
# Lighting and Shading

CS 355: Introduction to 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”

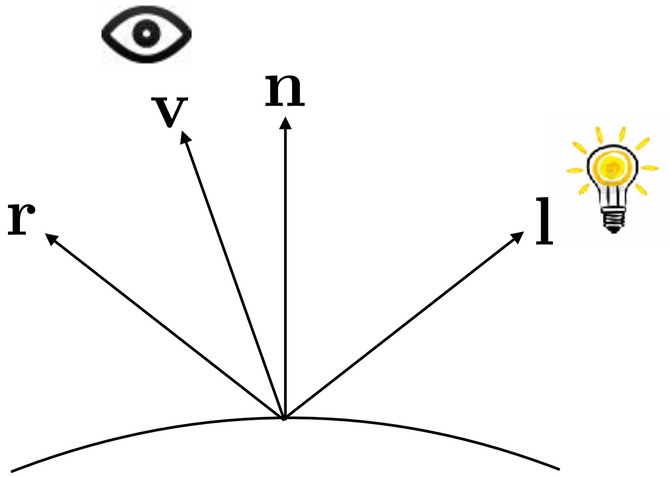
# Light Sources

**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

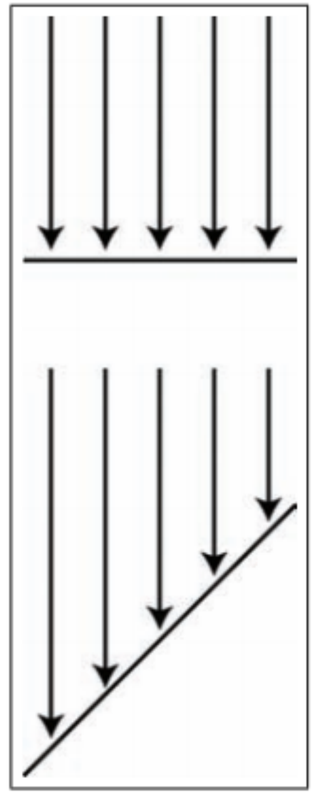
- Most objects don't give off light
  - reflect some of the light that falls on them
  - absorb the rest
- The wavelengths reflected give the object its color
- The effect is multiplicative: i.e., "reflects 40% of the green light"
- If we model the light as RGB, we can also model reflectance as RGB
-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

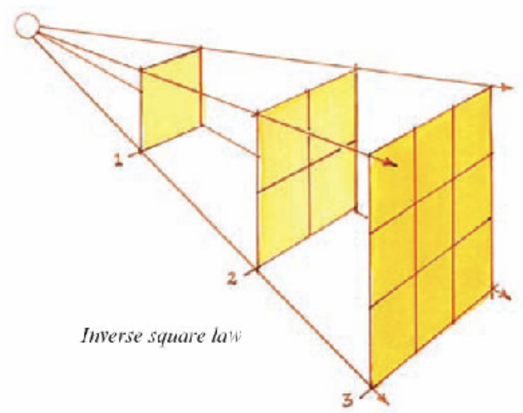
# Irradiance

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

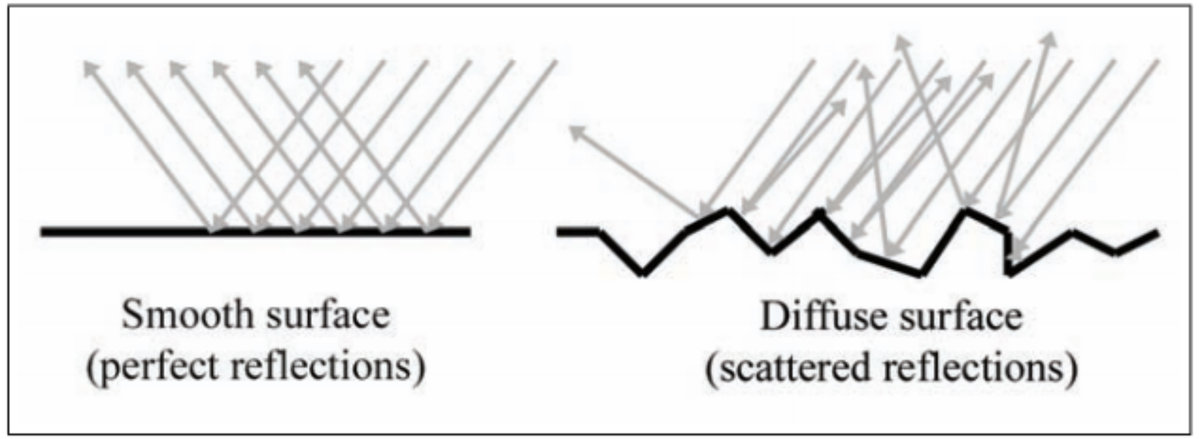
# Irradiance

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





# Specular vs. Diffuse

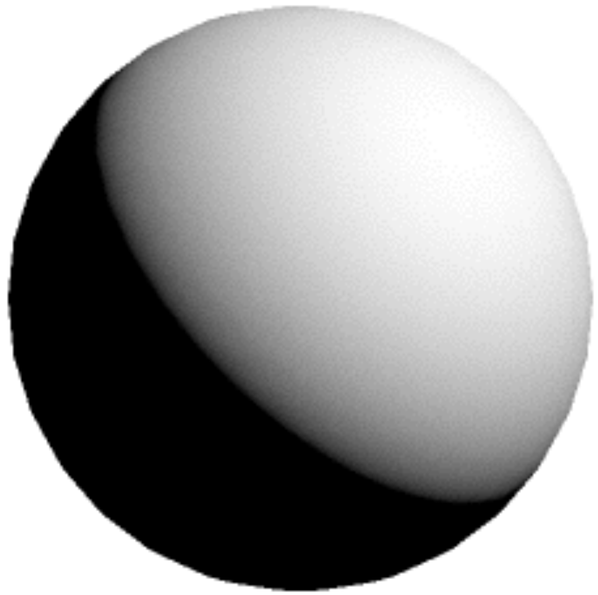



Some light is reflected perfectly (specular)

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

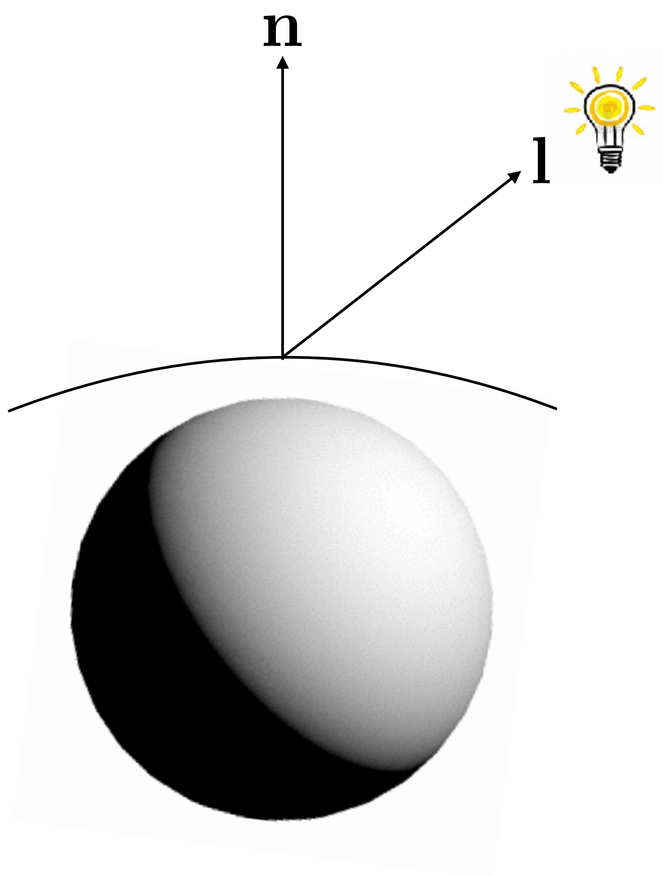
pointwise multiply RGB

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

diffuse reflected color

source intensity

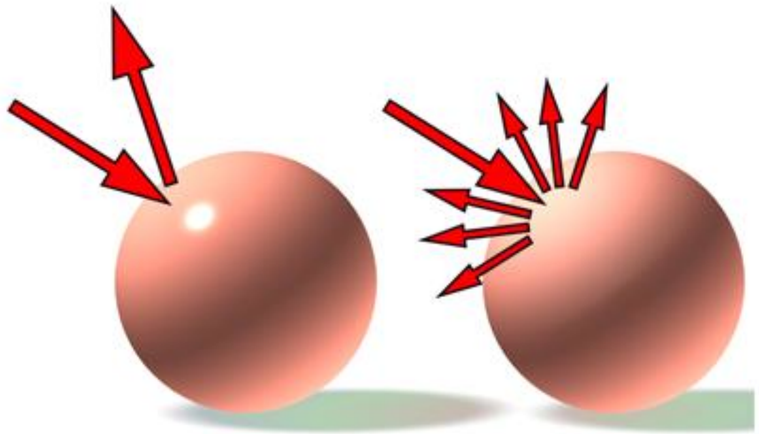
material diffuse reflectance

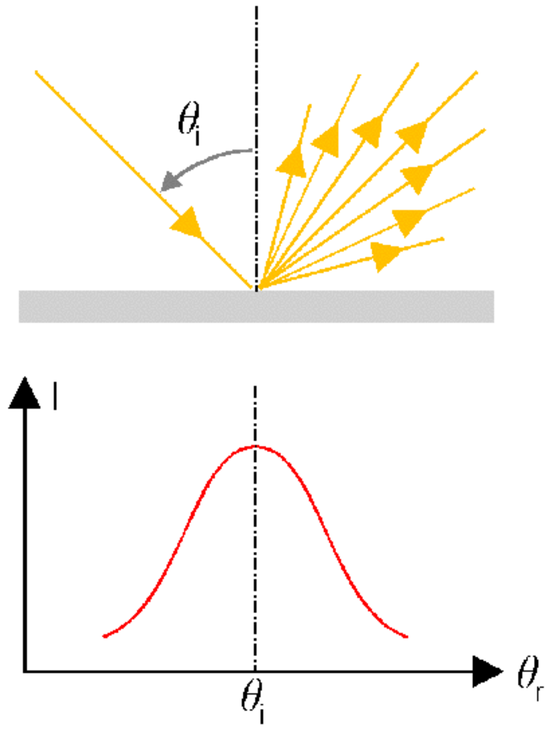



Assumes constant lighting direction and strength

# Specular Reflections

# Specular Reflections






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

# Specular Reflections

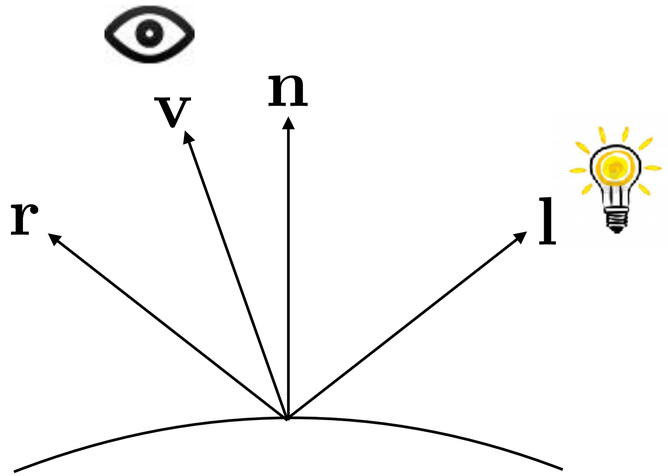
how glossy the surface is

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

specular reflected color

source intensity

material specular reflectance



# Specular Reflections

$m_{\text{gls}}$

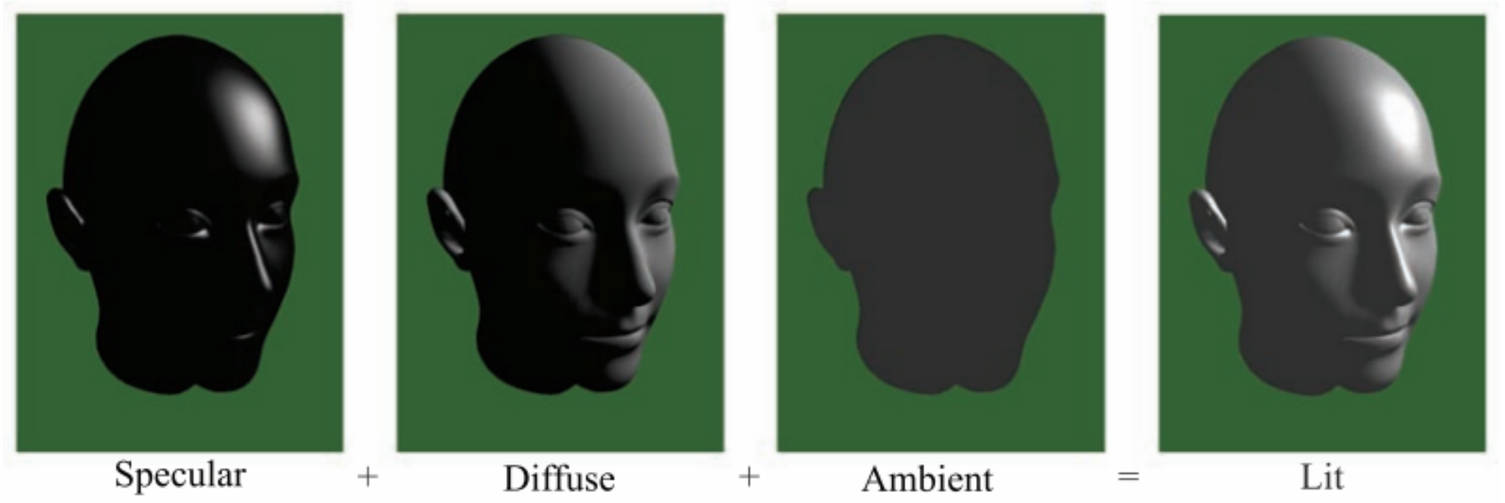
$\mathbf{m}_{\text{spec}}$

# 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
- Real reflections are not a simple mix of pure diffuse and pure specular
- Function of both incoming direction and outgoing direction
- Reflectance isn’t constant across the surface

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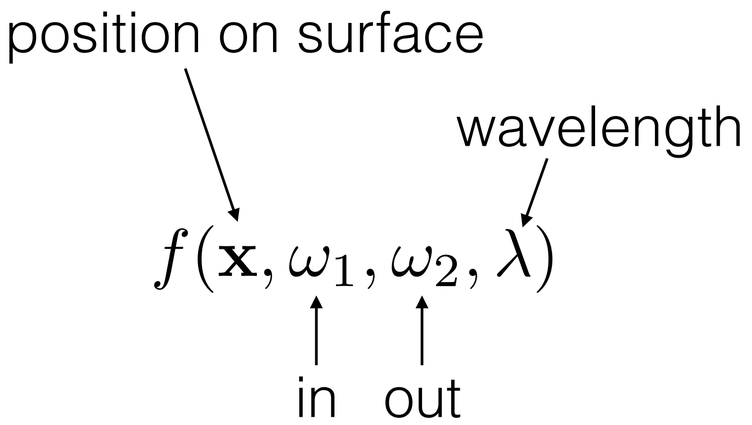
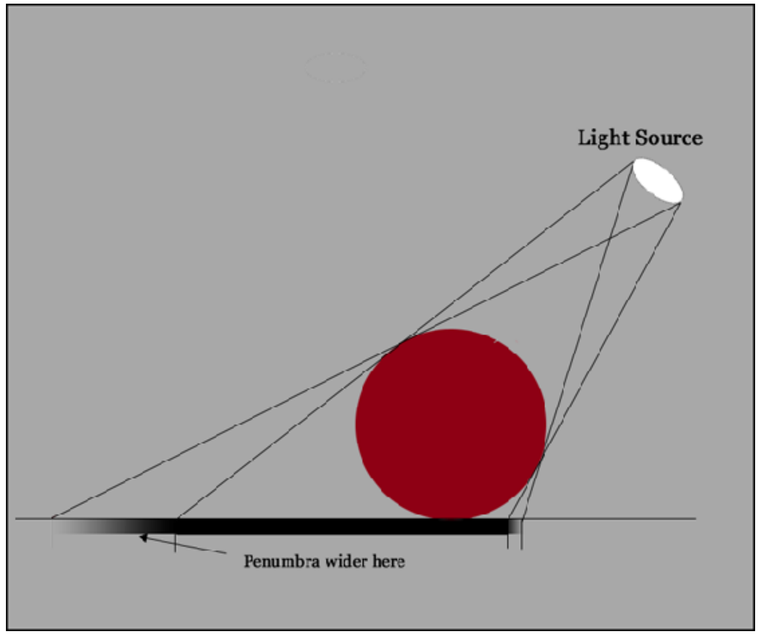



Bidirectional Reflectance Distribution Function

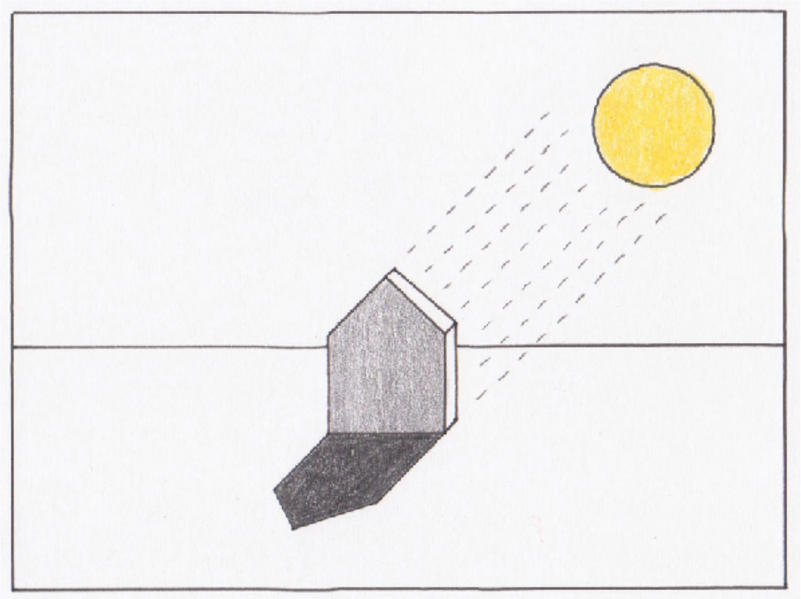
# What About Shadows?

- 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!*
- Z-buffering can also be used for distance-based falloff



# Coming up...

- More on lighting and shading