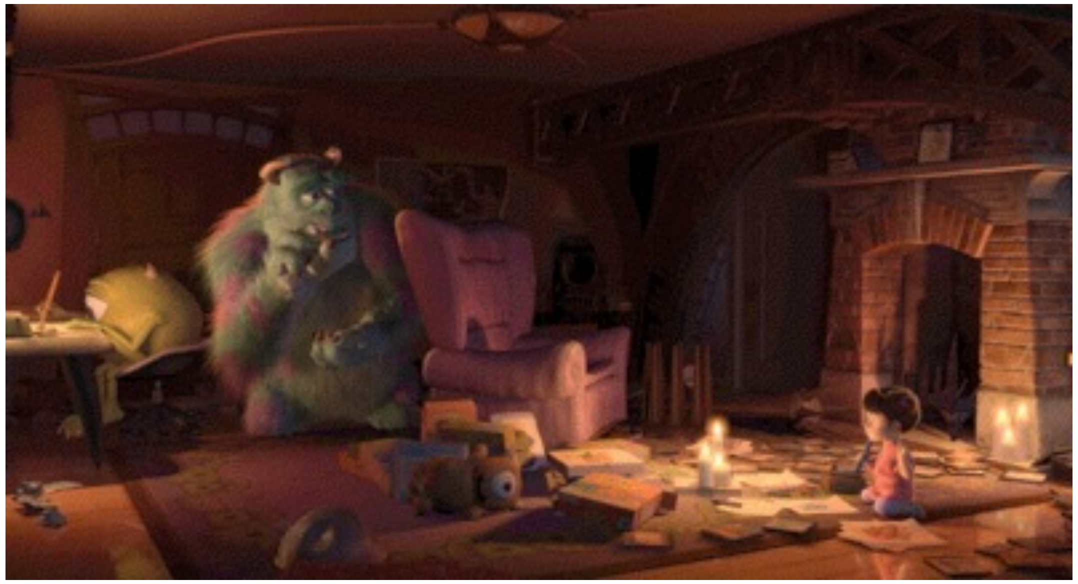
Lighting

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"

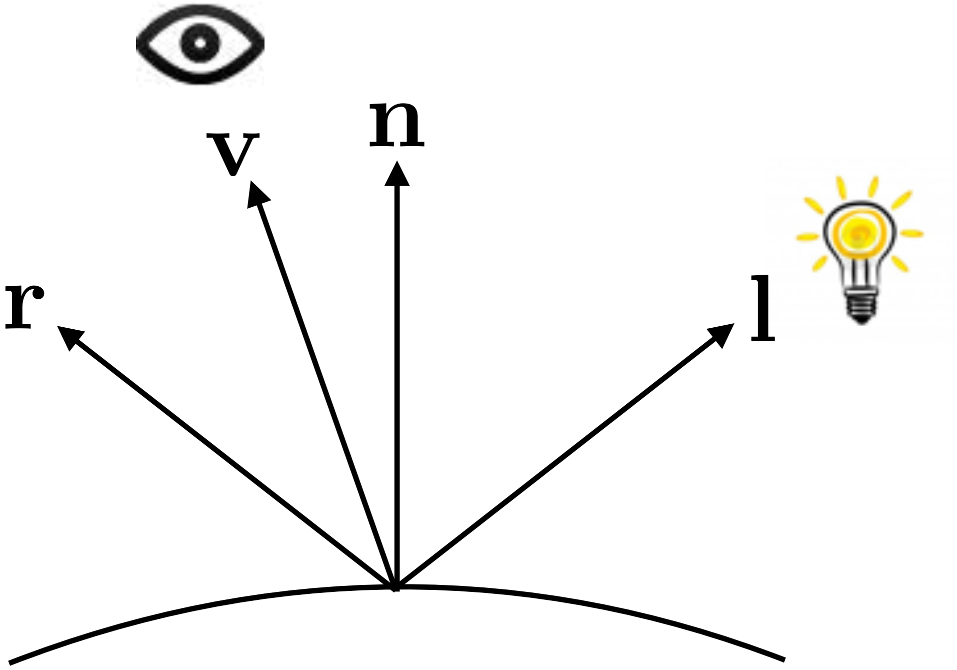
Light Sources

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 reflectance as RGB
- Reflectance is also sometimes called *albedo*

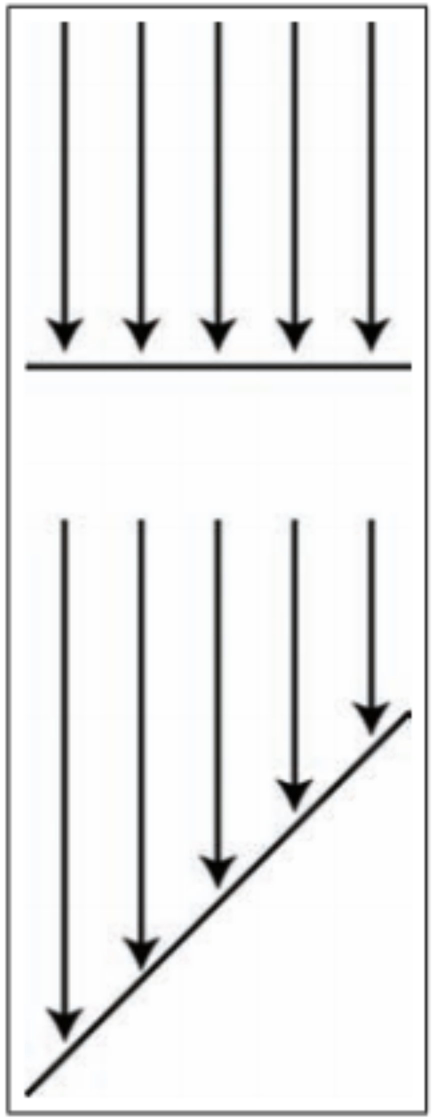
Irradiance

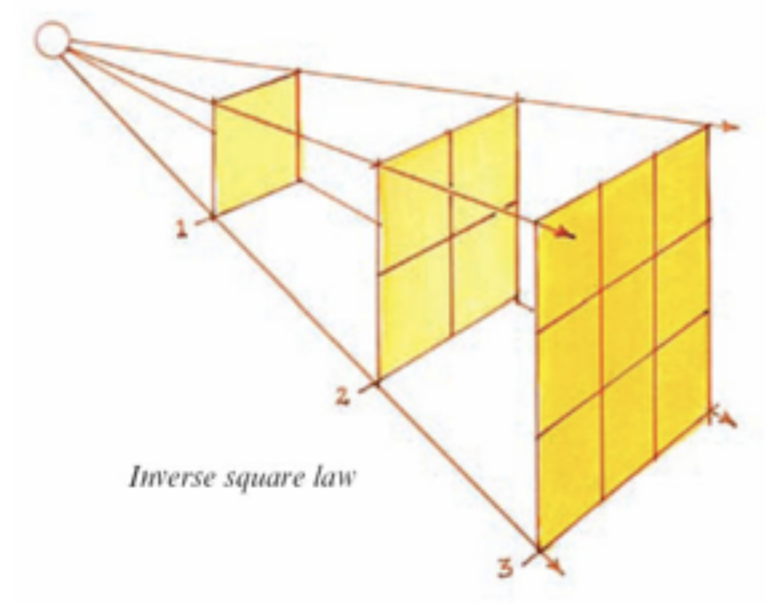
- We sometimes say
  “the amount of light”
- But it’s really how much light
  per unit area
- This quantity is called the
  irradiance

Irraddiance
Power/Unit Area

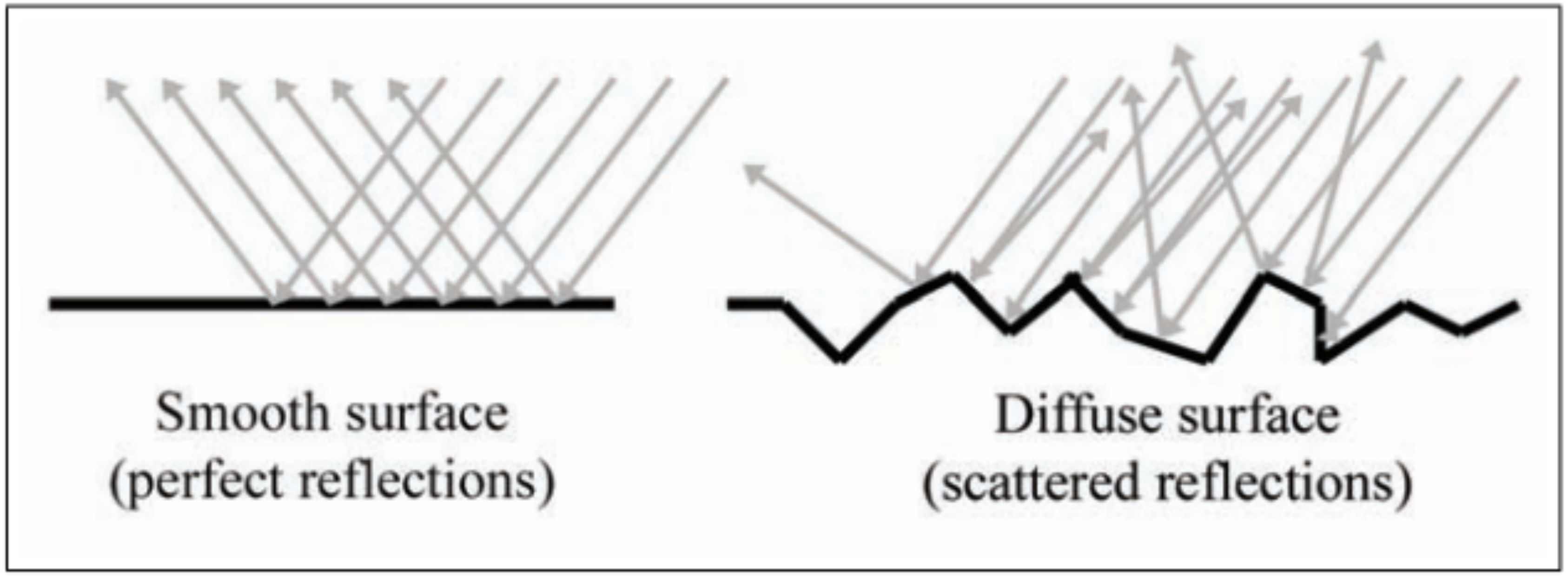
Irradiance

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





Specular vs. Diffuse

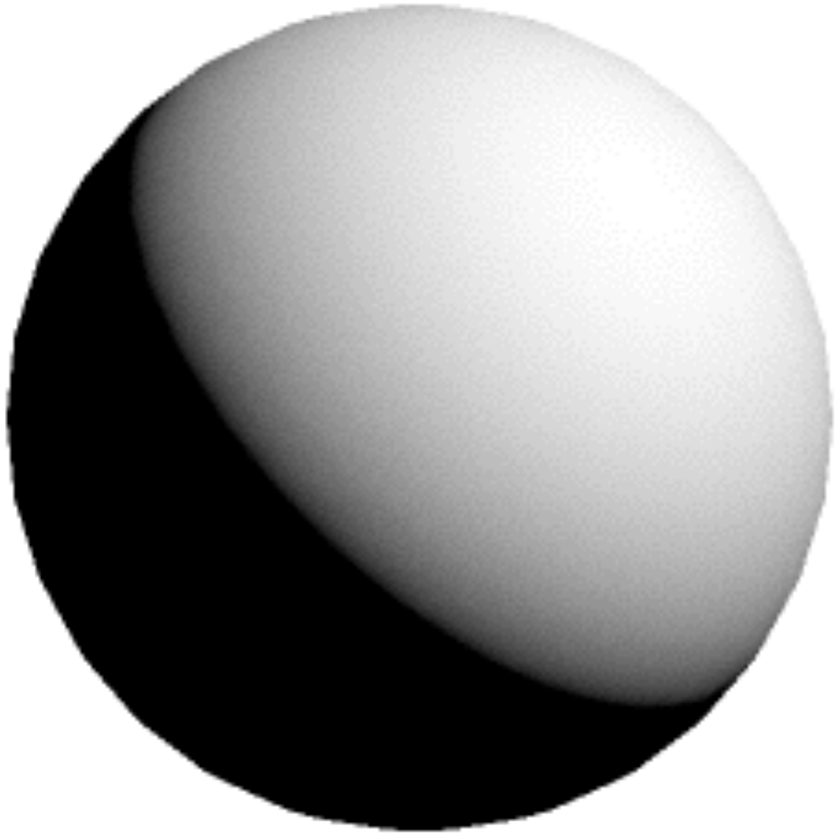


Some light is
reflected perfectly
(specular)

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

pointwise multiply RGB

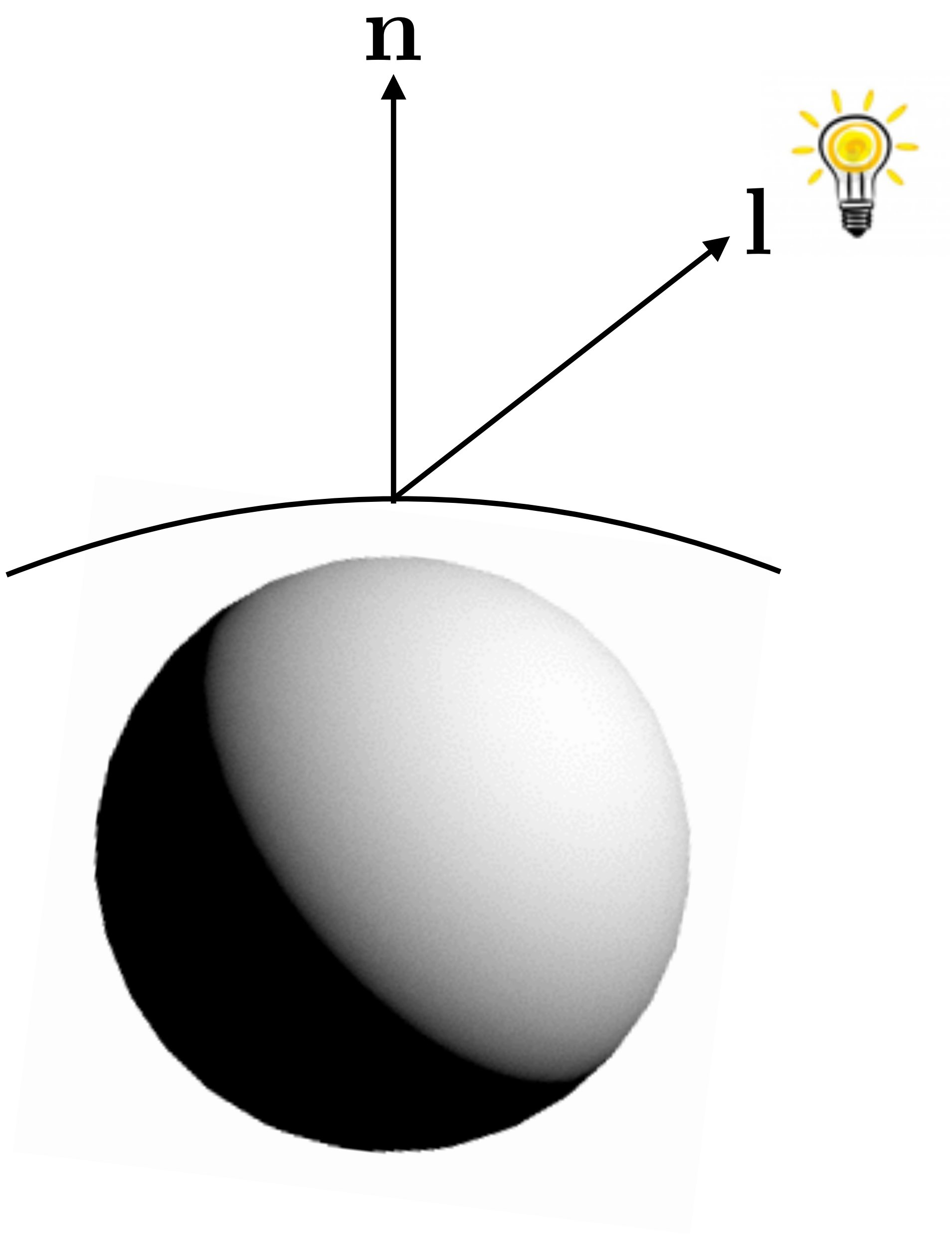
$$\mathbf{c}_{\text{diff}} = (\mathbf{s} \otimes \mathbf{m}_{\text{diff}})\boxed{(\mathbf{n} \cdot \mathbf{l})}$$

diffuse reflected color

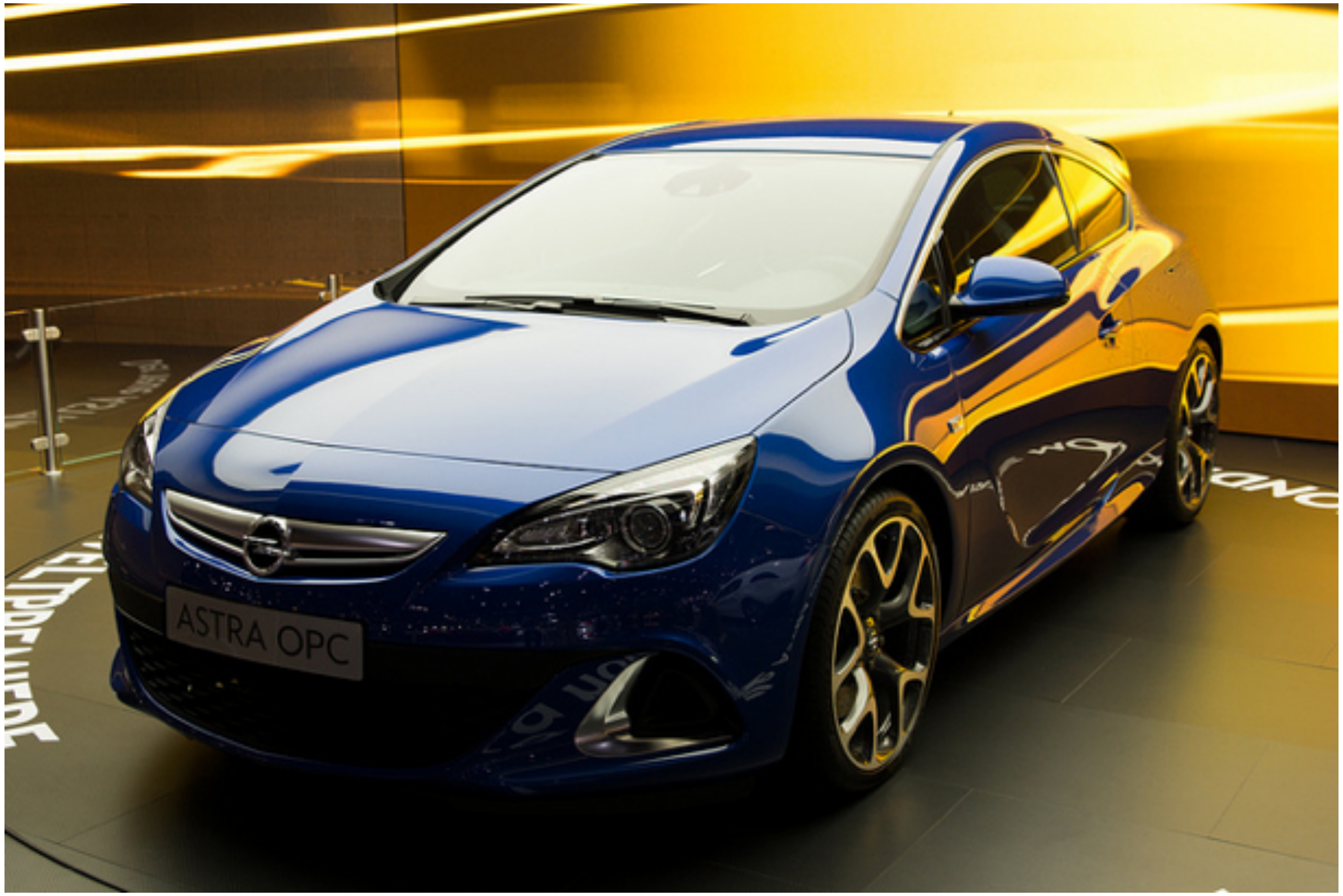
source intensity

material diffuse reflectance

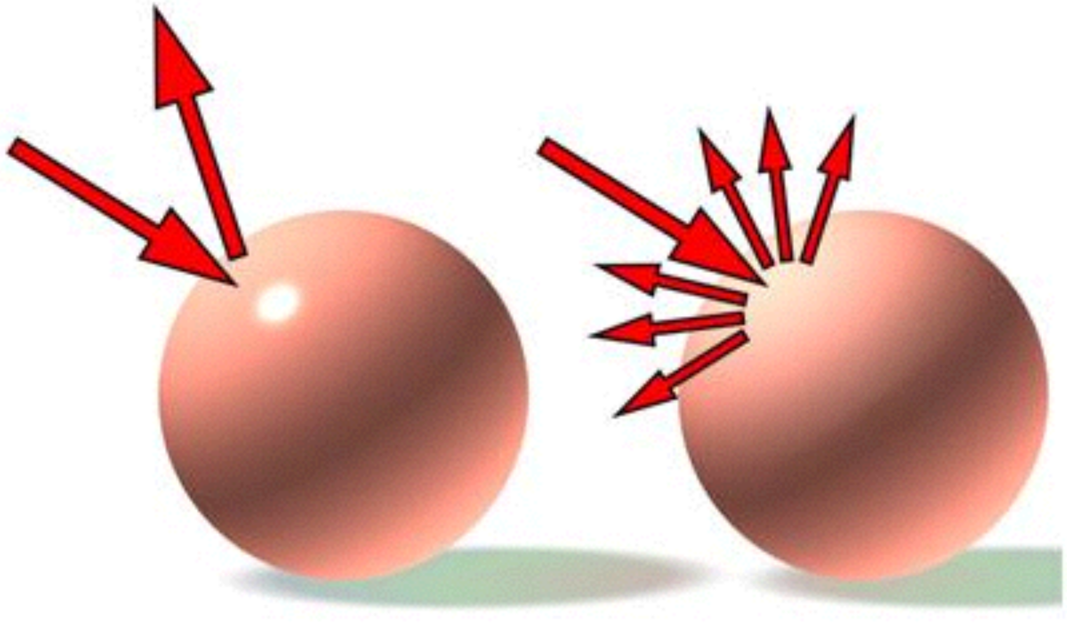
Assumes constant lighting direction and strength

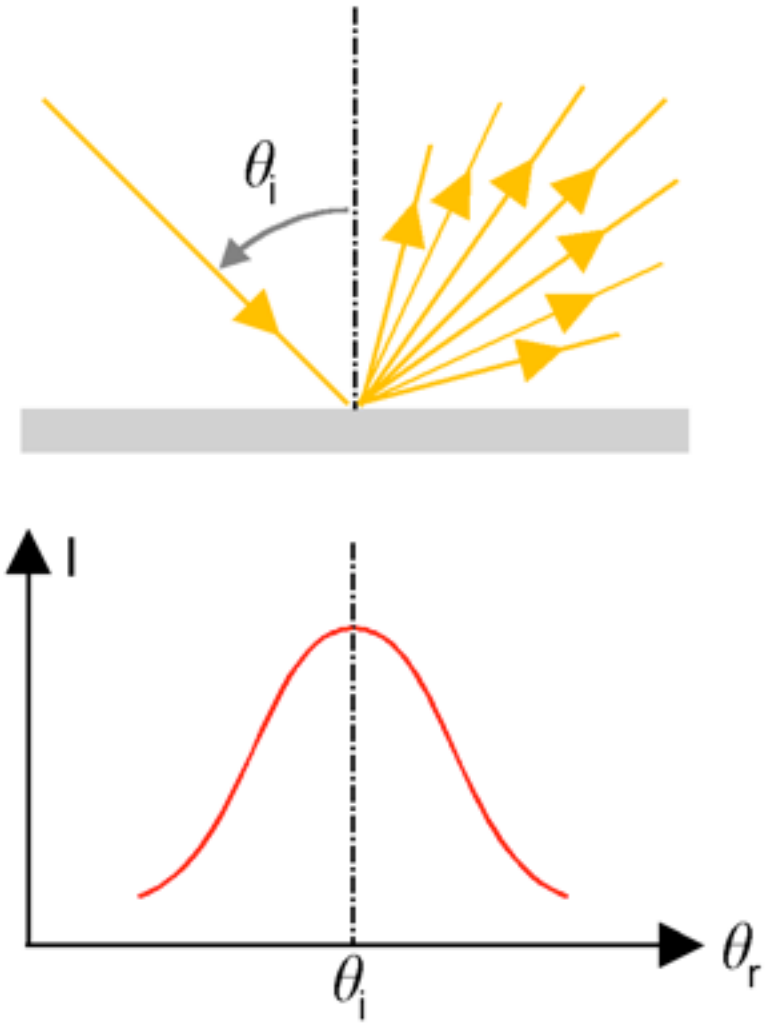


Specular Reflections



Specular Reflections





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

Specular Reflections

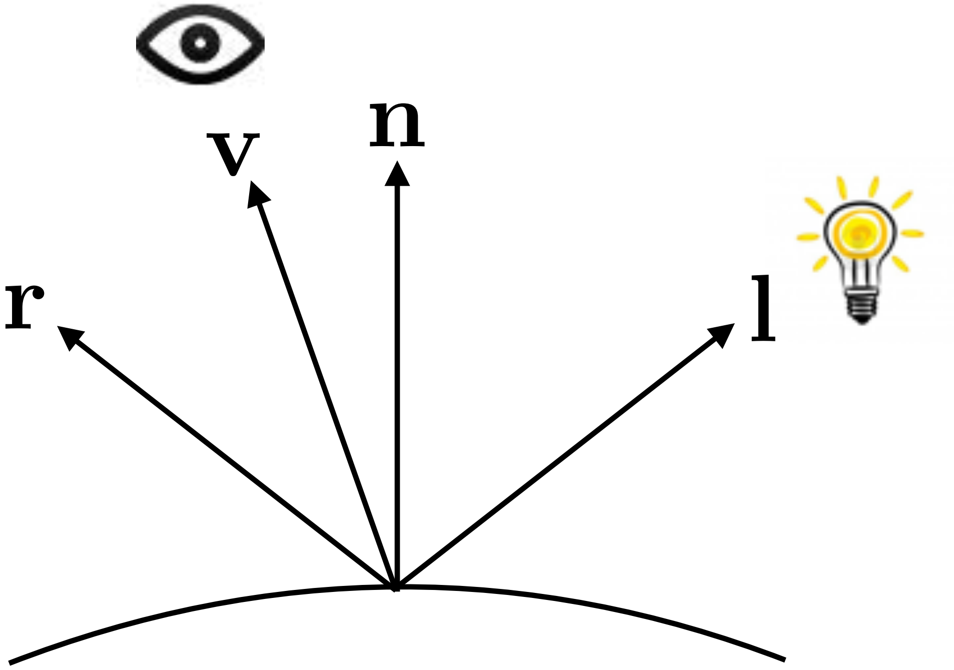
how glossy the surface is

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

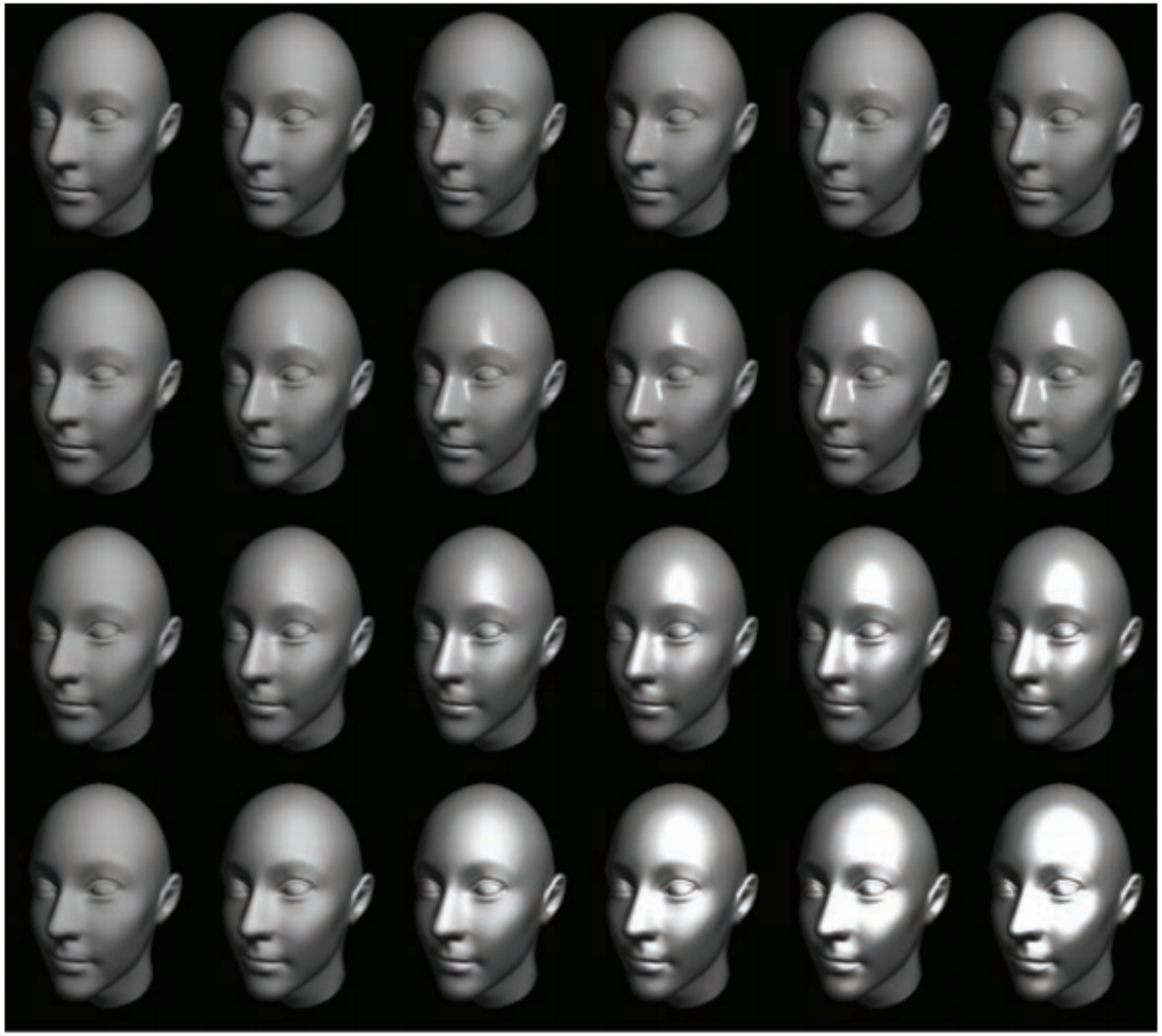
specular reflected color

source intensity

material specular reflectance



Specular Reflections



m_{gls}

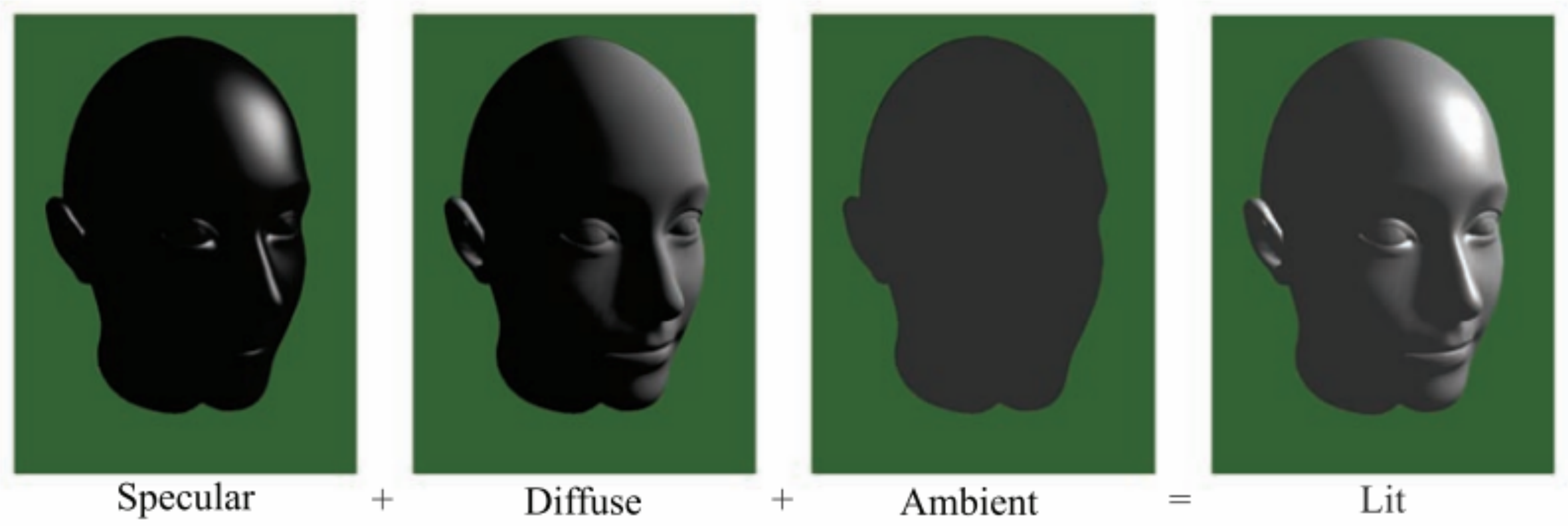
$\mathbf{m}_{\text{spec}}$

Ambient Reflection

- Ambient light is “all around”, so directions don’t matter
- Just the product of the ambient light and the surface reflectance

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

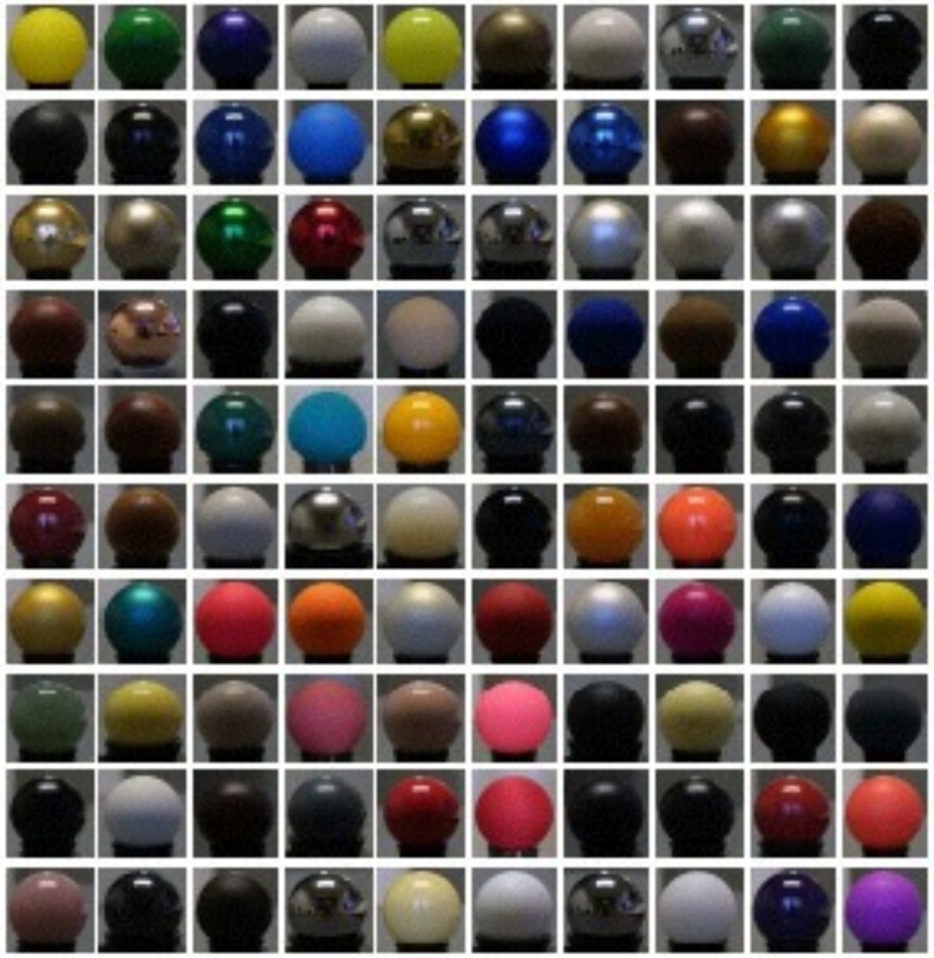
All Together Now…



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



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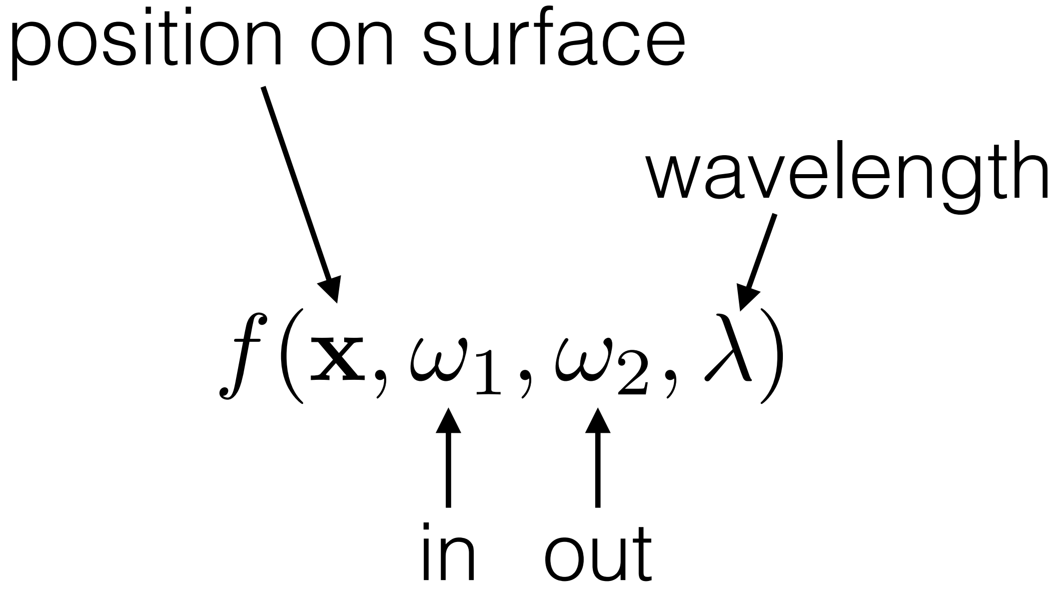
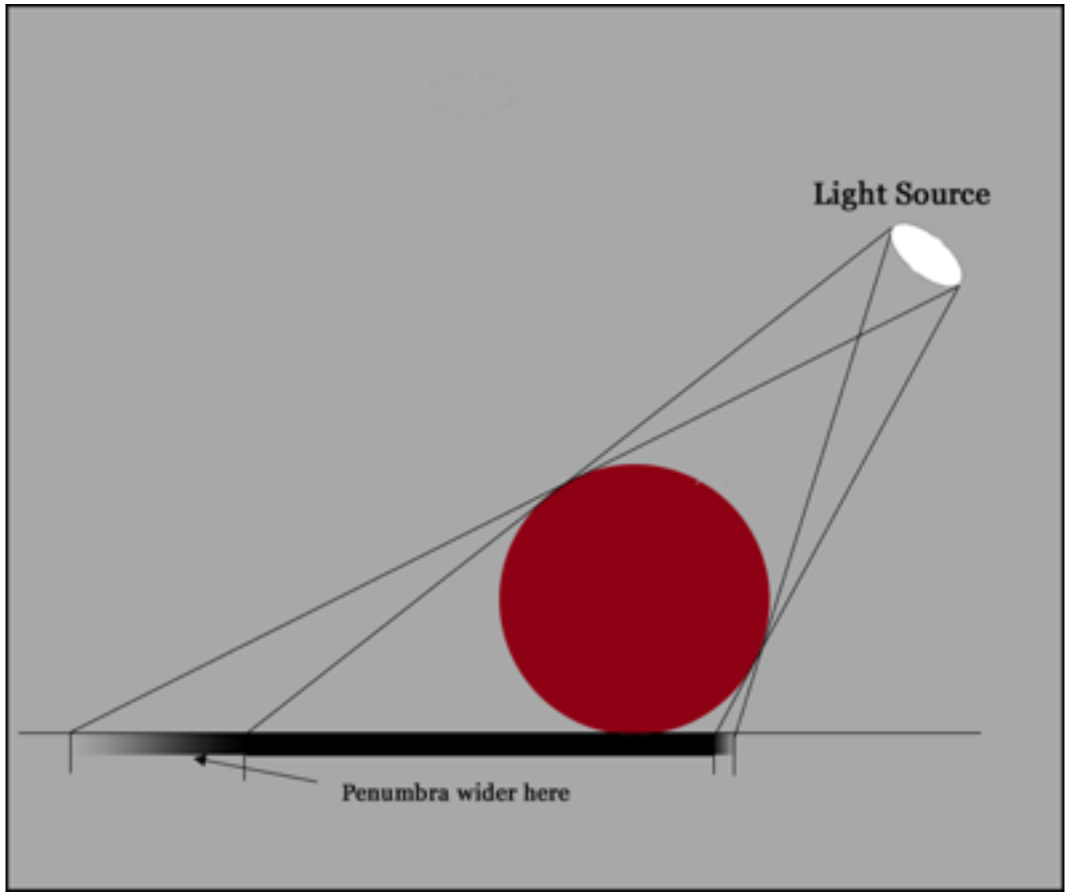


$$f(\mathbf{x}, \omega_1, \omega_2, \lambda)$$

Bidirectional Reflectance Distribution Function

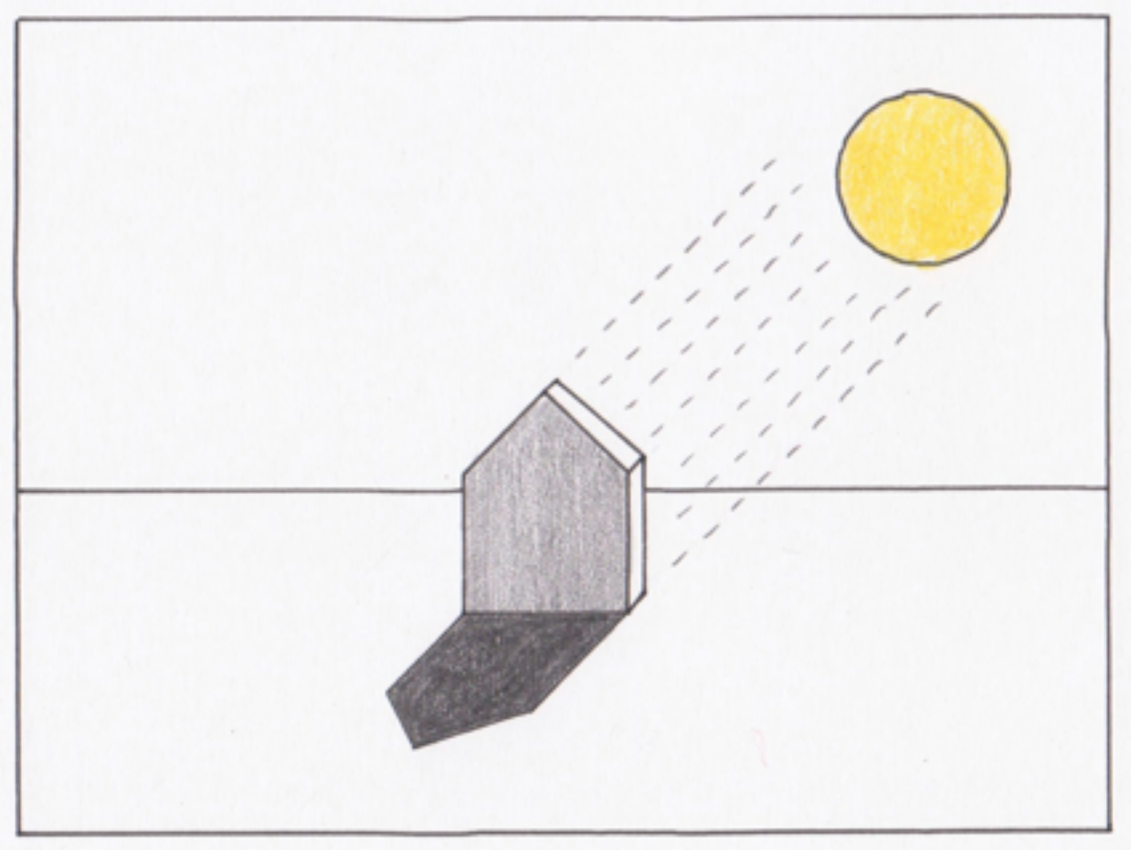
What About Shadows?

- 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
- Cameras and image acquisition revisited
- Image processing