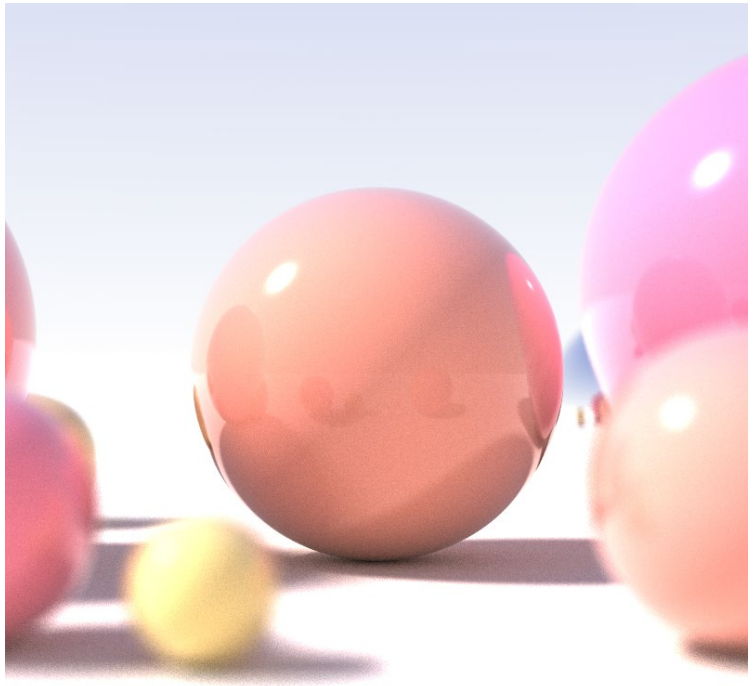
Ray Tracing



Some Slides/Images adapted from Marschner and Shirley and David Levin

Announcements

Assignment 2 is due tonight

Assignment 3 is available (due 2 June)

Any Questions?

Ray Tracing

(Today)

Review Ray Casting

Point and Directional Lights

Lambertian Shading Model

Blinn-Phong Shading Model

(Next week)

Shadows

Reflection

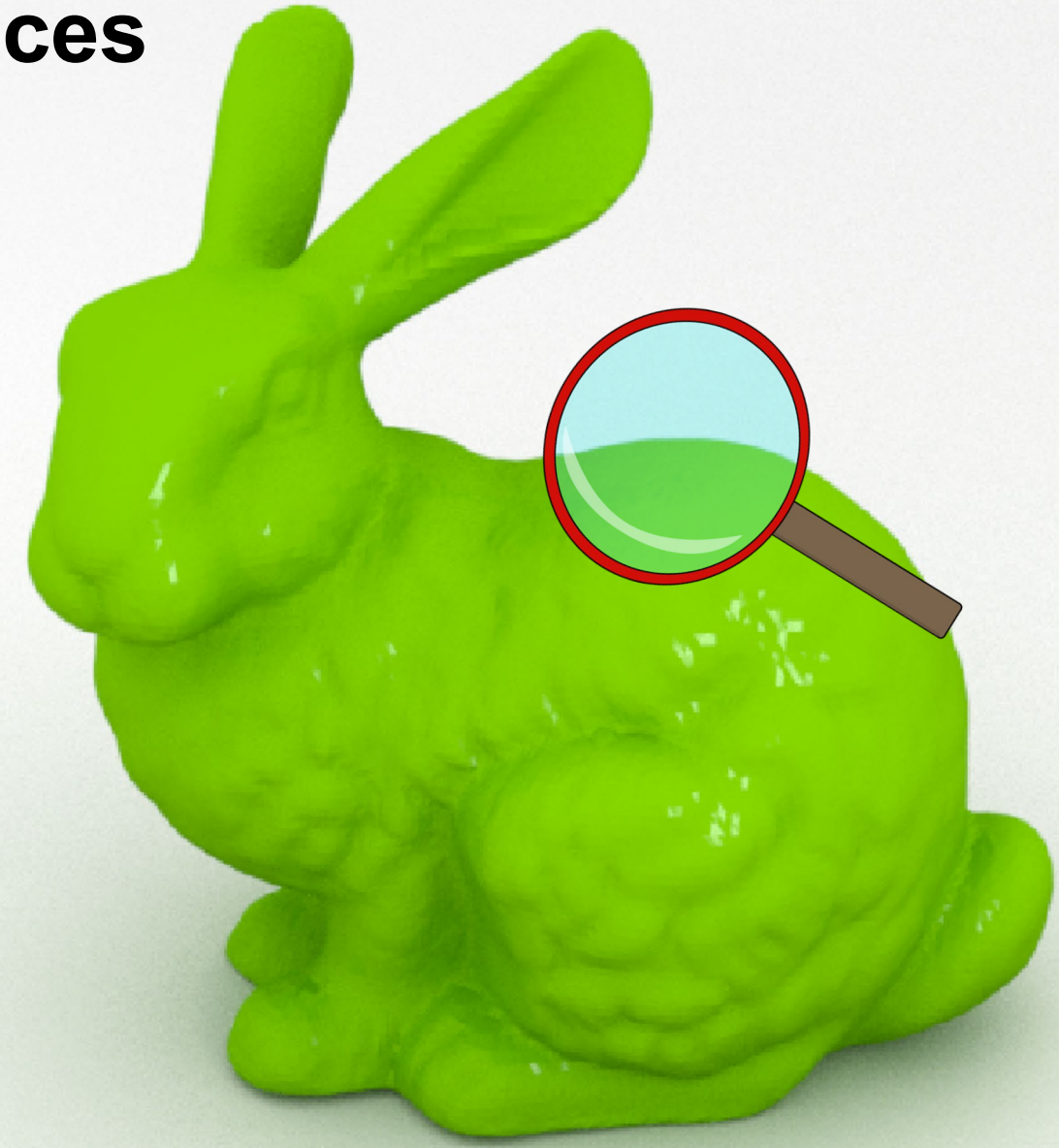
Transparency and Refraction

Ray Casting

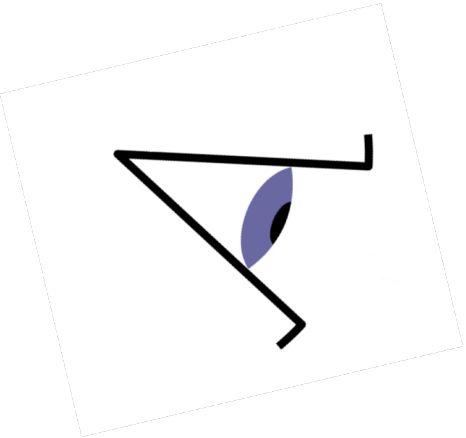
```
for each pixel in the image {
    Generate a ray
    for each object in the
    scene {
        if (Intersect ray with
            object) {  Set pixel
            colour
        }
    }
```

Light and Surfaces

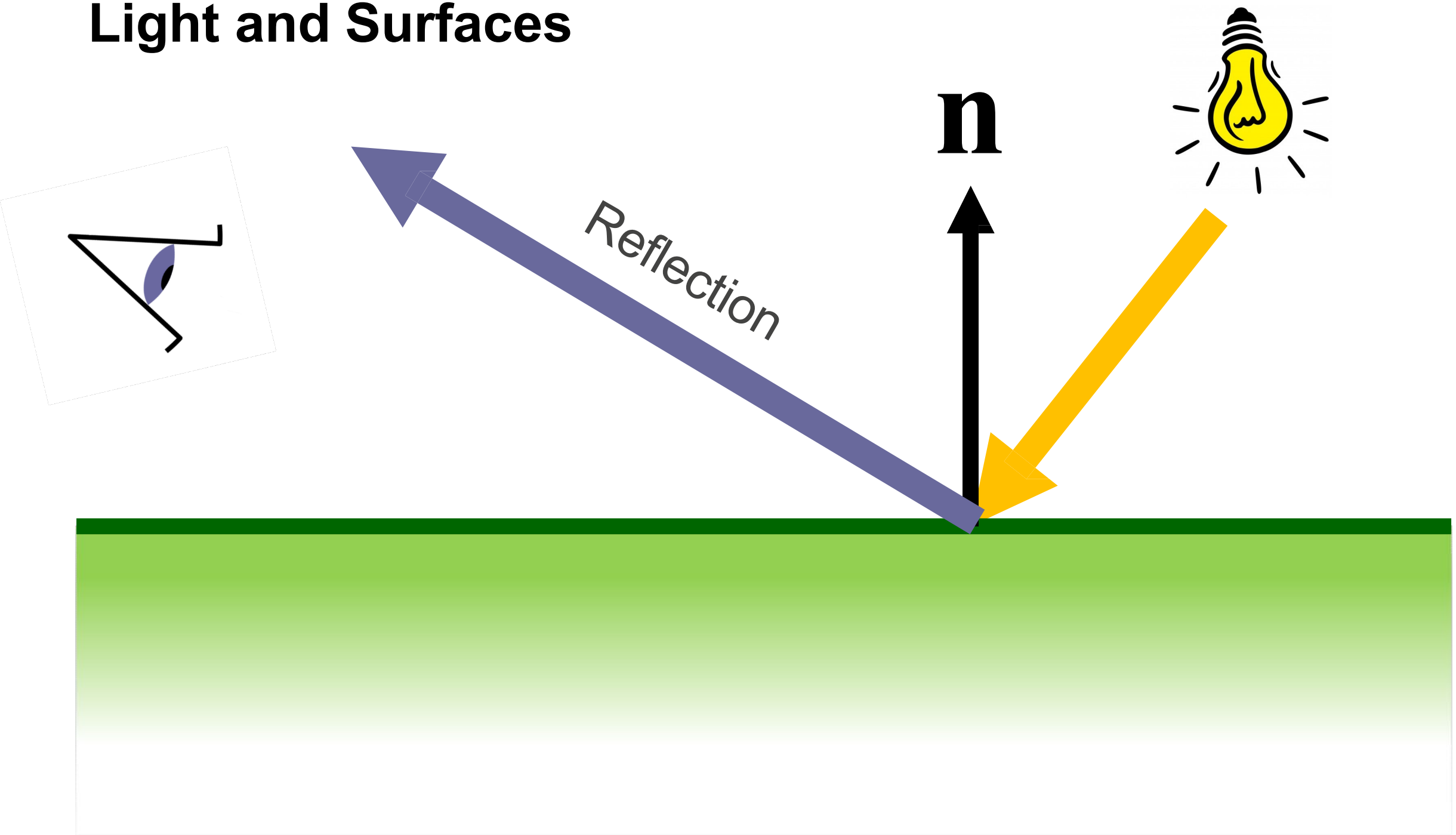
Light and Surfaces



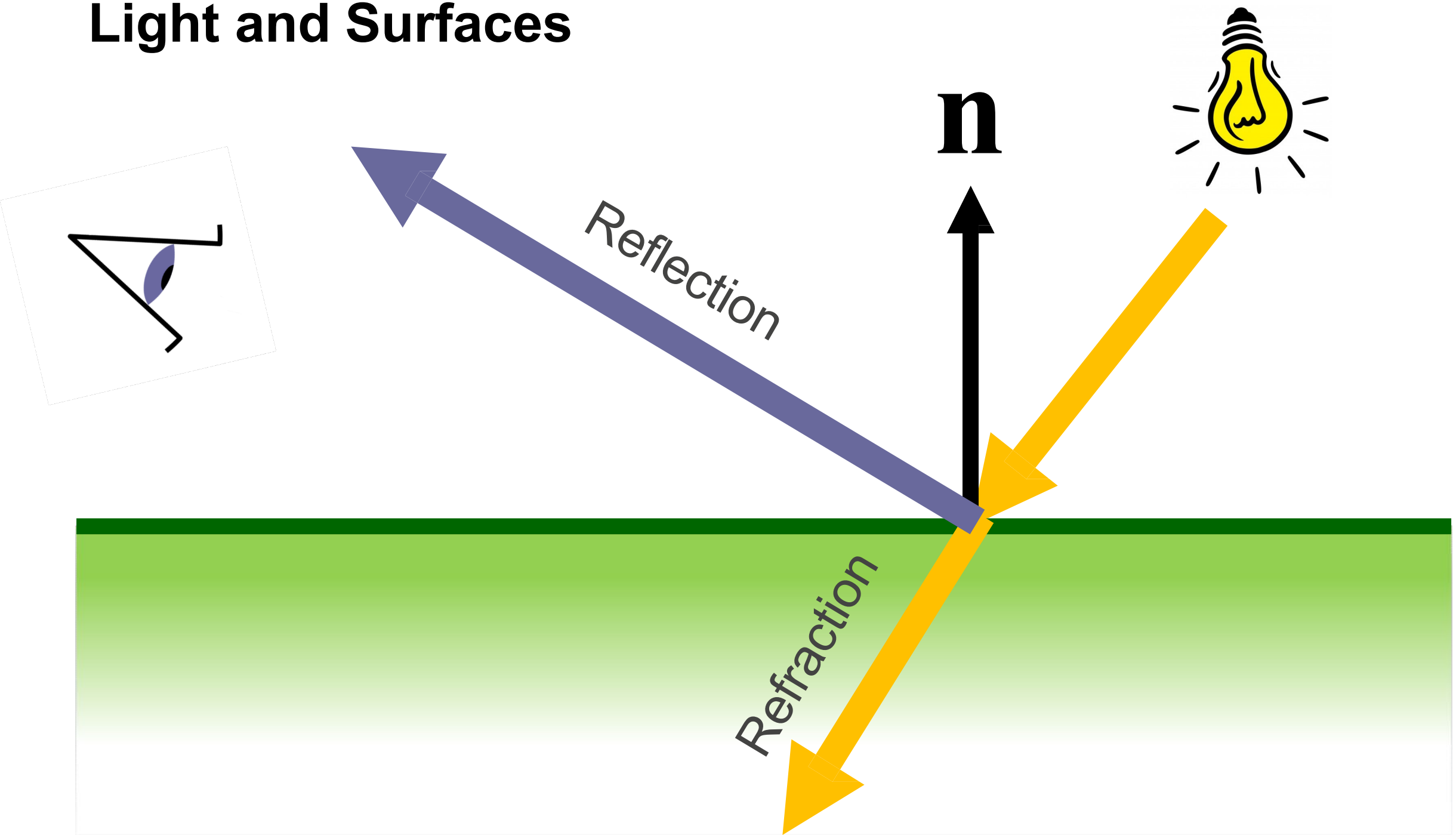
Light and Surfaces



Light and Surfaces



Light and Surfaces



Lights

Two types of lights:

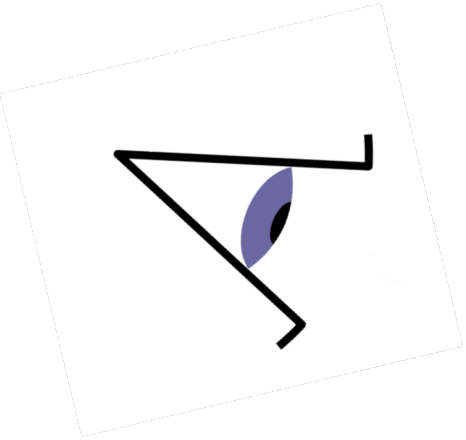
Directional Light:

Direction of light does not depend on the position of the object. **Light is very far away**

Point Light

Direction of light depends on position of object relative to light.

Directional Light



Lights

Two types of lights:

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Point Light

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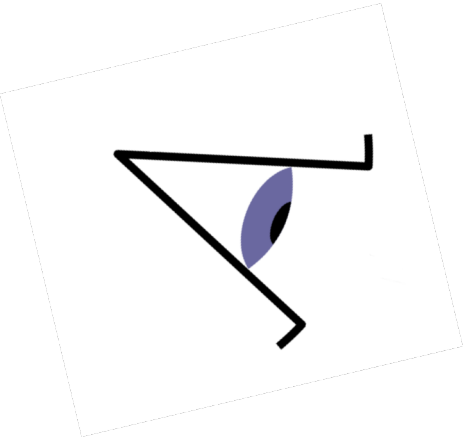
Point Light



Ray Casting

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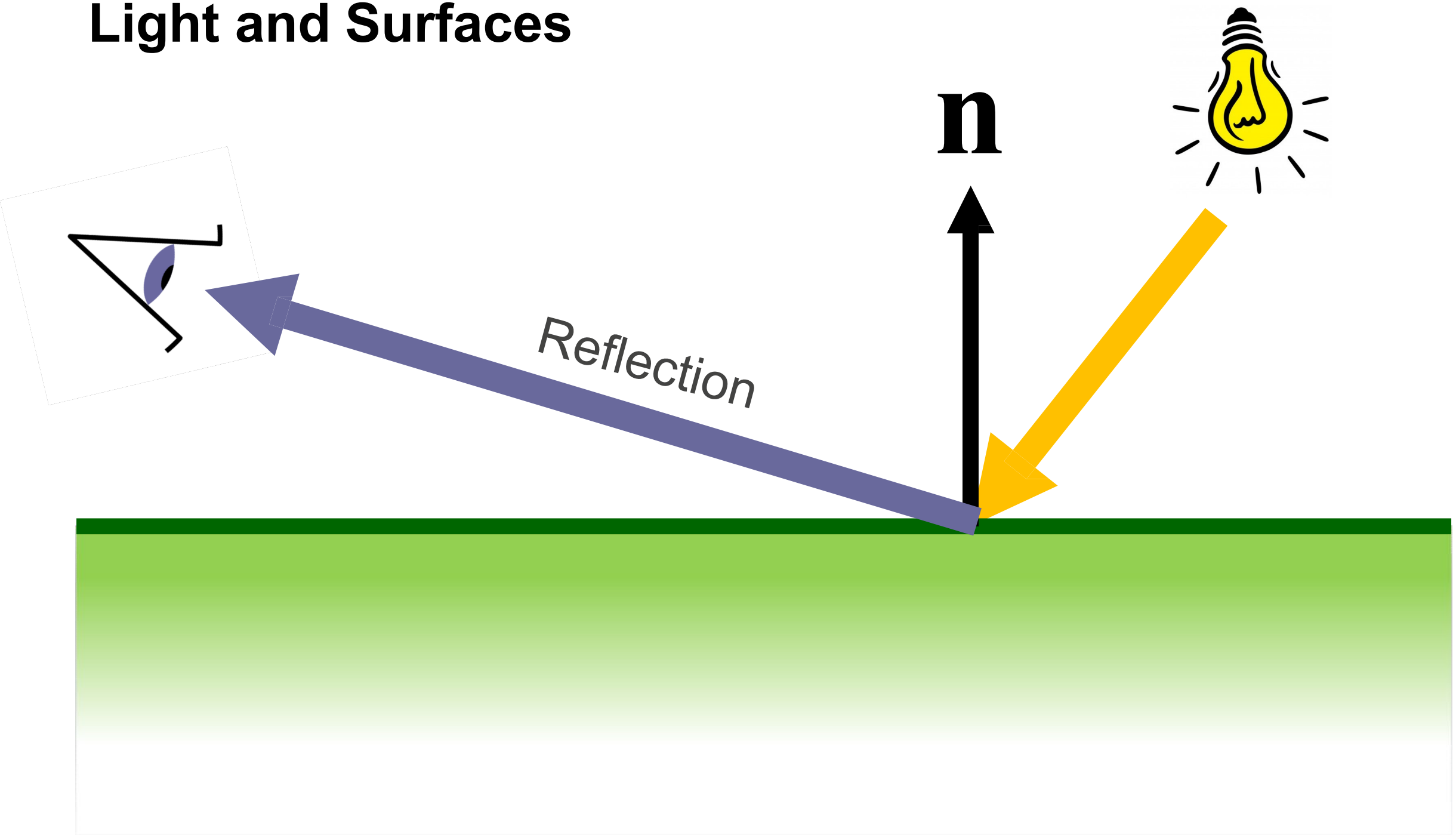
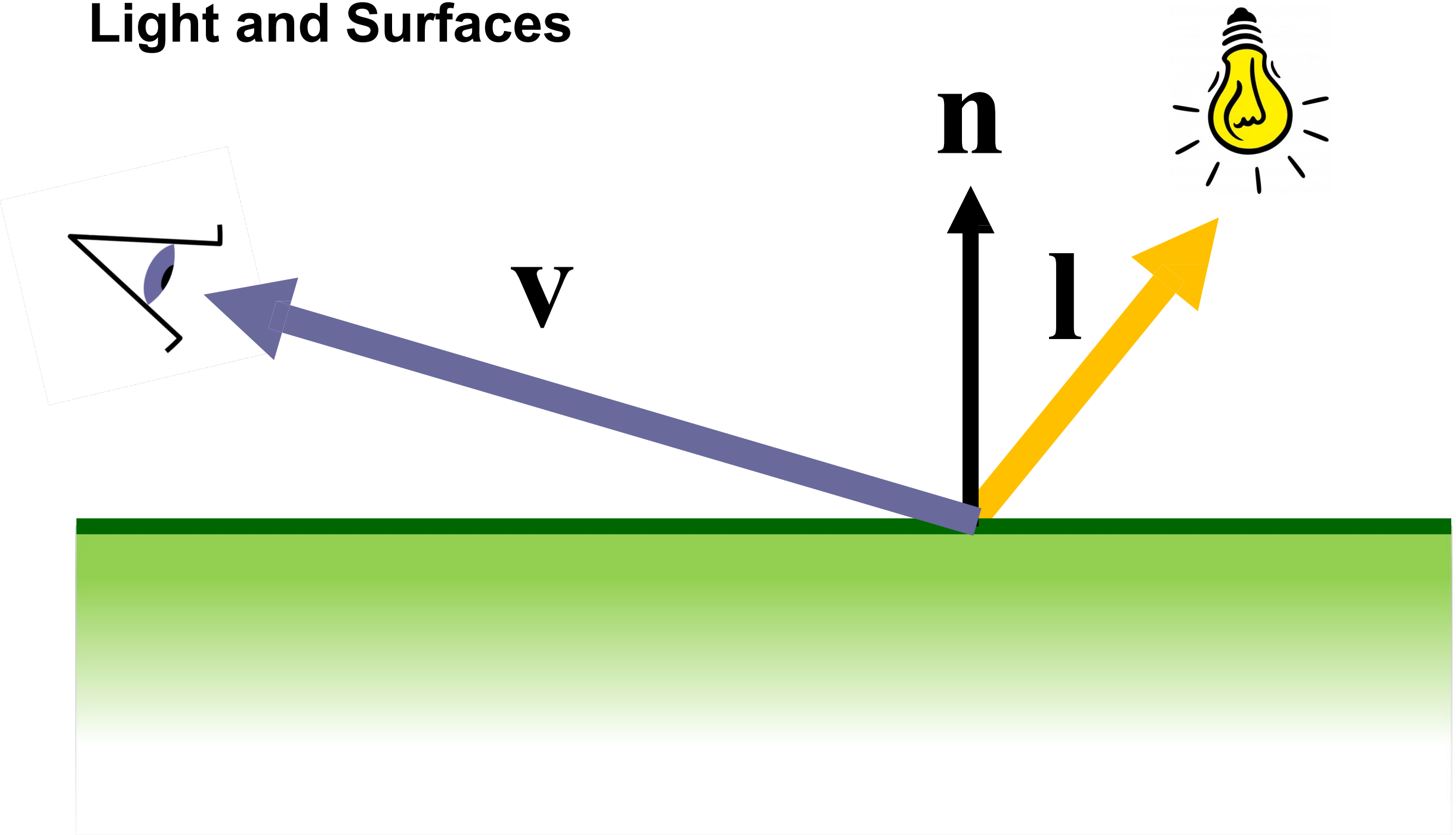
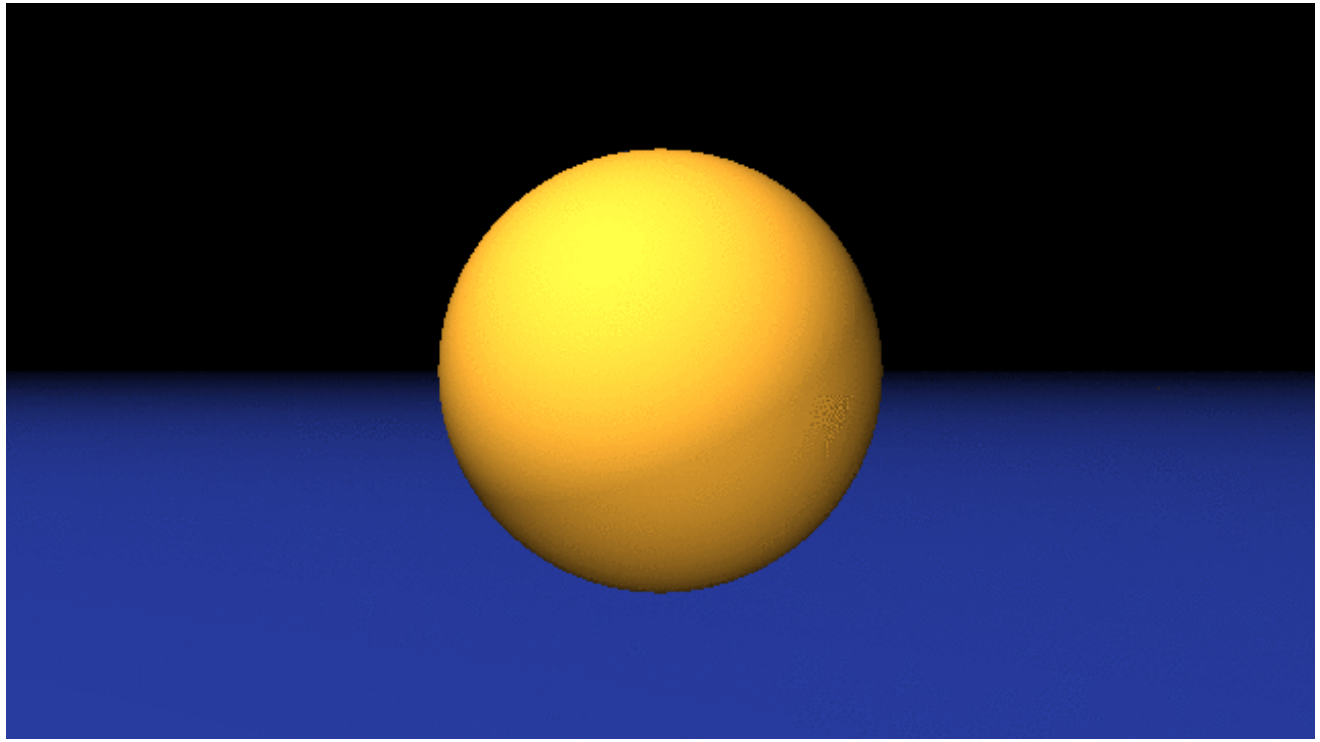
Light and Surfaces



Light and Surfaces



Lambertian (Diffuse) Shading



Lambertian (Diffuse) Shading

the amount of energy from a light source that falls on an area of surface depends on the angle of the surface to the light.

- Lambert (18th century)

Lambertian (Diffuse) Shading

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- Lambert (18th century)

$$\mathbf{a} \cdot \mathbf{b} = \|\mathbf{a}\|\|\mathbf{b}\|\cos(\theta_{\mathbf{b}}^{\mathbf{a}})$$

Lambertian (Diffuse) Shading

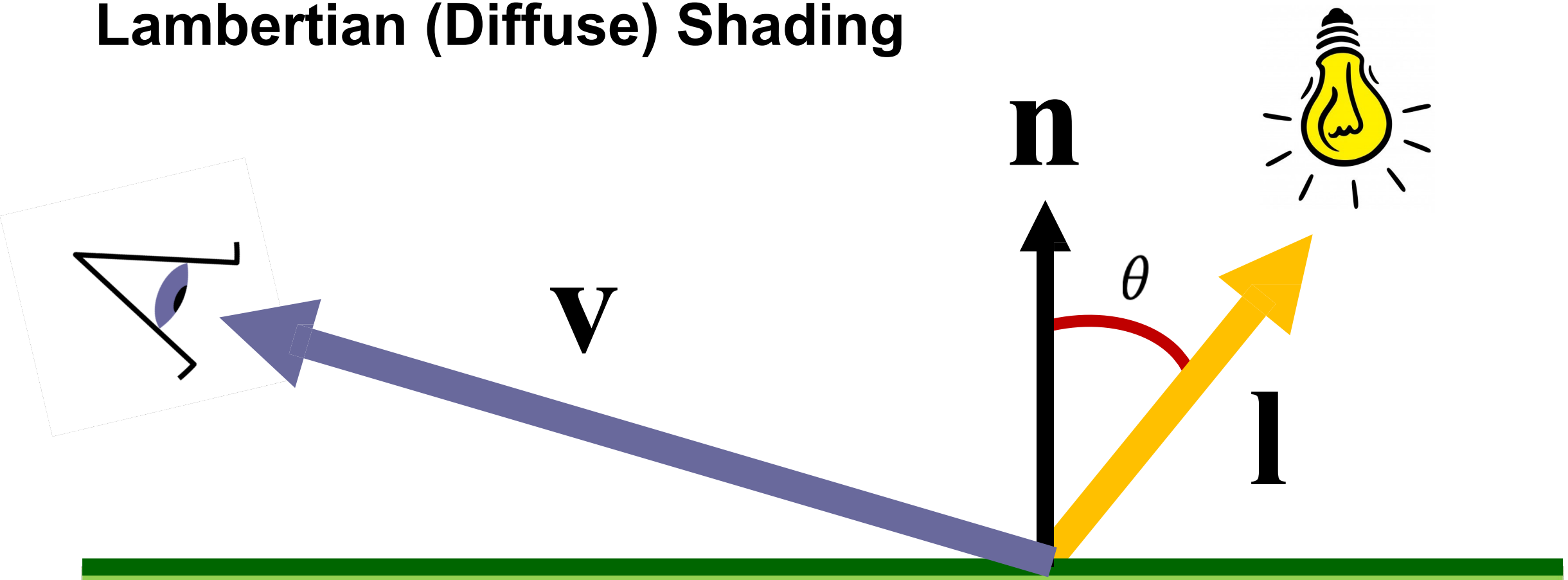
the amount of energy from a light source that falls on an area of surface depends on the angle of the surface to the light.

- Lambert (18th century)

$$L = k_d \, I \, \max(0, \mathbf{n} \cdot \mathbf{l})$$

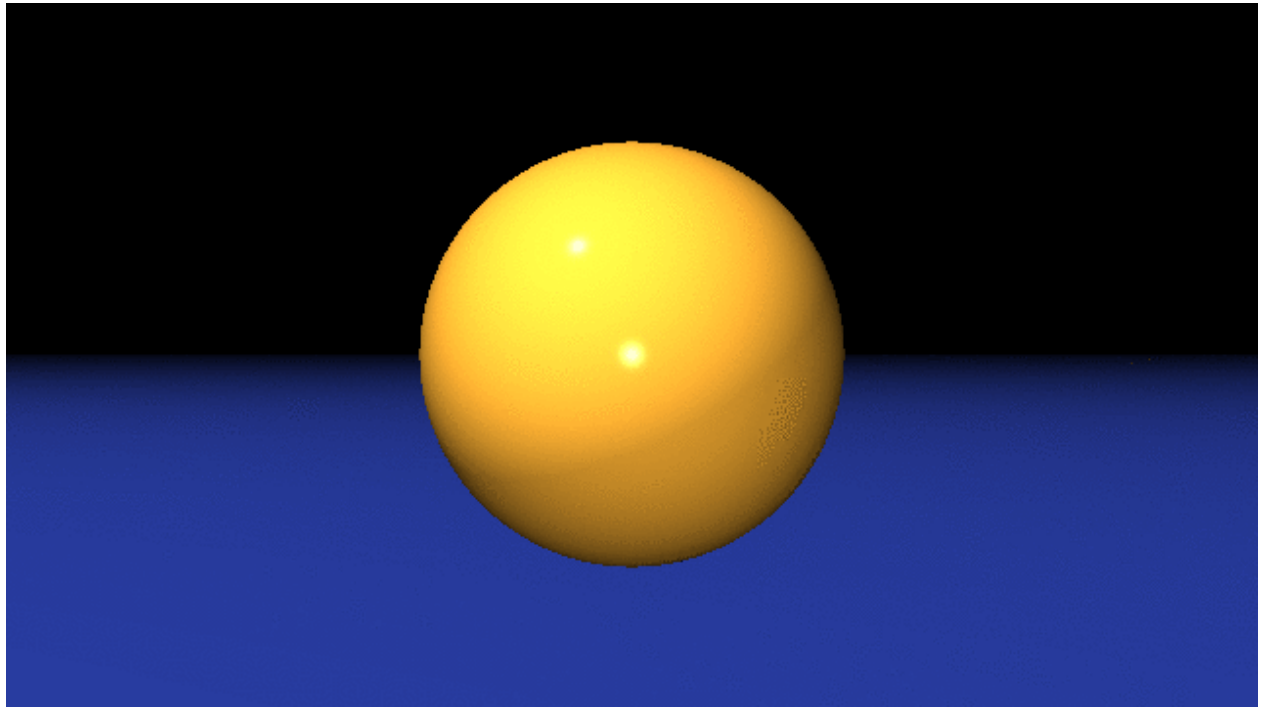
https://en.wikipedia.org/wiki/Lambert%27s_cosine_law

Lambertian (Diffuse) Shading



$$L = k_d \, I \, \max(0, \mathbf{n} \cdot \mathbf{l})$$

Specular Reflection

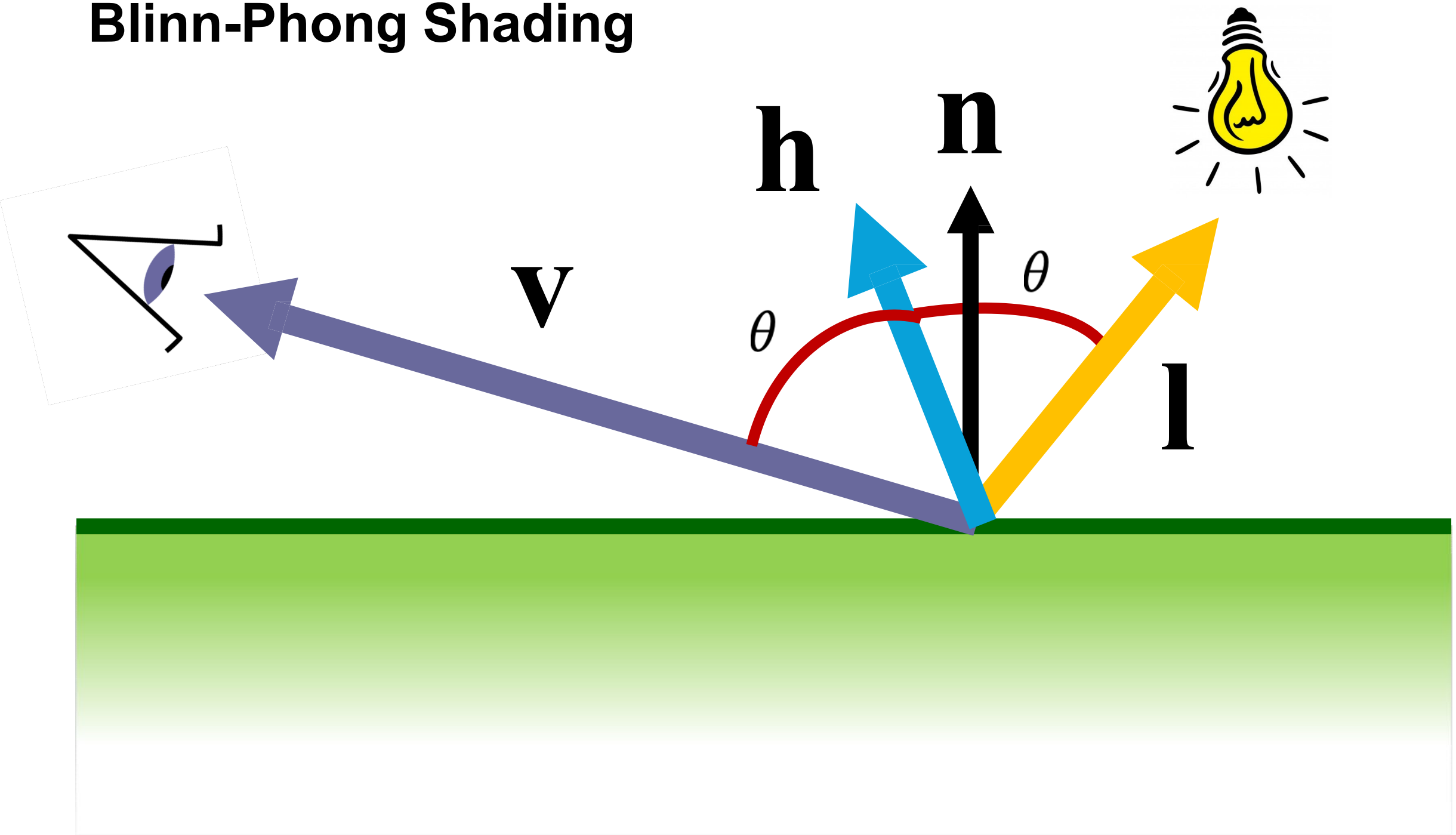


Blinn-Phong Shading Model

“The idea is to produce reflection that is at its brightest when v and l are symmetrically positioned across the surface normal, which is when mirror reflection would occur; the reflection then decreases smoothly as the vectors move away from a mirror configuration.”

– Marschner and Shirley

Blinn-Phong Shading



The Half Vector

$$\mathbf{h} = \frac{\mathbf{v} + \mathbf{l}}{\|\mathbf{v} + \mathbf{l}\|}$$

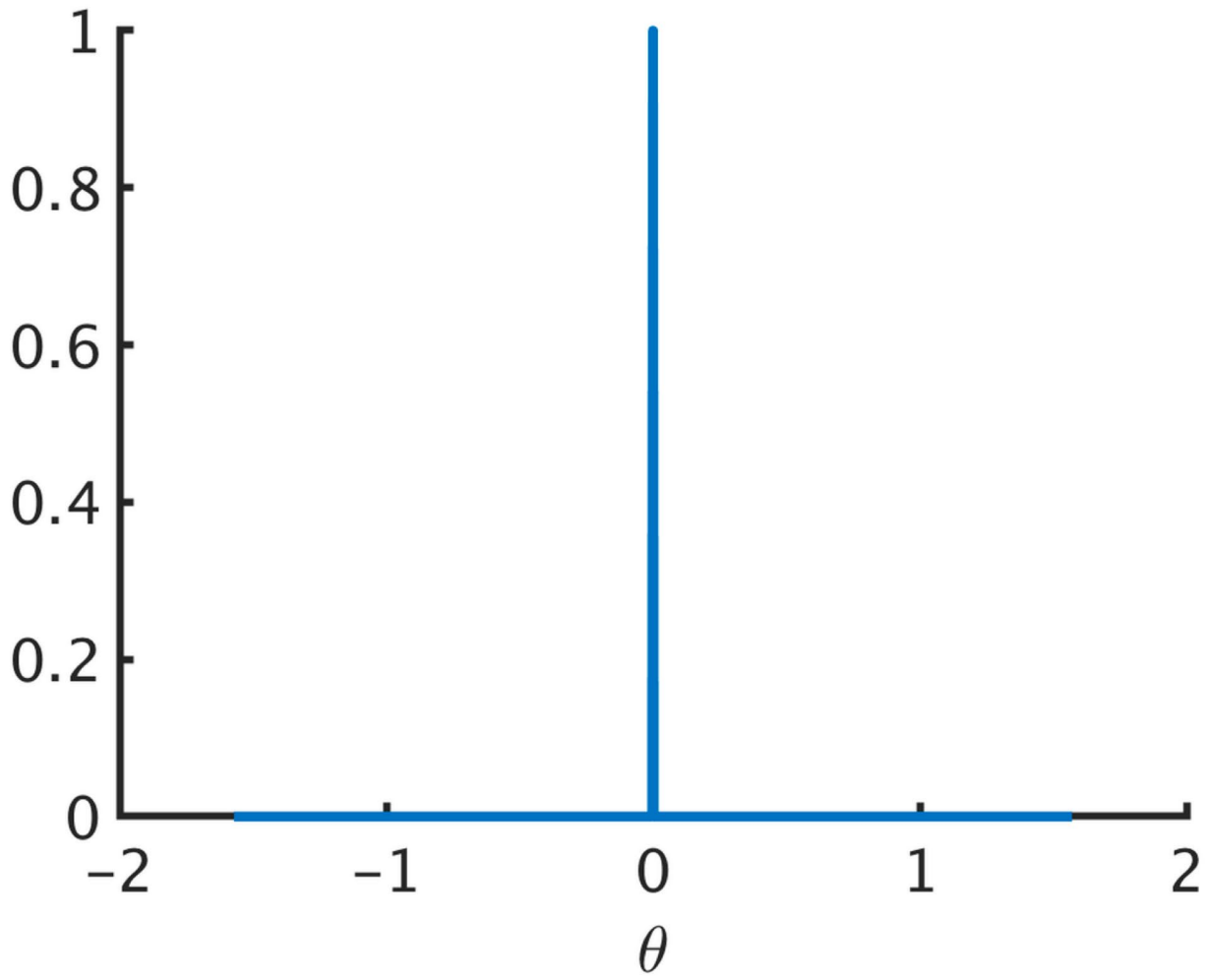
The Half Vector

$$\mathbf{h} = \frac{\mathbf{v} + \mathbf{l}}{\|\mathbf{v} + \mathbf{l}\|}$$

$$L \propto \theta_{\mathbf{h}}^{\mathbf{n}}$$

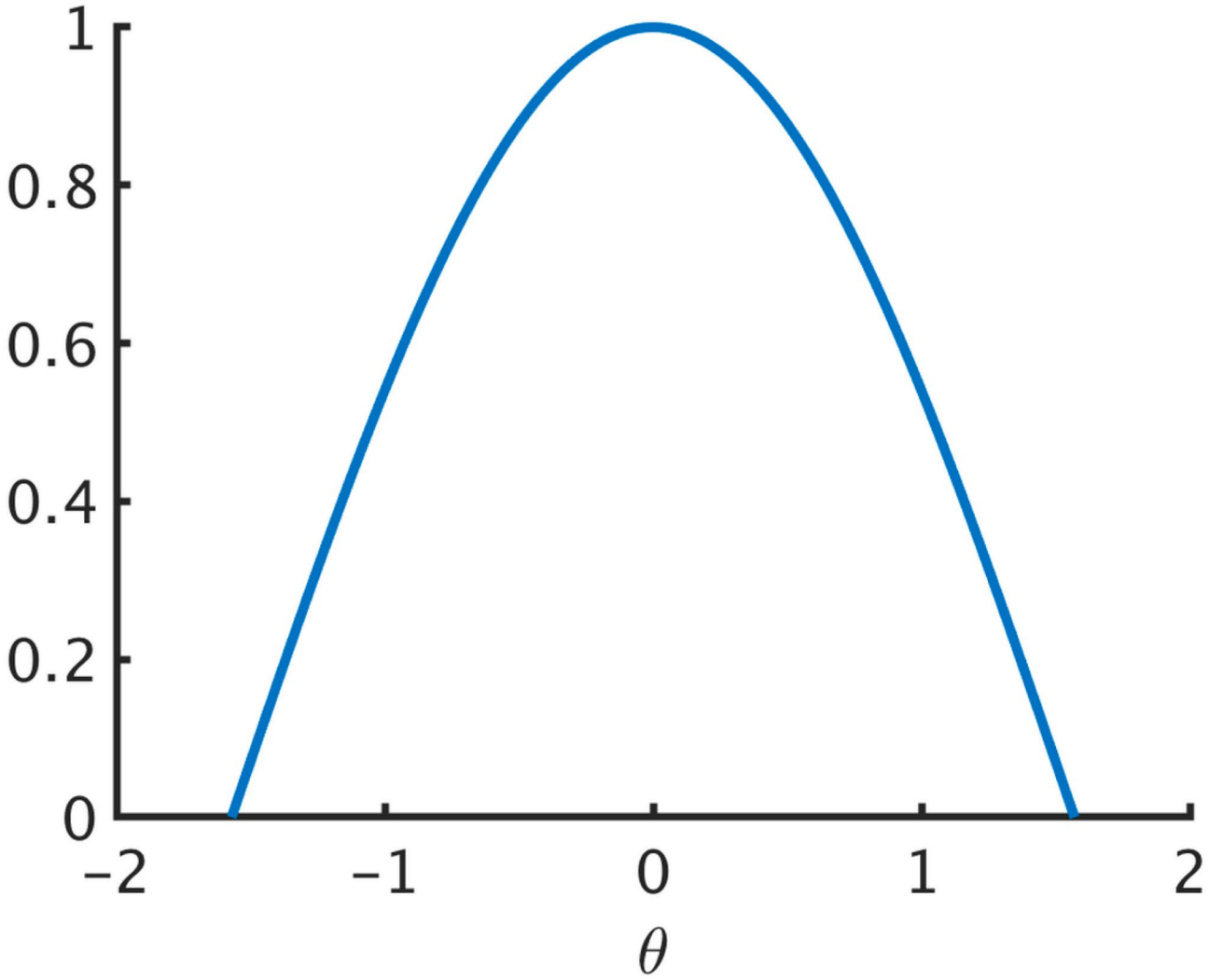
Measuring the Angle

$$L = k_s \; I \; \max(0, \delta(\theta_{\mathbf{n}}^{\mathbf{h}}))$$



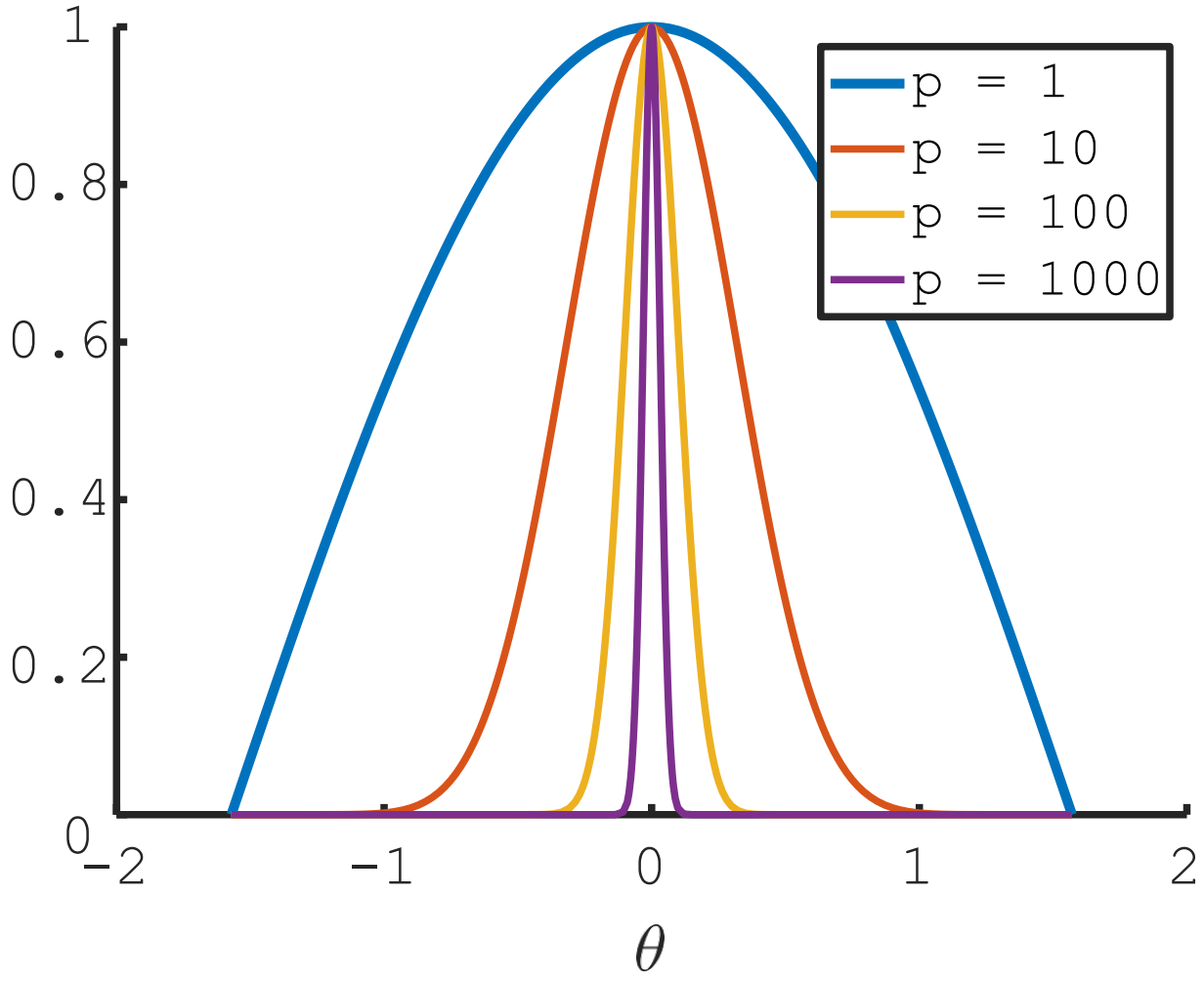
Measuring the Angle

$$L = k_s \; I \; \max(0, \cos(\theta_{\mathbf{n}}^{\mathbf{h}}))$$



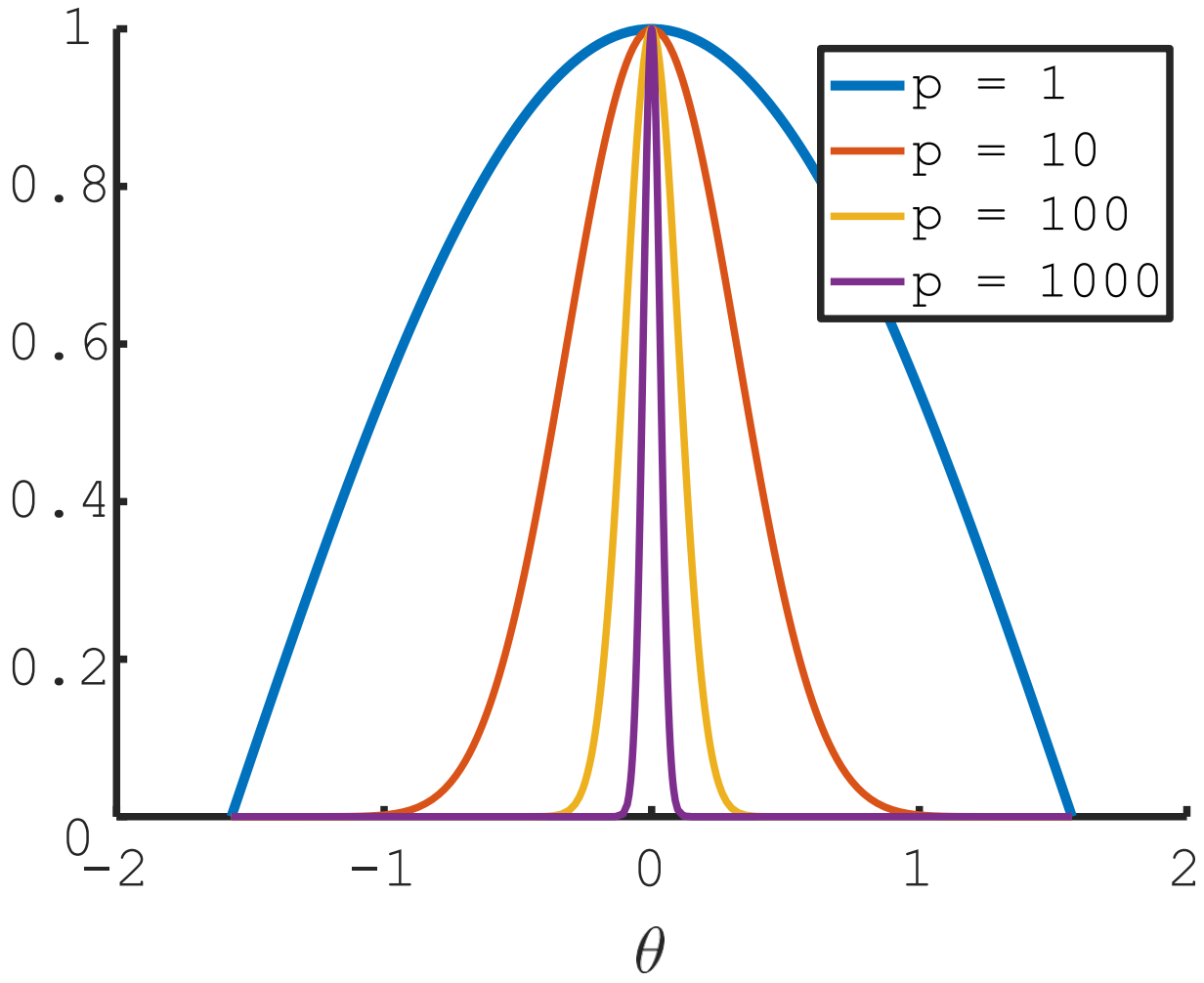
Measuring the Angle

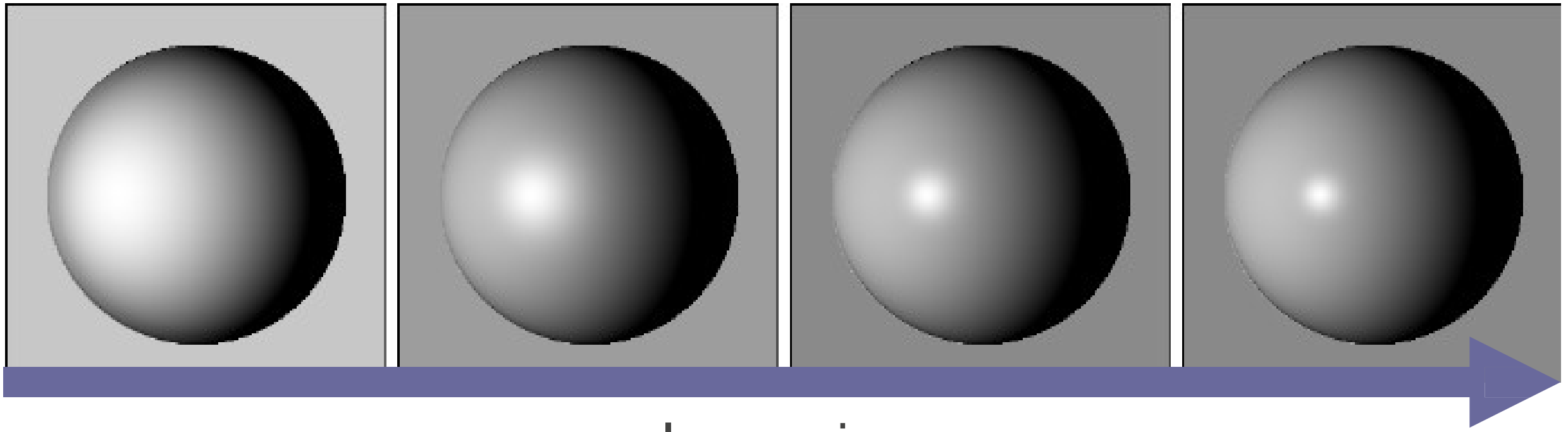
$$L = k_s \, I \, \max(0, \cos(\theta_{\mathbf{n}}^{\mathbf{h}}))^p$$



Measuring the Angle

$$L = k_s \, I \, \max(0, \mathbf{n} \cdot \mathbf{h})^p$$





Increasing p

Putting it All Together: The Full Blinn-Phong Model

Light obeys the superposition principle

Total amount of received light is sum of light from all incoming sources.

$$L = \text{lambertian} + \text{specular}$$

https://en.wikipedia.org/wiki/Superposition_principle

Putting it All Together: The Full Blinn-Phong Model

Light obeys the superposition principle

Total amount of received light is sum of light from all incoming sources.

$$L = k_d \, I \, \max(0, \mathbf{n} \cdot \mathbf{l}) + k_s \, I \, \max(0, \mathbf{n} \cdot \mathbf{h})^p$$

Putting it All Together: The Full Blinn-Phong Model

Light obeys the superposition principle

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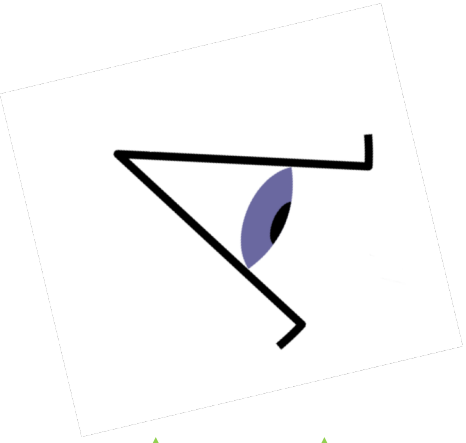
Ambient Light



Putting it All Together: The Full Blinn-Phong Model

Light obeys the superposition principle

Total amount of received light is sum of light from all incoming sources.

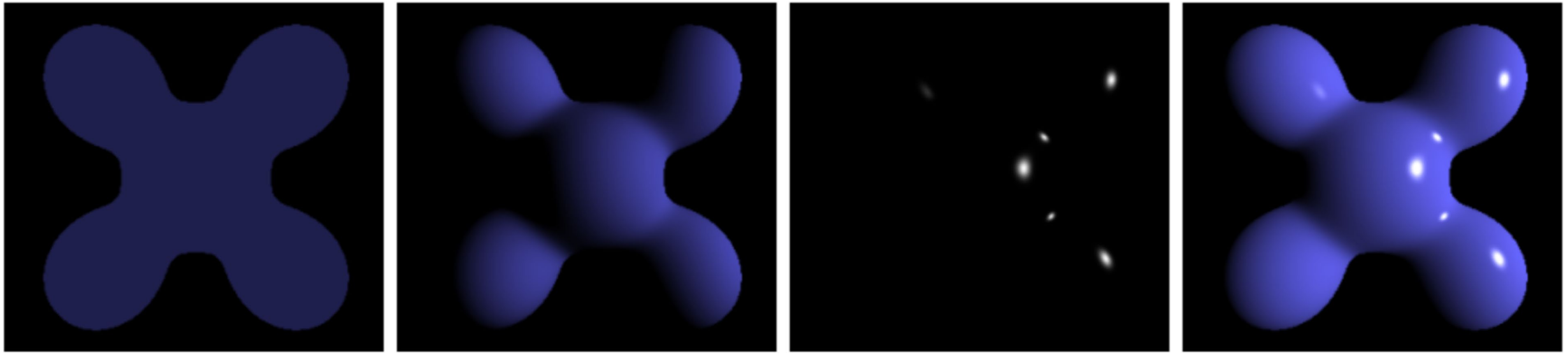
$$L = k_a \, I_a + k_d \, I \, \max(0, \mathbf{n} \cdot \mathbf{l}) + k_s \, I \, \max(0, \mathbf{n} \cdot \mathbf{h})^p$$

Putting it All Together: The Full Blinn-Phong Model

Light obeys the superposition principle

Total amount of received light is sum of light from all incoming sources.

$$L = k_a\ I_a + \sum_{i=1}^{N} (k_d\ I_i\ \max(0, \mathbf{n} \cdot \mathbf{l_i}) + k_s\ I_i\ \max(0, \mathbf{n} \cdot \mathbf{h_i})^p)$$



Ambient Diffuse Specular Final

Wikipedia | Brad Smith

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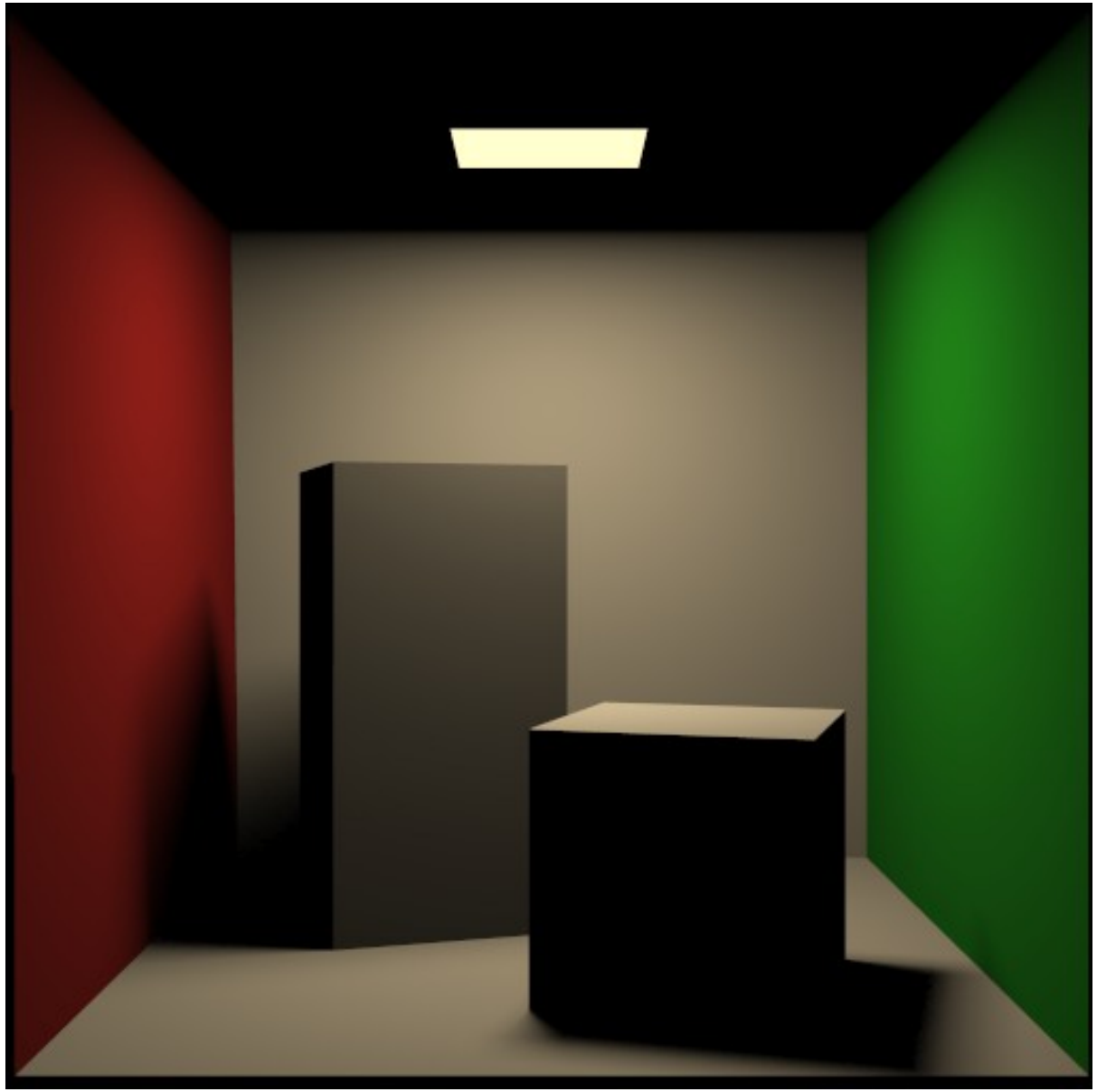
No Global Effects



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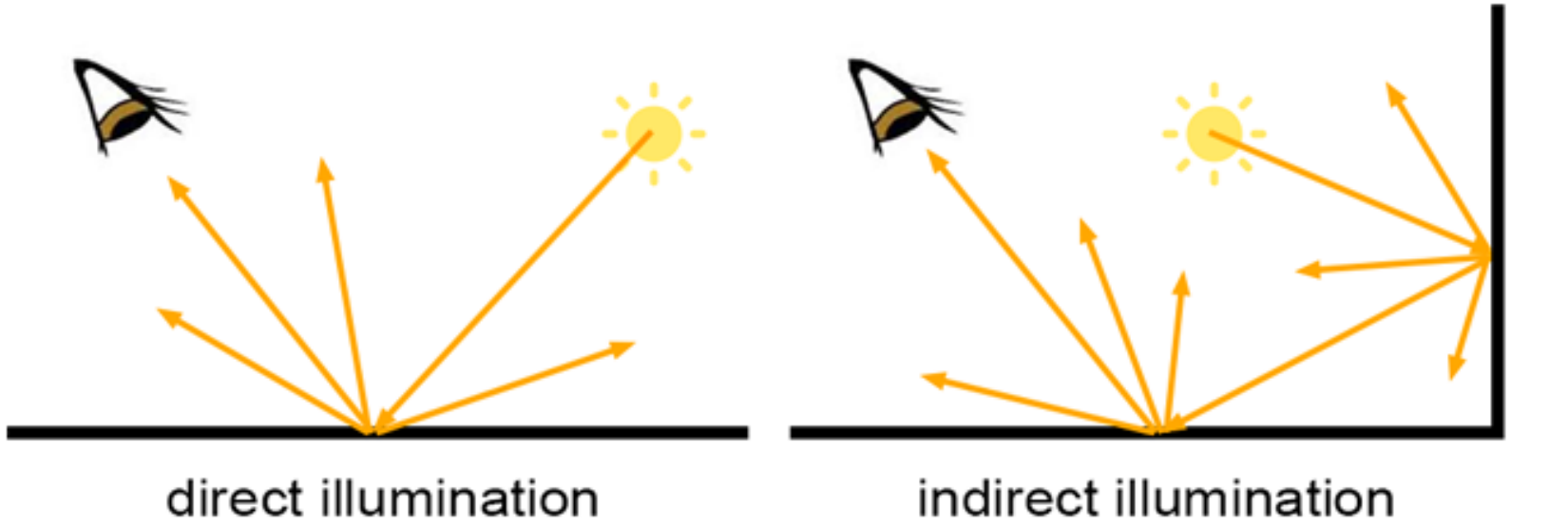

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