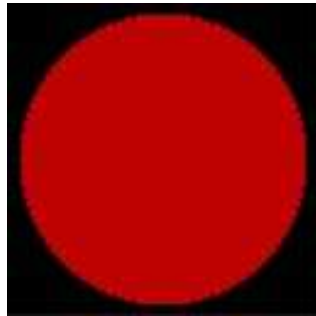


Tonalização



Colorir com mesma cor a superfície

Colorir com tonalidades variadas

Qual das duas imagens parece uma bola vermelha?

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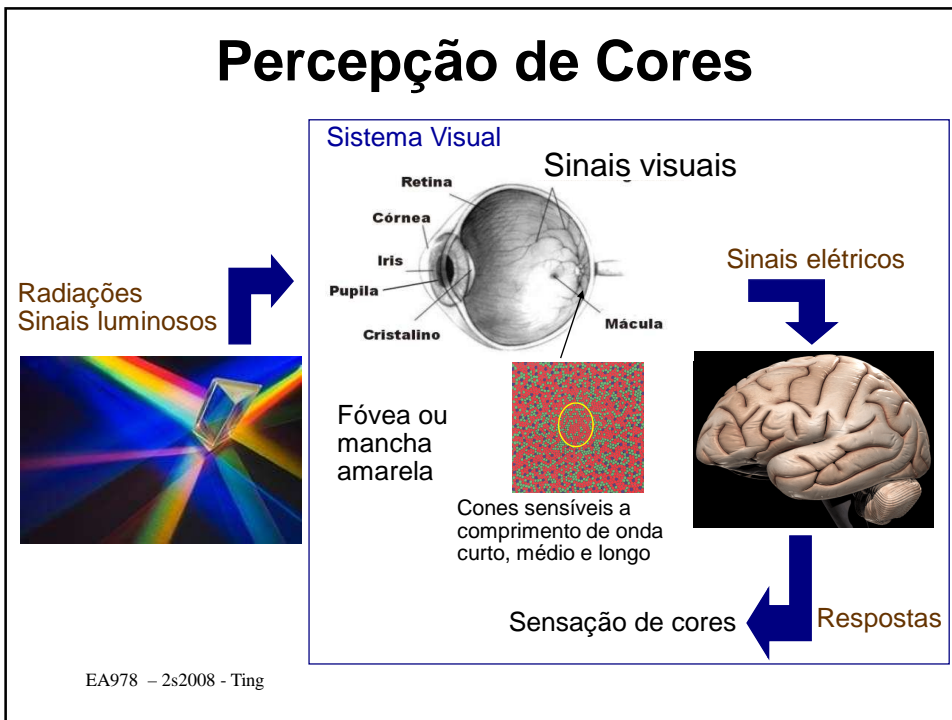
Modelagem de Cenas



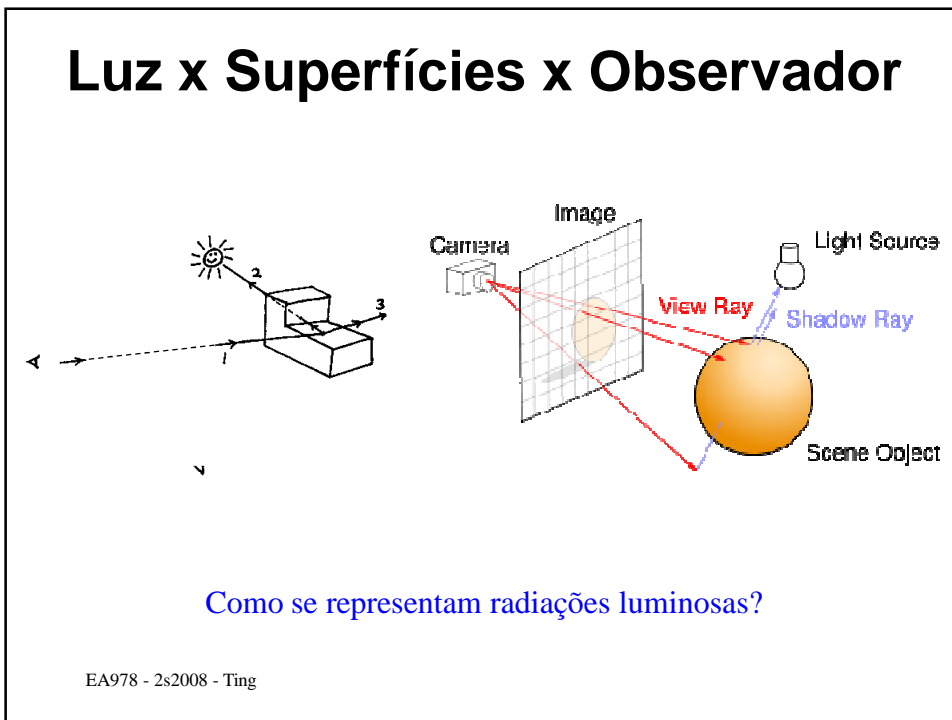
Imagens foto-realistas podem ter um grande número de cores e tonalidades distintas numa única superfície

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Percepção de Cores



Luz x Superfícies x Observador



Cores Percebidas



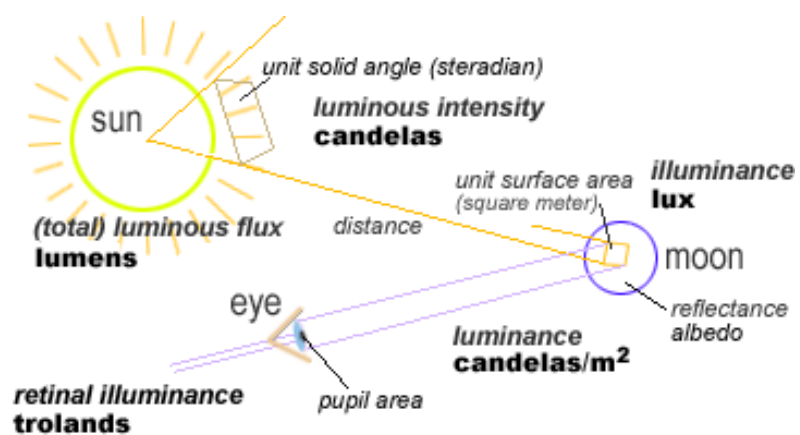
Interações entre fontes luminosas, materiais (superfícies) e visão do observador



Percepção de distintas cores

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Iluminação



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Cor da Luz

Teoria Tricromática

$\begin{bmatrix} R_R \\ R_G \\ R_B \end{bmatrix}$

$\begin{bmatrix} I_R \\ I_G \\ I_B \end{bmatrix}$

Direção?

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Fontes de Luz

Fonte Pontual

Light Source Centre

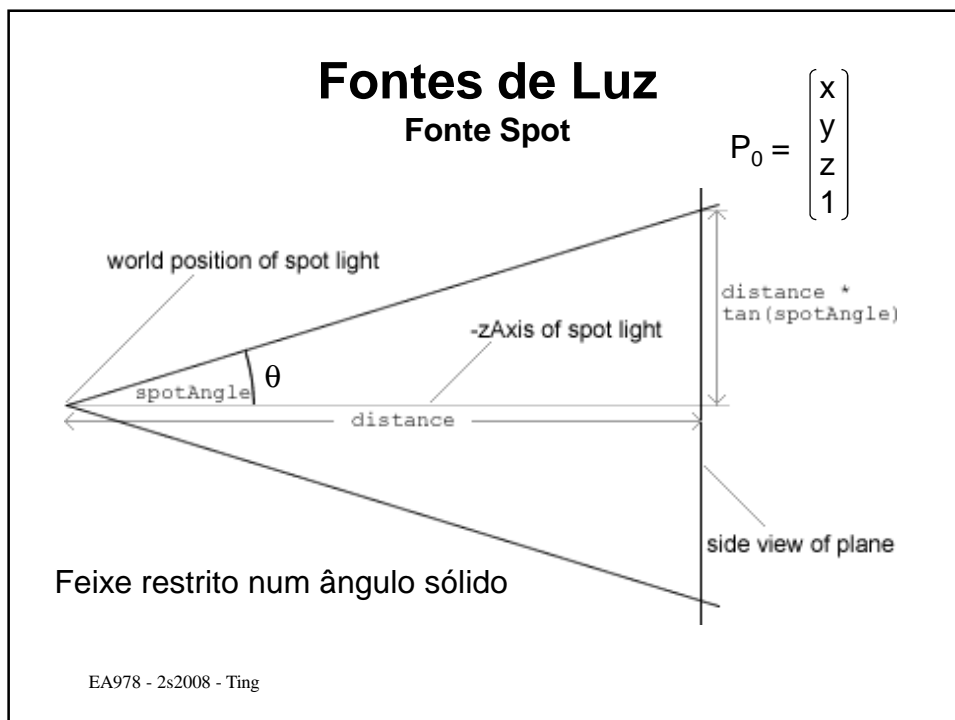
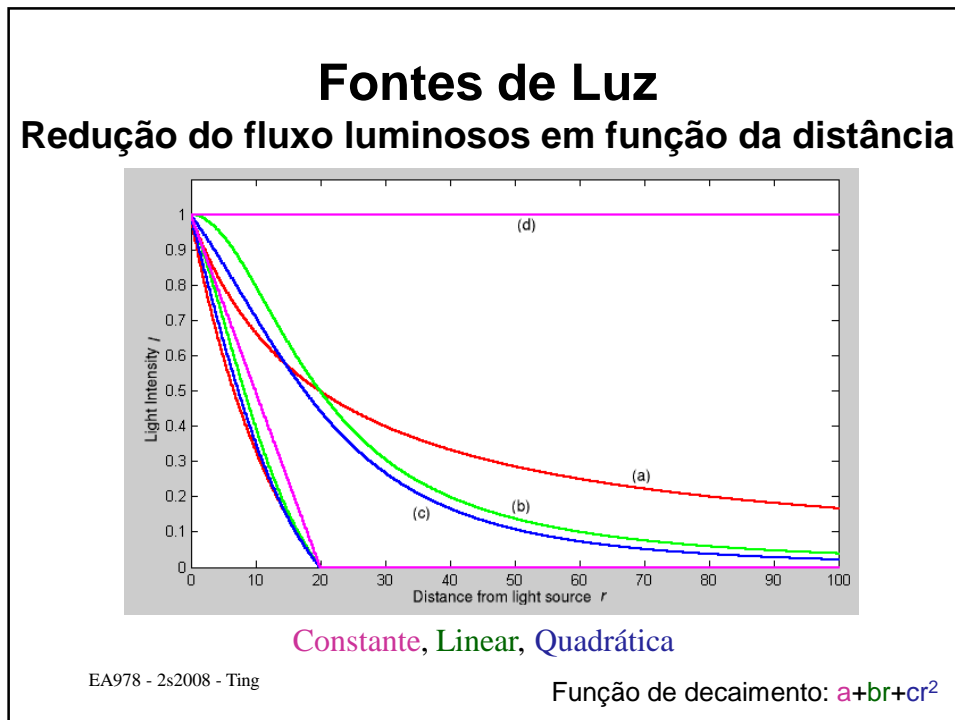
Size/Distance

$$P_0 = \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Various Point Lights

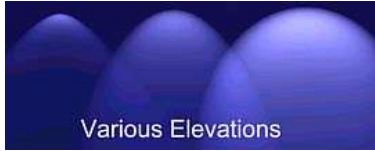
Direção radial

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Fontes de Luz


Fonte Spot




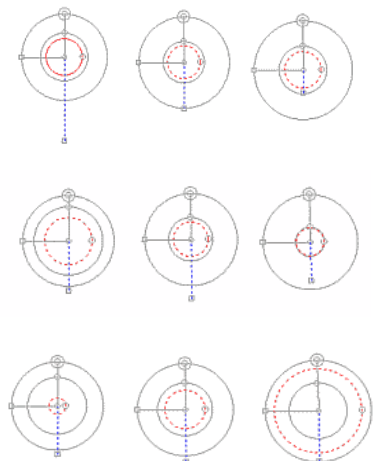
Various Elevations



Various Cone Angles



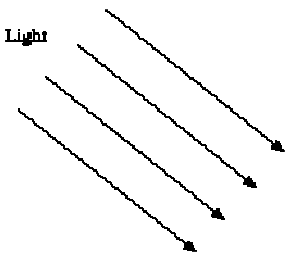
Various Focus

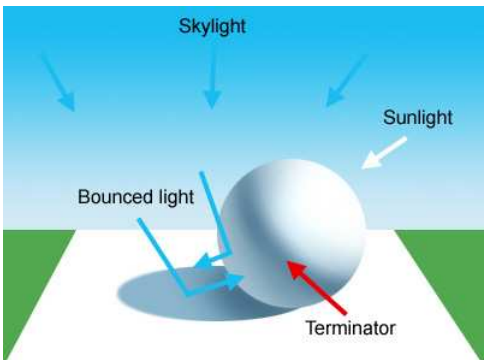
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Fontes de Luz

Fonte Direcional ou Distante

$$P_0 = \begin{pmatrix} x \\ y \\ z \\ 0 \end{pmatrix}$$


Direção paralela



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Fontes de Luz

Fonte Extensa

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Interações Luz x Superfície

Reflexão e Refração

Lei de Snell-Descartes

$$\theta = \theta'$$

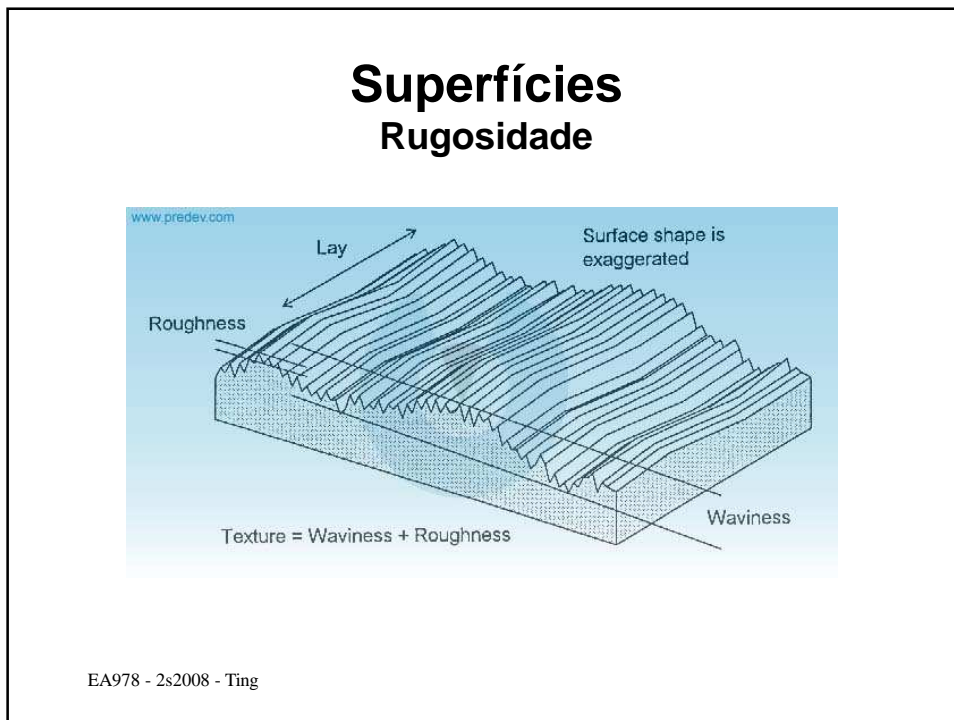
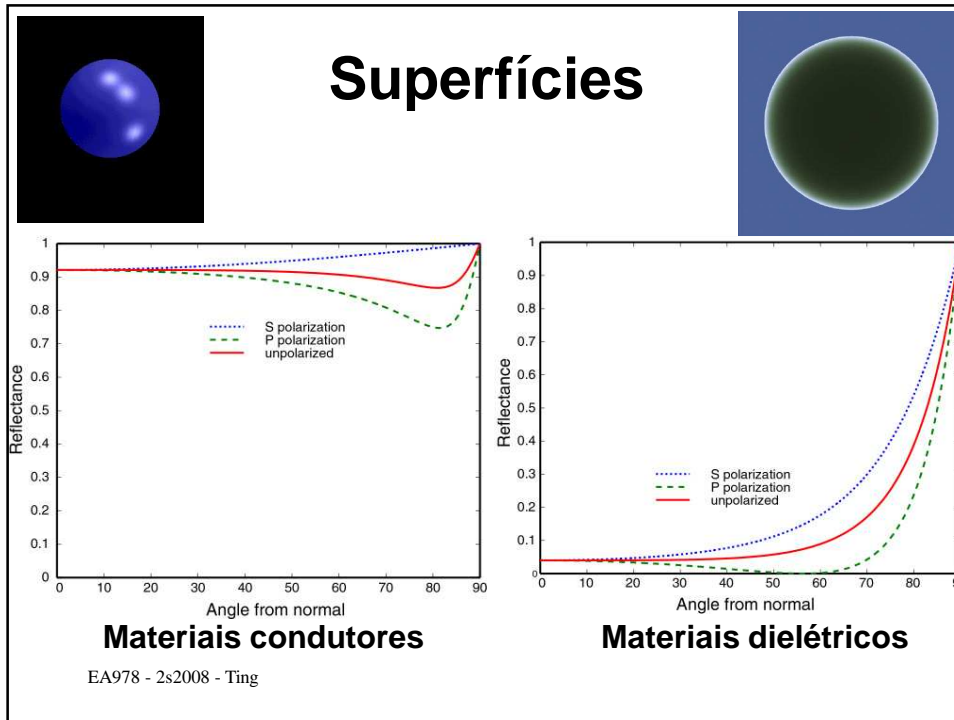
$$n_1 \sin \theta = n_2 \sin \theta''$$

Equações de Fresnel:

coeficiente de reflexão: $R = \phi_r/\phi_i = f(n_1, \theta)$

coeficiente de transmissão: $T = \phi_t/\phi_i = g(n, \theta)$

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Interações Luz x Superfície

Reflections From the Surface of Water



Smooth Water Surface

Wavy Water Surface

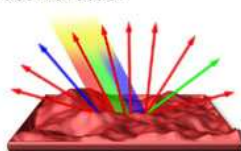
Figure 1

Specular and Diffuse Reflection



(raios são "espelhados")

Specular Reflection



Mais raios podem ser obstruídos

Diffuse Reflection

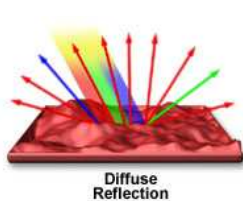
(raios são "espalhados" igualmente em todas direções)

Figure 3

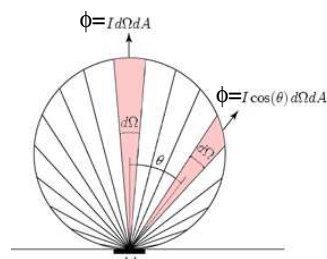
Modelo de Iluminação Phong

Reflexões Difusas

Intensidade luminosa refletida é diretamente proporcional ao cosseno do ângulo θ



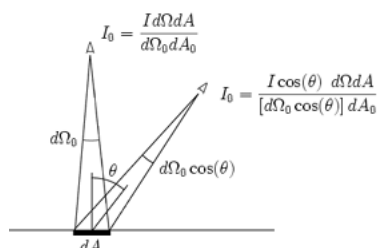
Diffuse Reflection



Intensidade percebida pelo observador independe da sua posição

$$I_d = k_d I_d \cos \theta$$

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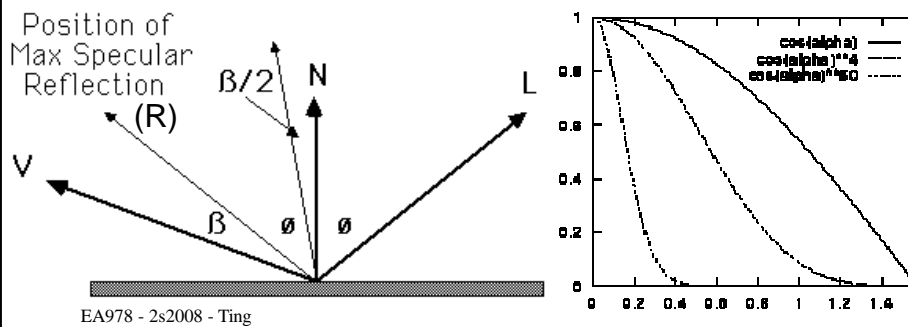
Modelo de Iluminação Phong

Reflexões Especulares



Intensidade luminosa refletida é diretamente proporcional à potência α do coseno do ângulo β

$$I_s = k_s I_s (\cos\beta)^\alpha$$



Modelo de Iluminação Phong

Multireflexões



Intensidade luminosa comum para todos os pontos do ambiente

$$I_a = k_a I_a$$

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Modelo de Iluminação Phong



ambiente

Modelo de Phong

$$I_p = k_a I_a + k_d I_d \cos\theta + k_s I_s (\cos\beta)^\alpha$$

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Modelo de Iluminação Phong



ambiente

Modelo de Phong

$$I_p = k_a I_a + k_d I_d \cos\theta + k_s I_s (\cos\beta)^\alpha$$

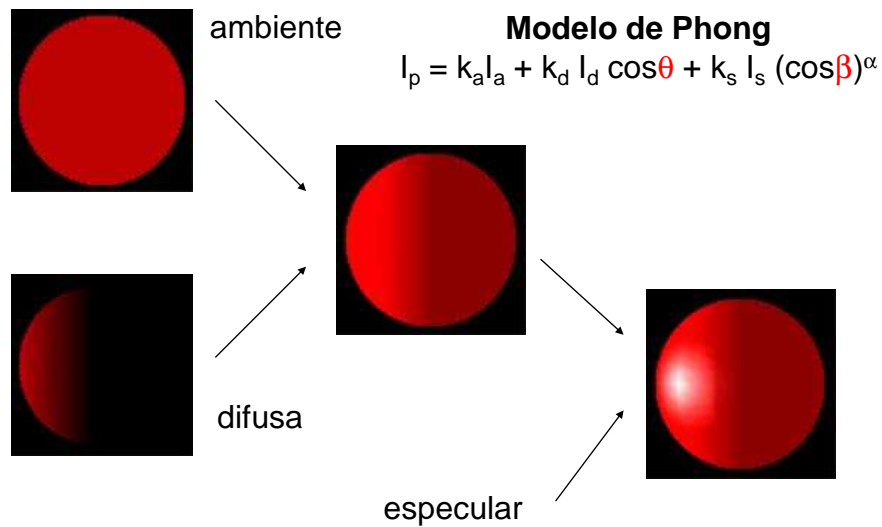


difusa



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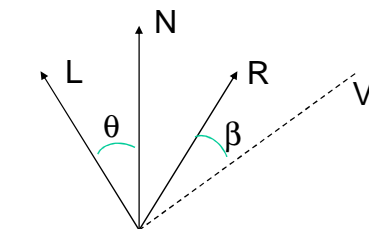
Modelo de Iluminação Phong



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Modelo de Iluminação Phong

$$I_p = k_a I_a + k_d I_d \cos\theta + k_s I_s (\cos\beta)^\alpha$$



$$\cos\theta = \mathbf{N} \cdot \mathbf{L} / (|\mathbf{N}| |\mathbf{L}|)$$

$$\cos\beta = \mathbf{R} \cdot \mathbf{V} / (|\mathbf{R}| |\mathbf{V}|)$$

$$\mathbf{R} = 2\mathbf{N}(\mathbf{N} \cdot \mathbf{L}) - \mathbf{L}$$

Vetor Normal no cálculo da componente especular!!

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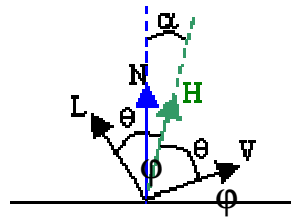
Modelo de Phong Modificado

$$I_p = k_a I_a + k_d I_d \cos\theta + k_s I_s (\cos\phi)^{\alpha'}$$

$$H = \frac{L + V}{\|L + V\|}$$

Intensidade luminosa refletida é diretamente proporcional à potência α' do coseno do ângulo θ

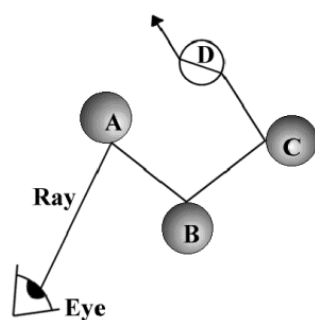
$$I_s = k_s I_s (\cos\phi)^{\alpha'}$$



Vantagem: Quando a fonte luminosa e o observador forem distantes, H é constante.

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Traçado de Raios



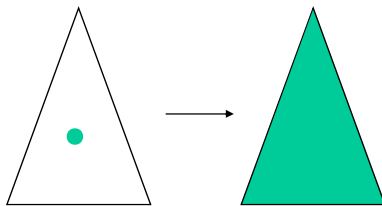
Imagens com refrações

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Tonalização (*Shading*)

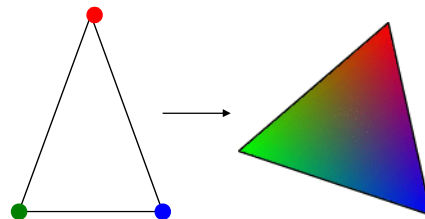
Calcular as propriedades gráficas ou geométricas em algumas amostras e **propagá-las** para o restante dos pontos

Cópia (*Flat shading*)



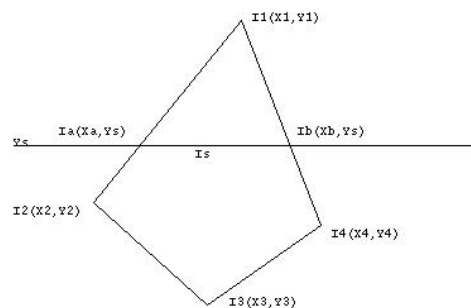
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Interpolação (*Gouraud shading*)



Tonalização

Interpolação Linear de Intensidades



Gouraud Shading

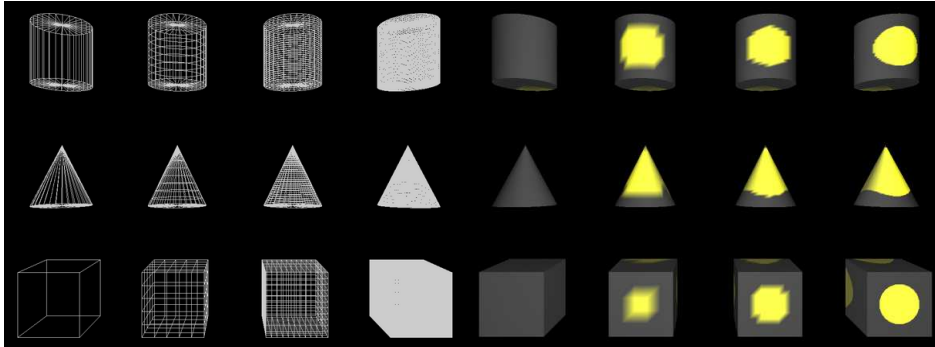
Interpolação linear de intensidades

$$I_a(t) = t I_1 + (1-t) I_2$$

$$I_b(t) = t I_1 + (1-t) I_4$$

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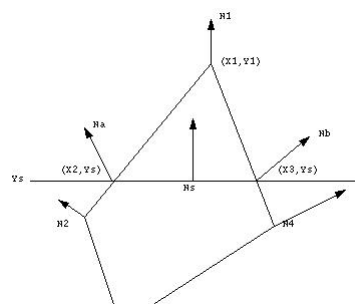
Tonalização Interpolação Linear



Resultados distintos para diferentes triangulações
Perda de pontos de brilho

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Tonalização Interpolação Linear de Intensidades



Phong Shading

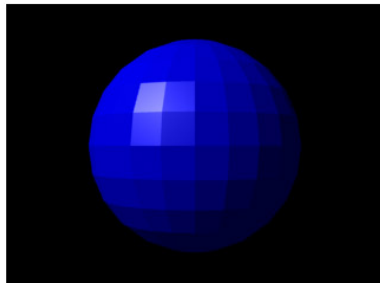
Interpolação linear de vetores normais

$$N_a(t) = t N_1 + (1-t) N_2$$

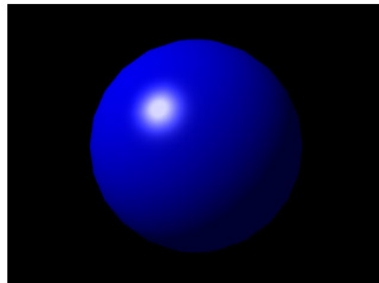
$$N_b(t) = t N_1 + (1-t) N_4$$

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Tonalização



FLAT SHADING



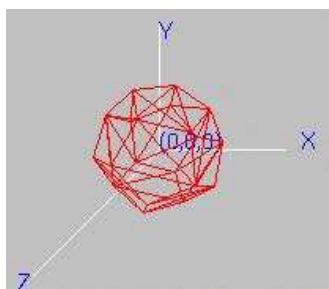
PHONG SHADING



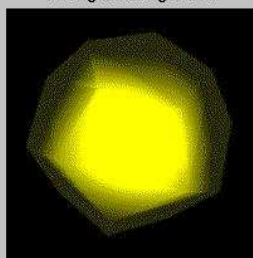
GOURAUD SHADING

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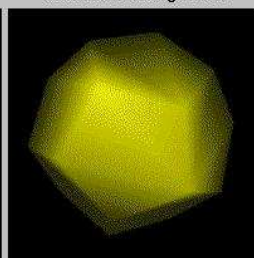
Tonalização



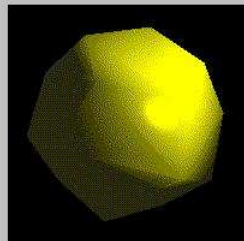
Phong Shading Demo



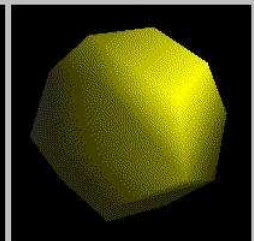
Gouraud Shading Demo



Phong Shading Demo



Gouraud Shading Demo



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