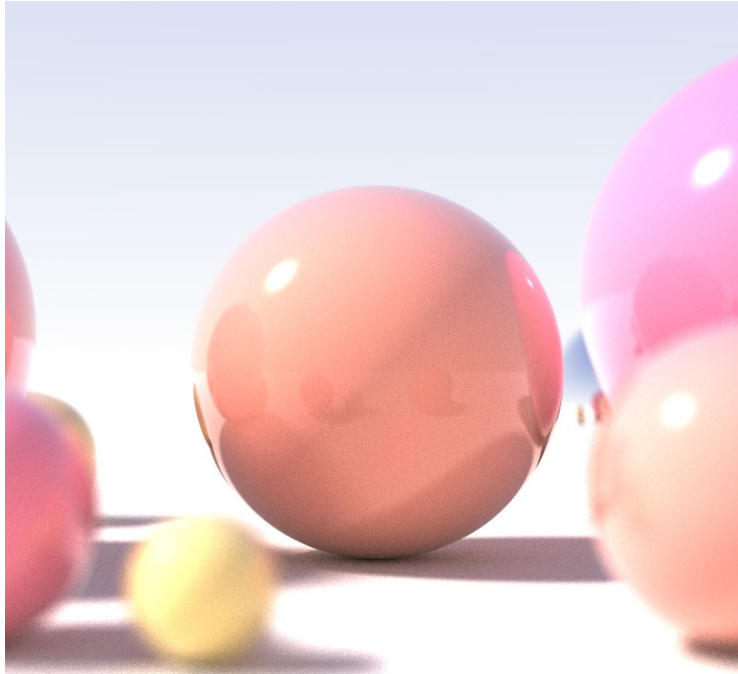# Ray Tracing

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

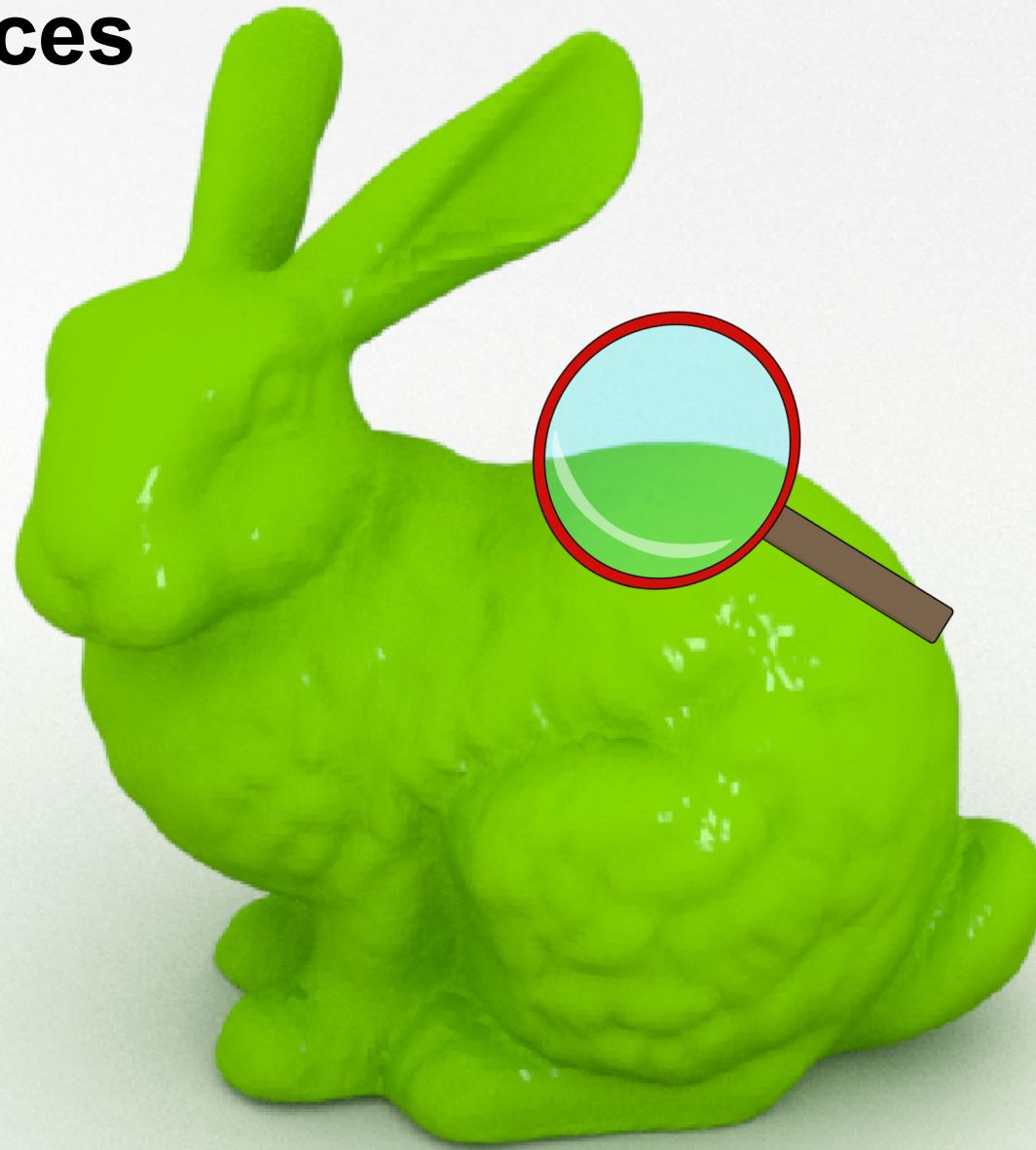Transparency and Refraction

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
    }
}
```
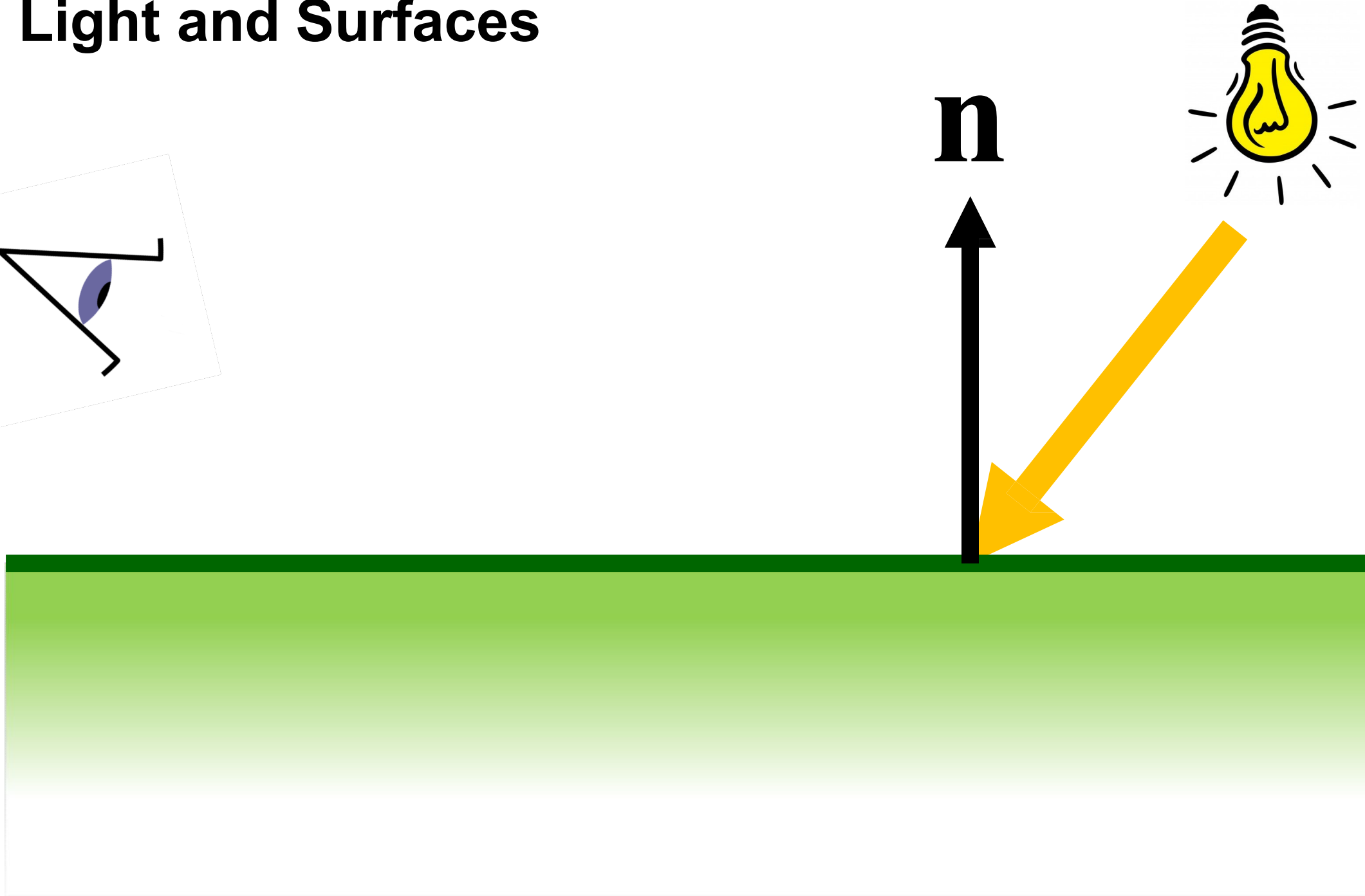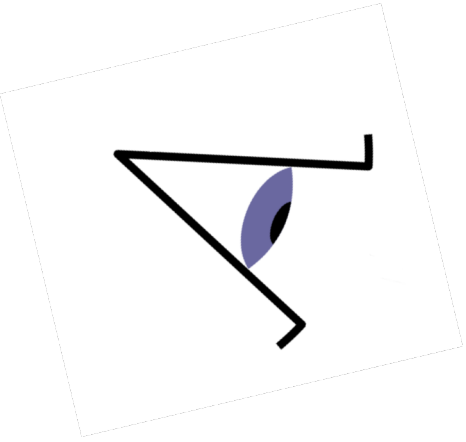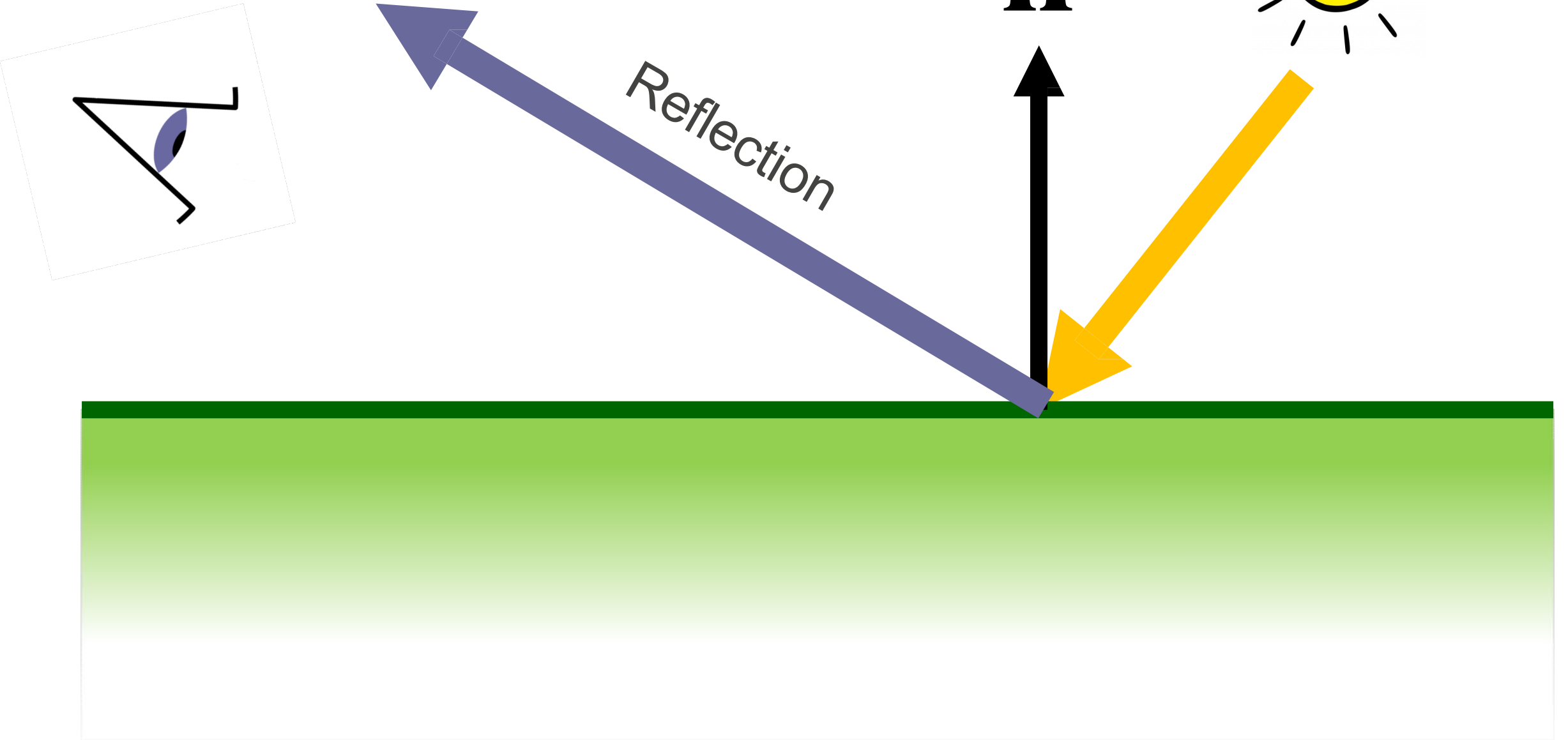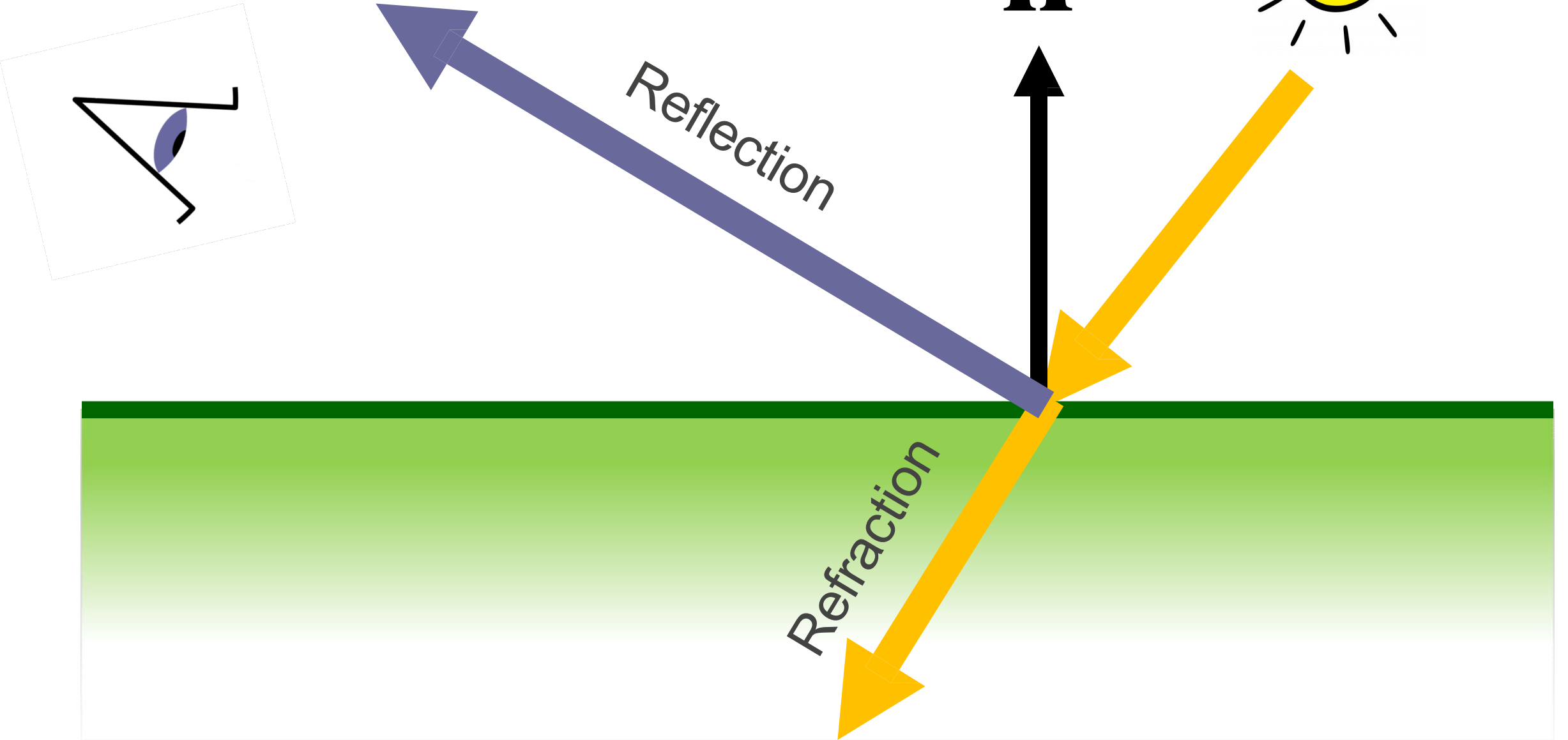
Light and Surfaces

Light and Surfaces

Light and Surfaces

n

Light and Surfaces

n

Reflection

Light and Surfaces

n

Reflection

Refraction

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.
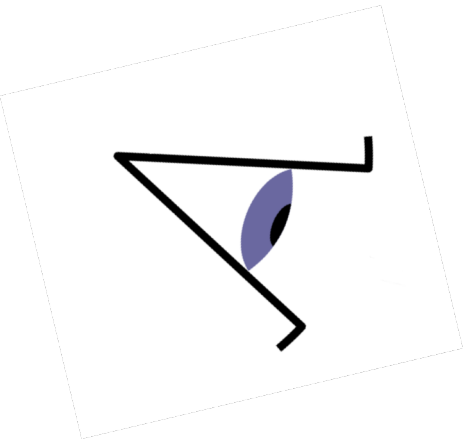
Directional Light

Lights

Two types of lights:

Directional Light:

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

Point Light

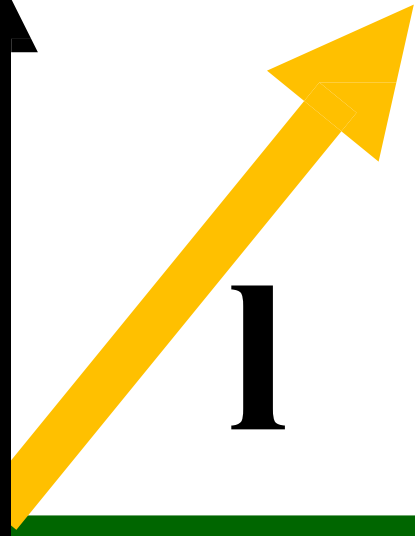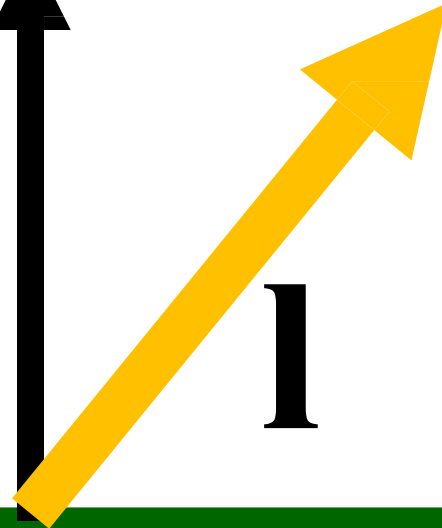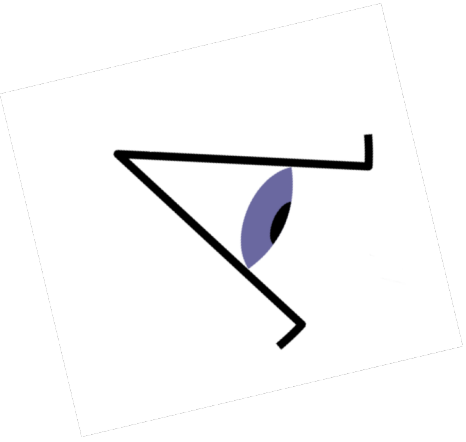Direction of light depends on position of object relative to light.
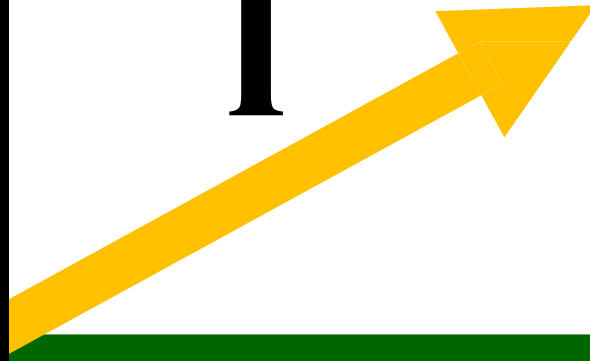
n

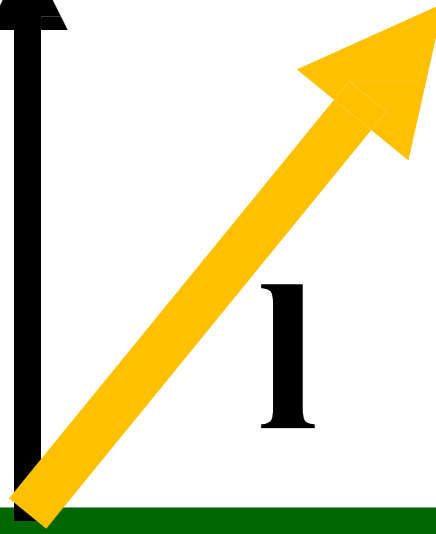**n**
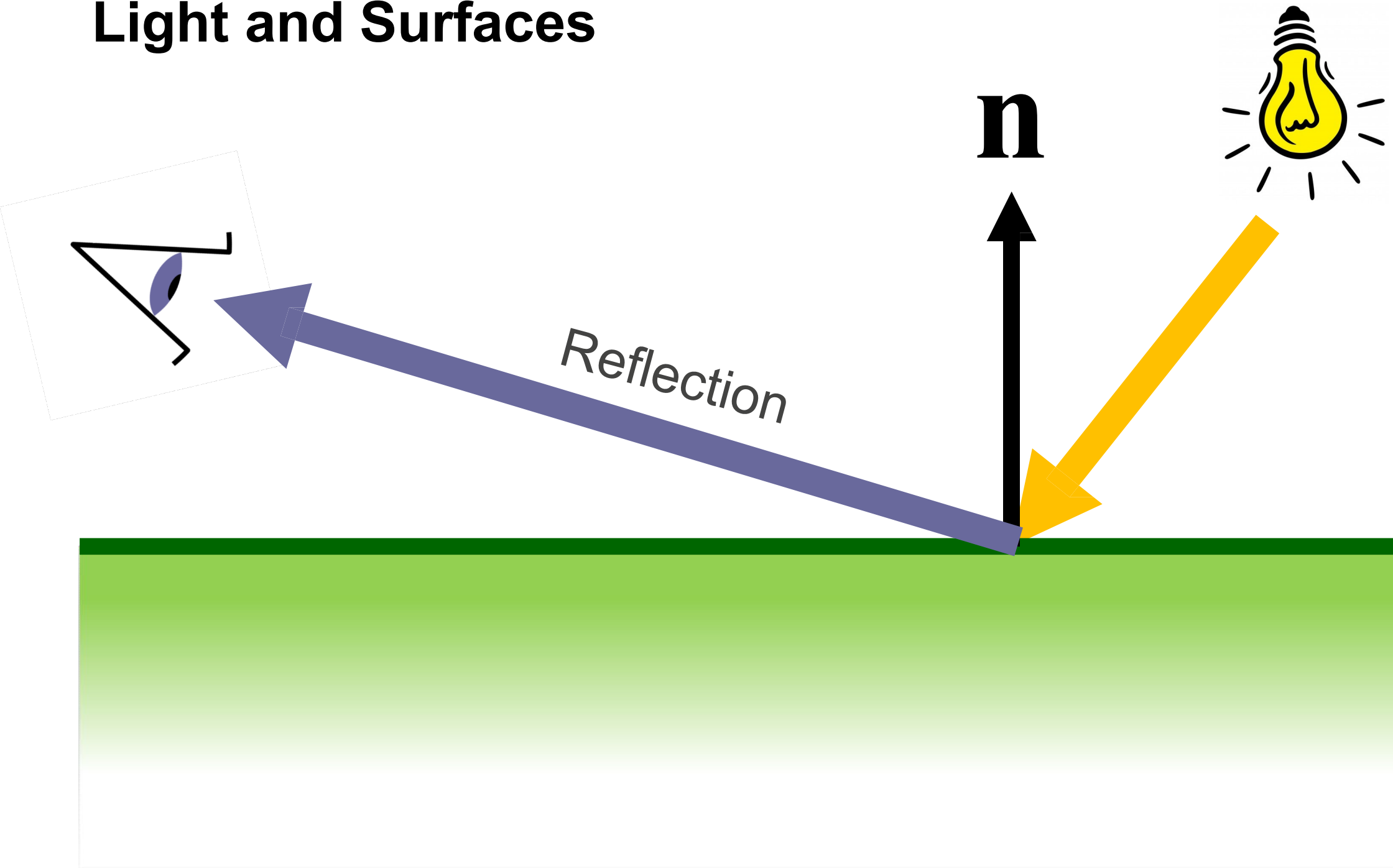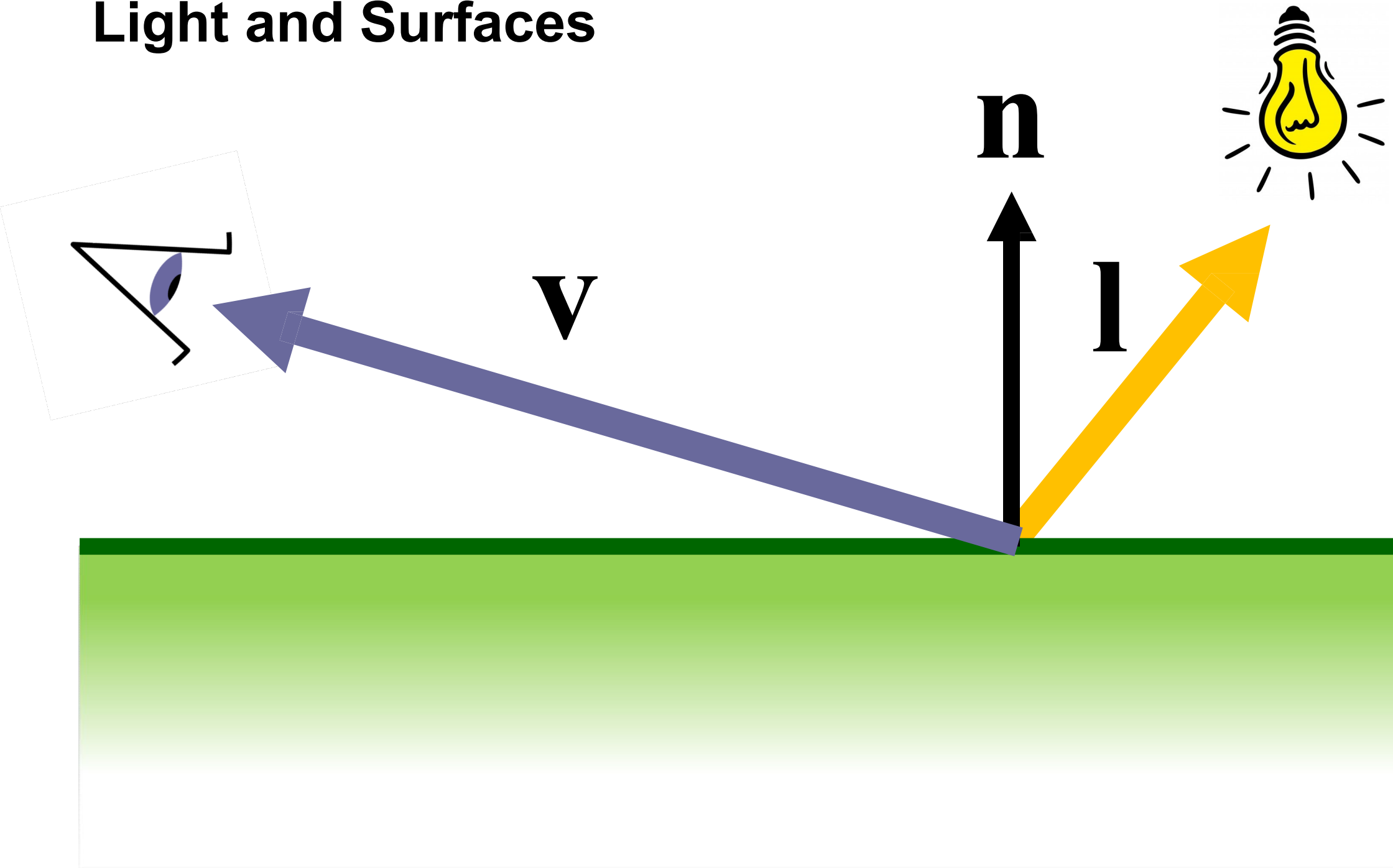
l

l

Ray Casting

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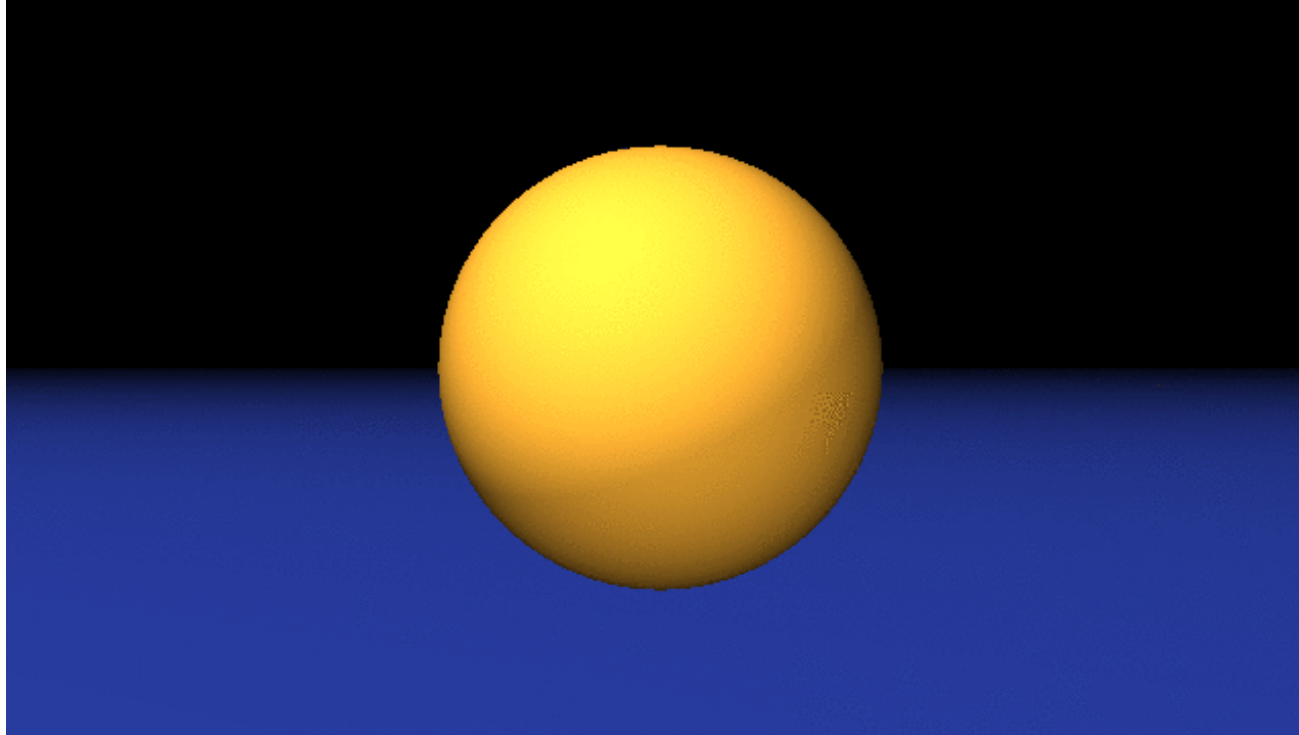
Light and Surfaces

n

Reflection

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)
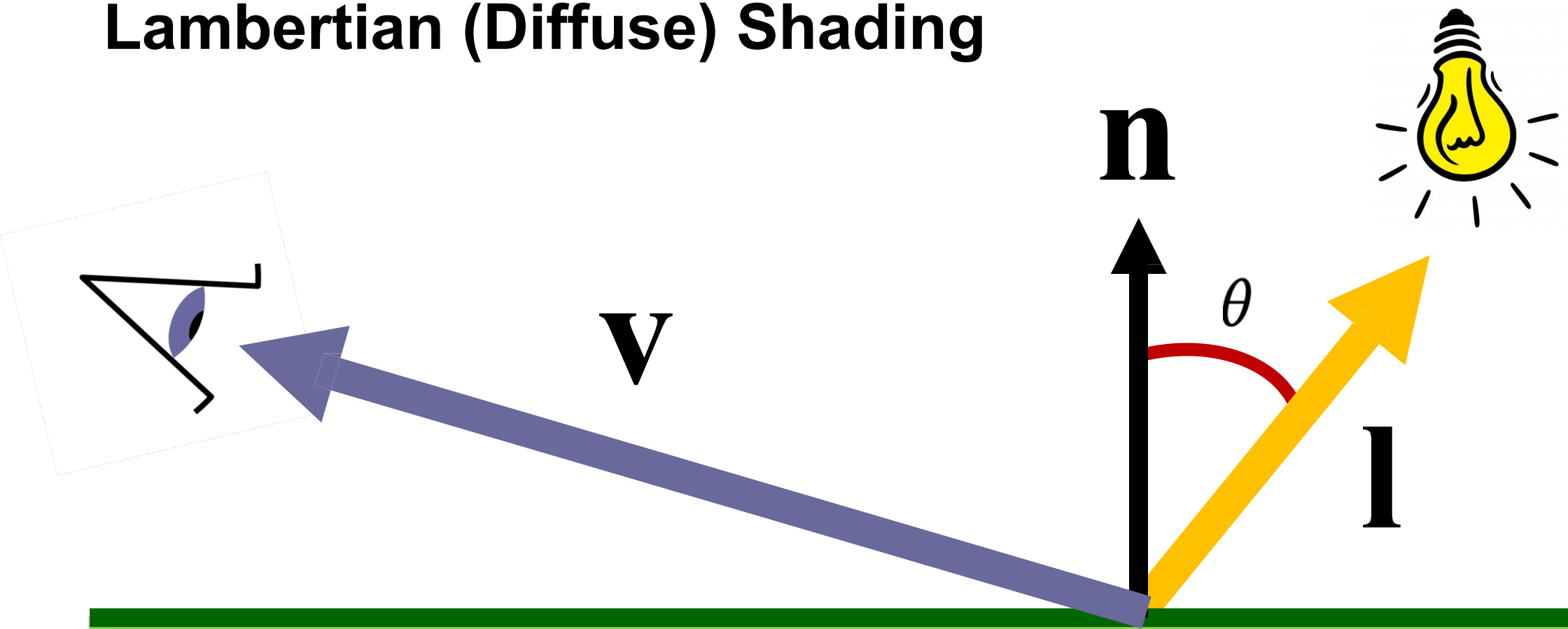
Lambertian (Diffuse) Shading

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.
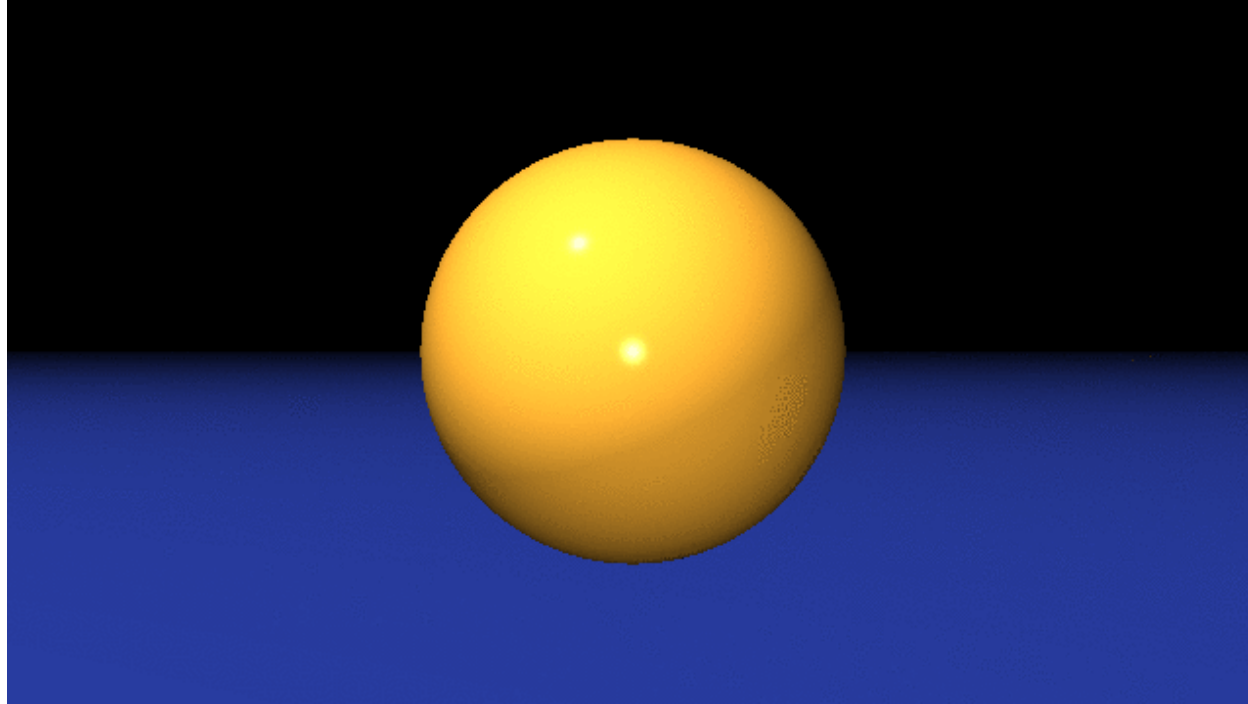
- Lambert (18th century)

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

Lambertian (Diffuse) Shading

n

θ

V

l

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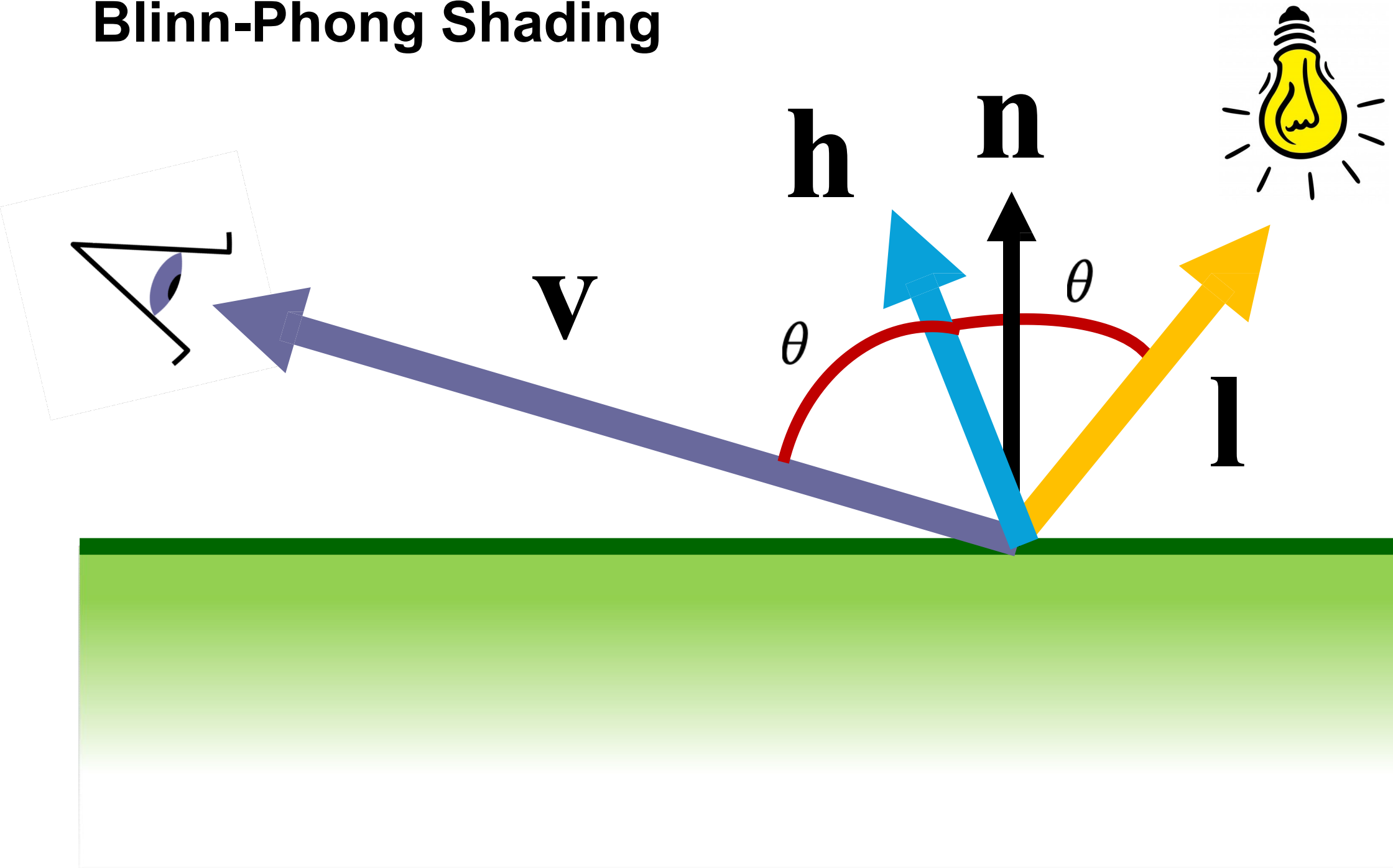
Specular Reflection

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

$\mathbf{h}$

$\mathbf{n}$

$\mathbf{v}$

θ

θ

$\mathbf{l}$

The Half Vector

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

The Half Vector

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

$$L \propto \theta_h^n$$

Measuring the Angle

$$L = k_s \, I \, \max(0, \delta(\theta^{\mathbf{h}}_{\mathbf{n}}))$$
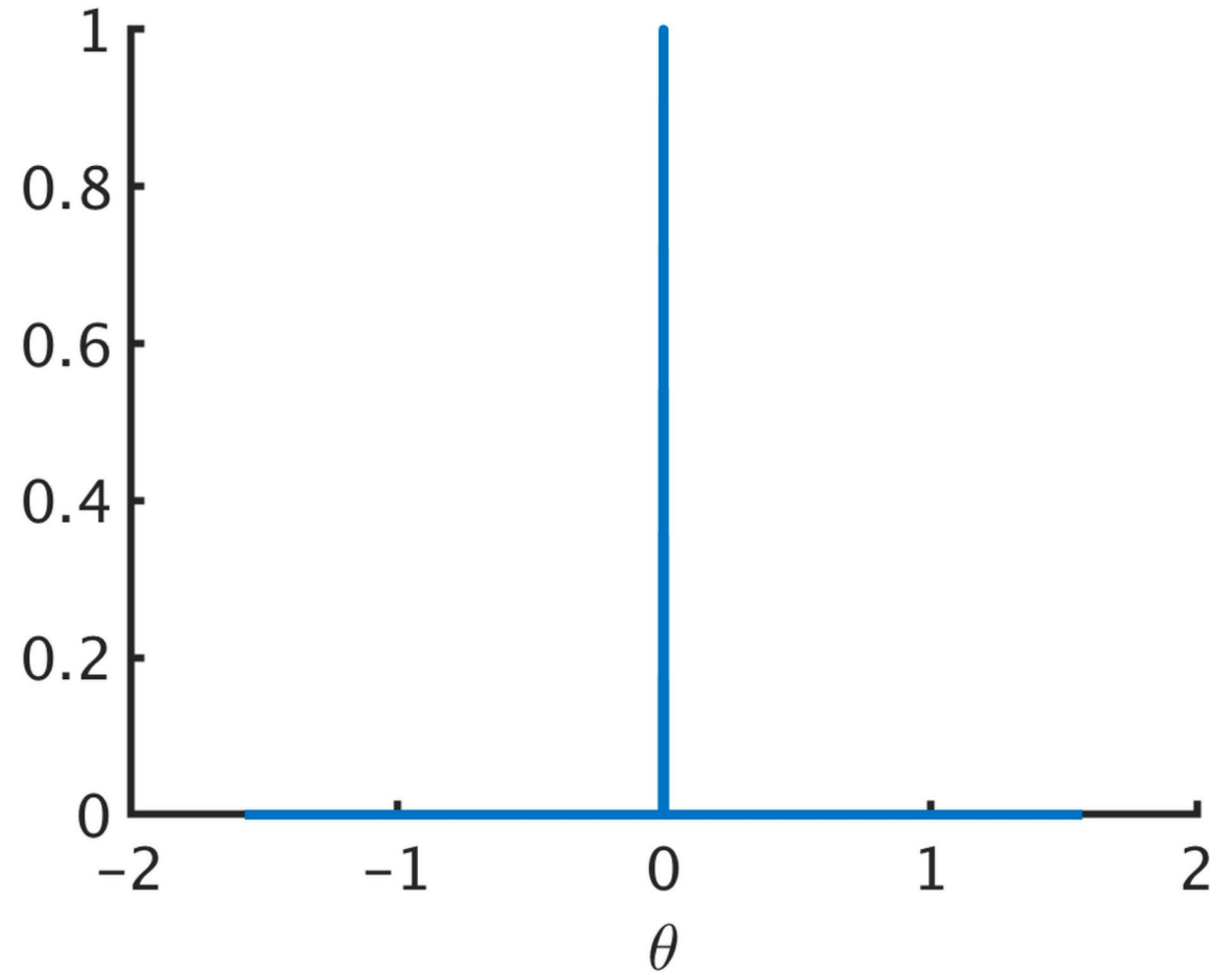
Measuring the Angle

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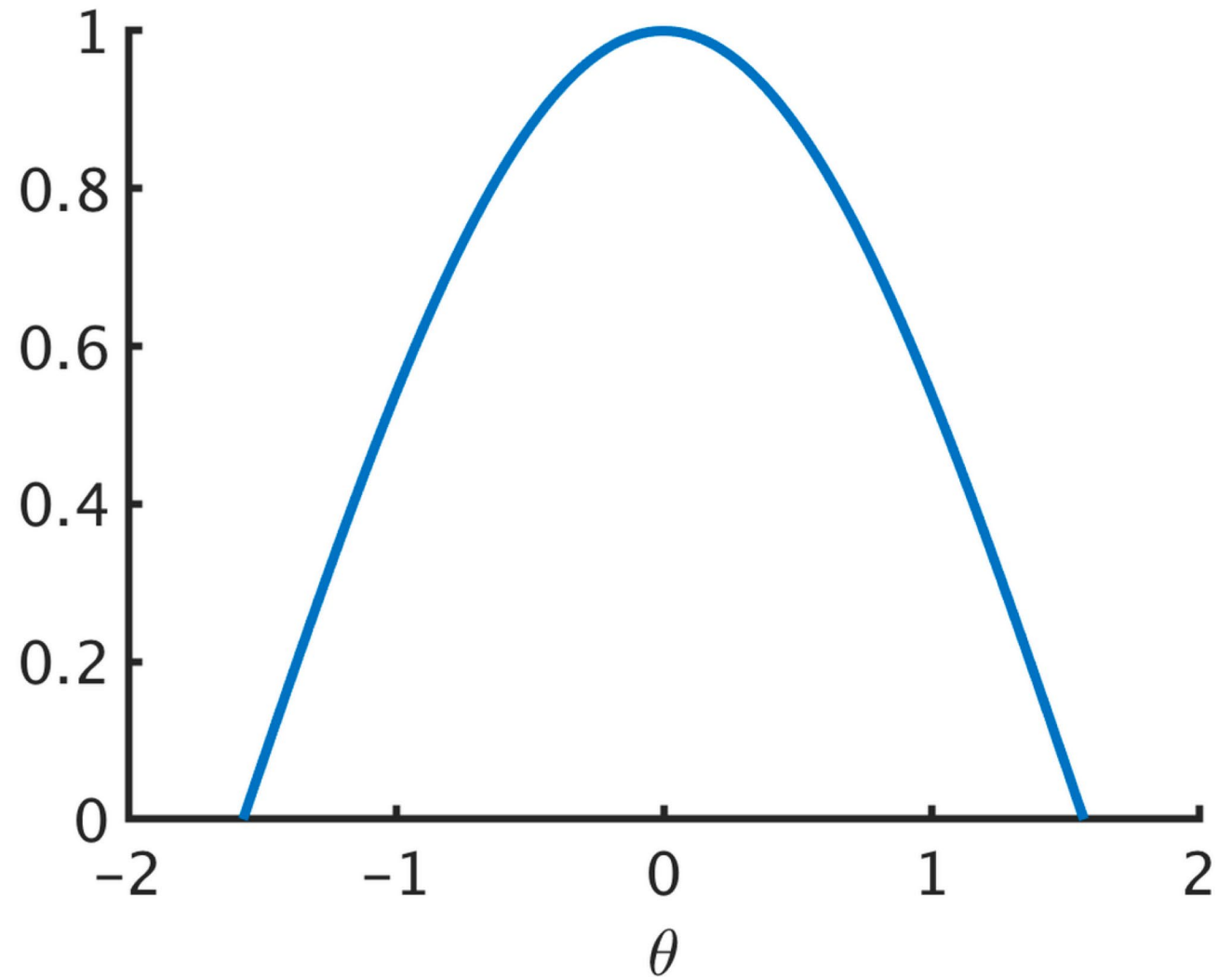
Measuring the Angle
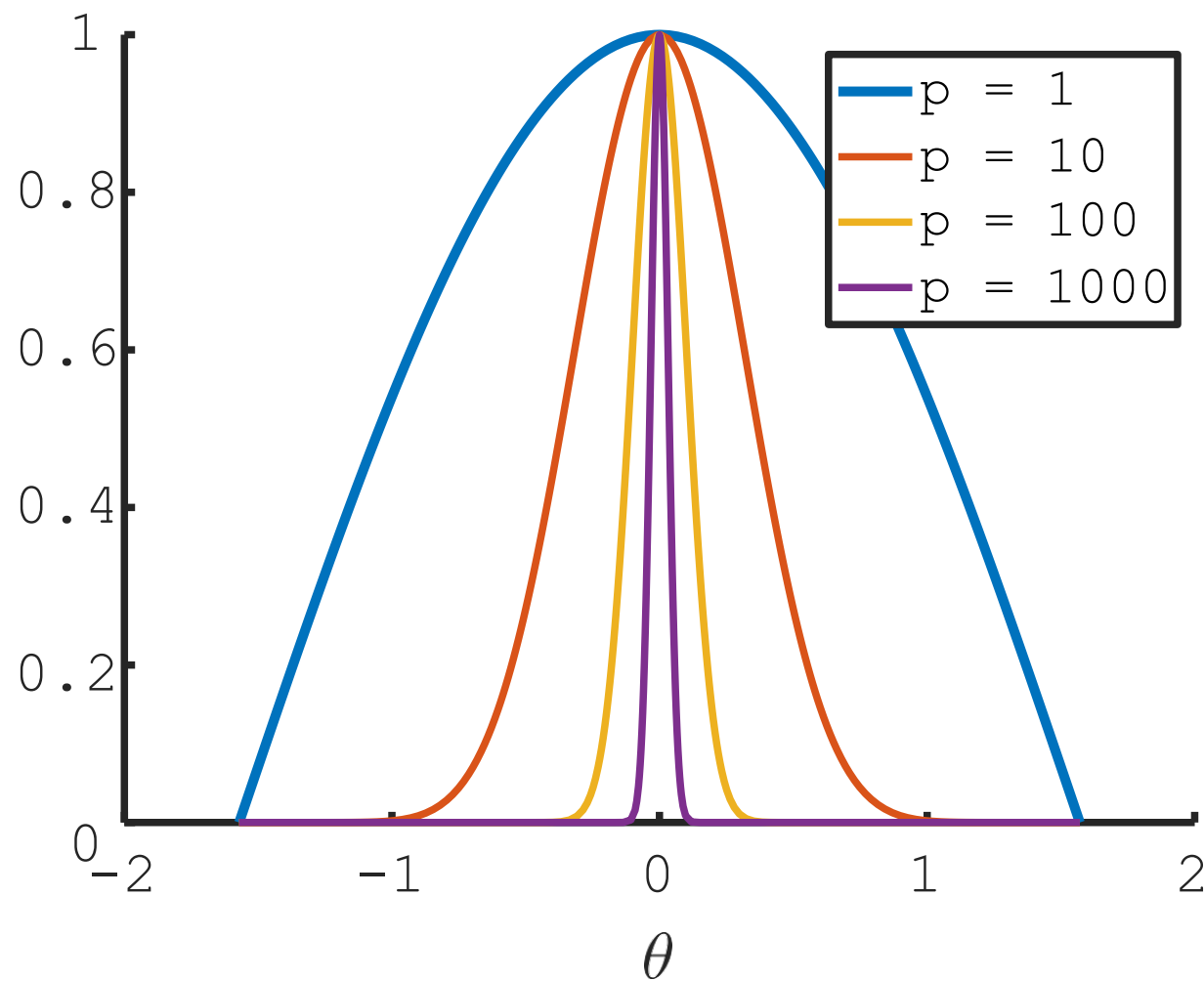
$$L = k_s \, I \, \max(0, \cos(\theta_{\mathbf{n}}^{\mathbf{h}}))^p$$

Measuring the Angle

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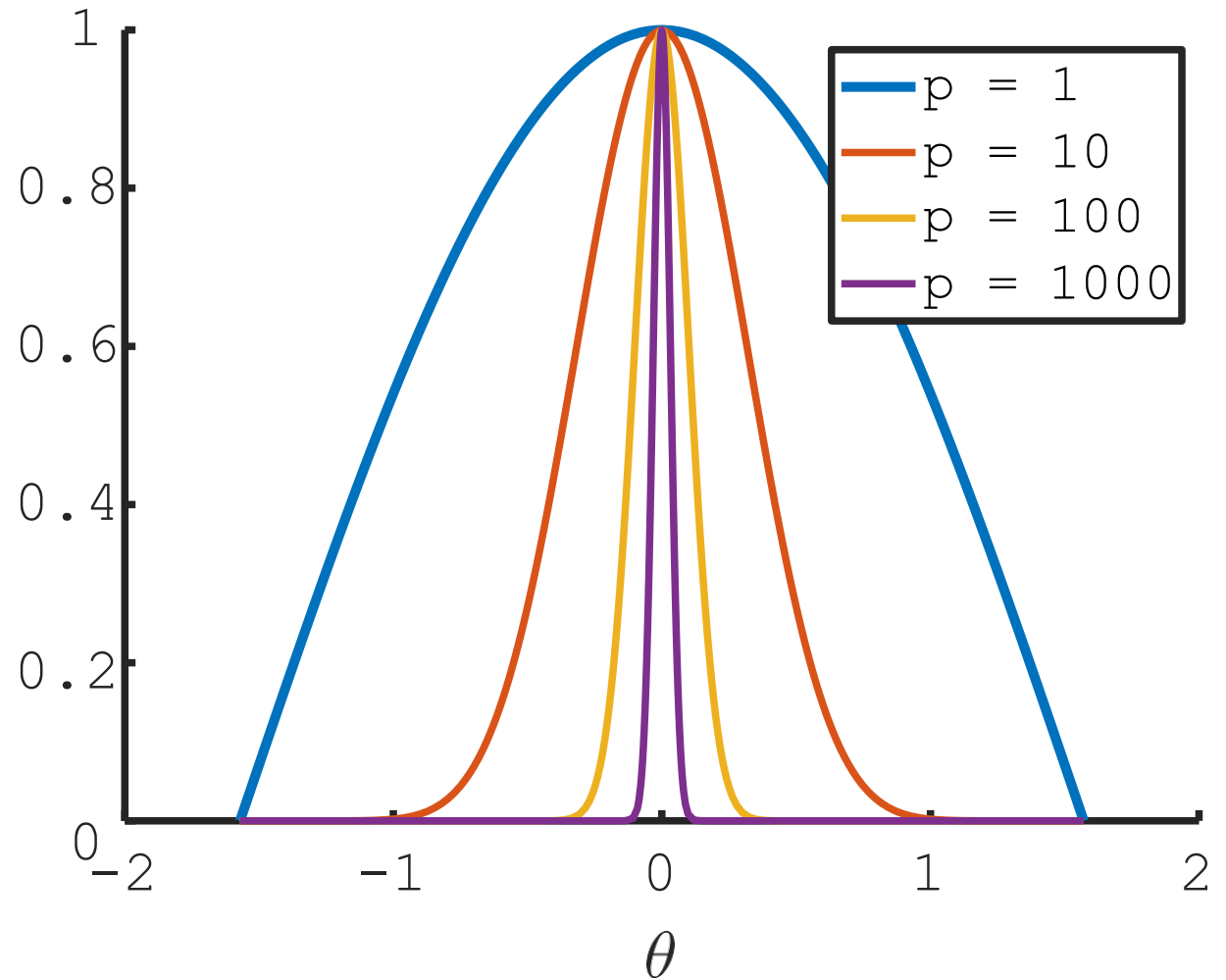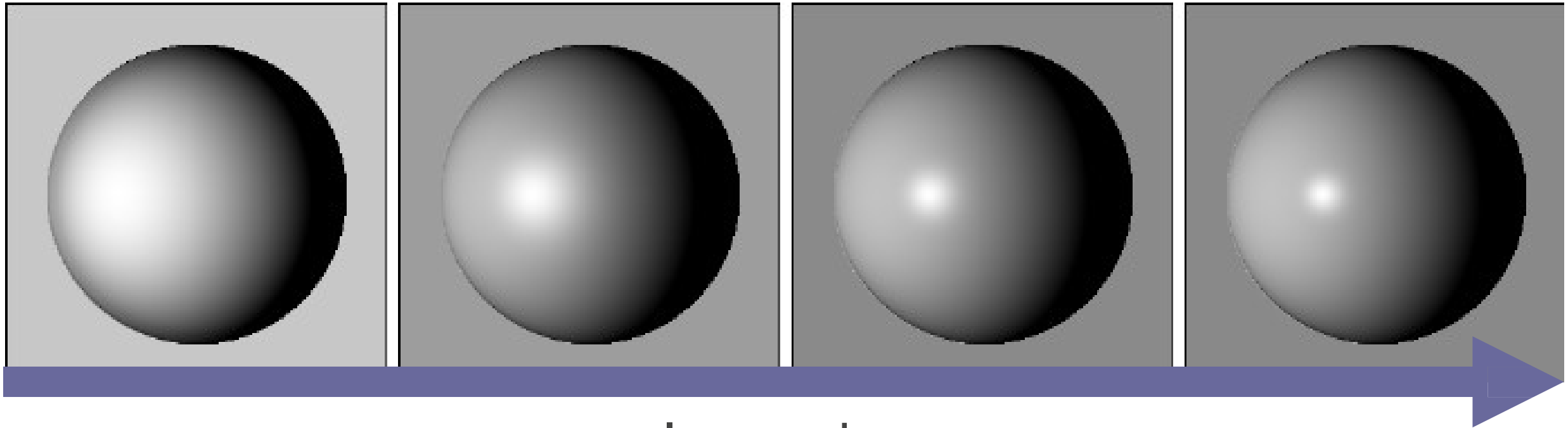
Increasing p

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.

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

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.

$$L = k_d \, I \, \max(0, \mathbf{n} \cdot \mathbf{l}) + k_s \, I \, \max(0, \mathbf{n} \cdot \mathbf{h})^p$$
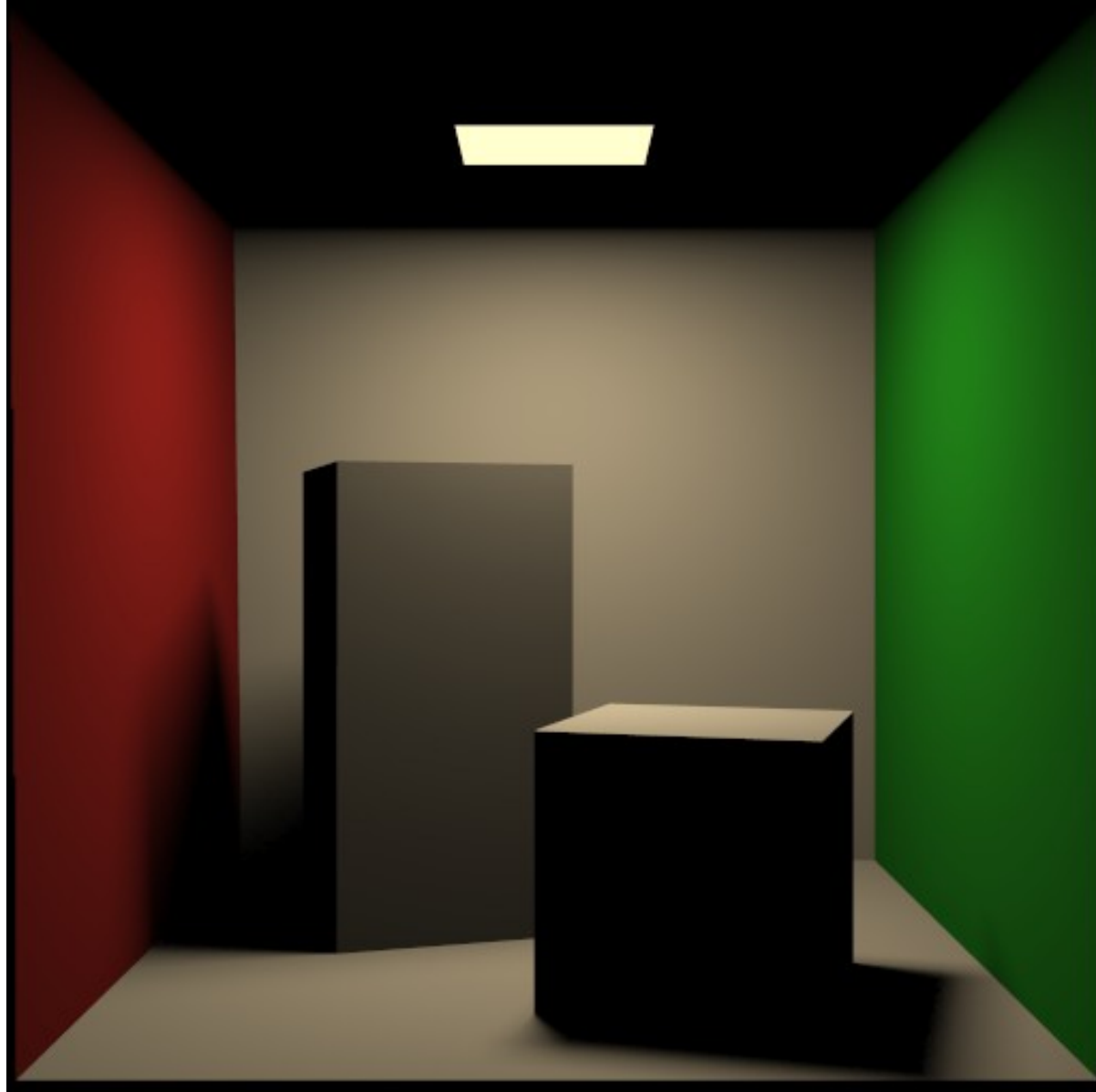
No Global Effects

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.

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

Ambient Light
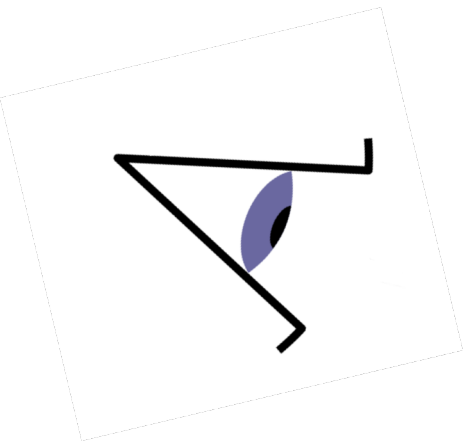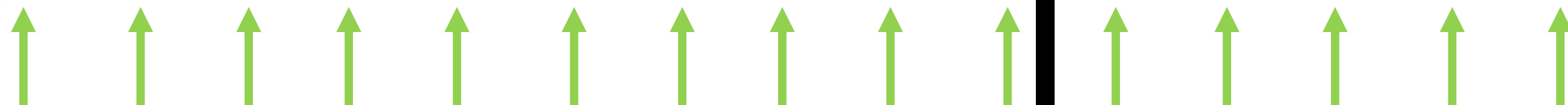
$$L = k_a \, I_a$$

n

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.

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

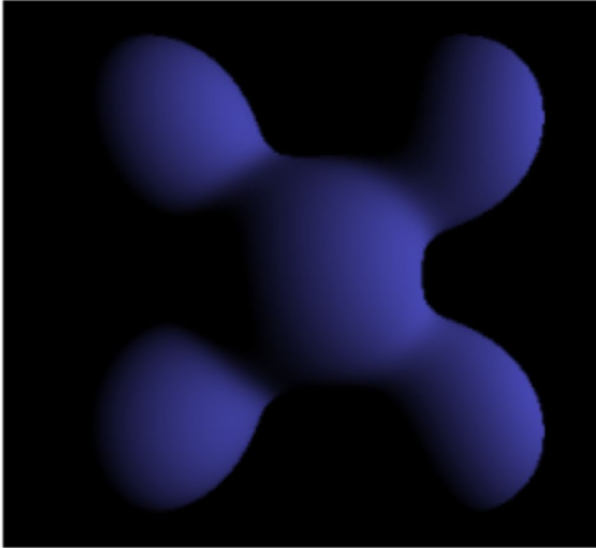# Putting it All Together: The Full Blinn-Phong Model

Light obeys the superposition principle

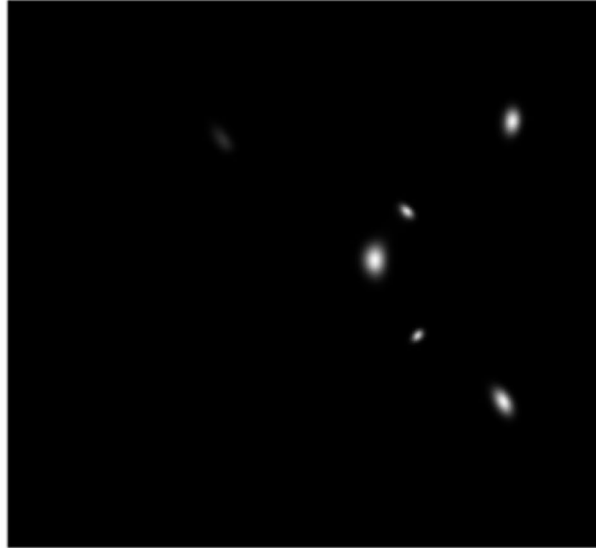Total amount of received light is sum of light from all incoming sources.

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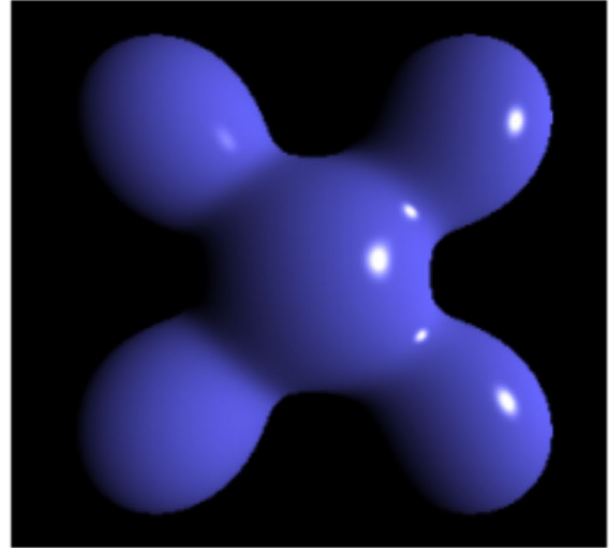
Ambient　　　　Diffuse　　　　Specular　　　　Final

Ray Casting

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