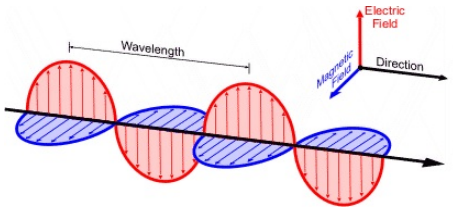
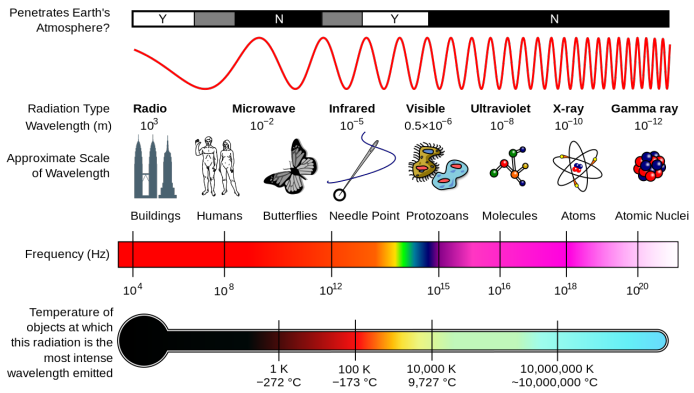
# Illumination and Lighting

- Interaction between light and matter complicated
- want computationally tractable approaches

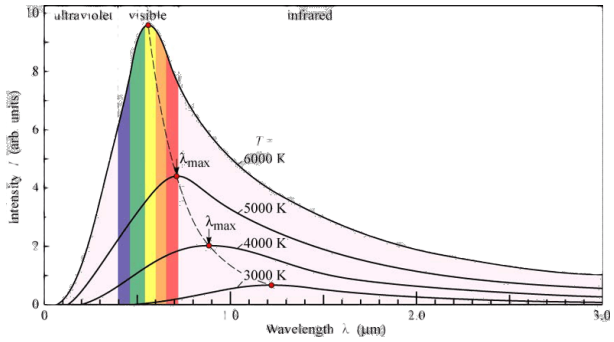
# Light

- an electromagnetic wave
- wavelength vs frequency
- wave vs particle

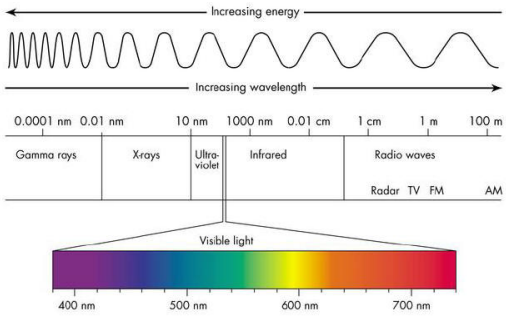


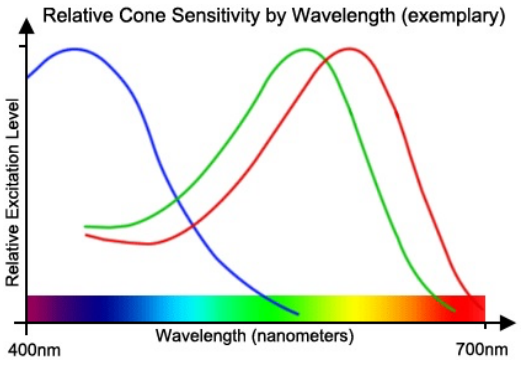
# Solar Radiation




# Visible Light



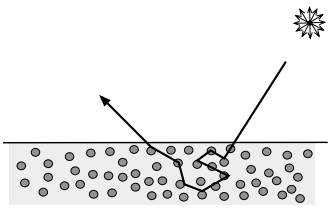

# Human Response

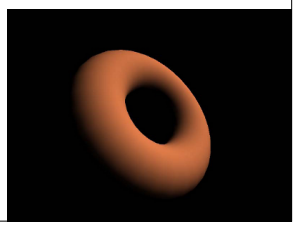


# Diffuse Reflection

(Lambertian Reflection)

- dull, matte surfaces
- reflect light equally in all directions
- light enters object, scatters internally
- eg: plastic, paint, paper, vegetation, snow, etc



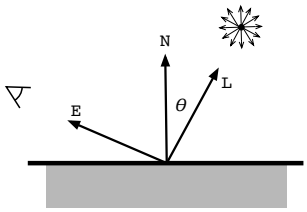


# Diffuse Reflection

- reflect light equally in all directions
- independent of eye direction
- amount of light falling on surface $\propto \cos(\theta) = \text{dot}(\mathtt{N},\mathtt{L})$

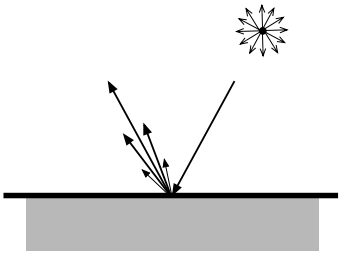
$$I = I_{light} \cdot K_d \cdot \cos(\theta)$$

[0…1]

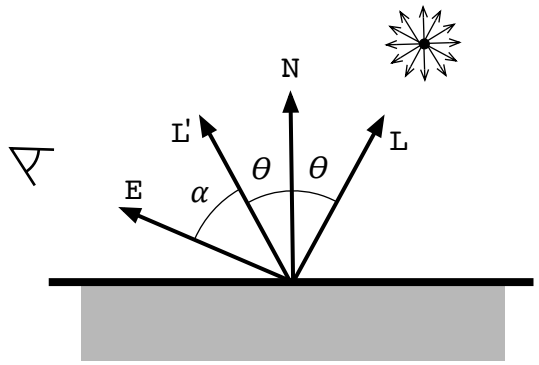



# Specular Reflection

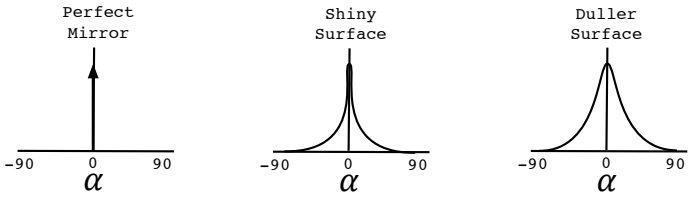
- shiny surfaces, highlights



# Specular Reflection



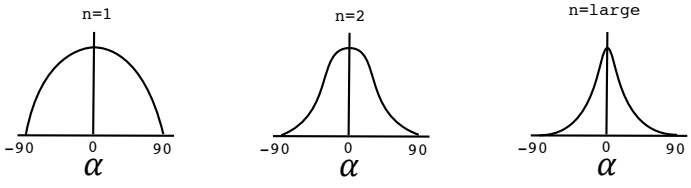

# Specular Reflection




# Phong Specular Model

- empirical model that “looks” good
- easy to compute, not exactly physics

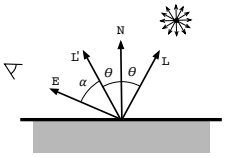
$\cos^n(\alpha)$



# Diffuse + Specular

$$I = I_{light} \cdot (K_d \cdot \cos(\theta) + K_s \cdot \cos^n(\alpha))$$

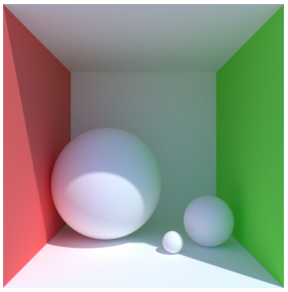
[0…1]




$\cos(\alpha) = \text{dot}(\mathbf{E}, \mathbf{L}')$

# Ambient Reflection

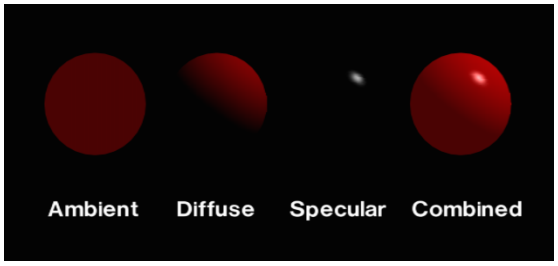
- modeling inter-reflection is hard
- parts in shadow are black (looks bad)
- approximate indirect lighting
- simplification:
  use constant $\boldsymbol{K_a}$



[0…1]

# All Three Components

$$I = I_{light} \cdot (K_a + K_d \cdot \cos(\theta) + K_s \cdot \cos^n(\alpha))$$

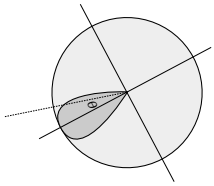


# Light Sources

- directional  $I_{light}$
- point source  $I_{light}$
  - attenuation $\frac{1}{r^2}, \frac{1}{r}, \frac{1}{ar^2+br+c}$

# Spotlights

- spotlights
  barn doors

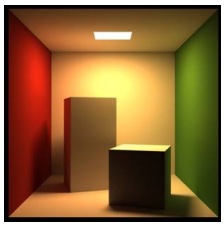


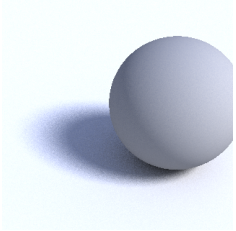
- location, direction, drop-off rate, max angle

# Spotlights

# Area Light Sources

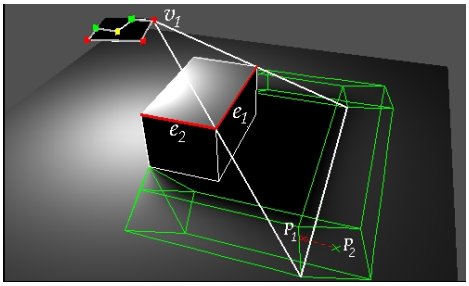
- point light sources too harsh





# Area Light Sources

- geometric solutions

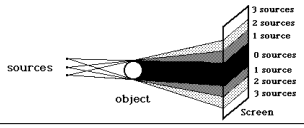



- can approximate with multiple point light sources

# Linear Light Sources

- geometric solutions

- can approximate with multiple point light sources



# Multiple Light Sources

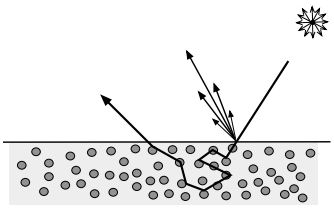
$$I = \sum_{i=1}^{l} I_{light_i} \cdot (K_a + K_d \cdot \cos(\theta_i) + K_s \cdot \cos^n(\alpha_i))$$

or

$$I = I_a K_a + \sum_{i=1}^{m} I_{light_i} \cdot (K_d \cdot \cos(\theta_i) + K_s \cdot \cos^n(\alpha_i))$$

# Color

- $K_a$, $K_d$, $K_s$ depend on $\lambda$, $I_{light}$ depends on $\lambda$
- highlights: white for many objects (actually, color of light)



# Color

- $K_a$, $K_d$, $K_s$ depend on $\lambda$, $I_{light}$ depends on $\lambda$
- metals: highlights color of surface, little diffuse