

Introduction To Lighting

(SENG 463 - Game Programming)

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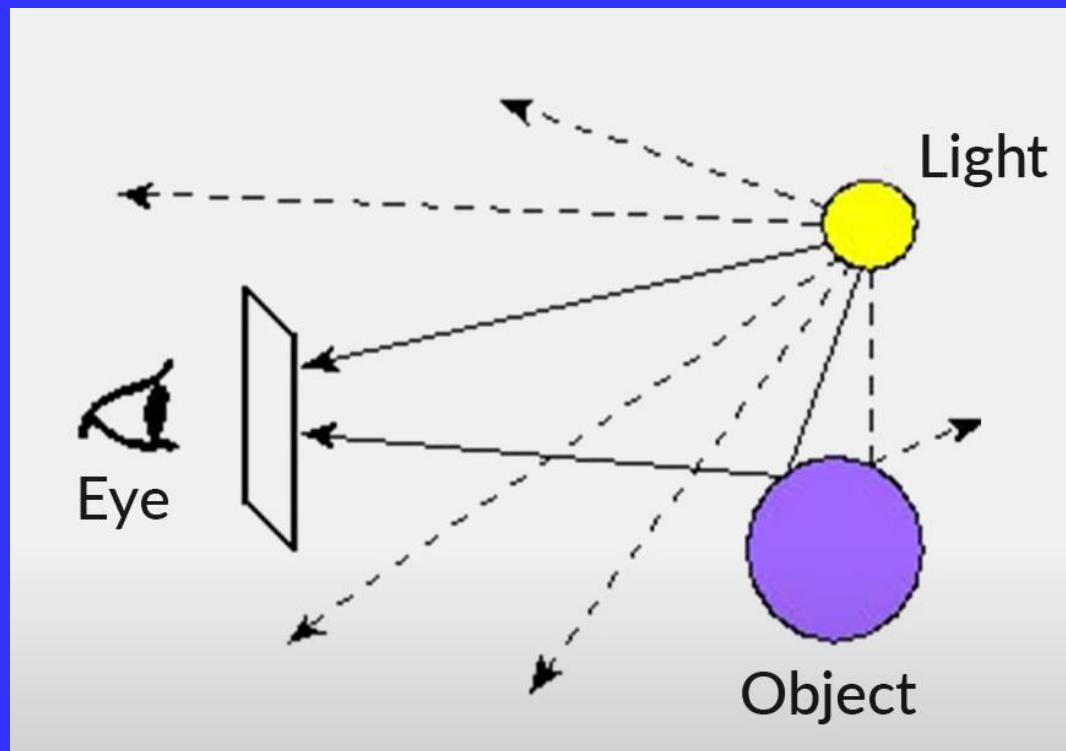
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Outline

- Direct & Indirect Lighting
- Global Illumination
- Baking
- Progressive Lightmapper
- Light Types
- Phong Illumination Model

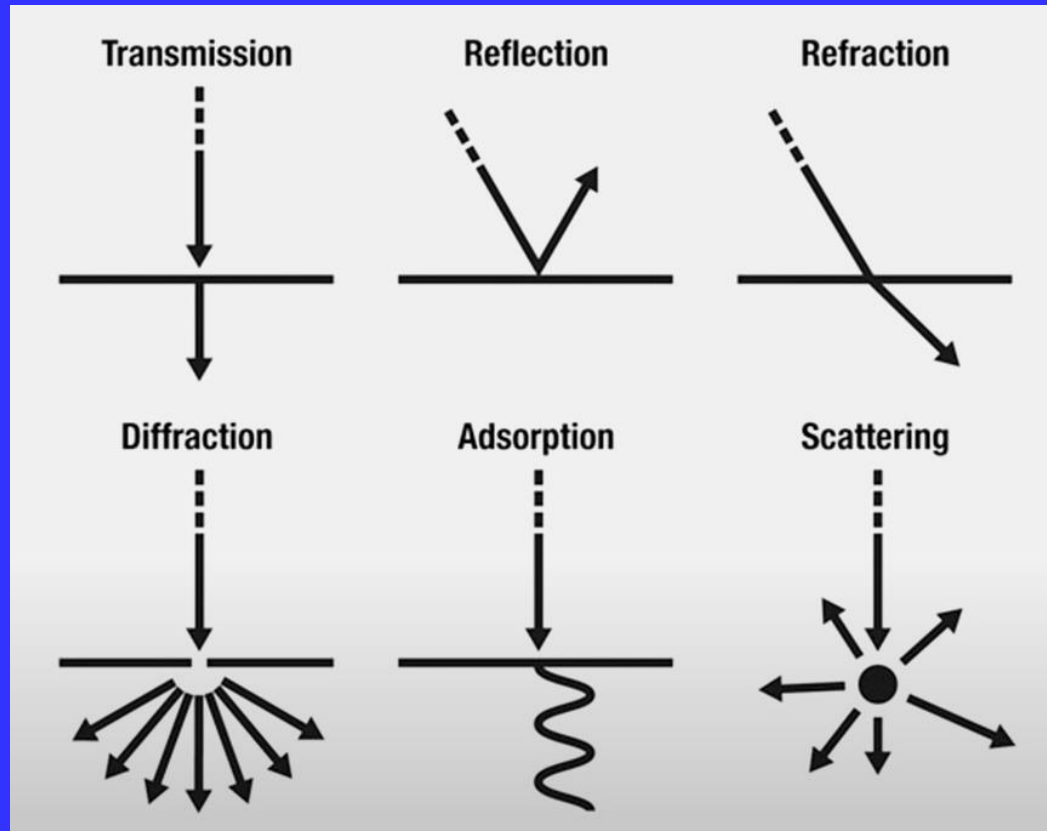
Lighting

- Eye see objects by sensing rays of light directly coming from lights or reflected from objects



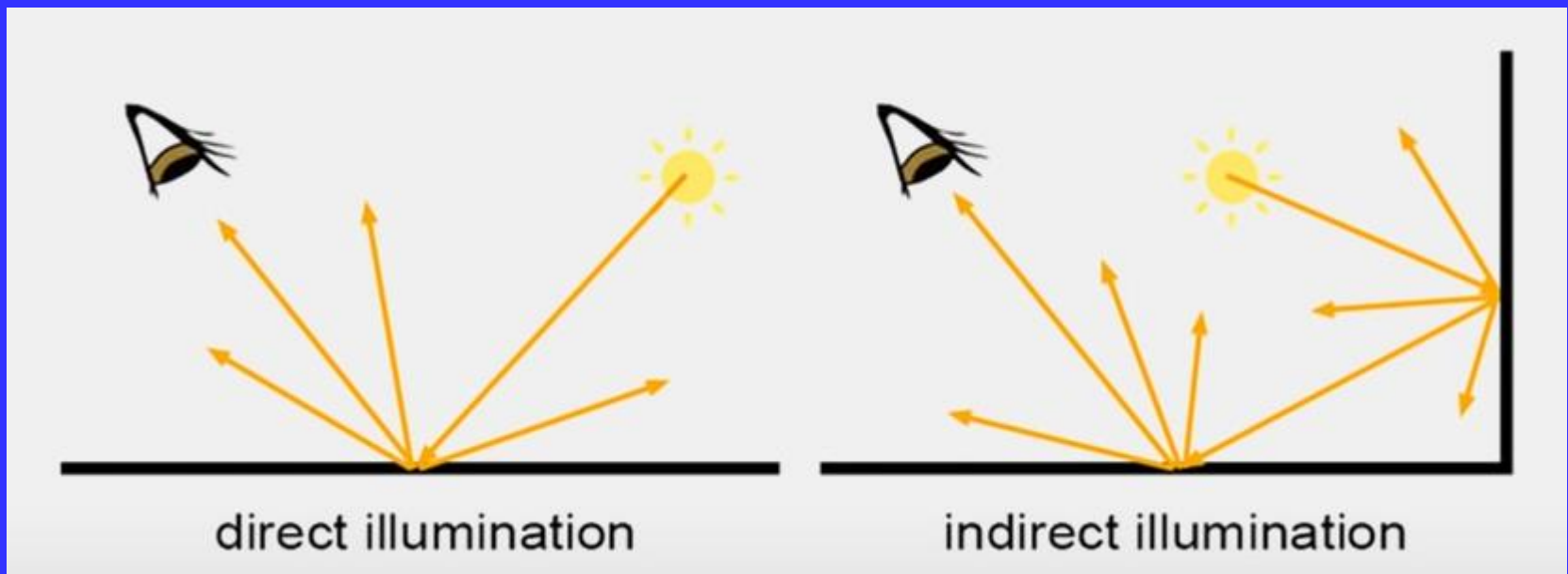
Lighting

- Every time a light hits an object,
- it is modified depending on the properties of object material



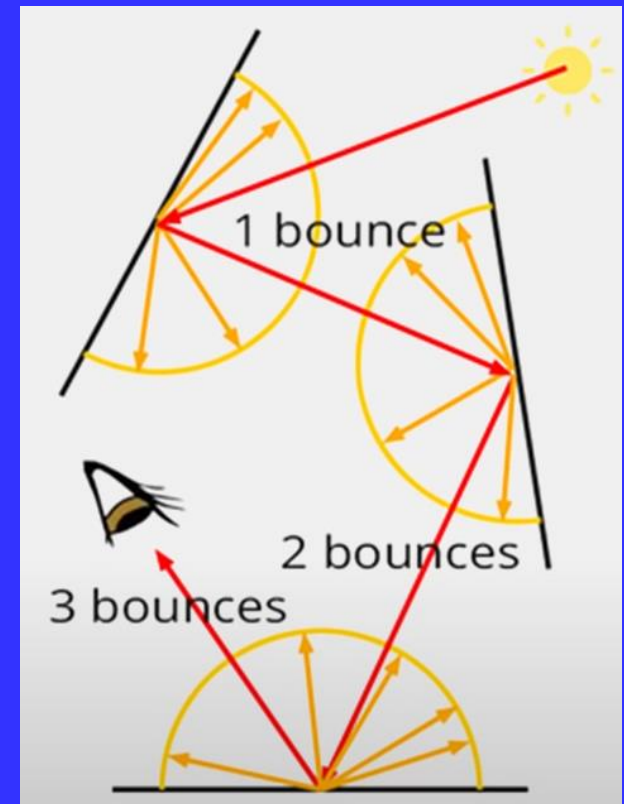
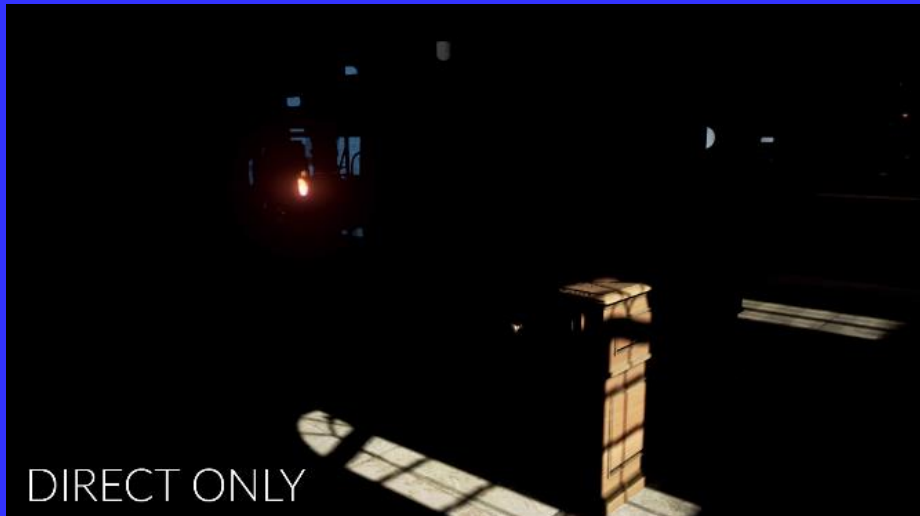
Direct & Indirect Lighting

- Direct lighting occurs if light is reflected from a surface once before reach the eyes
- Indirect lighting occurs if light is reflected from multiple surfaces before reach the eyes



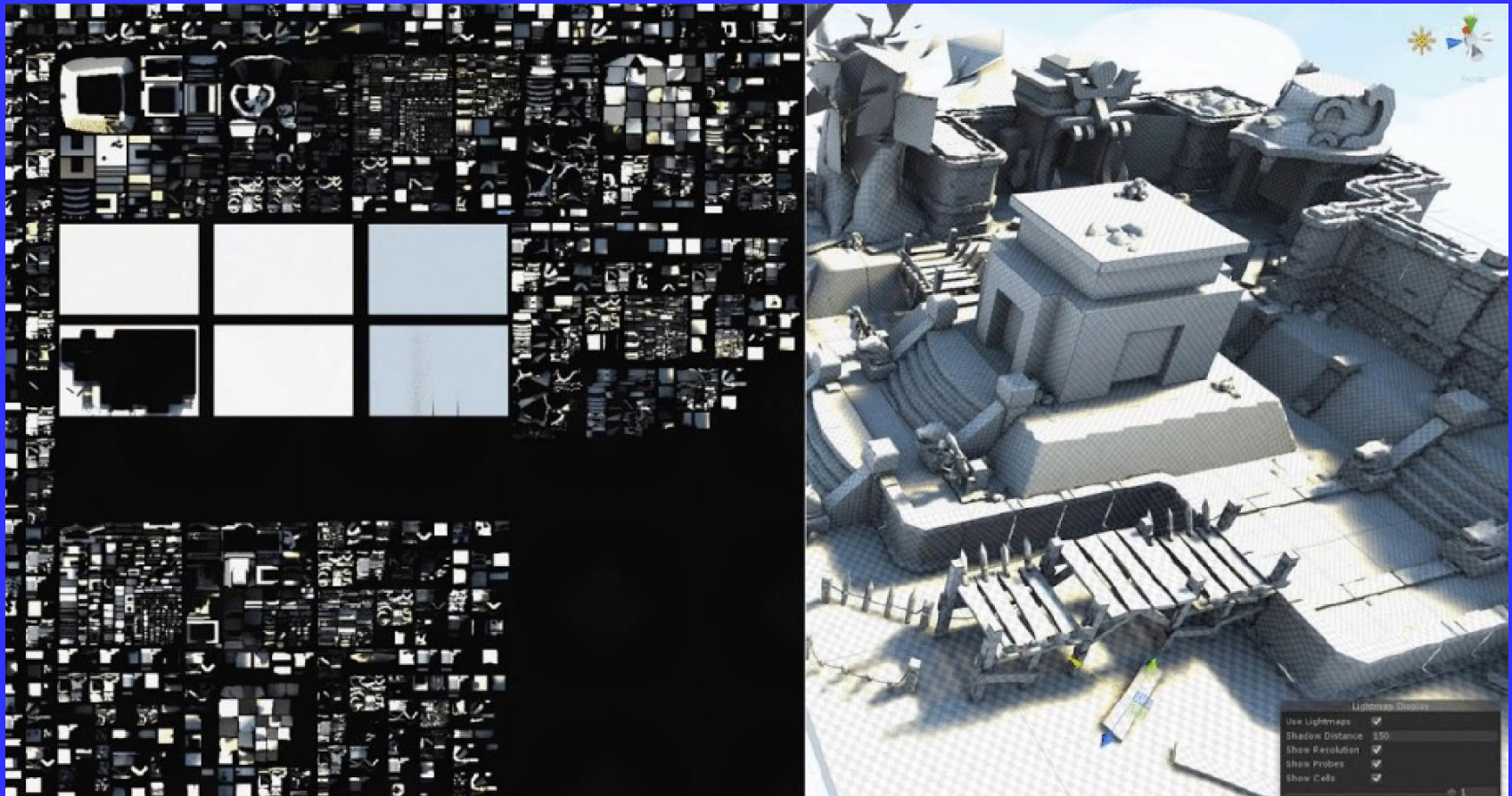
Global Illumination

- The more indirect bouncing the more realistic



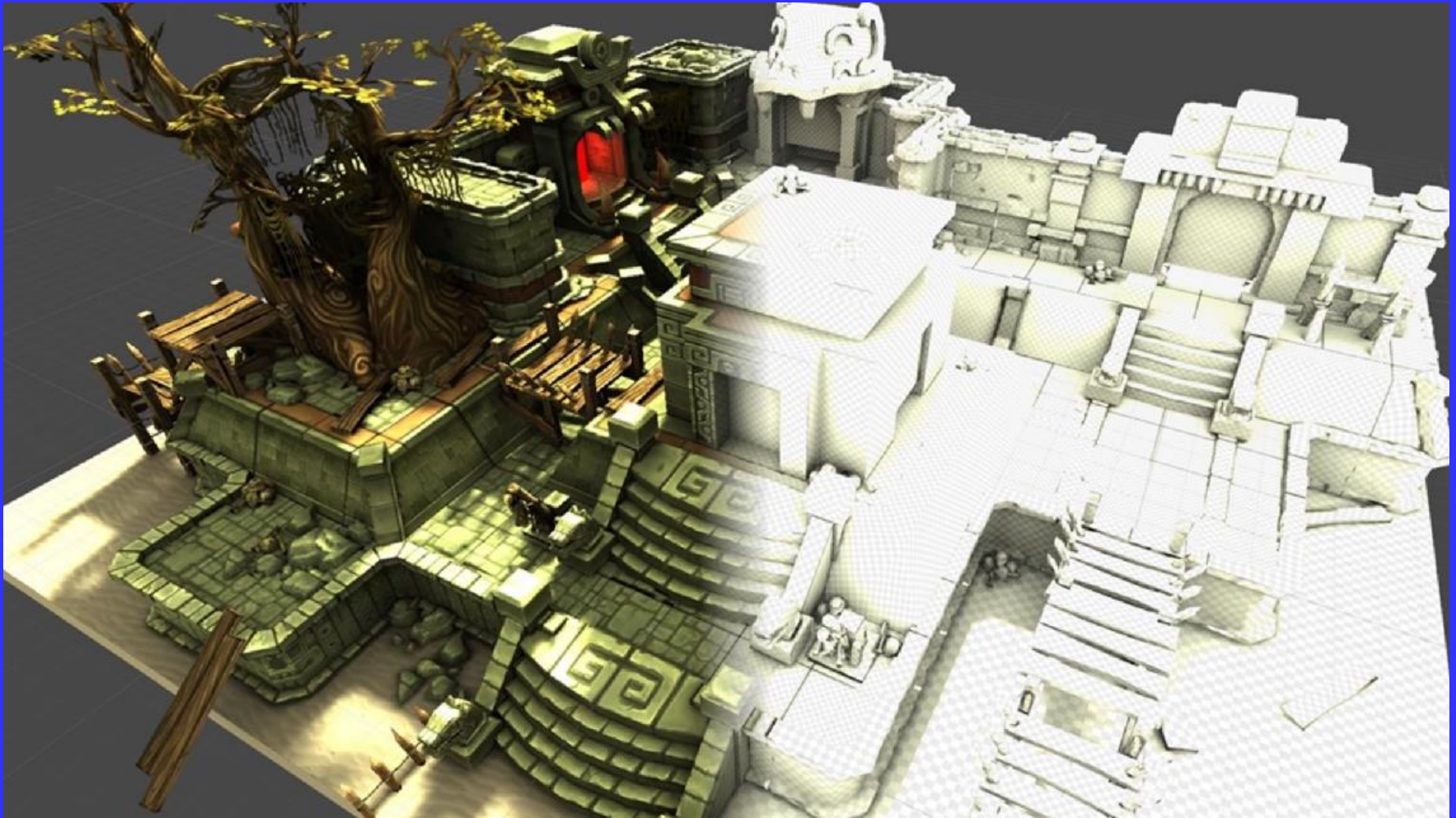
Baking

- Preprocess and calculate all the lighting into a large texture. In run-time use the texture.



Baking

- Overlap lightmap texture on top of objects



Progressive Lightmapper

- If you cannot use baked static light maps
 - You can use progressive lightmapper
- It is a path tracing base light mapper and
- It will realistically simulate light bouncing in the scene
- It actually uses baked lightmaps again, but maps are updated progressively and refined in time.
- It will take time to make the scene look good

Progressive Lightmapper



See for details <https://youtu.be/VnG2gOKV9dw>
<https://youtu.be/foMZJrwRGr0>

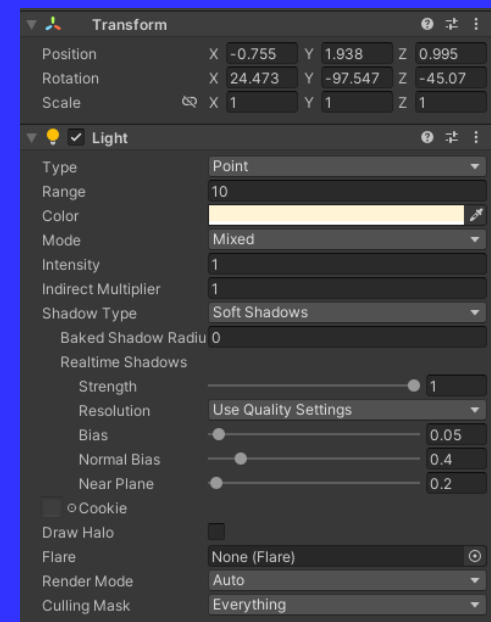
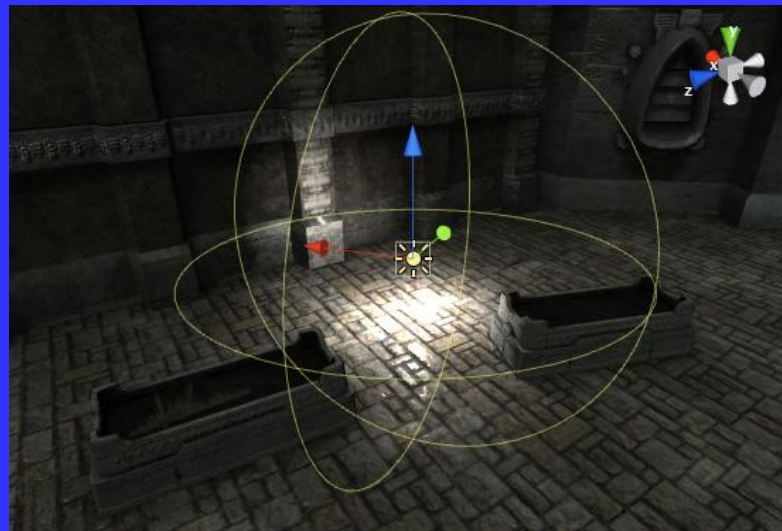
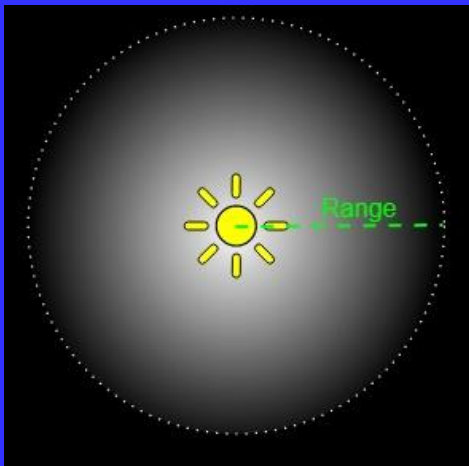
Light Types

- Point
- Directional
- Spot
- Area (For baked lightmaps only)



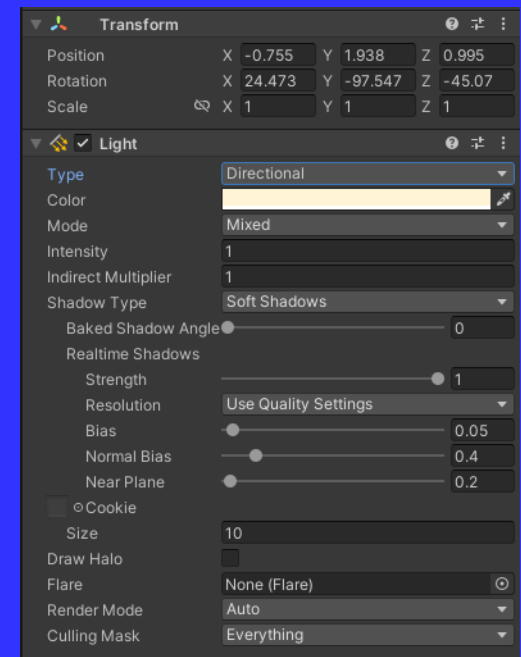
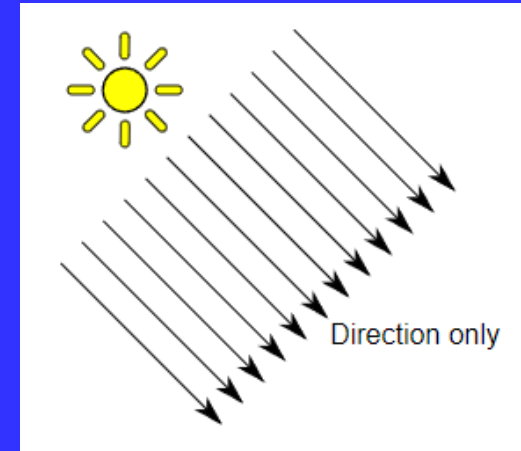
Point Lights

- A Point Light is located at a point in space
- Sends light out in all directions equally.
- The direction of light hitting a surface is the line from the point of contact back to the center of the light object.
- The intensity diminishes with distance from the light, reaching zero at a specified range.
- Light intensity is inversely proportional to the square of the distance from the source.



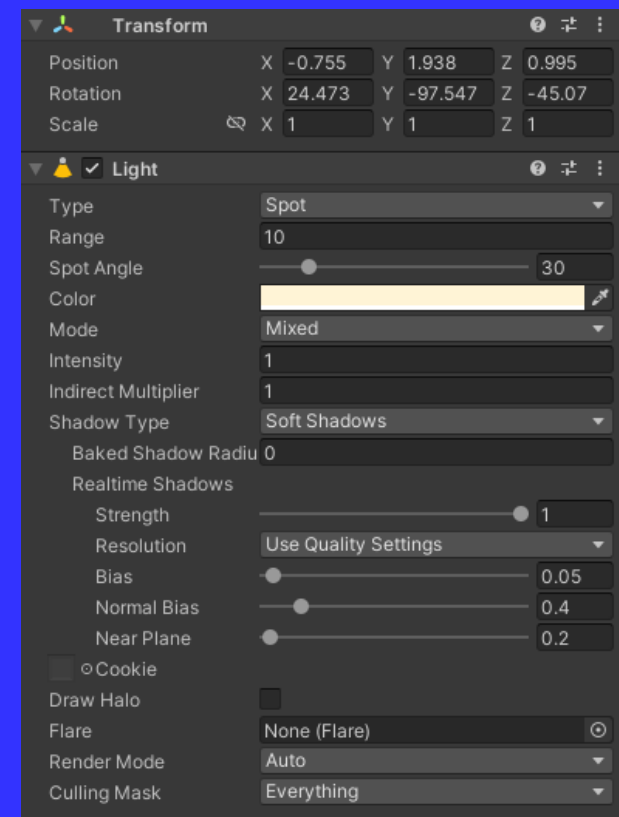
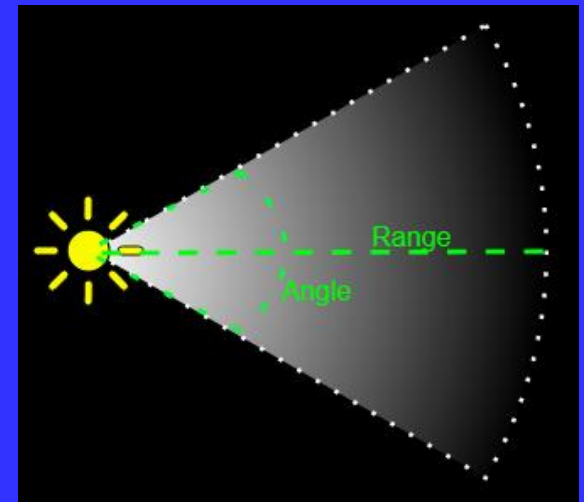
Directional Lights

- Usefull for creating effects such as sunlight in your scenes.
- Behaving in many ways like the sun
- Directional lights can be thought of as distant light sources which exist infinitely far away.
- A Directional Light doesn't have any identifiable source position
 - The light object can be placed anywhere in the scene.
- All objects in the scene are illuminated as if the light is always from the same direction.
- The distance of the light from the target object isn't defined and so the light doesn't diminish.



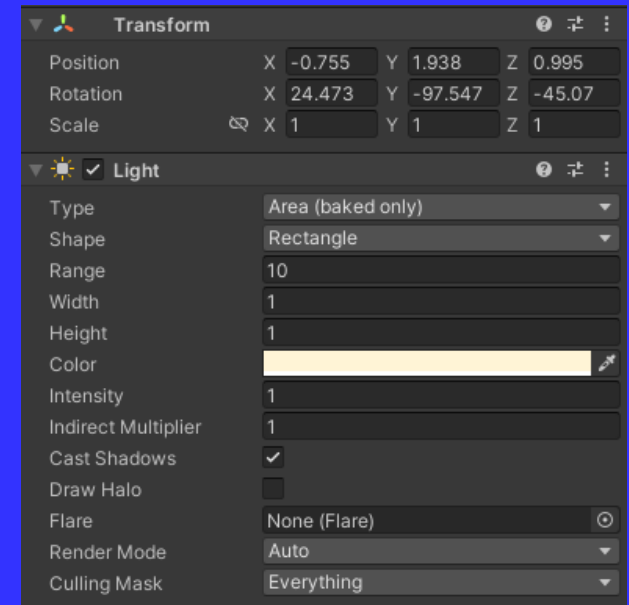
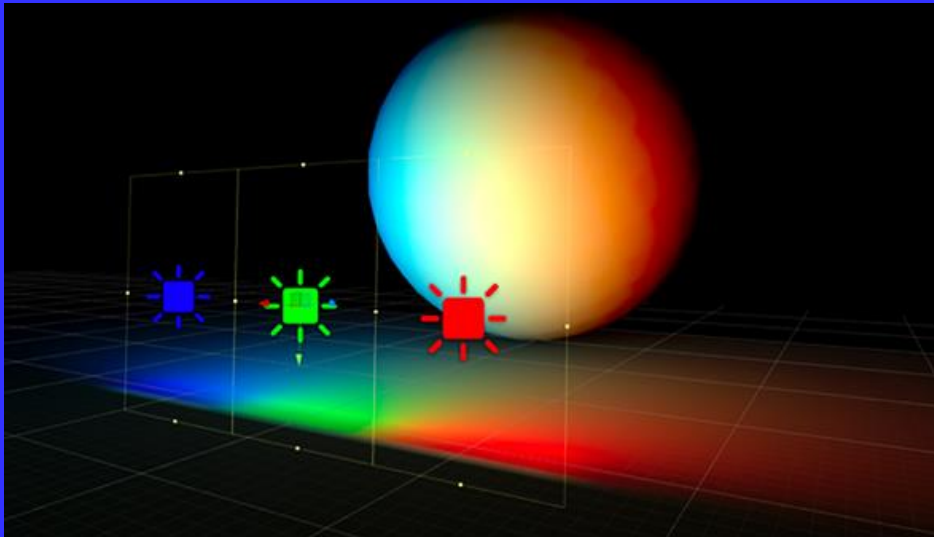
Spot Lights

- Like a Point Light, a Spot Light has a specified location and range over which the light falls off.
- A Spot Light is constrained to an angle, resulting in a cone-shaped region of illumination.
- The center of the cone points in the forward (Z) direction of the light object.
- Light also diminishes at the edges of a Spot Light's cone.
- Widening the angle increases the width of the cone and with it increases the size of this fade.



Area Lights

- Define an Area Light by one of two shapes in space: a rectangle or a disc.
- An Area Light emits light from one side of that shape.
- Emitted light spreads uniformly in all directions across that shape's surface area.
- The **Range** property determines the size of that shape.
- The intensity of the illumination provided by an Area Light diminishes at a rate determined by the inverse square of the distance from the light source
- Only of baked lighting

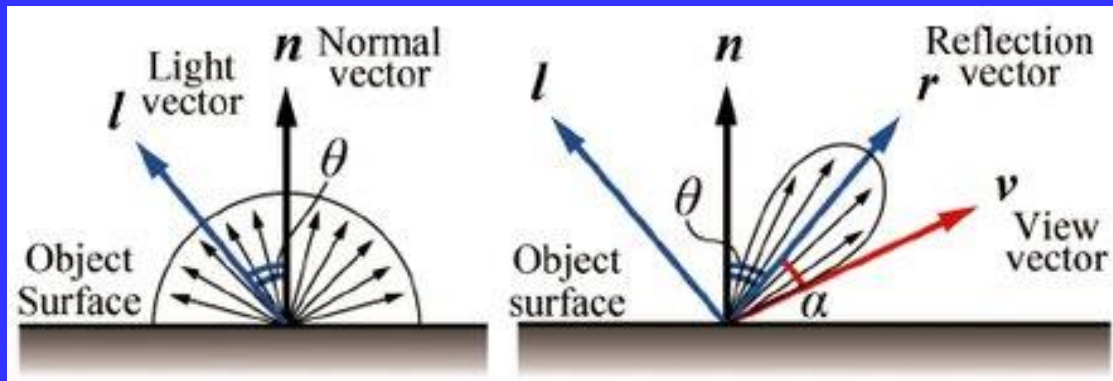


Basic Illumination Model

- Basic illumination model used in computer graphics for lighting computations is Phong Illumination Model.
- It has 3 components:
 - Diffuse Reflection
 - Specular Reflection
 - Ambient light



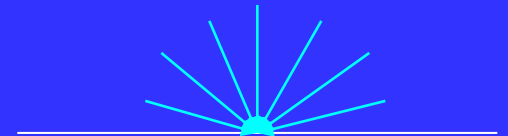
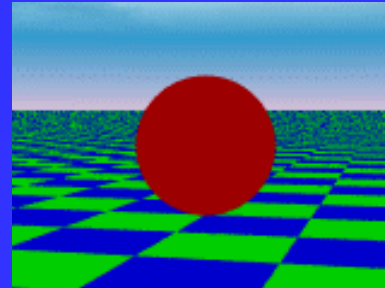
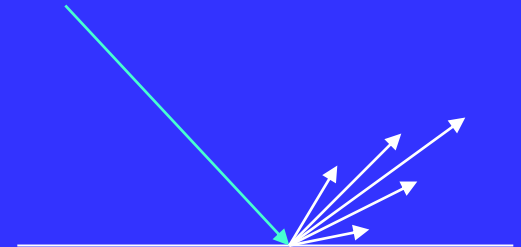
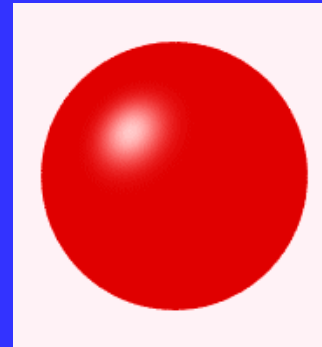
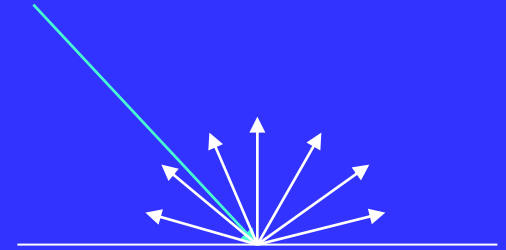
Diffuse lighting



Specular lighting

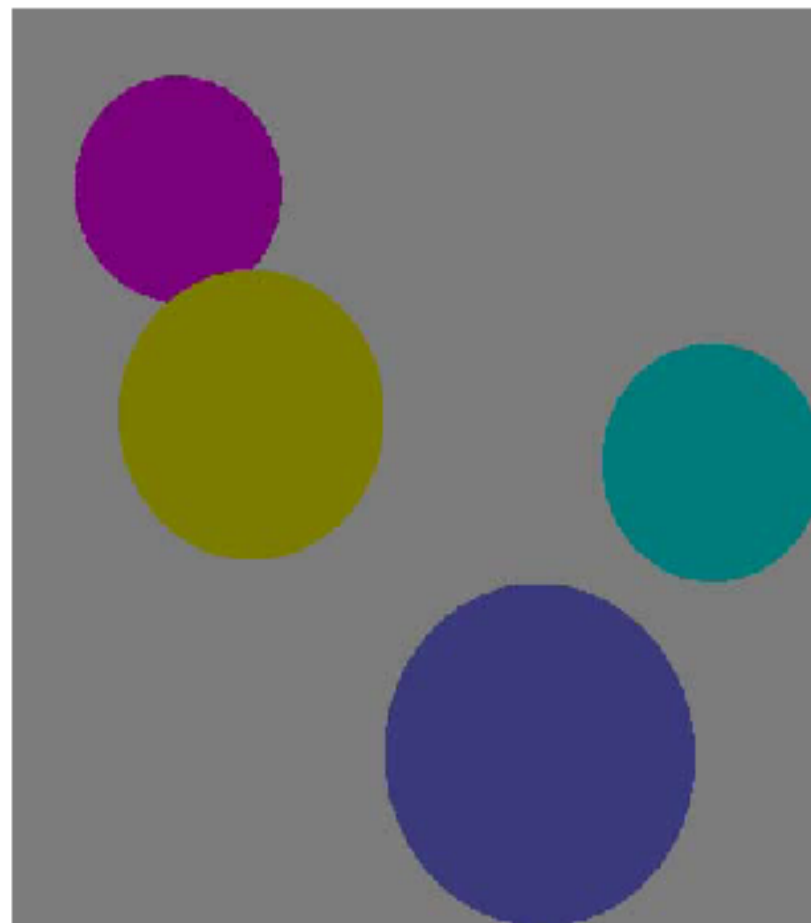
Basic (Phong) Illumination Model

- Three terms linearly combined:
 - *Diffuse* component for the amount of incoming light reflected equally in all directions
 - *Specular* component for the amount of light reflected in a mirror-like fashion
 - *Ambient* term to approximate light arriving via other surfaces



Ambient Light

- Reflected light from the environment and the nearby objects cause other objects to illuminate
- Also called background light
- Constant color reflected from all points on the surface.
- Tells us how bright the surface will look like when no light source can directly reach the surface
- When used alone, does not produce very interesting pictures



Ambient lighting only

Modeling Ambient Light

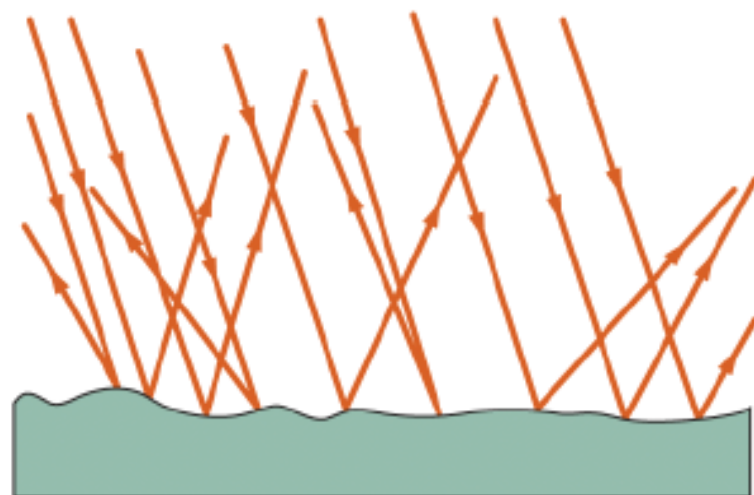
- We can use an ambient intensity parameter I_a that describes the level of ambient light in a scene.
- Every object in the scene will be illuminated by this amount independent of the surface orientation and viewer location.
- But different surfaces may reflect different amount of ambient light based on their absorbance/reflectance properties. We can model this by a constant factor for each surface:

$$k_a I_a$$

Diffuse reflection

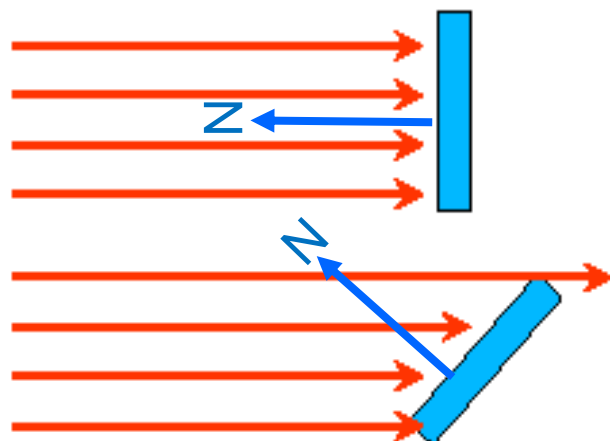


- The light that is reflected in all directions is called diffuse reflection.
- The reflected light is independent of the viewing position (equally bright from all viewing directions)
- But the light position with respect to the surface orientation is important to determine the light reflected from the surface.
- When an object is illuminated with white light the original color of the object is what we see as the diffuse reflection.
- If a blue object is illuminated with red light, it will appear black.



Modeling Diffuse Reflection

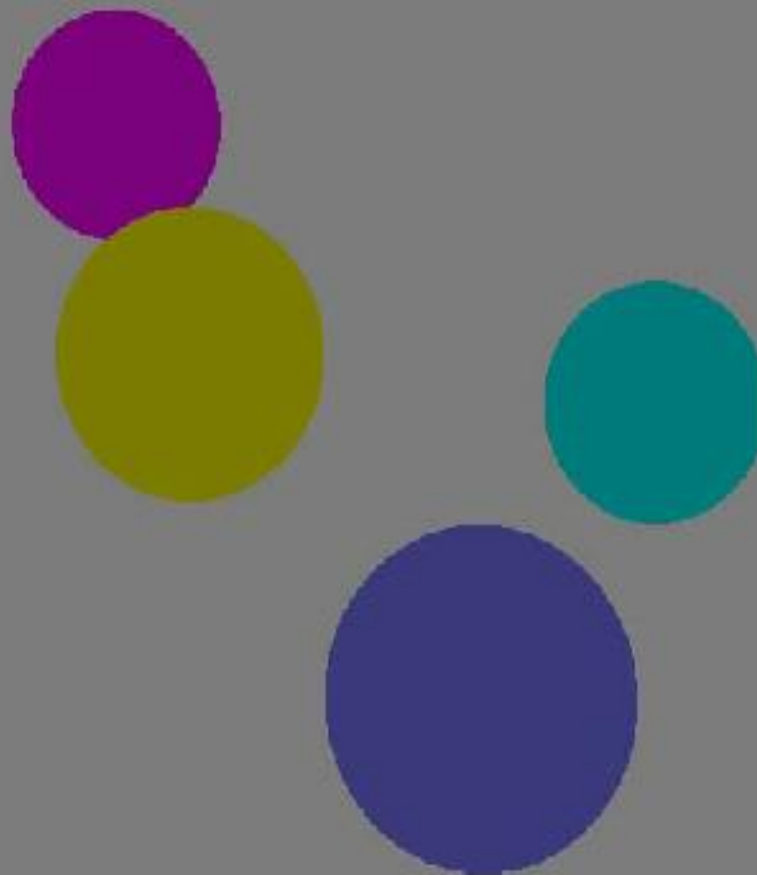
- Orientation of the surface determines the amount of light incident on the surface



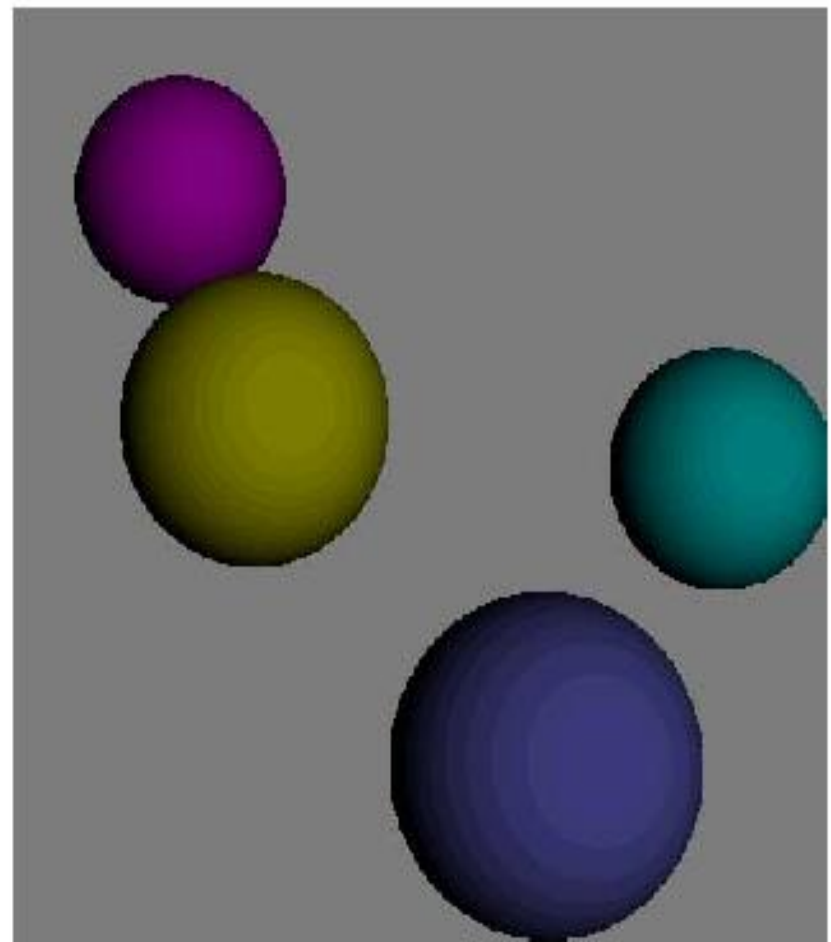
Given the angle θ between the surface normal and the incident light direction, we can write the diffuse reflection equation as:

$$\begin{aligned} I_{l,diff} &= k_d I_{l,incident} \\ &= k_d I_l \cos \theta \end{aligned}$$

Ambient Light vs. Diffuse Reflection



Ambient lighting only



With diffuse lighting

Specular reflection



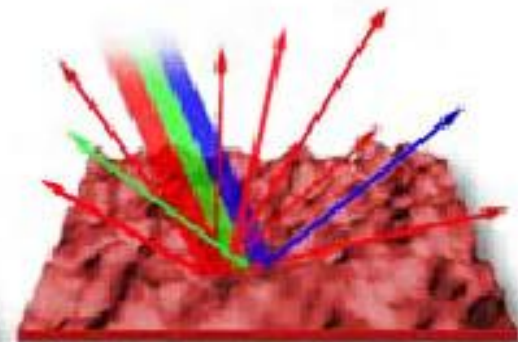
- Light reflected from a certain spot on the object is concentrated and appears as a lot brighter compared to other spots. This is due to specular reflection and is an important property of shiny objects.

Specular and Diffuse Reflection

- Specular reflection is both dependent on the light direction, surface orientation, and ***viewer position***



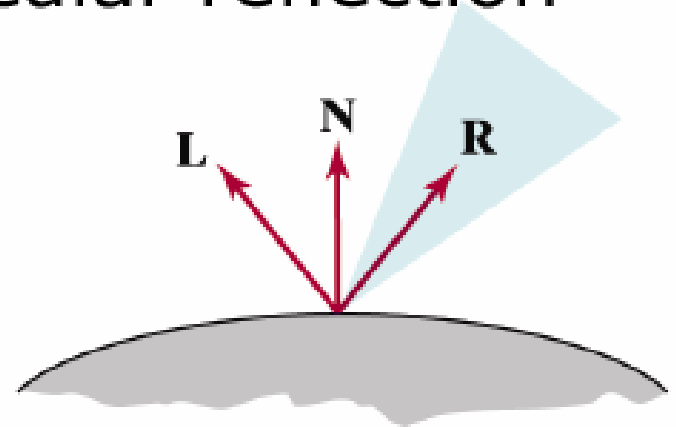
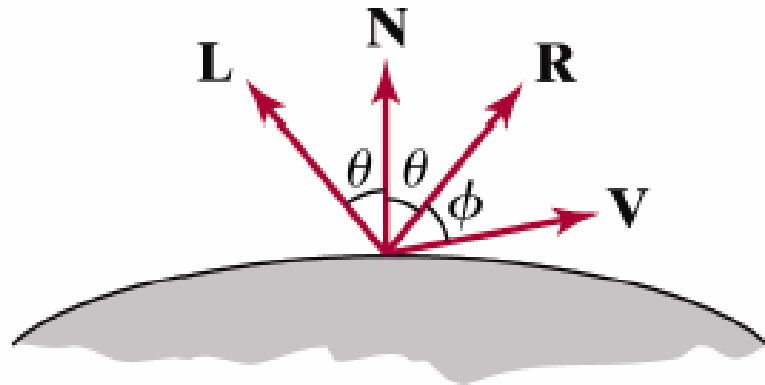
Specular
Reflection



Diffuse
Reflection

Modeling Specular Reflection

- Let us try to picture specular reflection



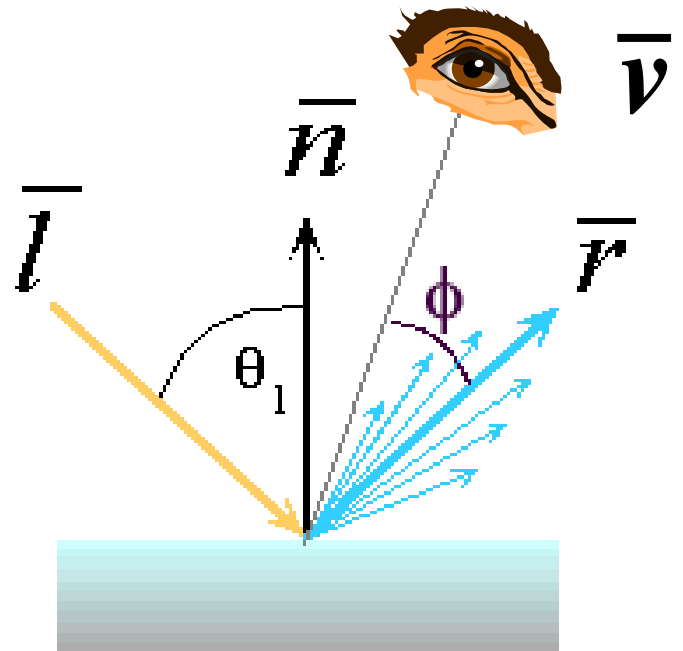
- The specular reflection angle equals angle of incidence
- The specular reflection is visible only at directions close to R . Shiny surfaces like mirrors have a narrow specular reflection range (given as parameter n_s , specular-reflection exponent.)

Specular Reflection In Phong Lighting

- The most common lighting model in computer graphics:

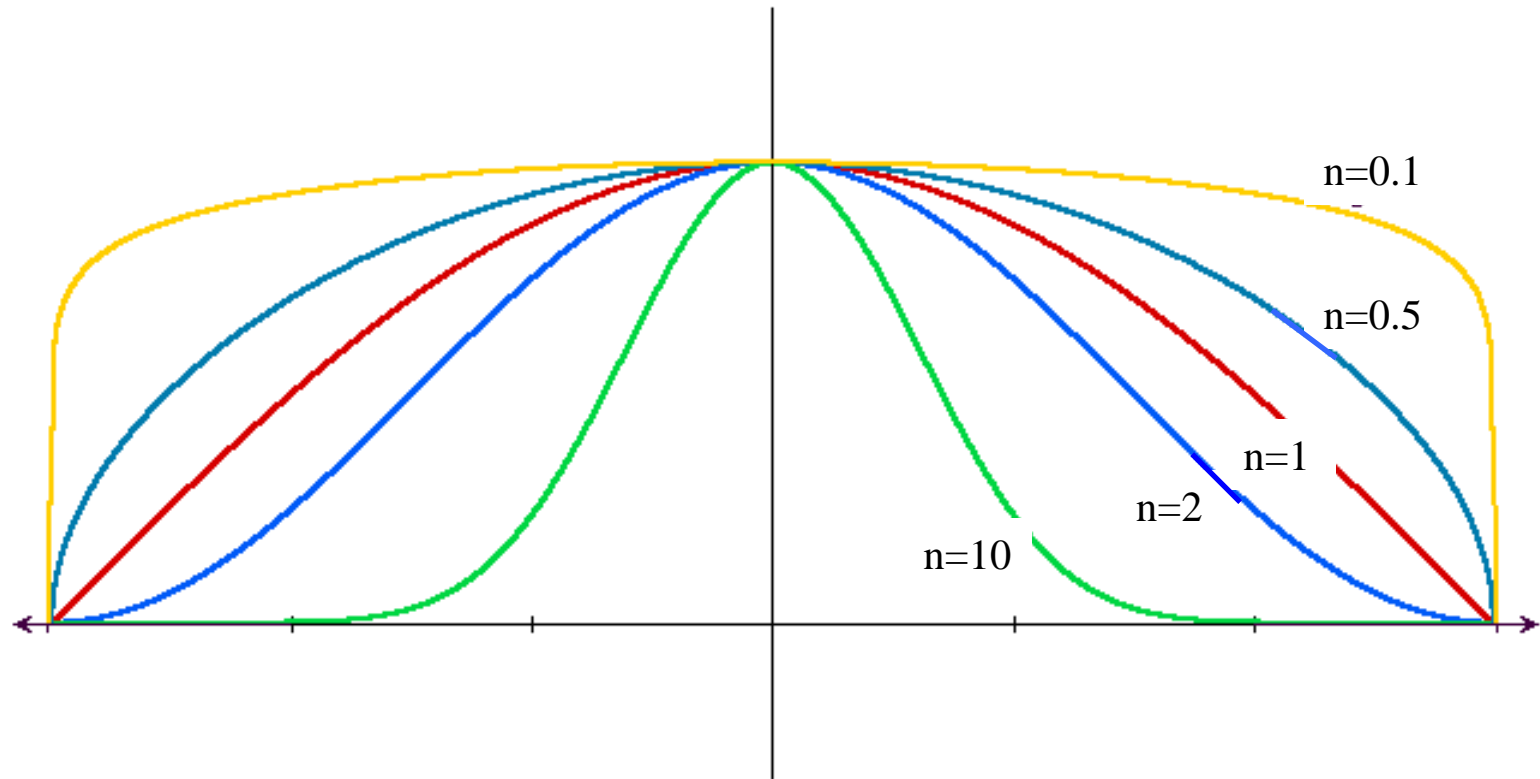
$$I_{specular} = k_s I_{light} (\cos \phi)^{n_{shiny}}$$

- The n_{shiny} term is a purely empirical constant that varies the rate of falloff
- Though this model has no physical basis, it works (sort of) in practice



The Shininess Coefficient n_s

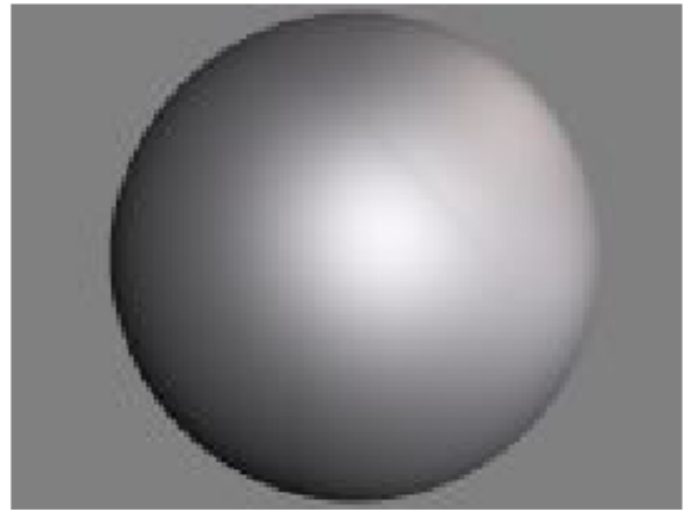
- Values between 100 and 200 correspond to metals
- Values between 5 and 10 give surface that look like plastic



Diffuse vs. Specular Reflection



Diffuse Reflection



Diffuse and Specular
Reflection