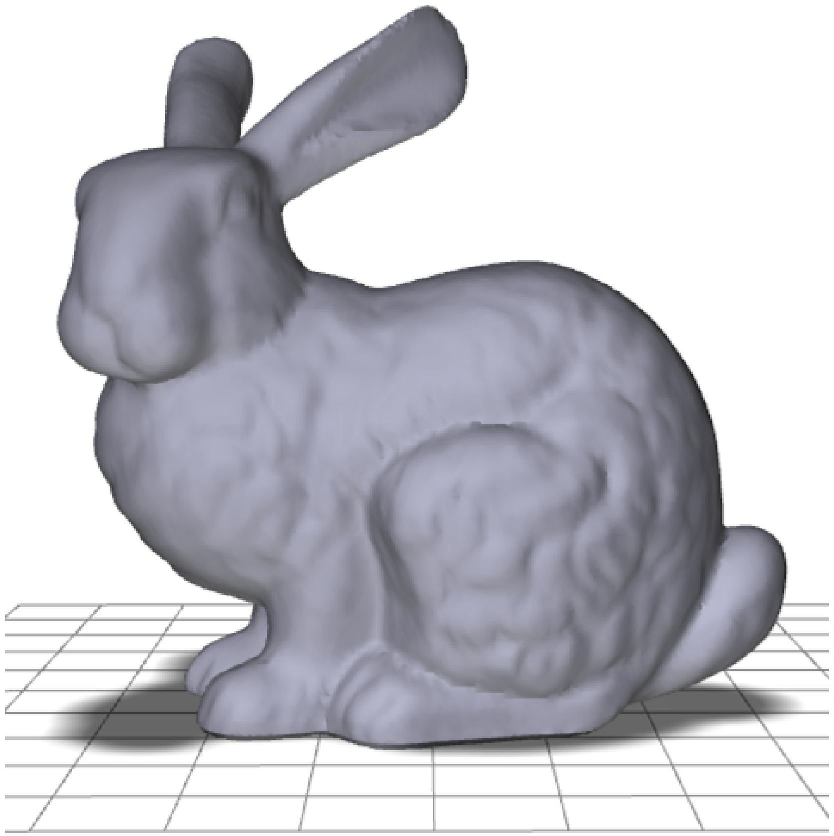
Specular Reflection

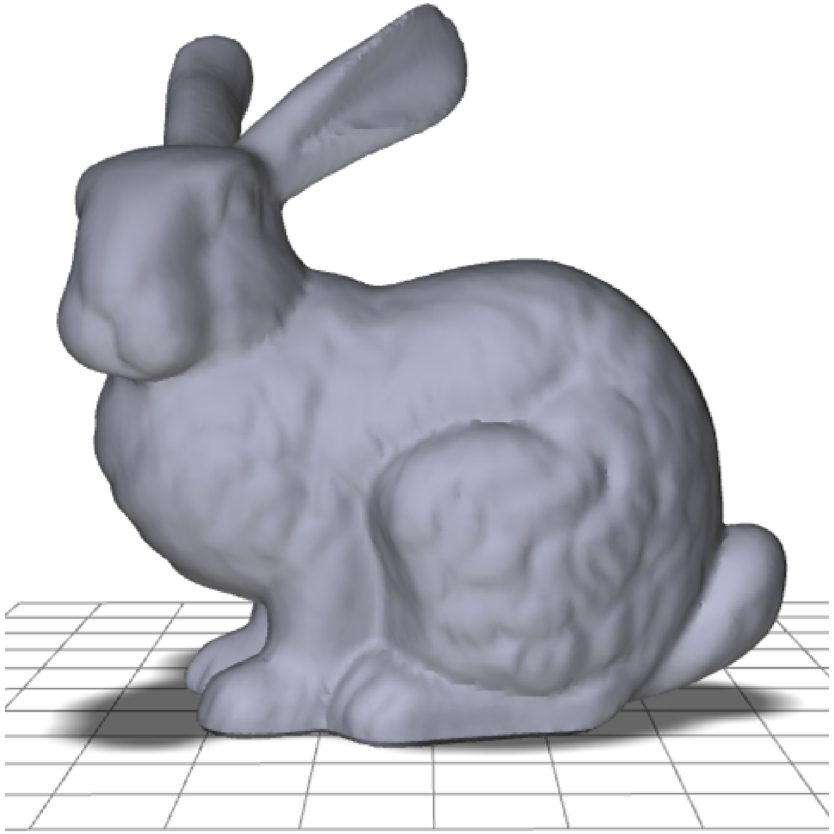
CS418 Computer Graphics
John C. Hart

Diffuse Reflection

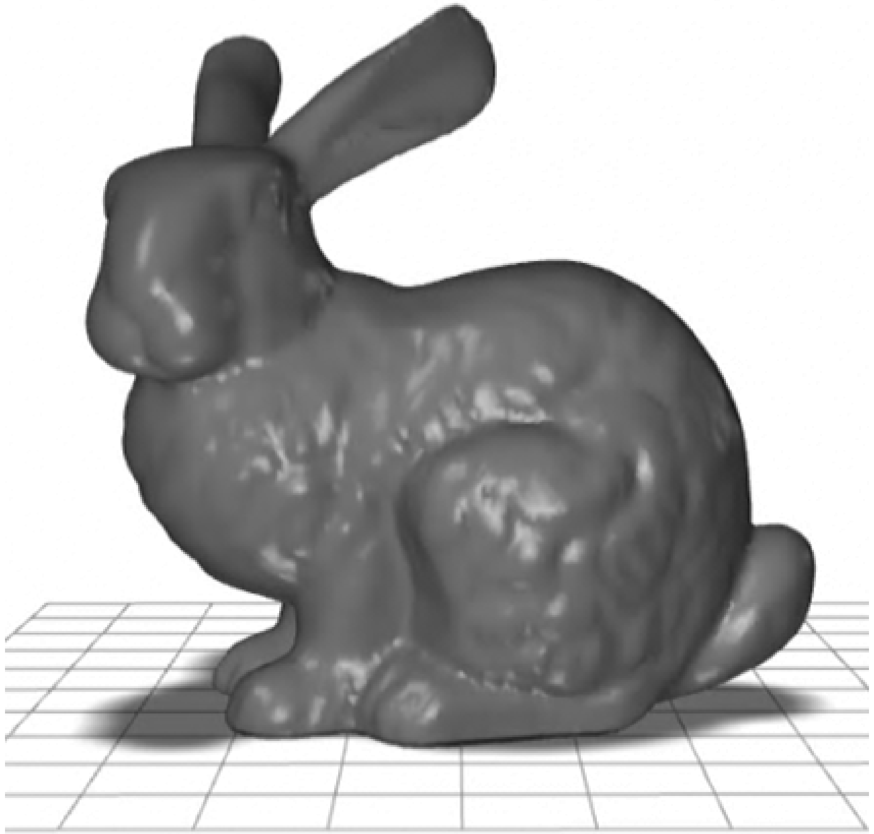


diffuse reflection

Specular Reflection

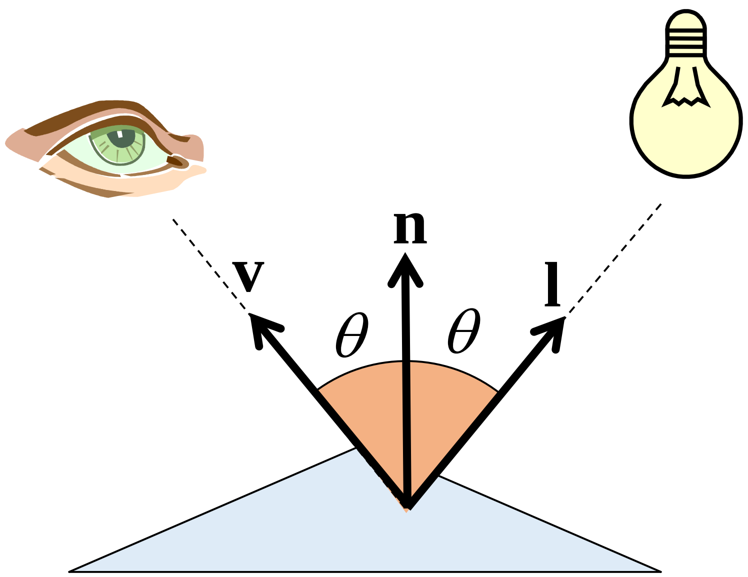


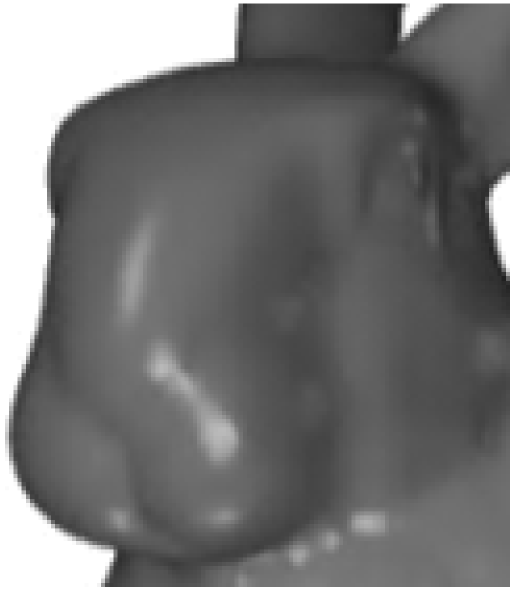
diffuse reflection



diffuse + specular reflection

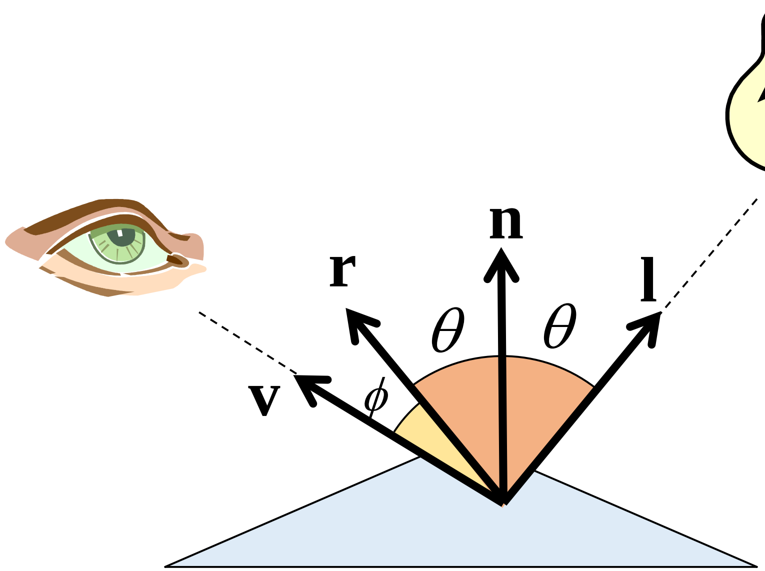
Specular Reflection

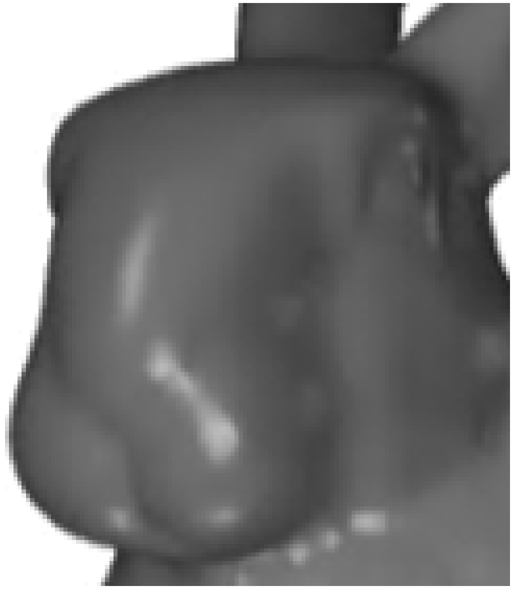




Specular gleem is a diffused mirror reflection of the light source

Specular Reflection

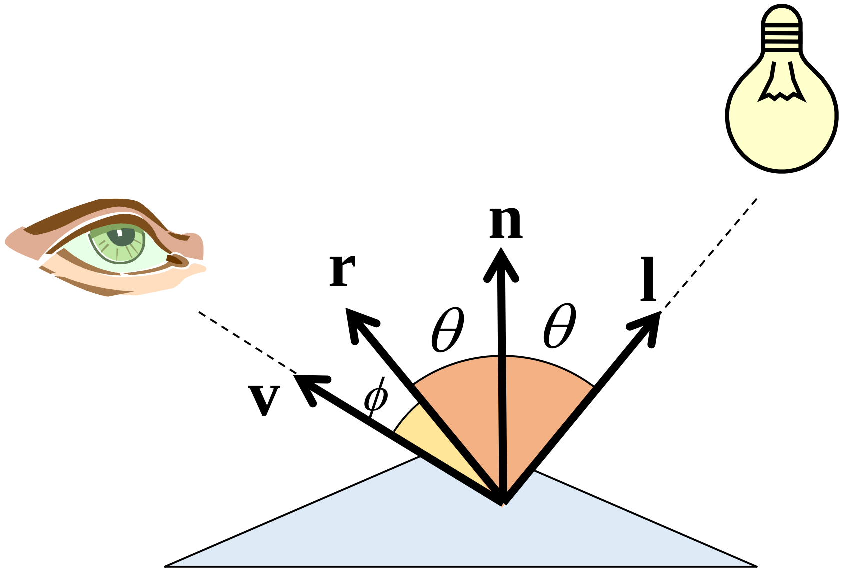


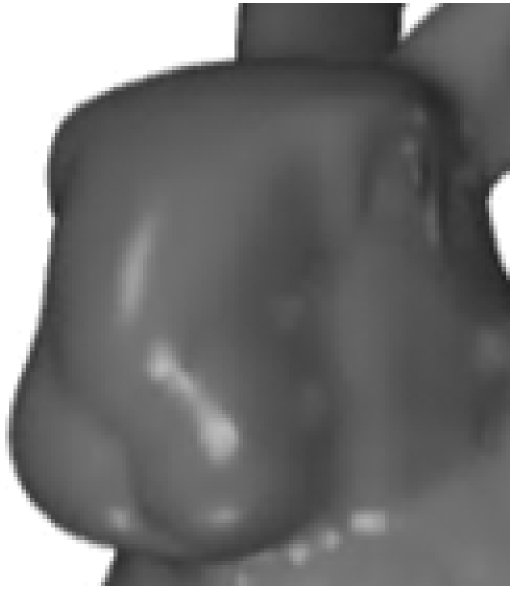


Specular gleem is a diffused mirror reflection of the light source

Gleem falls off as eye moves away from mirror-bounce reflection direction

Specular Reflection (Phong)

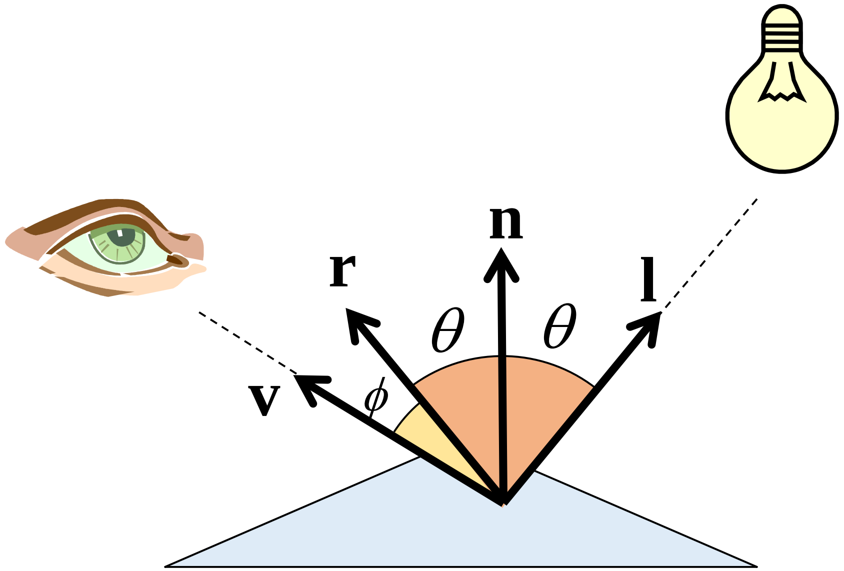




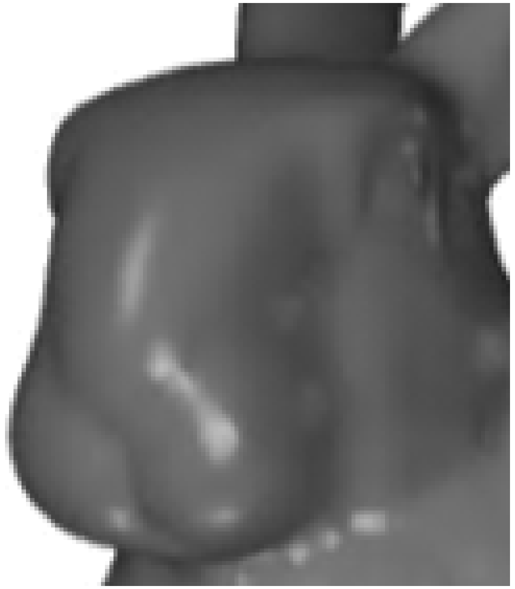
$$L_o = L_i \, k_s \cos^n \phi$$

% of light reflected
(rest is absorbed)

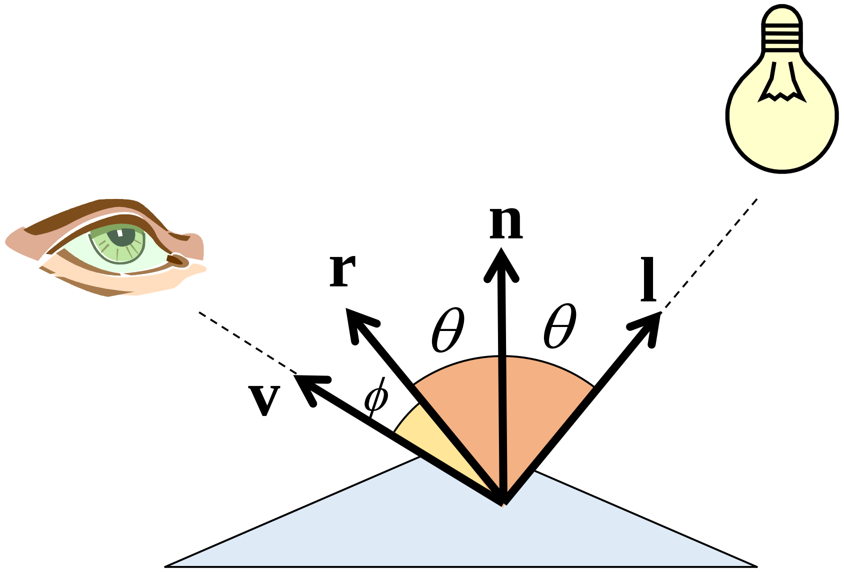
Specular Reflection (Phong)



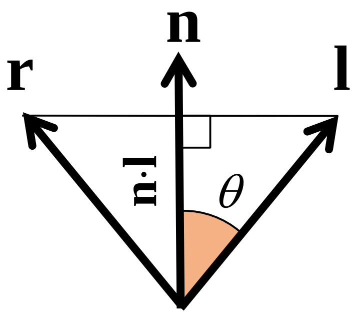
$$L_o = L_i \, k_s \cos^n \phi$$
$$= L_i \, k_s \, (\mathbf{v} \cdot \mathbf{r})^n$$



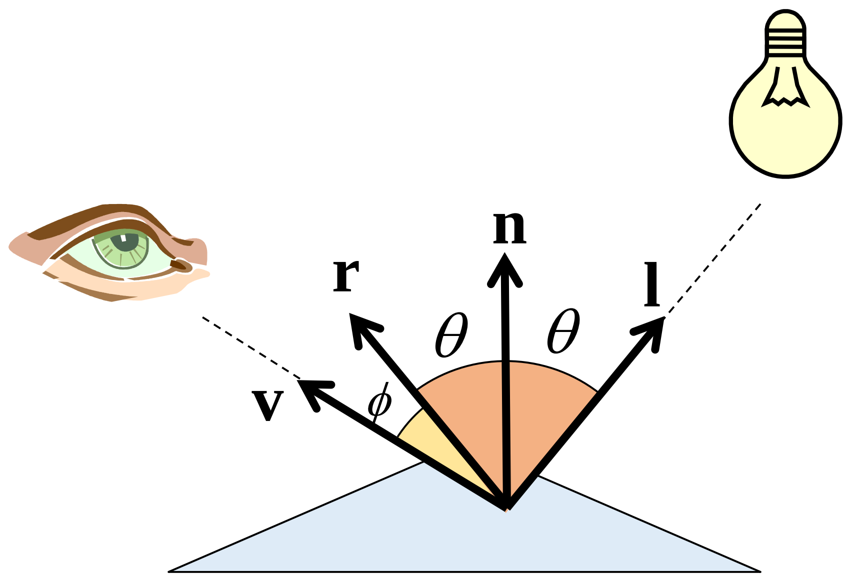
Specular Reflection (Phong)



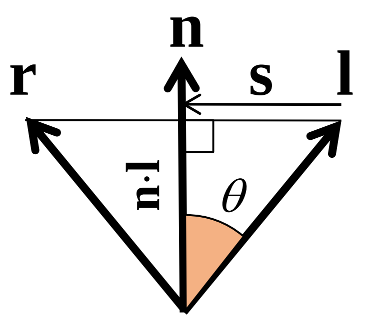
$$L_o = L_i\, k_s \cos^n \phi$$
$$= L_i\, k_s\, (\mathbf{v}\cdot\mathbf{r})^{\,n}$$



Specular Reflection (Phong)

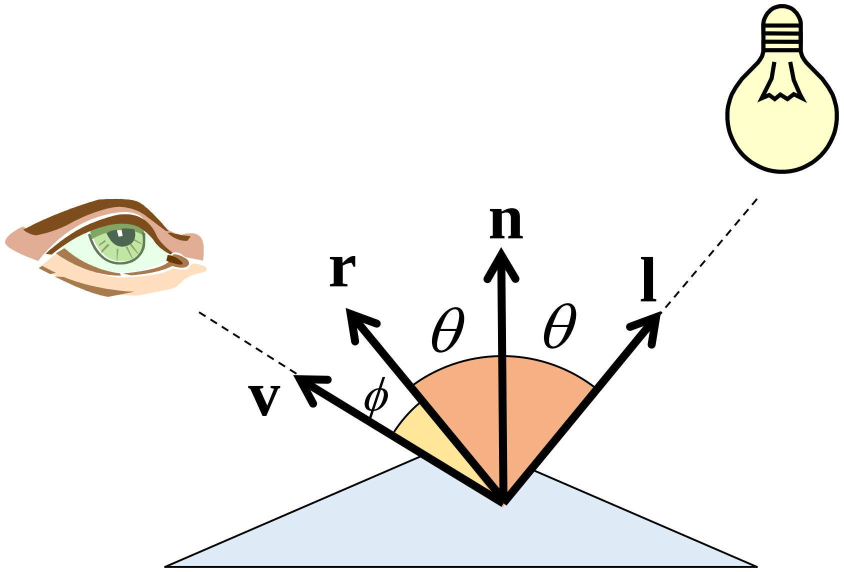


$$L_o = L_i \, k_s \cos^n \phi$$
$$\quad = L_i \, k_s \, (\mathbf{v} \cdot \mathbf{r})^n$$

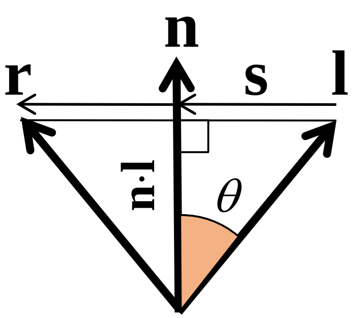


$$\mathbf{s} = (\mathbf{n} \cdot \mathbf{l})\mathbf{n} - \mathbf{l}$$

Specular Reflection (Phong)

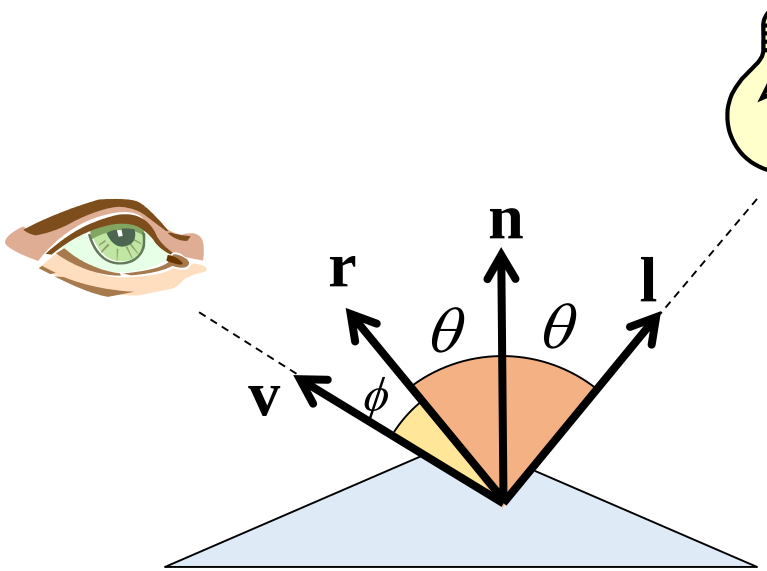


$$L_o = L_i\, k_s \cos^n \phi$$
$$= L_i\, k_s\, (\mathbf{v}\cdot\mathbf{r})^{\,n}$$

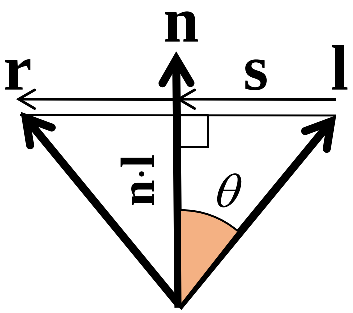


$$\mathbf{s} = (\mathbf{n}\cdot\mathbf{l})\mathbf{n} - \mathbf{l}$$
$$\mathbf{r} = \mathbf{l} + 2\mathbf{s}$$

Specular Reflection (Phong)

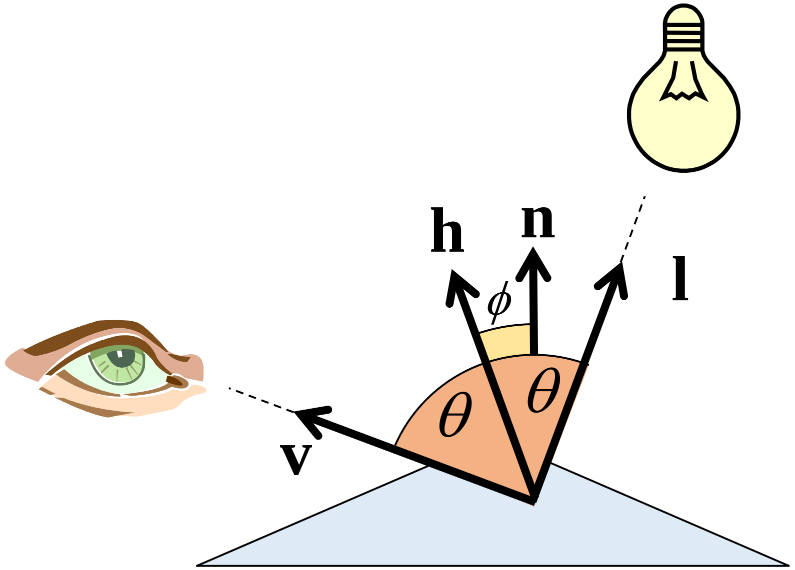


$$L_o = L_i\, k_s \cos^n \phi$$
$$= L_i\, k_s\, (\mathbf{v}\cdot\mathbf{r})^{\,n}$$



$$\mathbf{s} = (\mathbf{n}\cdot\mathbf{l})\mathbf{n} - \mathbf{l}$$
$$\mathbf{r} = \mathbf{l} + 2\mathbf{s}$$
$$= \mathbf{l} + 2(\mathbf{n}\cdot\mathbf{l})\mathbf{n} - 2\mathbf{l}$$
$$= 2(\mathbf{n}\cdot\mathbf{l})\mathbf{n} - \mathbf{l}$$

Specular Reflection (Blinn)

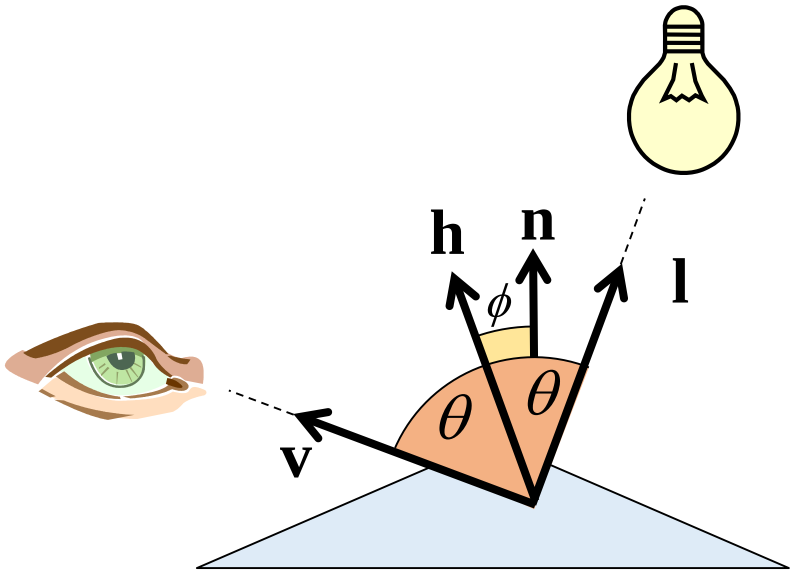


$$\mathbf{h} = (\mathbf{l} + \mathbf{v})/\|\mathbf{l} + \mathbf{v}\|$$

$$L_o = L_i\, k_s \cos^n \phi$$

$$= L_i\, k_s\, (\mathbf{n} \cdot \mathbf{h})^n$$

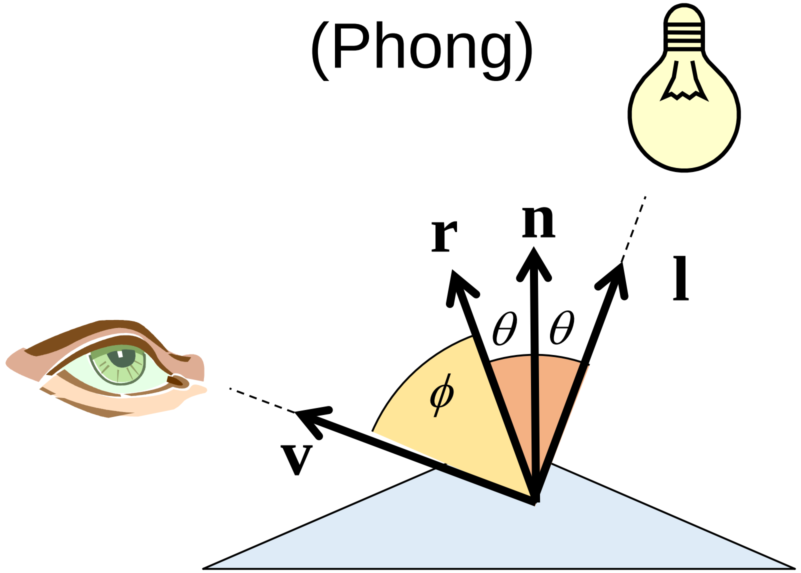
Specular Reflection (Blinn)



$$\mathbf{h} = (\mathbf{l} + \mathbf{v})/||\mathbf{l} + \mathbf{v}||$$

$$L_o = L_i \, k_s \cos^n \phi$$
$$= L_i \, k_s \, (\mathbf{n} \cdot \mathbf{h})^n$$

(Phong)



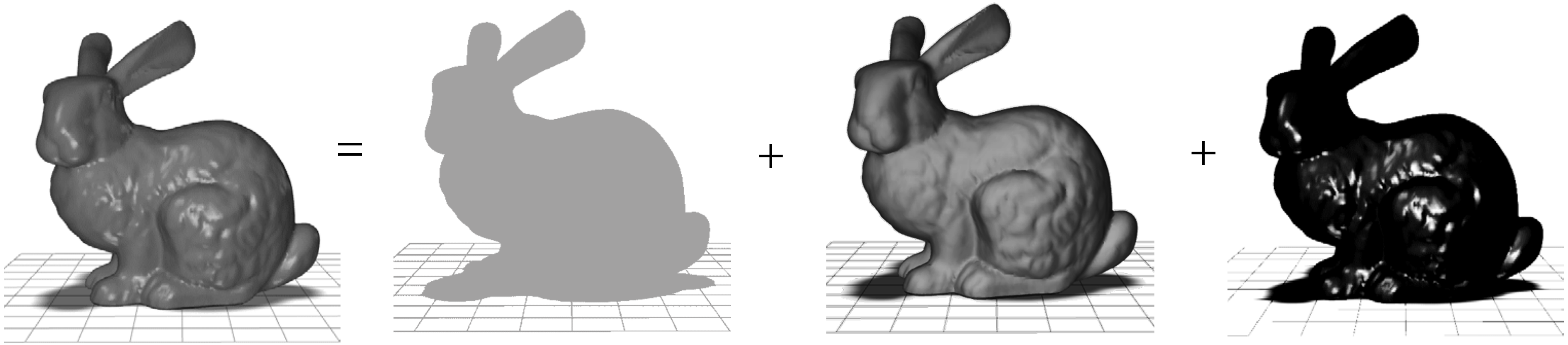
$$\mathbf{r} = 2(\mathbf{n} \cdot \mathbf{l})\mathbf{n} - \mathbf{l}$$

$$L_o = L_i \, k_s \cos^n \phi$$
$$= L_i \, k_s \, (\mathbf{v} \cdot \mathbf{r})^n$$

The Phong Lighting Model

- Monochromatic

$$L_{\mathrm{o}} = k_{\mathrm{a}} L_{\mathrm{a}} + L_{\mathrm{i}} (k_{\mathrm{d}} \, \mathbf{n}\cdot\mathbf{l} + k_{\mathrm{s}} \, (\mathbf{v}\cdot\mathbf{r})^{n})$$



The Phong Lighting Model

- Monochromatic

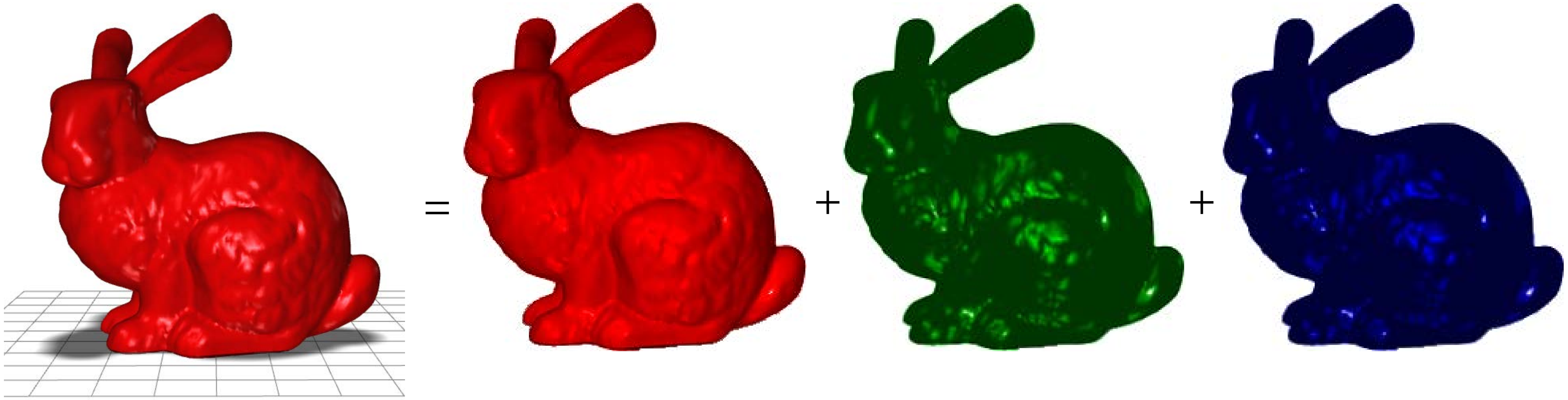
$$L_o = k_a L_a + L_i (k_d \, \mathbf{n} \cdot \mathbf{l} + k_s (\mathbf{v} \cdot \mathbf{r})^n)$$

- Tristimulus (RGB) color model

$$L_{o(R)} = k_{a(R)} L_{a(R)} + L_{i(R)} (k_{d(R)} \, \mathbf{n} \cdot \mathbf{l} + k_{s(R)} (\mathbf{v} \cdot \mathbf{r})^n)$$

$$L_{o(G)} = k_{a(G)} L_{a(G)} + L_{i(G)} (k_{d(G)} \, \mathbf{n} \cdot \mathbf{l} + k_{s(G)} (\mathbf{v} \cdot \mathbf{r})^n)$$

$$L_{o(B)} = k_{a(B)} L_{a(B)} + L_{i(B)} (k_{d(B)} \, \mathbf{n} \cdot \mathbf{l} + k_{s(B)} (\mathbf{v} \cdot \mathbf{r})^n)$$



The Phong Lighting Model

- Monochromatic

$$L_o = k_a L_a + L_i (k_d \mathbf{n}\cdot\mathbf{l} + k_s (\mathbf{v}\cdot\mathbf{r})^n)$$

- Tristimulus (RGB) color model

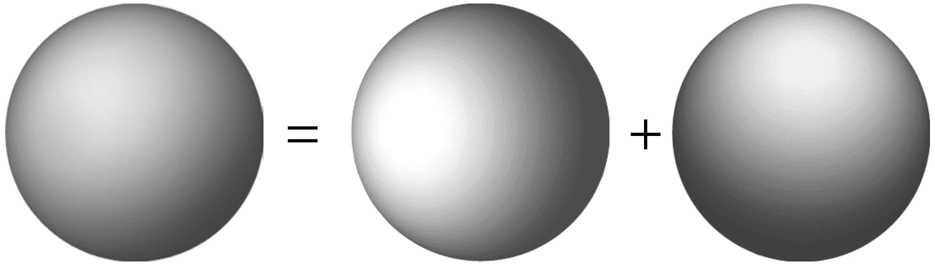
$$L_{o(R)} = k_{a(R)} L_{a(R)} + L_{i(R)} (k_{d(R)} \mathbf{n}\cdot\mathbf{l} + k_{s(R)} (\mathbf{v}\cdot\mathbf{r})^n)$$

$$L_{o(G)} = k_{a(G)} L_{a(G)} + L_{i(G)} (k_{d(G)} \mathbf{n}\cdot\mathbf{l} + k_{s(G)} (\mathbf{v}\cdot\mathbf{r})^n)$$

$$L_{o(B)} = k_{a(B)} L_{a(B)} + L_{i(B)} (k_{d(B)} \mathbf{n}\cdot\mathbf{l} + k_{s(B)} (\mathbf{v}\cdot\mathbf{r})^n)$$

- Multiple light sources

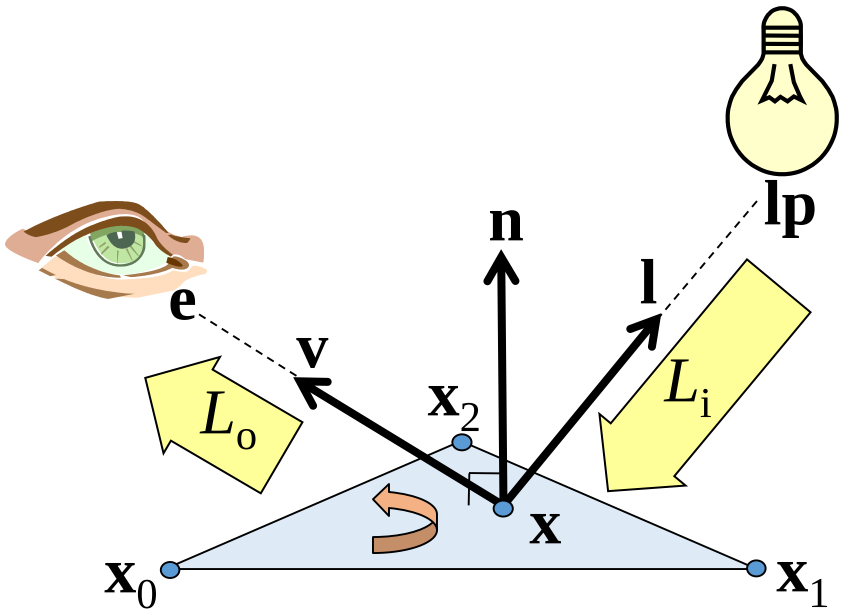
$$L_o = k_a L_a + L_{i(1)} (k_d \mathbf{n}\cdot\mathbf{l}_{(1)} + k_s (\mathbf{v}\cdot\mathbf{r}_{(1)})^n) + L_{i(2)} (k_d \mathbf{n}\cdot\mathbf{l}_{(2)} + k_s (\mathbf{v}\cdot\mathbf{r}_{(2)})^n) + \ldots$$



Attenuation

- Local Illumination

$L_o = k_a L_a + L_i (k_d \mathbf{n} \cdot \mathbf{l} + k_s (\mathbf{v} \cdot \mathbf{r})^n)$



Attenuation

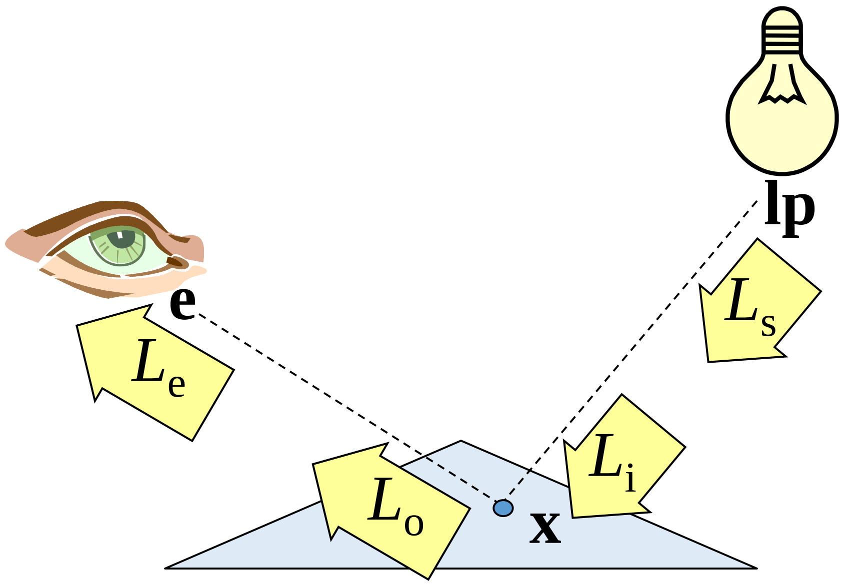
- Local Illumination

$$L_o = k_a L_a + L_i (k_d \mathbf{n} \cdot \mathbf{l} + k_s (\mathbf{v} \cdot \mathbf{r})^n)$$

- Global Illumination

$$L_i = F_{att}(||\mathbf{x}\text{-}\mathbf{e}||) L_s$$

$$L_e = F_{att}(||\mathbf{x}\text{-}\mathbf{e}||) L_o$$



Attenuation

- Local Illumination

  $L_o = k_a L_a + L_i (k_d \mathbf{n}\cdot\mathbf{l} + k_s (\mathbf{v}\cdot\mathbf{r})^n)$

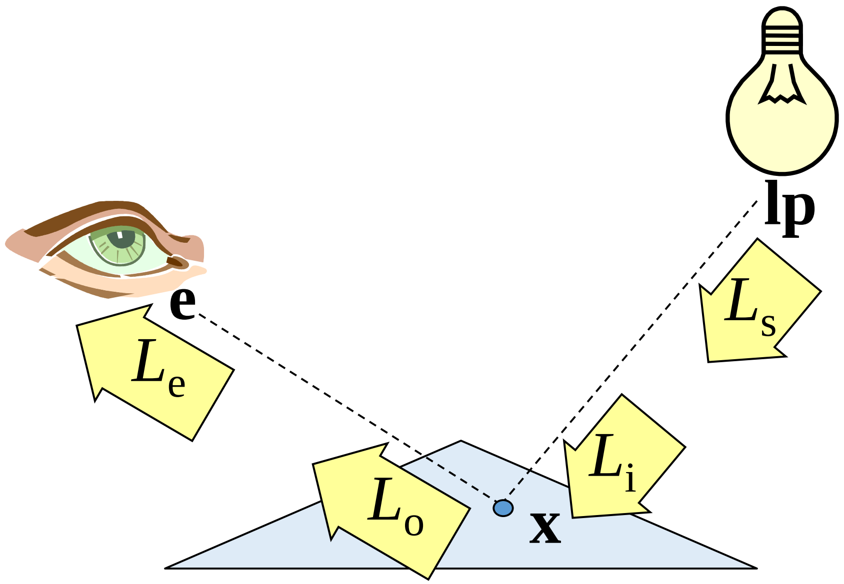
- Global Illumination

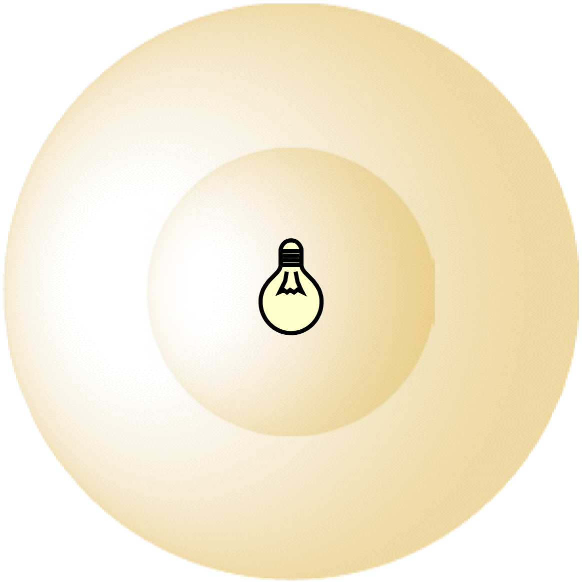
  $L_i = F_{att}(\|\mathbf{x}-\mathbf{e}\|)\, L_s$

  $L_e = F_{att}(\|\mathbf{x}-\mathbf{e}\|)\, L_o$

Physical: $F_{att}(d) = 1/d^2$

Plausible: $F_{att}(d) = 1/(F_0 + F_1 d + F_2 d^2)$





Sphere Area = $4 \pi r^2$