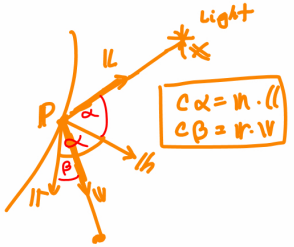
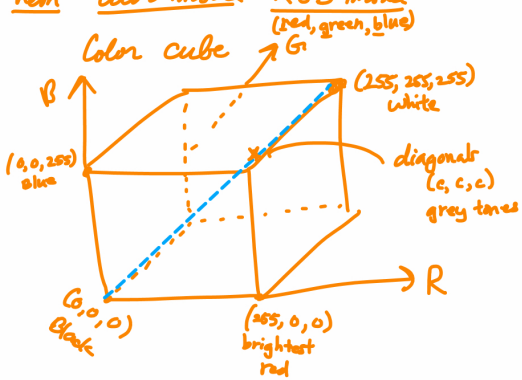
Lighting / illumination: PHONG model



x - position of light
p - point on surface
n - OUTWARD (unit) normal vector
l - light vector: $l = \frac{x-p}{\|x-p\|}$
v - view vector: $v = \frac{e-p}{\|e-p\|}$
r - reflection vector: $r = -l + 2(n \cdot l)n$

Rem: Color model: RGB model (red, green, blue) HSV



Phong:

$$I(p) = k_a \cdot I_a + \frac{I_L}{\|x-p\|+C} \cdot \left(k_d \cdot c\alpha + k_s \cdot (c\beta)^n\right) = I_{amb} + I_{diff} + I_{spec}$$

$I(p)$ = brightness of p
I_a = intensity of ambient light
I_L = " " light source

k_a, k_d, k_s ambient, diffuse, specular (color) coefficients

C constant (for $\|x-p\|$)

$n \in \{1,2,3\ldots\}$ Phong constant

Large n: highlight highly concentrated (e.g. metal)

Phong WITH COLOR (using RGB model):

$$I_p = \begin{pmatrix} I_R \\ I_G \\ I_B \end{pmatrix}(p) = \begin{pmatrix} k_a^R \\ k_a^G \\ k_a^B \end{pmatrix} \cdot I_a + \frac{I_L}{\|x-p\|+C} \cdot \left(\begin{pmatrix} k_d^R \\ k_d^G \\ k_d^B \end{pmatrix} \cdot c\alpha + \begin{pmatrix} k_s^R \\ k_s^G \\ k_s^B \end{pmatrix} \cdot (c\beta)^n \right)$$

Thus: User must define ambient, diffuse, specular colors!
↳ POINT SPECIFIC

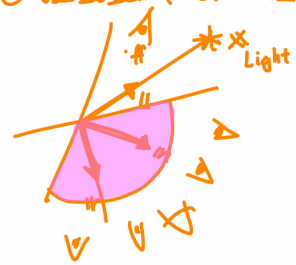
- NORMALIZE ONCE COLOR INTENSITIES COMPUTED FOR ALL POINTS:
  ① determine the MAX = max value of ALL I^R, I^G, I^B values
  ② divide all color intensities I^R, I^G, I^B by MAX ⇒ normalization done
- MAP TO RGB MODEL: multiply all color intensities by 255

"Good" values for some Phong parameters:

- $k_a^R, k_a^G, k_a^B, \ldots, k_s^B \quad \in [0,1]$
- $I_a, I_L \quad \in [0,1]$
- $n \in \{1,2,\ldots,10\}$

But: experiment with all parameter values

② VISIBILITY OF HIGHLIGHTS RESTRICTED



NO highlight if

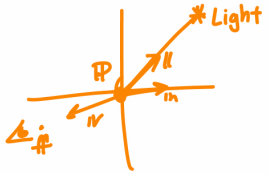
$$r \cdot v < 0$$

$$\Rightarrow I_{(p)} = k_a \cdot I_a + k_s \cdot c_a \cdot \frac{I_L}{\|p-p\|+c}$$

$$= \text{AMB} + \text{DIFF}$$

Special Cases

① Light source and viewer on opposite sides



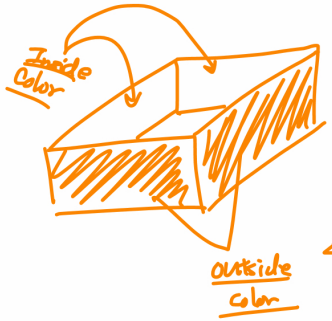
$$(n \cdot l > 0 \ \wedge \ n \cdot v < 0)$$

$$\vee (n \cdot l < 0 \ \wedge \ n \cdot v > 0)$$

$\Rightarrow$ EYE, LIGHT ON OPPOSITE SIDES

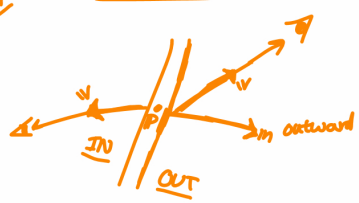
$\Rightarrow I_{(p)} = k_a \cdot I_a = \text{AMB}$

③ Inside VS OUTSIDE



$\Rightarrow$ must store OUT & IN diffuse color coeff.'s

CONDITION:



$n \cdot v > 0$ out-color

$n \cdot v < 0$ in-color