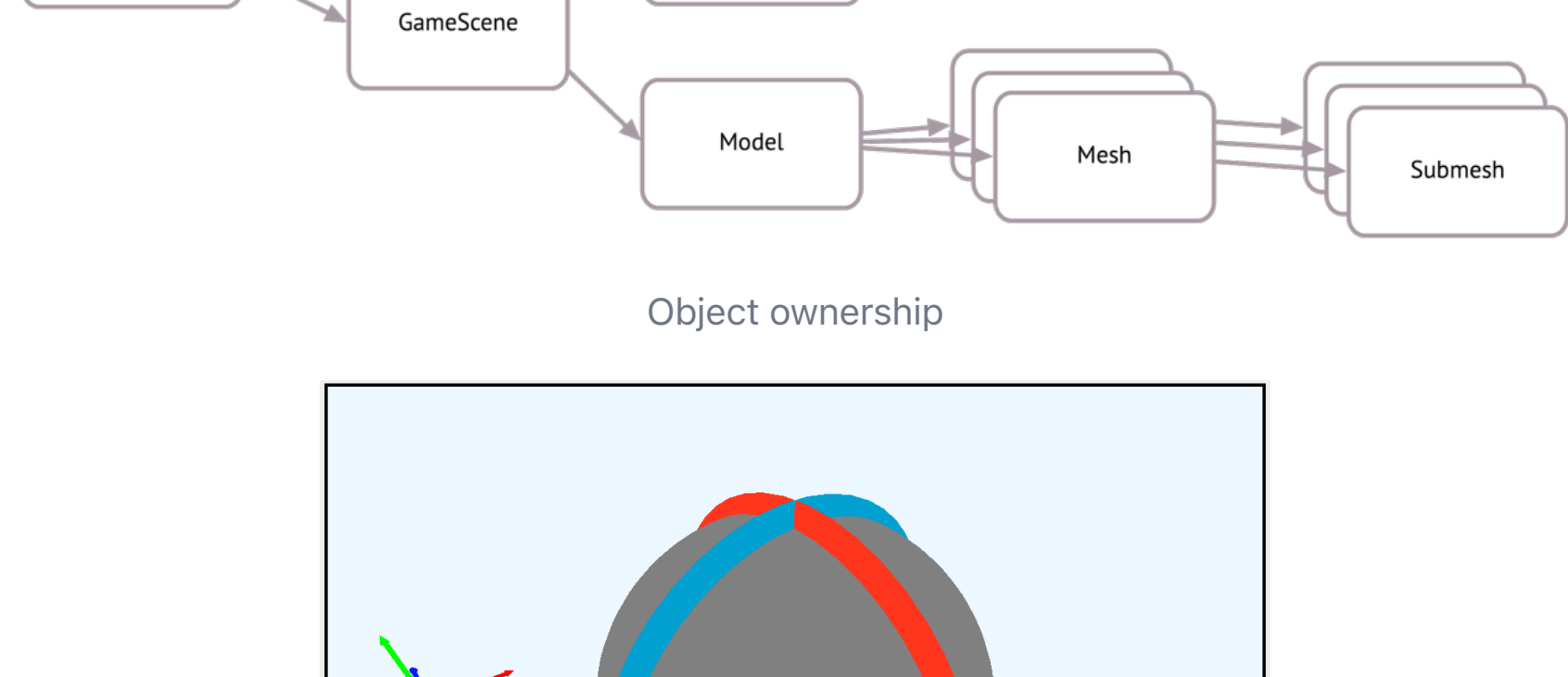
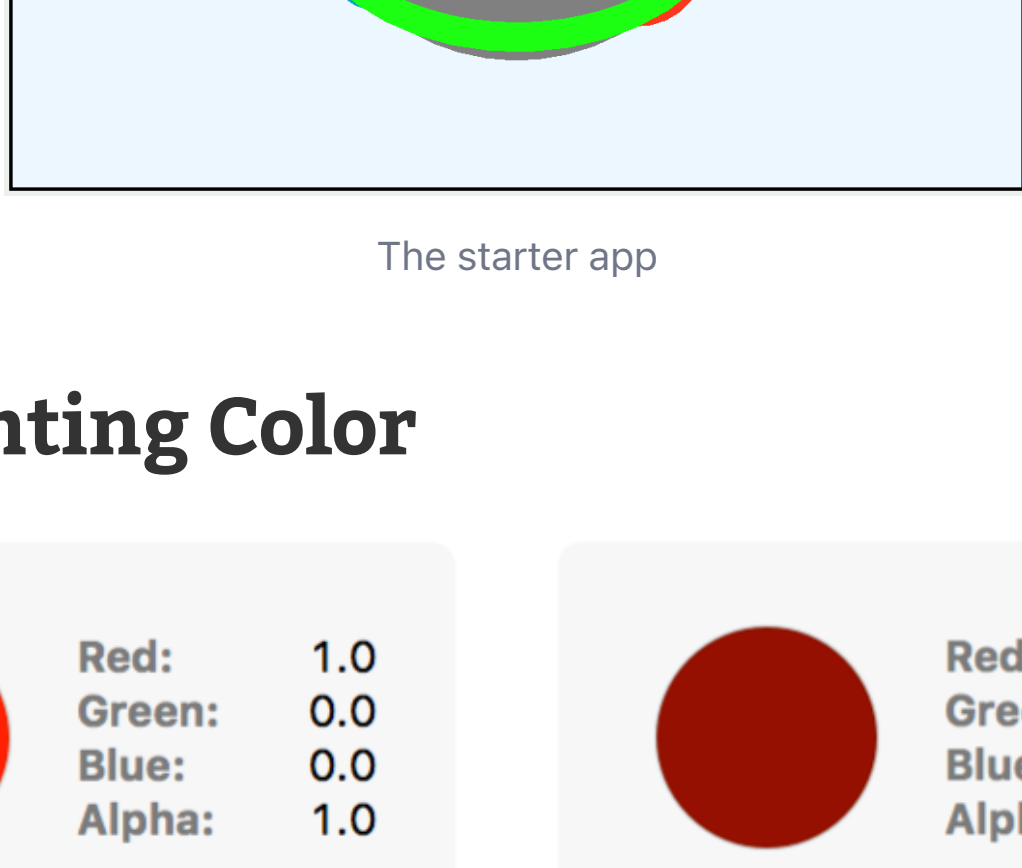


# 10 Lighting Fundamentals

## The Starter Project



Object ownership

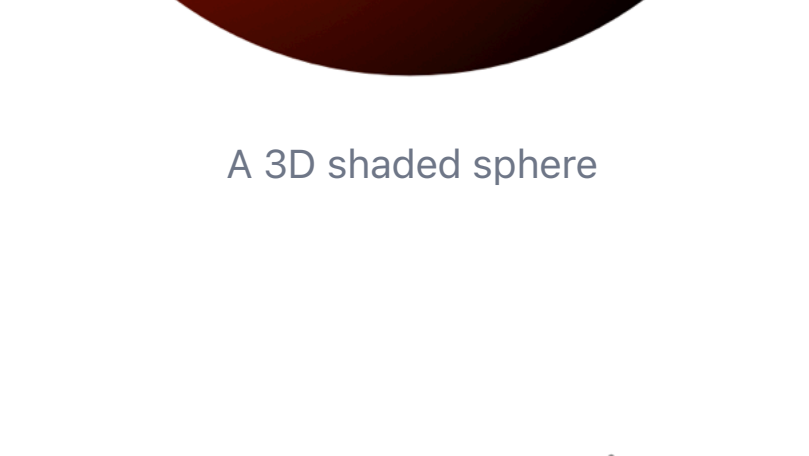


The starter app

## Representing Color

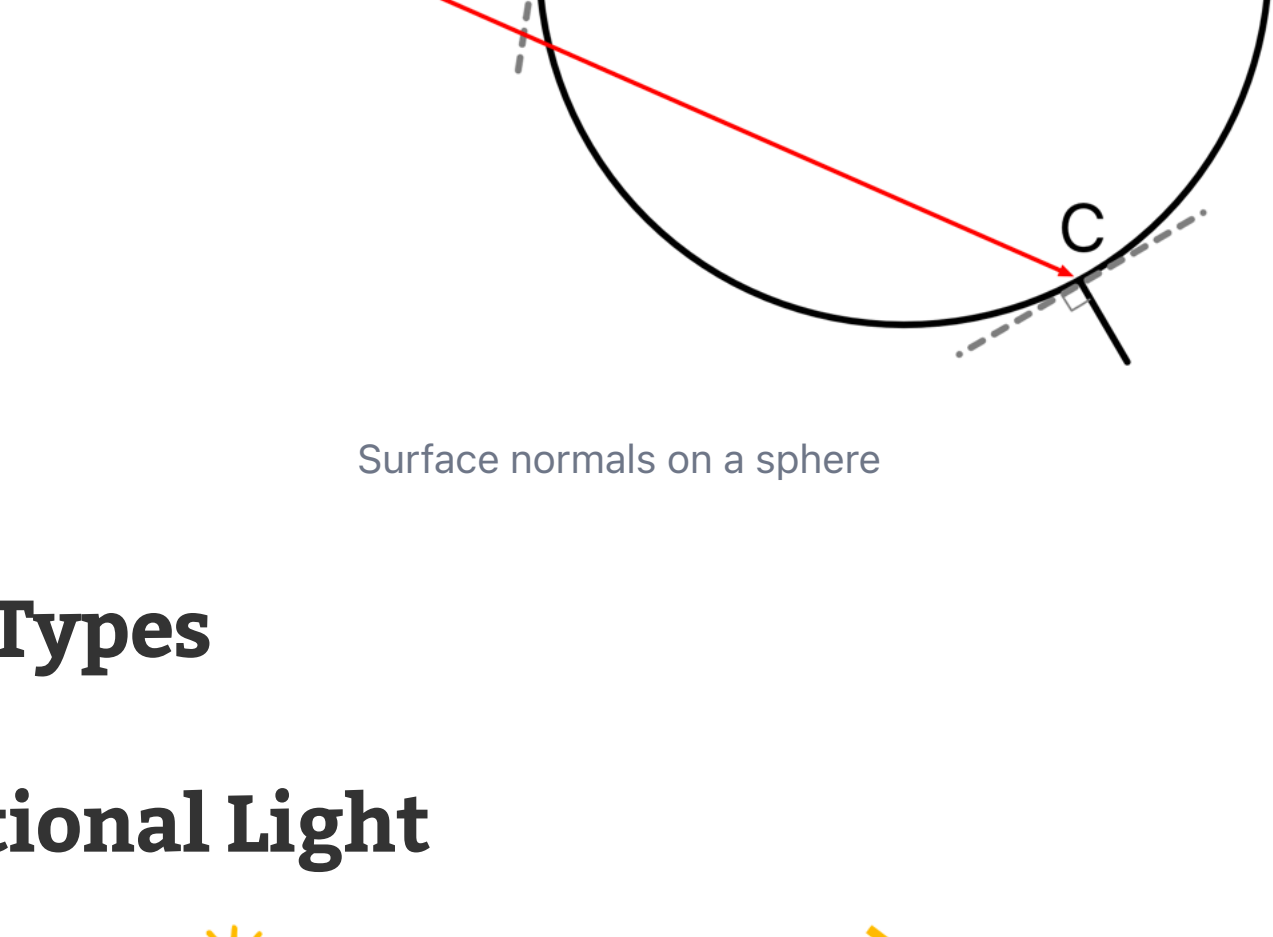


Color shading



A 3D shaded sphere

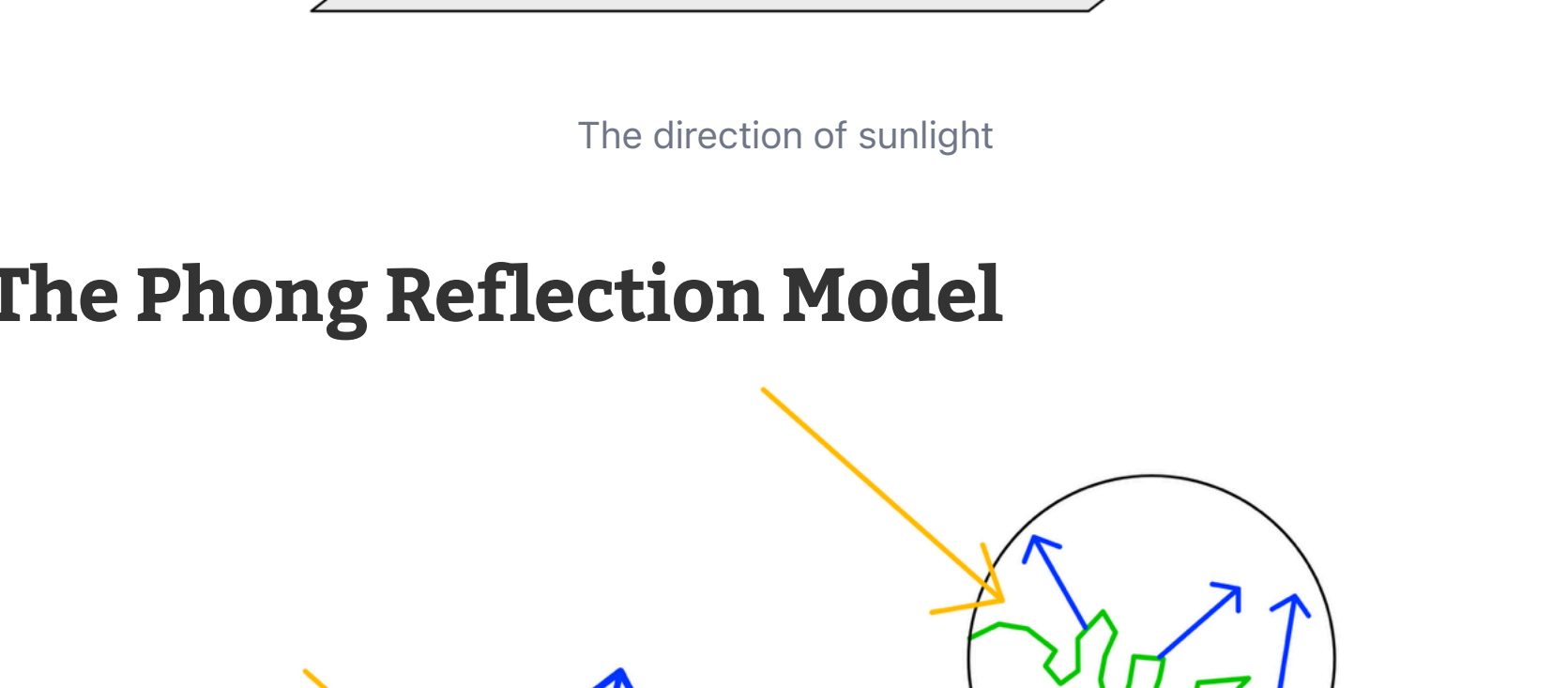
## Normals



Surface normals on a sphere

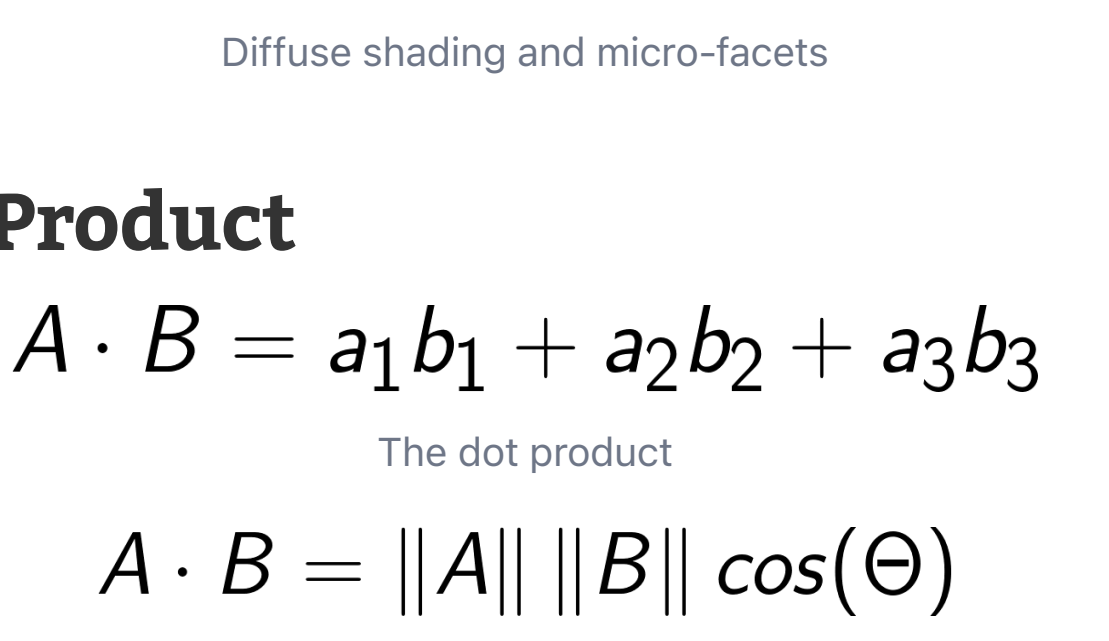
## Light Types

### Directional Light



The direction of sunlight

### The Phong Reflection Model



Diffuse shading and micro-facets

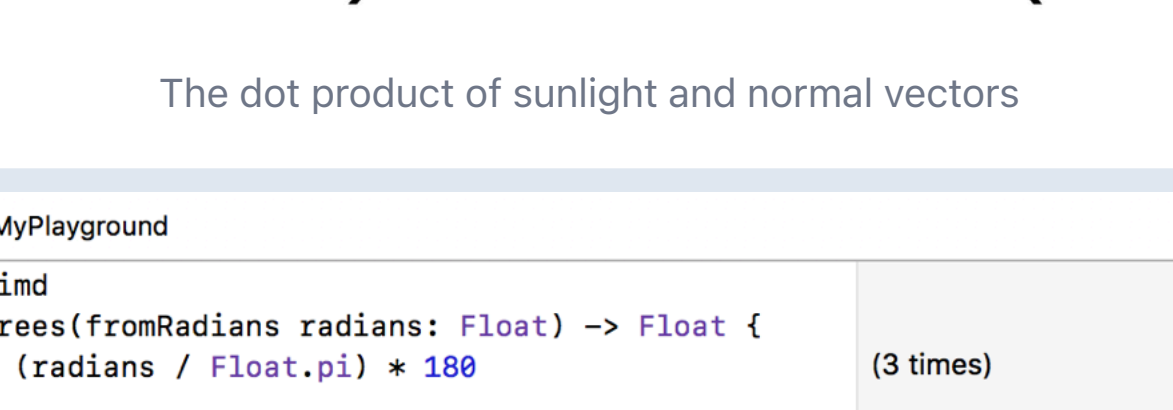
### The Dot Product

$$A \cdot B = a_1 b_1 + a_2 b_2 + a_3 b_3$$

The dot product

$$A \cdot B = \|A\| \|B\| \cos(\Theta)$$

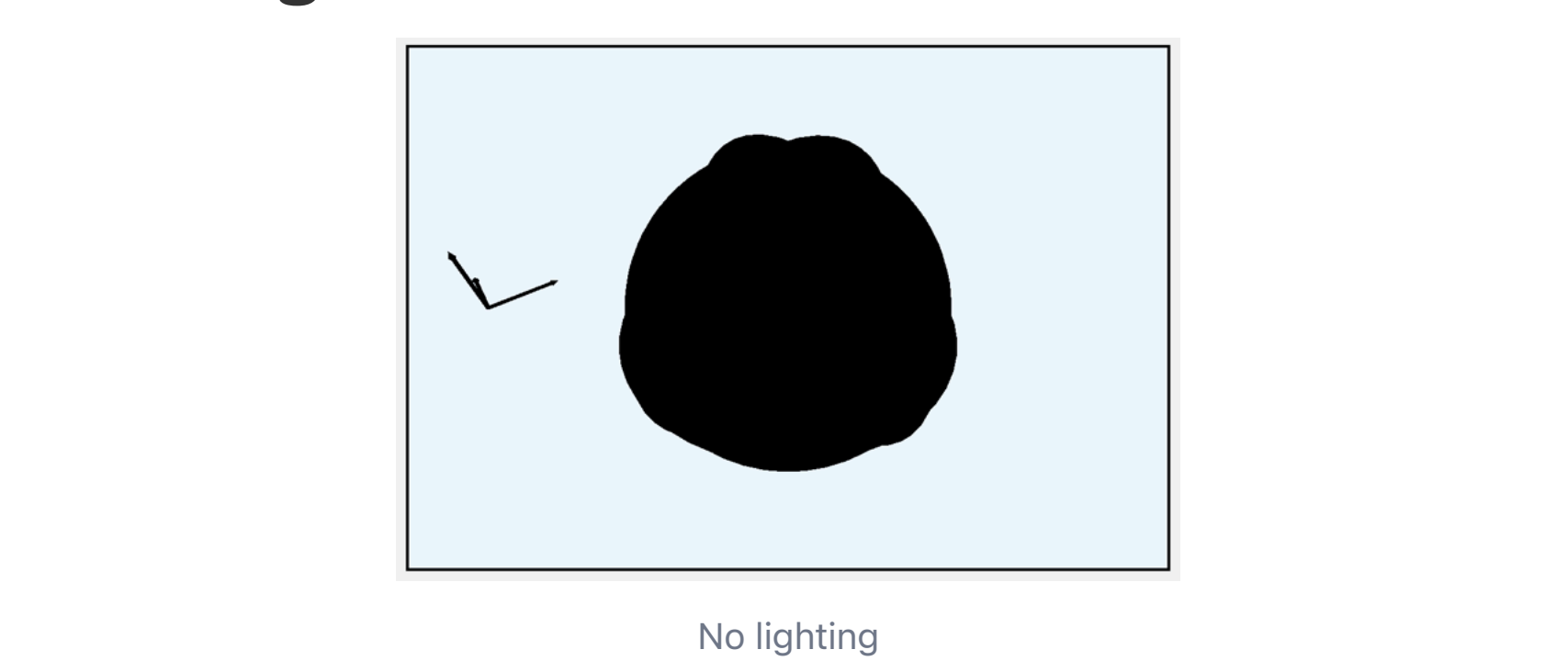
The dot product



The dot product



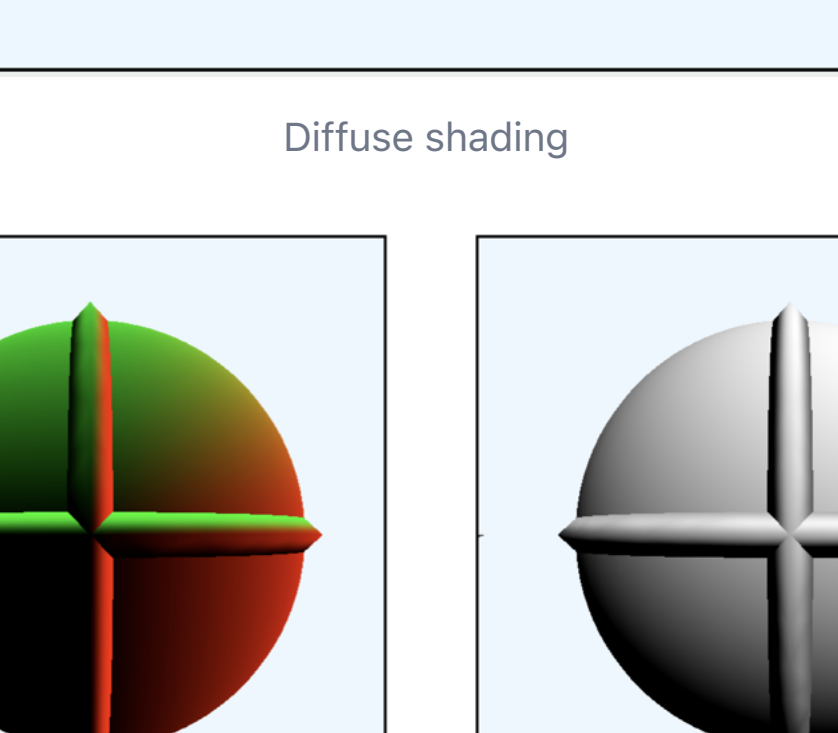
The dot product of sunlight and normal vectors



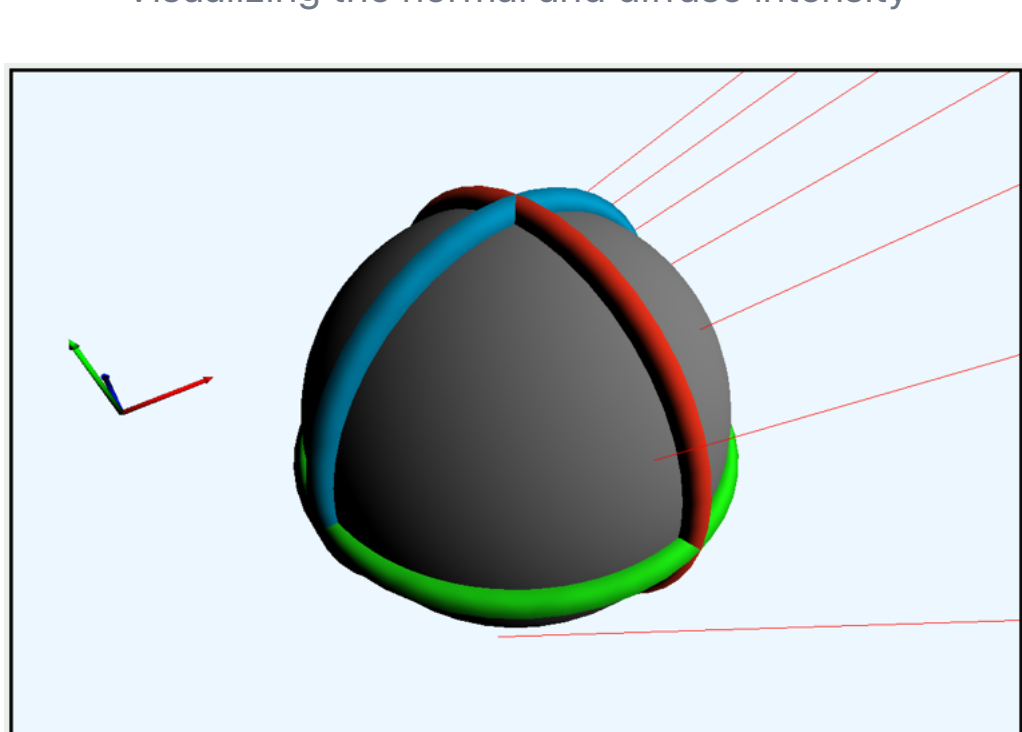
Dot product playground code

### Diffuse Reflection

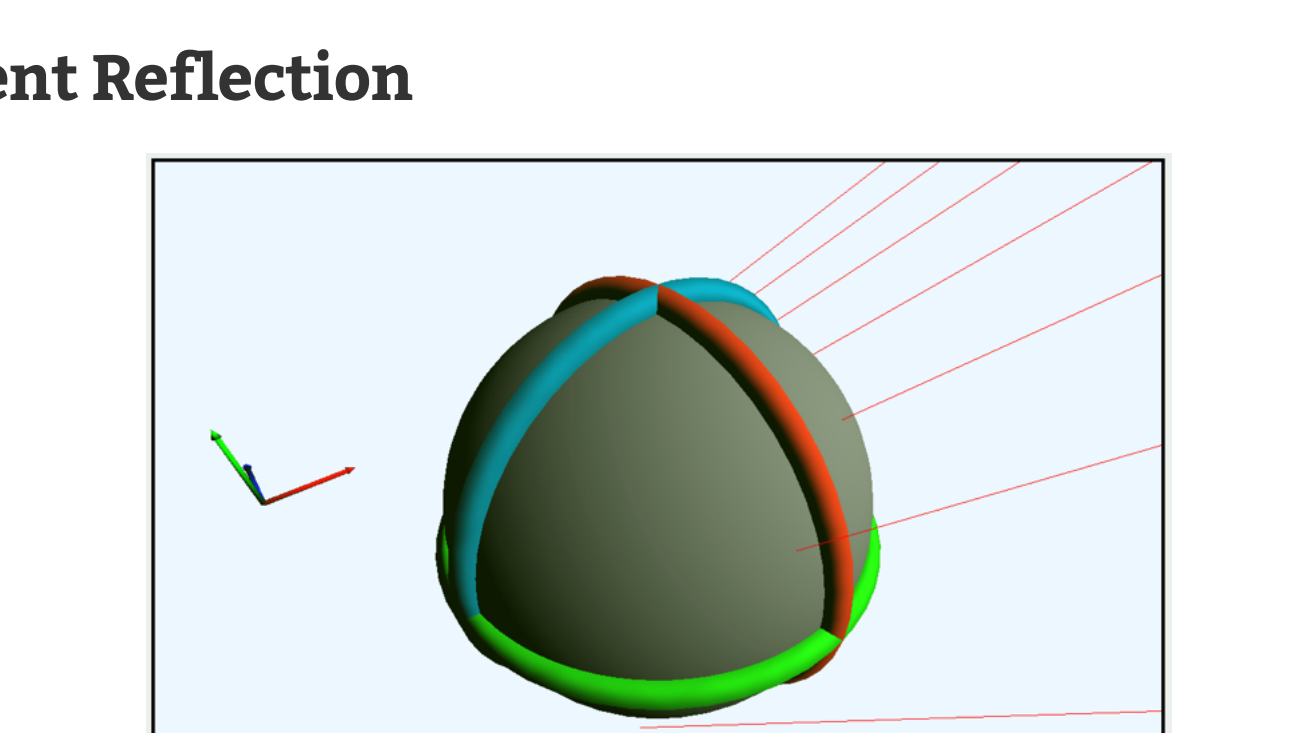
### Creating Shared Functions in C++



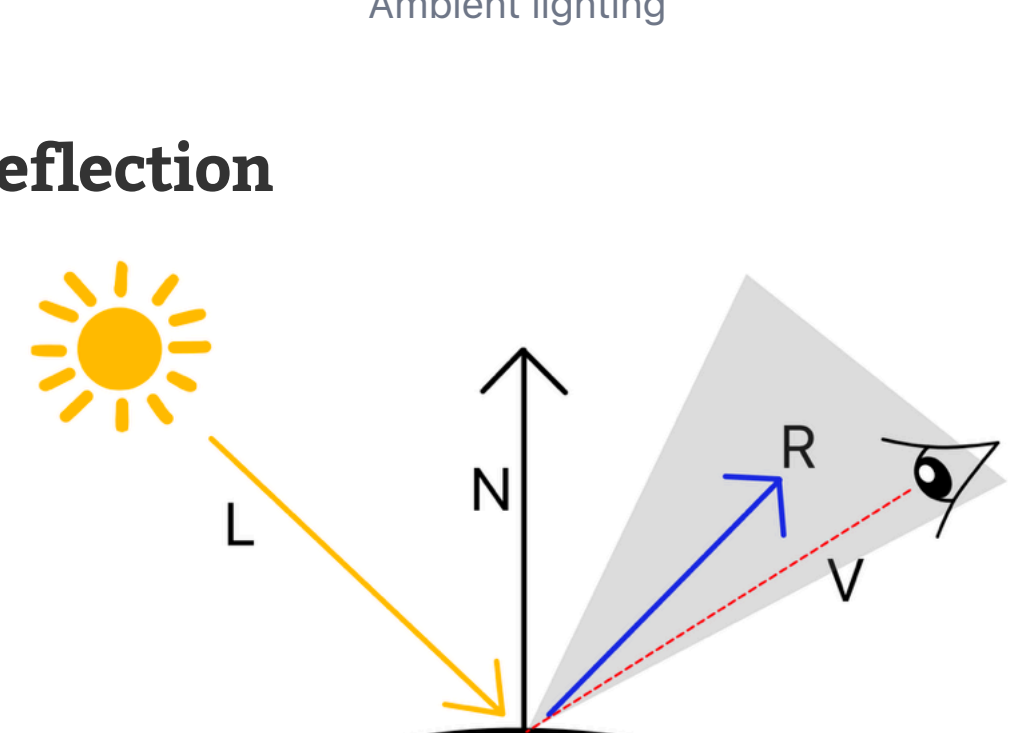
No lighting



Diffuse shading

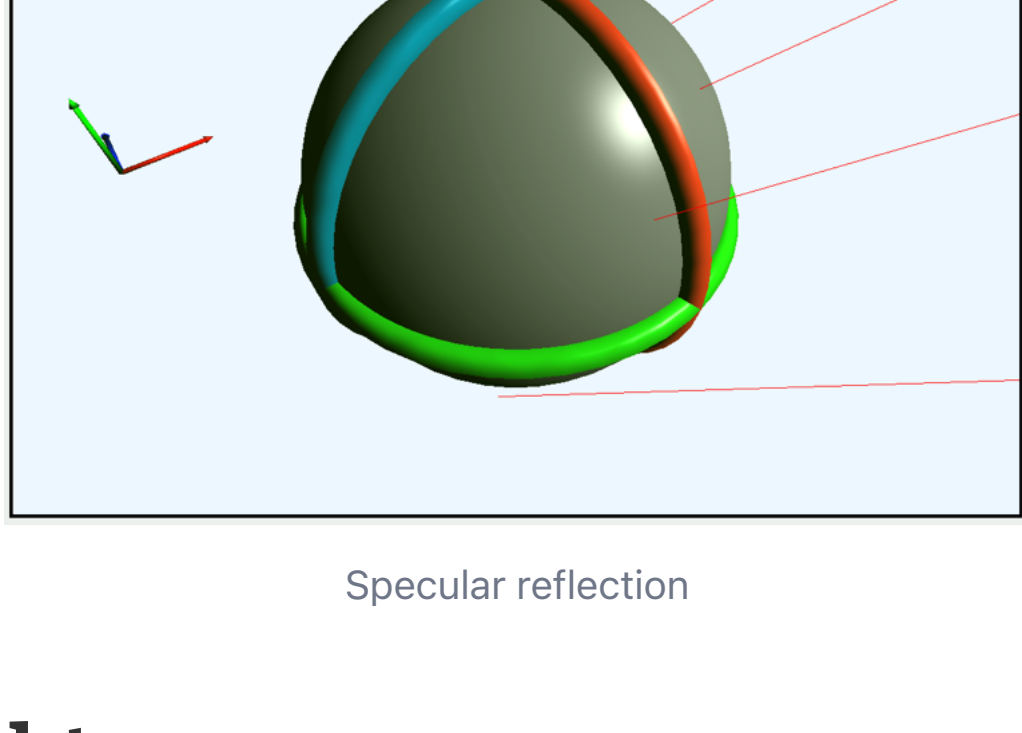


Visualizing the normal and diffuse intensity



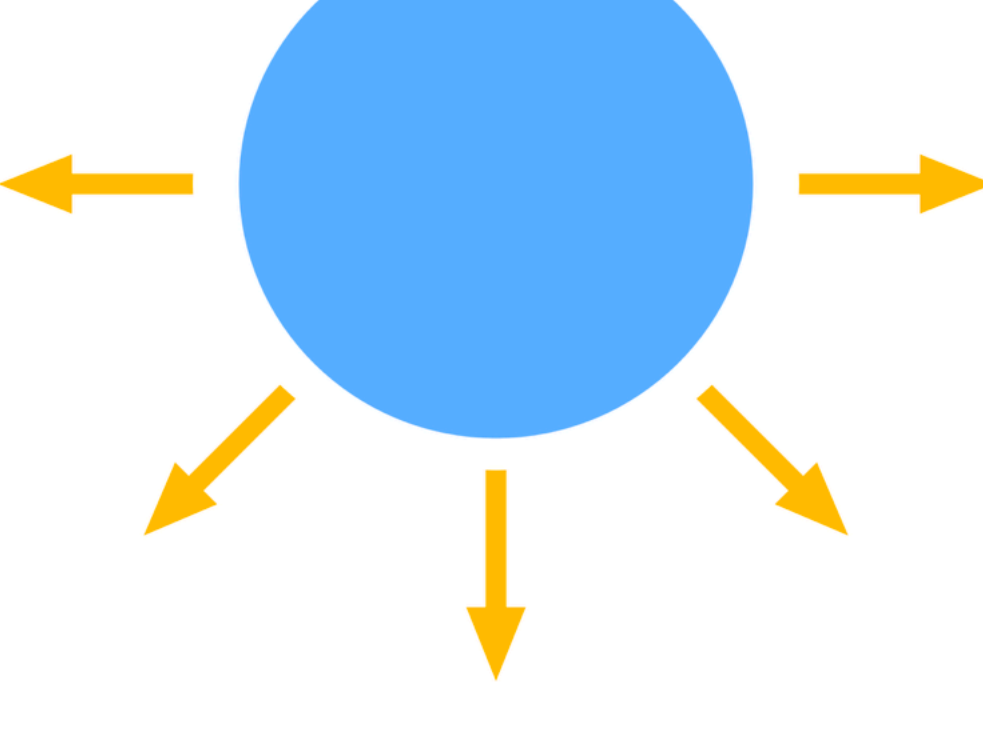
Debugging sunlight direction

### Ambient Reflection

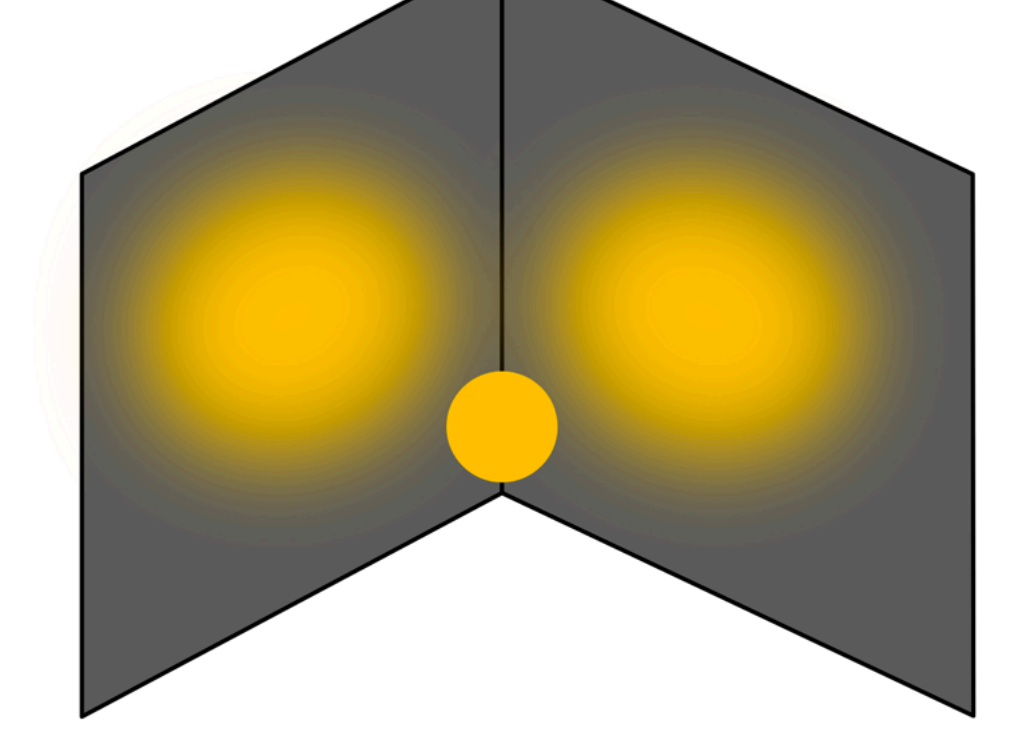


Ambient lighting

### Specular Reflection

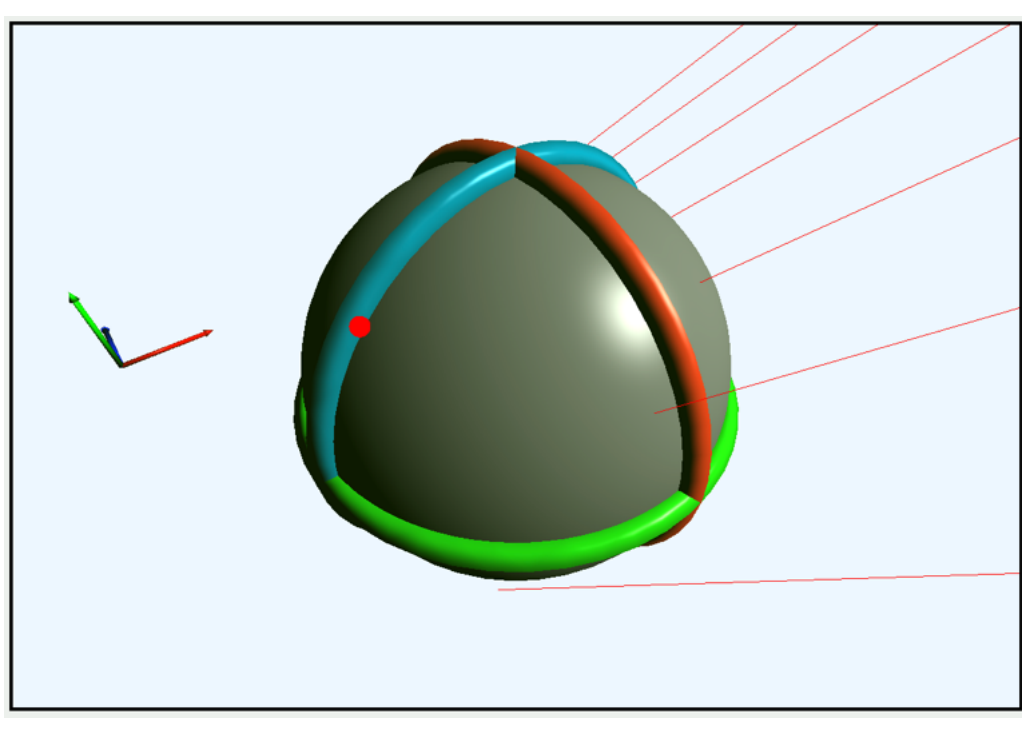


Specular reflection

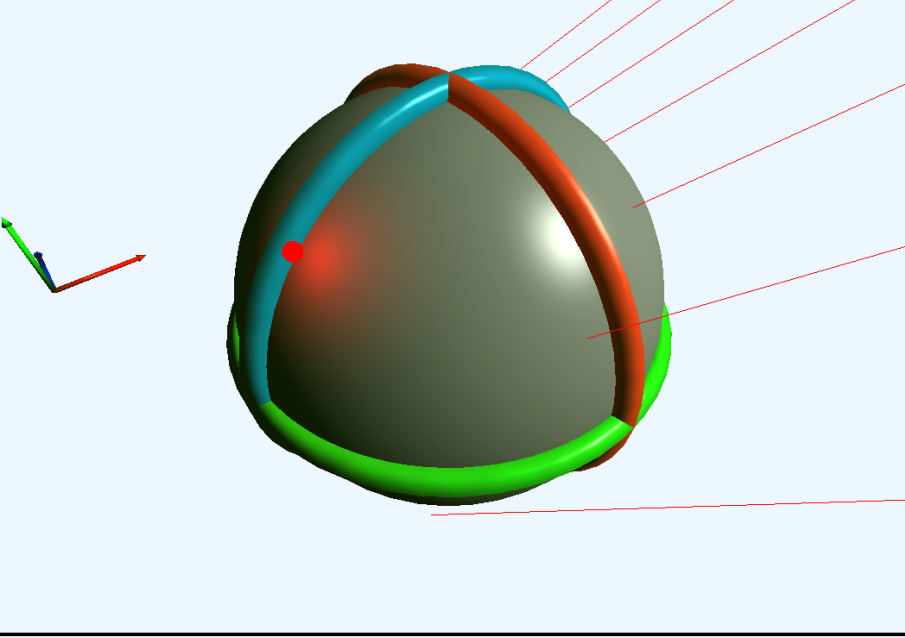


Specular reflection

### Point Lights



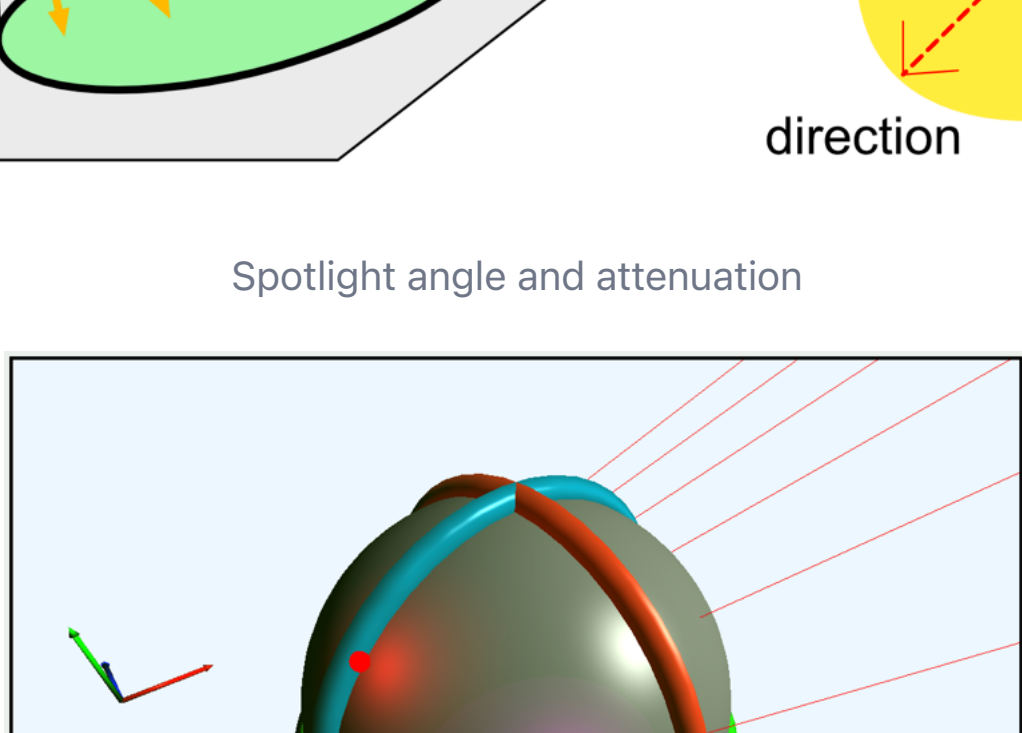
Point light direction



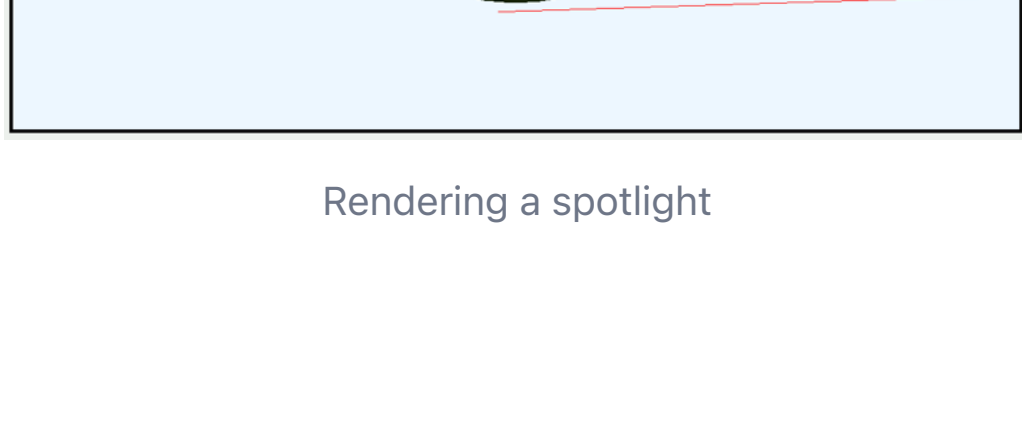
Point light attenuation

$$\frac{1.0}{x + y * distance + z * distance^2}$$

Attenuation formula



Debugging a point light



Rendering a point light

### Spotlights



Spotlight angle and attenuation



Rendering a spotlight