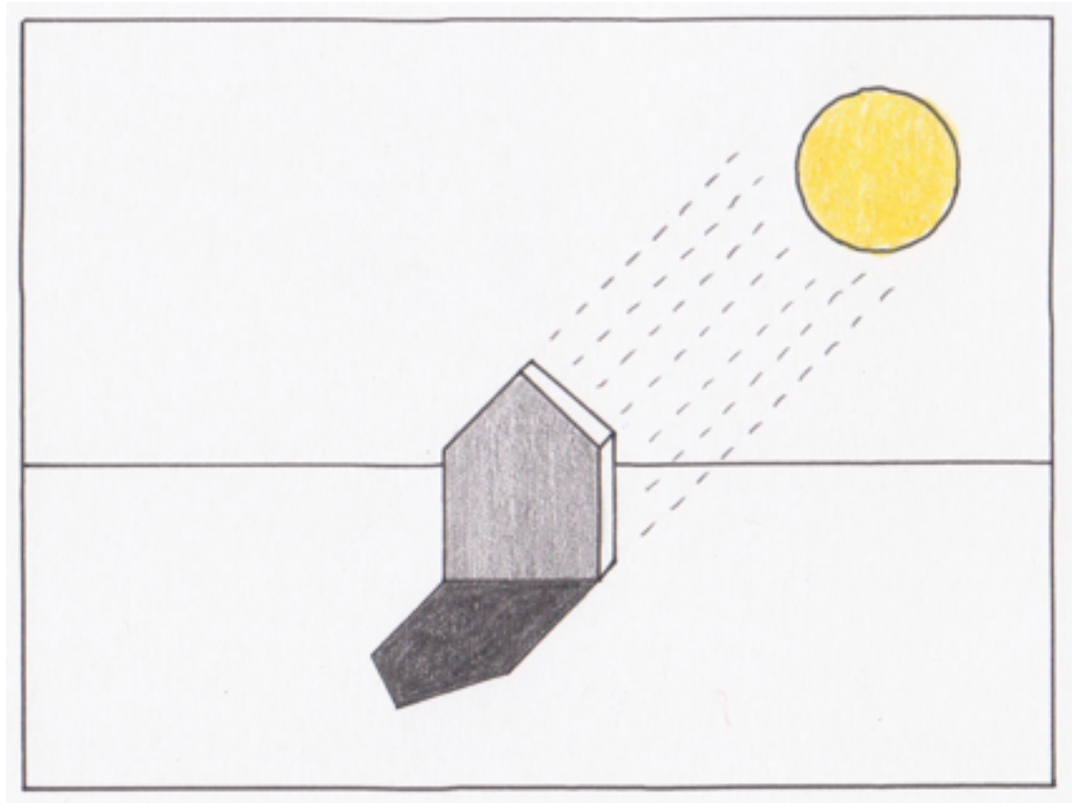


Simple Shadows

- For point lights, shadows are pretty simple

- *Do a visibility test from the point of view of the light!*

- Can also be used for distance-based falloff



Coming up...

- More lighting
- Interpolation (in general)
- Curves and surfaces