# Illuminating a Virtual World

## Computer Graphics Lecture 2

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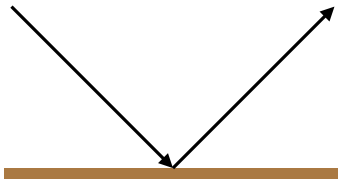
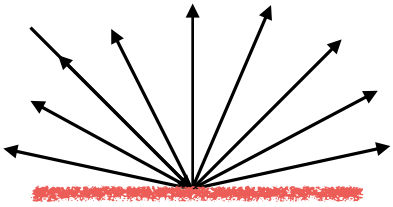
# Types of Reflector



**Specular**



**Diffuse**

**A purely specular reflector is a perfect mirror**
**Diffuse reflectors look the same from all directions**
**All surfaces reflect in both ways**

In this lecture we will present several different methods for adding illumination to a virtual world.

We will start with the simplest method.

We will improve our physical models to better reflect physics.



# Method: Flat Shading

Two types of light: background ambient light, and a light source.

Assumption: light source is infinitely far away. Light source is given a direction rather than a location.

Break illumination up into three categories: ambient, diffuse, and specular.

For each surface,
Identify the amount of light reflected in each category, and sum them up.

# Ambient Lighting

**Light present throughout all volume of interest.**
**Example: sunlight through window blinds.**

http://cdn.home-designing.com/wp-content/uploads/2013/01/elegant-modern-living-room.jpg



# Modeling Ambient Lighting

**Assign each polygon in your mesh an "ambient reflectivity".**

**The light intensity due to ambient lighting is:**

$$\mathcal{I}_{\text{measured}} = r_a \mathcal{I}_a$$

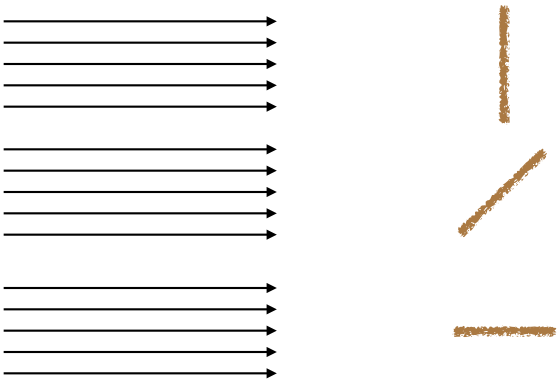
$\mathcal{I}_a$ **is the ambient light intensity.**

$r_a \in [0, 1]$ **is the polygon's ambient reflectivity.**

# Flux

**The rate of flow per unit area.**

**Light Rays** **Diffuse Reflectors**



**Reflects a lot of light**

**Reflects some light**

**Doesn't reflect any light**

**We see a cosine dependence for the amount of reflected light.**



# Diffuse Reflectivity

**Assign each polygon in your mesh a "diffuse reflectivity".**

**The light intensity due to diffuse reflectivity is:**

$$\mathcal{I}_{\text{measured}} = r_d \, \mathcal{I}_{\text{source}} \, \cos(\theta)$$

$\mathcal{I}_{\text{source}}$ **is the ambient light intensity.**

$r_d \in [0, 1]$ **is the polygon's diffuse reflectivity.**

$\theta$ **is the angle between the light rays and the normal vector of the surface**

**Recall: the angle between two vectors $L$ and $N$ is**

$$\cos(\theta) = \frac{L \cdot N}{\|L\|_2 \|N\|_2}$$

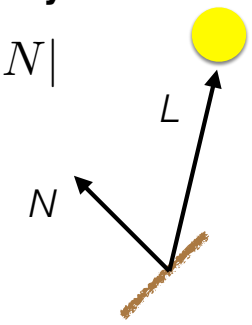


# Diffuse Reflectivity

**Assign each polygon in your mesh a "diffuse reflectivity".**

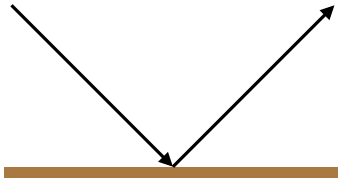
**The light intensity due to diffuse reflectivity is:**

$$\mathcal{I}_{\text{measured}} = r_d \, \mathcal{I}_{\text{source}} \, |L \cdot N|$$

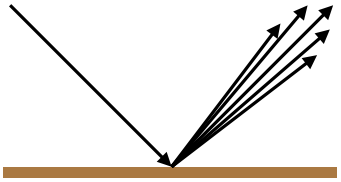



**$N$ is the normal vector of the surface.**
**$L$ is a vector pointed at the light source.**
**$L$ and $N$ are assumed to be unit vectors.**

# Specular Reflection



**Ideal Specular Reflector**



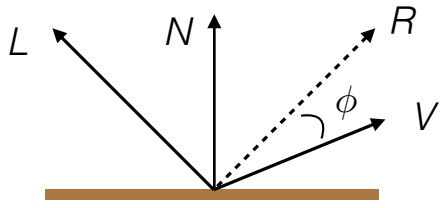
**Non-Ideal Specular Reflector**



## Phong Model for Specular Reflection

**The light intensity due to diffuse reflectivity is:**

$$\mathcal{I}_{\text{measured}} = r_s \, \mathcal{I}_{\text{source}} \, \cos^k(\phi) = r_s \, \mathcal{I}_{\text{source}} \, |R \cdot V|^k$$




*R* **is the direction of ideal specular reflection.**
*V* **is the direction of interest.**
*k* **is a parameter of the model (*k* ~ 10 should be good).**

# Summing Effects

$$\mathcal{I}_{\text{measured}} = r_a \mathcal{I}_a + r_d \mathcal{I}_{\text{source}} |L \cdot N| + r_s \mathcal{I}_{\text{source}} |R \cdot V|^k$$



# Color

**To process color imagery, you would need to do the above procedure for each color channel.**

**Each polygon gets a red, blue, and green value reflectivity for each type of illumination.**

***You can now add shading to your virtual world!***