Lighting & Illumination

Illumination and Shading

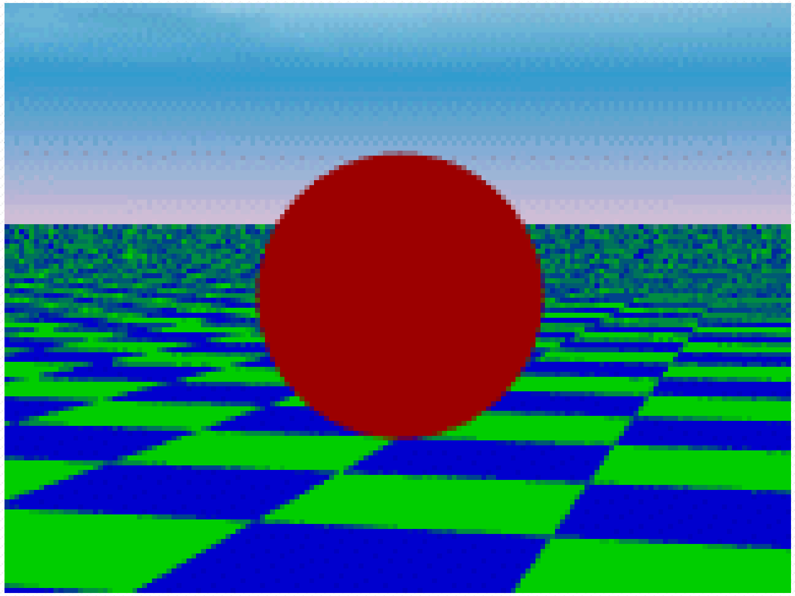
- Ambient Light Sources
- Diffuse Reflection
- Specular Reflection

C = specular + diffuse + ambient

Illumination and Shading

- Ambient Light Sources
  - Ambient light assumption is an equal intensity vector from all directions
  - No spatial or directional characteristics; illuminates all surfaces equally
  - Amount reflected depends o

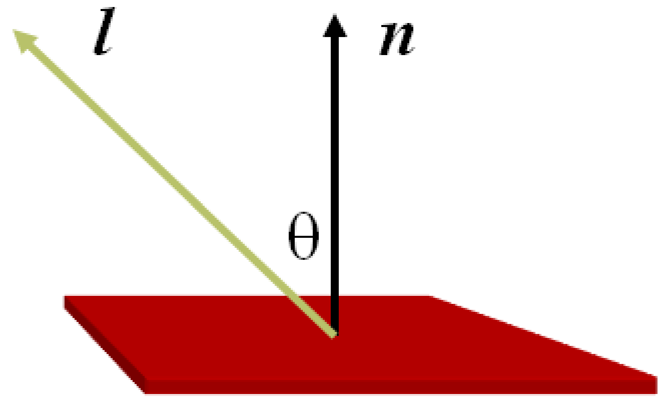
$$\boxed{I_{reflected} = k_{ambient} I_{ambient}}$$



Illumination and Shading

- Diffuse Reflection
- Ideal diffuse surfaces reflect according to *Lambert's cosine law*:

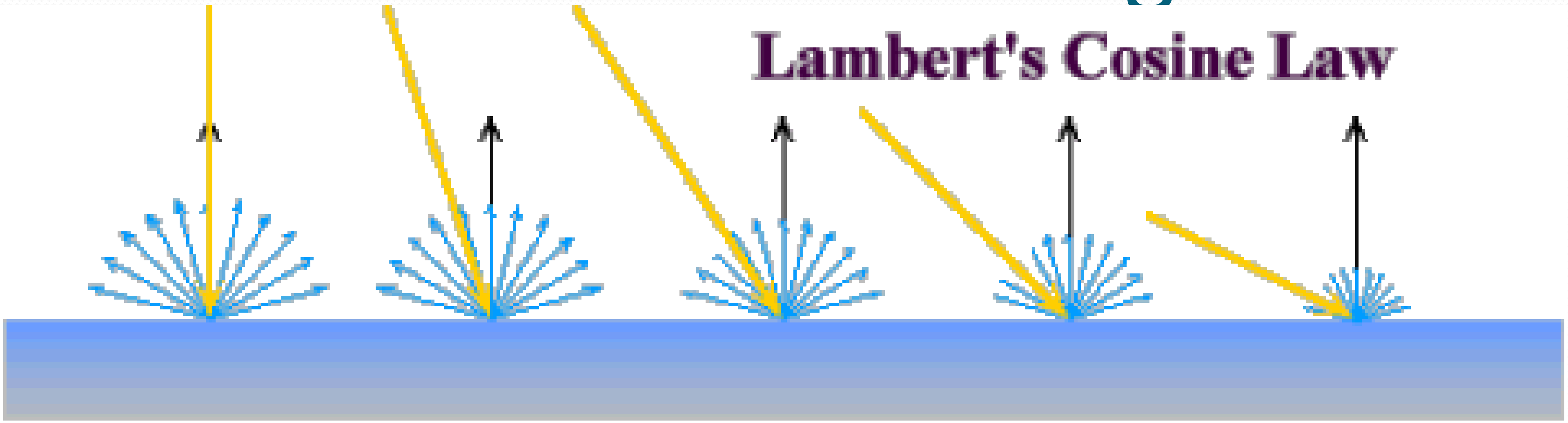
The energy reflected by a small portion of a surface from a light source in a given direction is proportional to the cosine of the angle between that

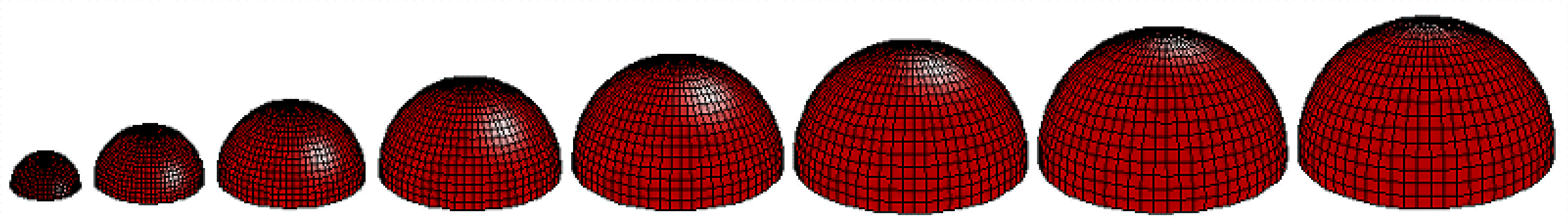


$$I_{diffuse} = k_d \, I_{light} \, \mathbf{cos}\,\theta$$

$$\Rightarrow \quad \boxed{I_{diffuse} = k_d \, I_{light} \, (\boldsymbol{n} \cdot \boldsymbol{l})}$$

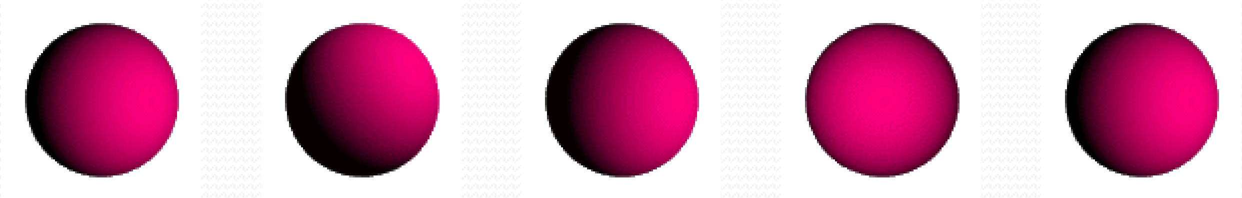
Illumination and Shading





Illumination and Shading

- Diffuse Reflection
- A Lambertian sphere seen at several different lighting angles:



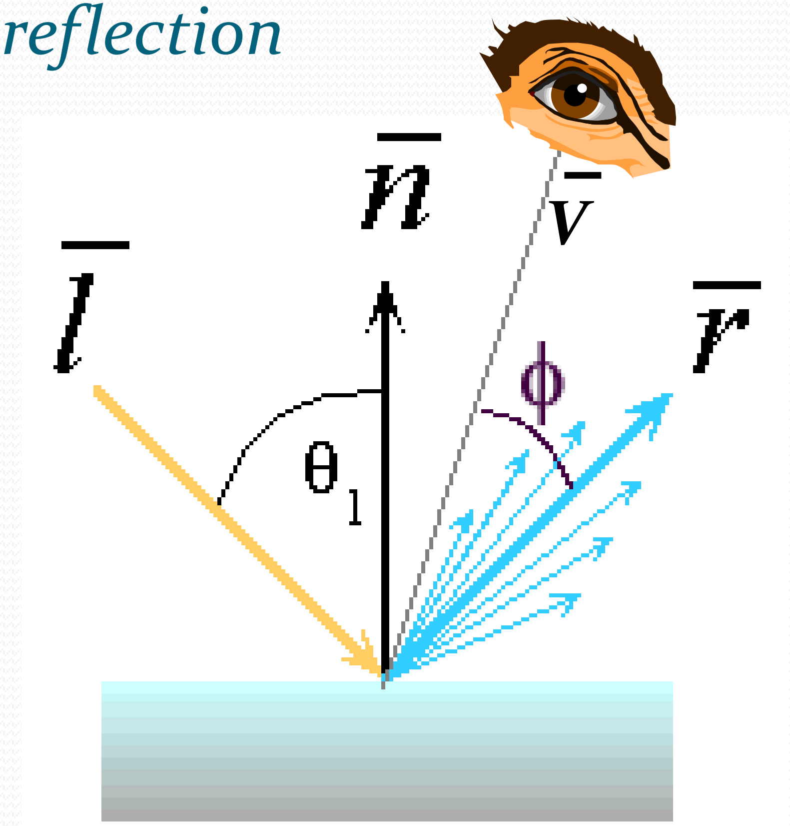
Illumination and Shading

- Specular Reflection
- Shiny surfaces exhibit *specular reflection*
  - Polished metal
  - Glossy car finish

Phong Lighting

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

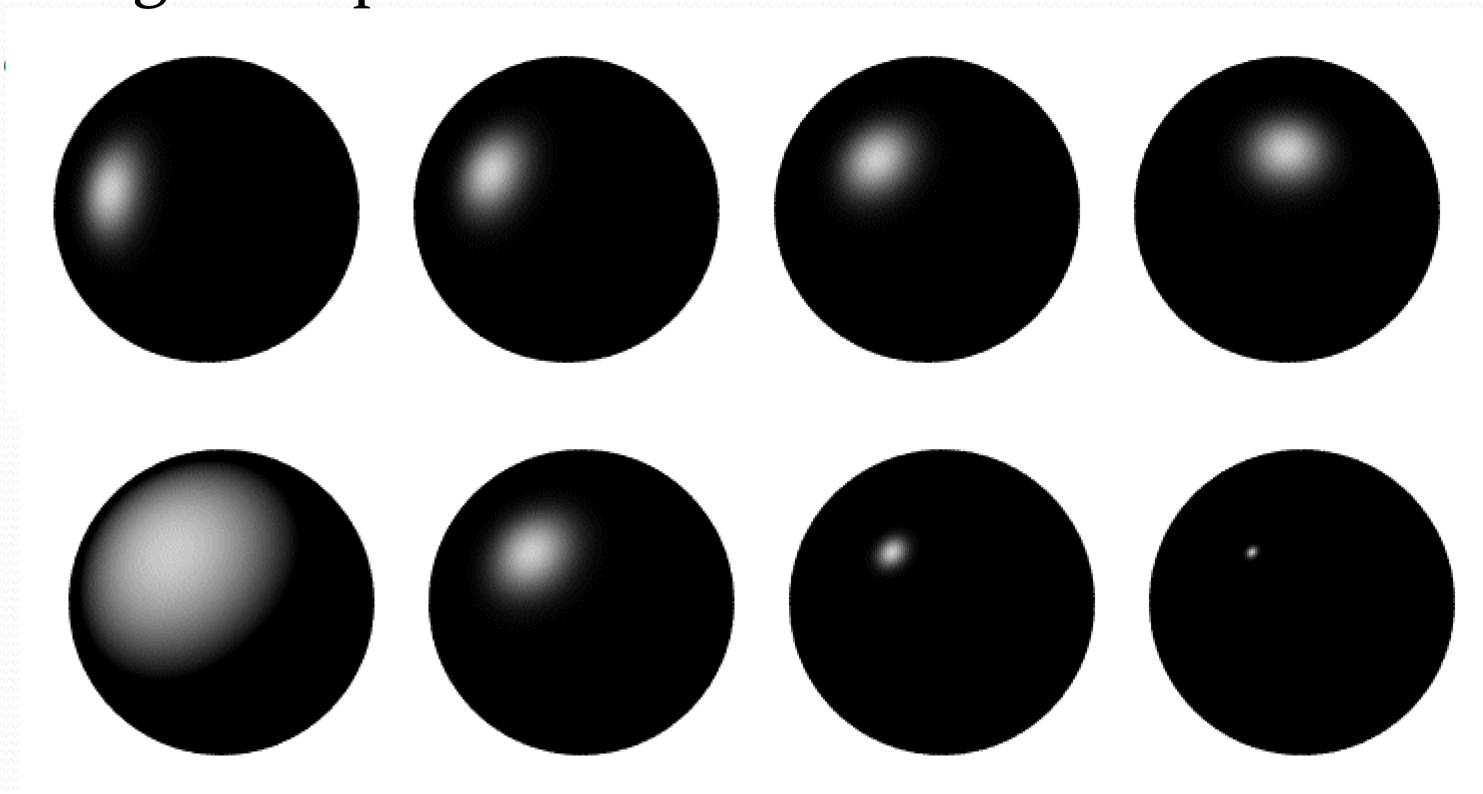
$$\boxed{I_{specular} = k_s I_{light} \left(\hat{V} \cdot \hat{R}\right)^{n_{shiny}}}$$



Illumination and Shading

- Specular Reflection
- Phong Examples

shiny



Illumination and Shading

- Our final empirically-motivated model for the illumination at a surface includes ambient, difuse, and specular components:

$$I_{total} = k_a I_{ambient} + \sum_{i=1}^{\#lights} I_i \left(k_d \left(\hat{N} \cdot \hat{L} \right) + k_s \left(\hat{V} \cdot \hat{R} \right)^{n_{shiny}} \right)$$

Ambient Light

- Approximation to global illumination
  - Each object is illuminated to a certain extent by “stray” light
  - Constant across a whole object
- Often used simply to make sure everything is lit, just in case it isn’t struck by light direct from a light source

Ambient Light

- Ambient light usually set for whole scene (I_a)
- Each object reflects only a proportion of that (k_a)
- So far then

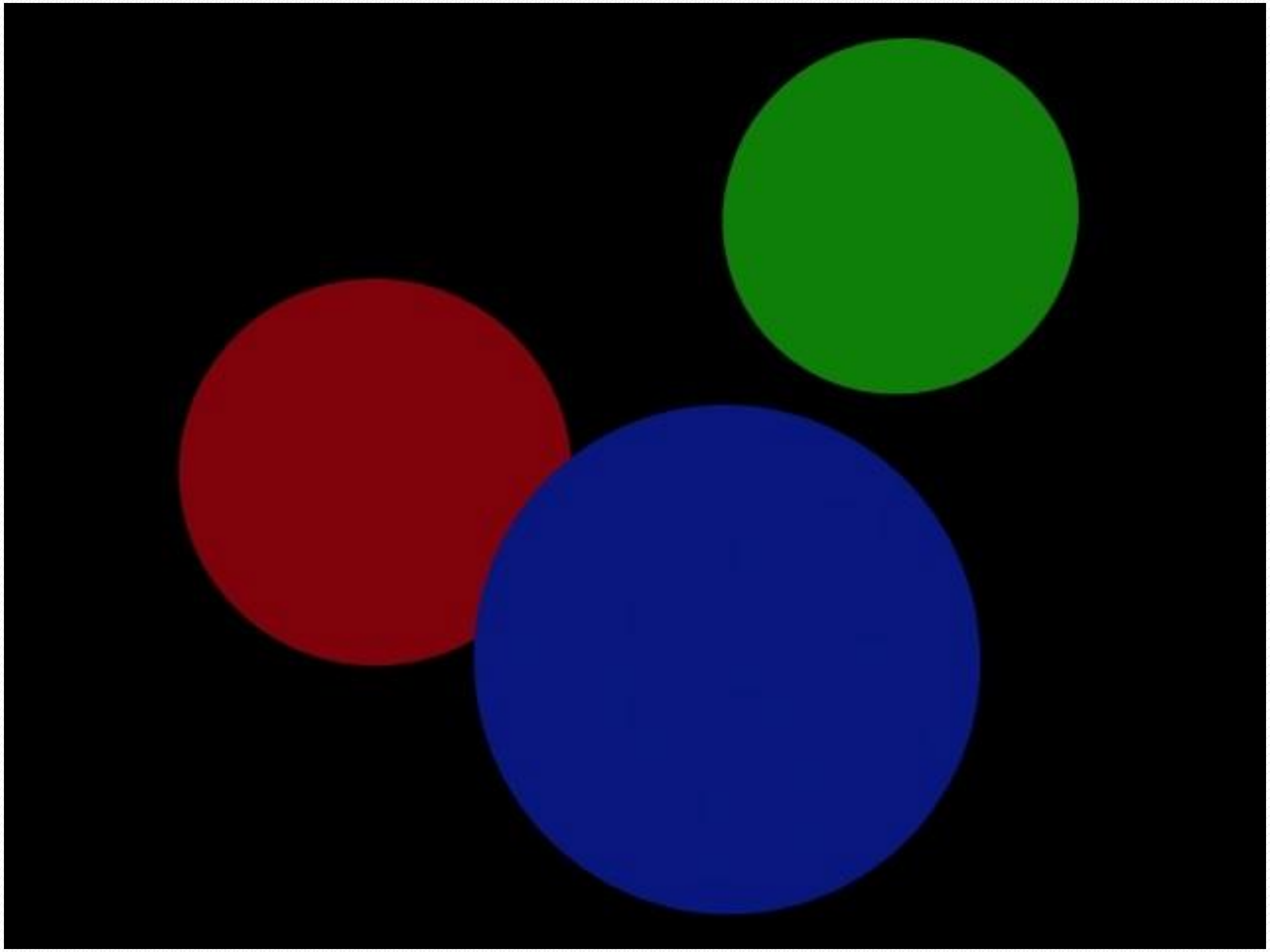
$$I_r = k_a I_a$$

Lighting Equation #1

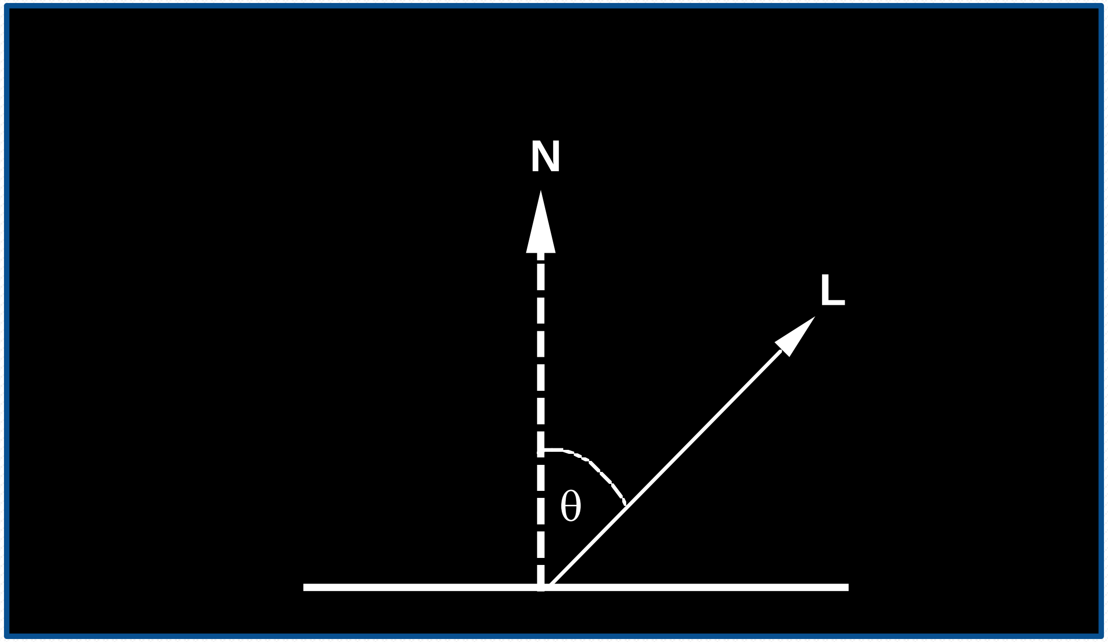
But we use RGB so

$$I_{r,\ red} = k_{a,red} I_{a,red}$$
$$I_{r,green} = k_{a,green} I_{a,green}$$
$$I_{r,blue} = k_{a,blue} I_{a,blue}$$

The Image - Ambient



Lambert's Law



- Reflected intensity is proportional to cos Θ
- L is the direction to the light
- N is the surface normal

Diffuse Light

- The normalised intensity of the light incident on the surface due to a ray from a light source
- The light reflected due to Lambert's law
- The proportion of light reflected rather than absorbed (k_d)

Lighting Equation #2

$$I_r = k_a I_a + k_d I_i \,(n.l)$$

- Ambient and diffuse components
- Again k_d is wavelength dependent and we work with $k_{d,red}$ $k_{d,green}$ and $k_{d,\ blue}$

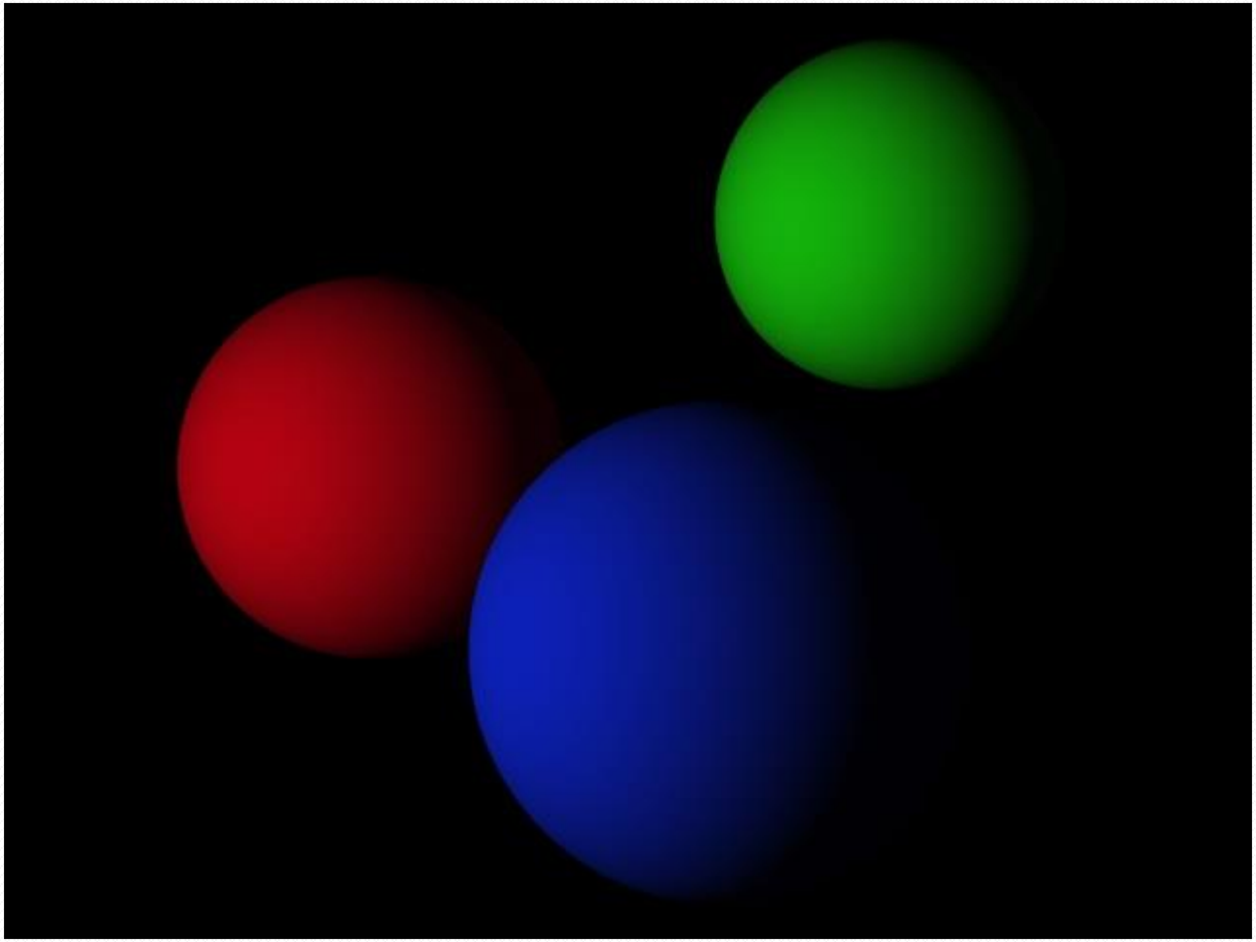
Multiple Lights?

- Add the diffuse terms

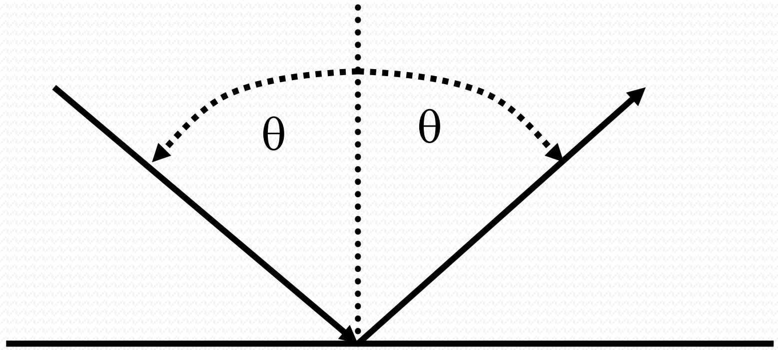
$$I_r = k_a I_a + \sum_{j=1}^{m} k_d I_{i,j} (n.l_j)$$

- $I_{i,j}$ is the incoming intensity of light j
- l_j is the vector to light j

The Image - Diffuse

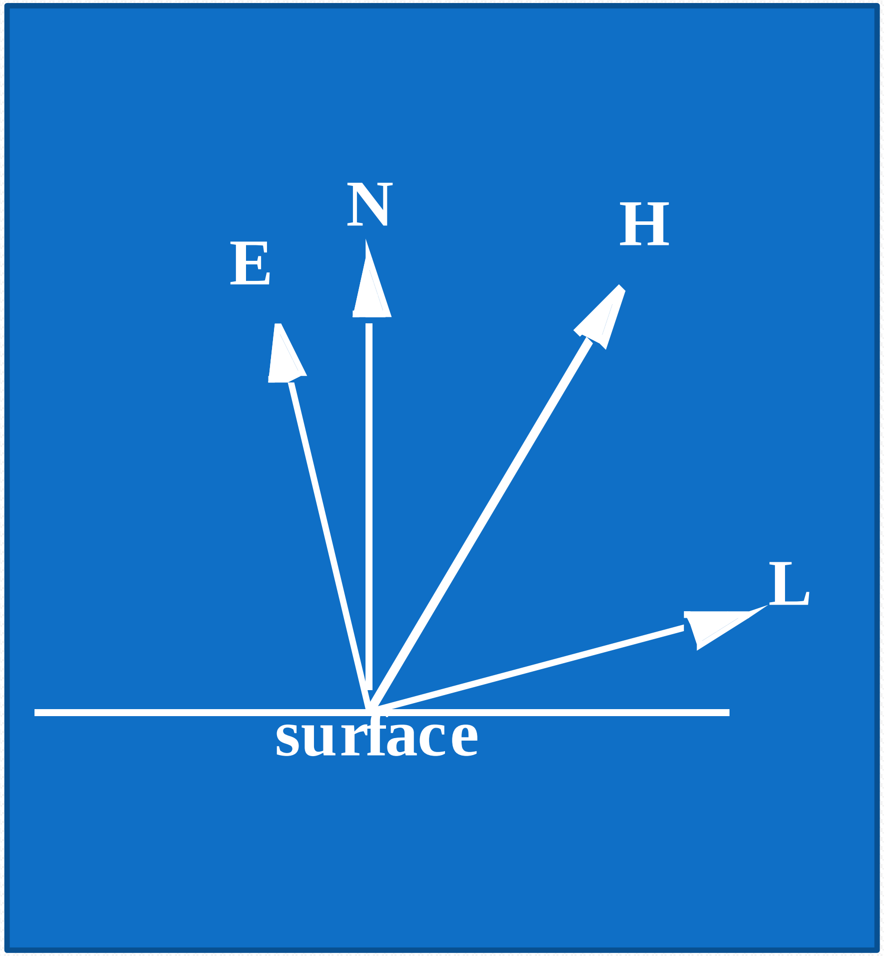


Perfect Specularity



- Would almost never see the specular highlight

Imperfect Specularity (Phong)



- E is the direction to the eye
- N is the normal
- L is the direction to the light
- H bisects E and L

Specular Component

$$k_s I_i \, (h.n)^m$$

- m is the power of the light
  - High m implies smaller specular highlight
  - Low m makes the highlight more blurred

Lighting Equation #3

$$I_r = k_a I_a + I_i\,(k_d\,(n.l) + k_s(h.n)^m\,)$$

- Ambient, diffuse&specular components
- Again if there are multiple lights there is a sum of the specular and diffuse components for each light

(This is the time to worry about clamping values to 0,1 required for monitor display)

The Image - Specular