# Phong Illumination Model

## Diffuse Reflection

- Diffuse reflection is based on Lambert's cosine law, which states that the intensity of light is proportional to the cosine of the angle between the light direction **l** and the surface normal **n**.
- The intensity of light is higher if the angle is sharper.
- The dot product $\boldsymbol{n} \cdot \boldsymbol{l}$ represents this cosine value, and I use max to ensure it is non-negative.
- $\boldsymbol{p} \cdot \boldsymbol{L}_{\text{light}}$ represents the final color of the object with light.

$$\boldsymbol{diffuse} = r_{\text{View}} \cdot \boldsymbol{p} \cdot \boldsymbol{L}_{\text{light}} \cdot \max(\boldsymbol{n} \cdot \boldsymbol{l}, 0.0)$$

## Ambient Reflection

- Ambient reflection represents the constant illumination of the object by the environment.
- It is usually a small constant value added to ensure that objects are visible even when not directly lit.
- Higher ambient strength means the entire object brightens up more by the same amount.

$$\boldsymbol{ambient} = \frac{1}{\pi} \cdot \mathit{ambientStrength} \cdot \boldsymbol{p} \cdot \boldsymbol{L}_{\text{light}}$$

## Specular Reflection

- Specular reflection represents the mirror-like reflection of light sources on shiny surfaces.
- It does not use the object color ($\boldsymbol{p}$) because specular highlights are typically the color of the light source.
- Higher shininess ($m$) means a smaller specular highlight.
- It is based on the dot product between the view direction **v** and the reflection direction **r**, raised to the power of the shininess factor ($m$).
- $s$ is the specular strength. Smaller specular strength means less intensity.

$$\boldsymbol{specular} = \boldsymbol{L}_{\text{light}} \cdot s \cdot \max(\boldsymbol{n} \cdot \boldsymbol{l}, 0.0) \cdot (\max(\boldsymbol{r} \cdot \boldsymbol{v}, 0.0))^m$$

### Final Color

Combine the three components to get the final color:

$$\boldsymbol{finalColor} = \boldsymbol{diffuse} + \boldsymbol{specular} + \boldsymbol{ambient}$$