ILLUMINATION MODEL CONTINUED

- From previous lecture, we know that Lamberts lighting model can be represented as:

$$I = K_d I_s \cos\theta$$
$$= K_d I_s \underbrace{\hat{N}\cdot\hat{L}}_{\text{dot product.}}$$

- **For circles & sphere's**

(i) $\vec{N} = (\text{point on surface} - \text{center})$

(ii) $\vec{L} = (L - P)$

Need to be normalised.

L → light source coordinates

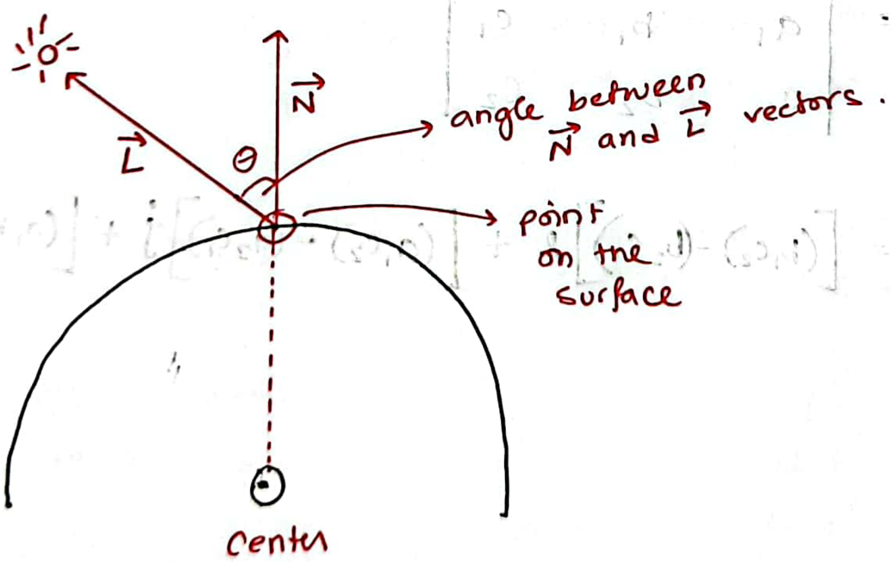
P → Point on the surface coordinates

(iii) I = cannot be negative {minimum value is 0}

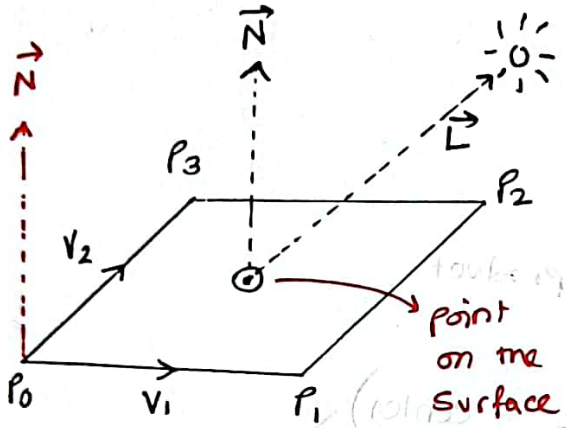
To normalize:

- $\hat{N} = \dfrac{\vec{N}}{|N|}$

- $\hat{L} = \dfrac{\vec{L}}{|L|}$



∅ For Polygonal surface (Flat)



∅ $\vec{N} = \underbrace{V_1 \times V_2}_{\text{cross product}}$

∅ $\vec{L} = \left(\text{light source} - \text{point on surface}\right)$

∅ $V_1 = (P_1 - P_0)$, $V_2 = (P_3 - P_0)$

$$\vec{N} = \begin{vmatrix} i & j & K \\ (P_1-P_0).x & (P_1-P_0).y & (P_1-P_0).z \\ (P_3-P_0).x & (P_3-P_0).y & (P_3-P_0).z \end{vmatrix}$$

$$\Rightarrow \vec{N} = \begin{vmatrix} i & j & K \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix}$$

$$\Rightarrow \vec{N} = \left[(b_1c_2) - (b_2c_1)\right]i + \left[(a_1c_2) - (a_2c_1)\right]j + \left[(a_1b_2) - (a_2b_1)\right]K$$

Ø Eventually, the lambertian light shading along with ambient lightning becomes:

$$I = K_a I_a + I_s K_d \hat{N} . \hat{L} \quad \text{------ (iv)}$$

Ø Local lightning model will always create a 3D model, but due to the positioning of the source light, we might / might not be able to create an idea for the shape.

(Attenuation of Light)

Ø it is the decrease in brightness of light due to the path travelled.

So, we use the inverse square law,

inversely proportional

$$f_{att} \propto \frac{1}{d_L^2} \quad \text{---- (v)}$$

distance of the object to light source.

attenuation factor

ranges, [0 ~ 1]

and the eqn stands as:

$$I = I_a K_a + f_{att} \left(I_s K_d \hat{N} . \hat{L} \right) \quad \text{---- (vi)}$$

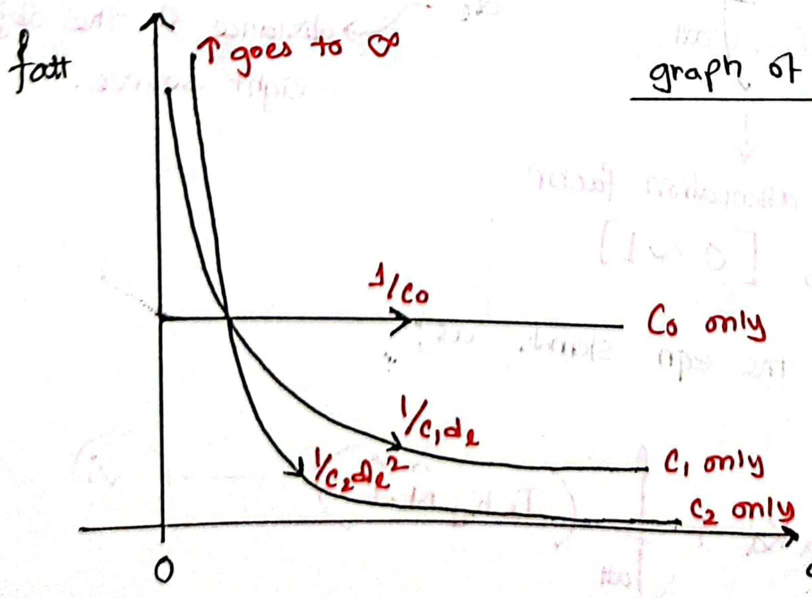
- although, in real life environment, this model / formula for attenuation factor doesn't work well. As if the light source is far away the shading doesn't happen, or if it is very close, it may give considerably different shades to a surface with minor difference in θ (angle between $\vec{N}$ & $\vec{L}$)

- Although it is hard to express natural atmospheric attenuation of light, a useful compromise is :

$$f_{att} = \min\left(1, \frac{1}{c_0 + c_1 d_L + c_2 d_L^2}\right) \quad \text{--- (vii)}$$

where, c_0, c_1, c_2 are user defined constants associated with the light source.

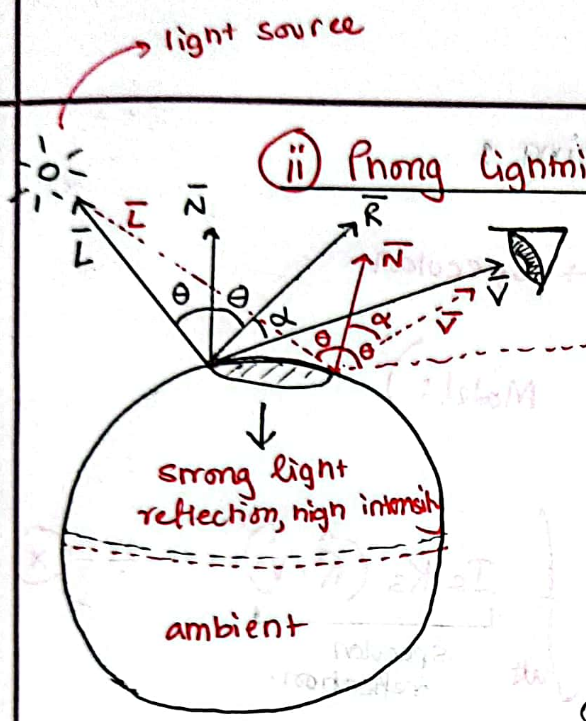
$\underbrace{\text{constants}}_{\text{coefficients}}$



graph of light source attenuation

(ii) Phong Lightning Model (Speculan Reflection)

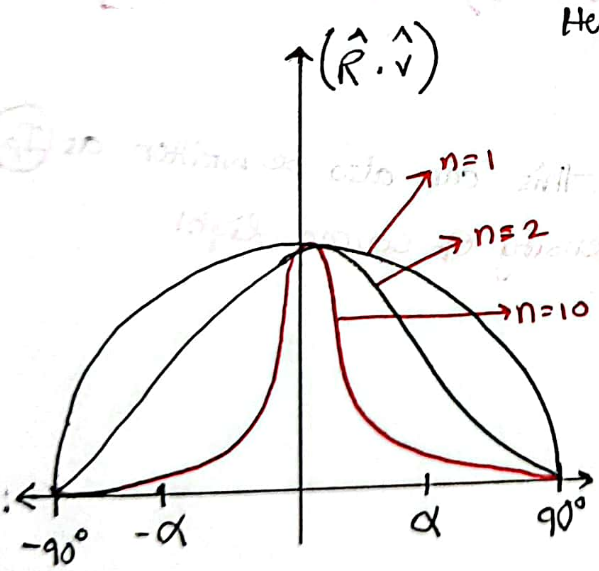
↳ for smooth surfaces



$$\varnothing \quad I = I_s k_s (\hat{R} \cdot \hat{V})^n \text{ ------ (viii)}$$

if attenuation is introduced

$$\varnothing \quad I = \int_{att} I_s K_s (\hat{R} \cdot \hat{V})^n \text{ ------ (ix)}$$



Here,

n ⟶ the factor of shininess

$\vec{V}$ ⟶ view point vector

$\vec{R}$ ⟶ Reflected light vector

$\vec{I_s}$ ⟶ Intensity of source light

$\vec{K_s}$ ⟶ absorption coefficient of specular surface.

(*) The higher the shininess the sharper the strong reflection point.

Ø finally accumulating everything :

$$I = \text{Ambient} + \text{Diffuse} + \text{Specular}.$$

(The Phong's lighting Model:)

$$I = I_a K_a + f_{att} \underbrace{I_s K_d (\hat{N} \cdot \hat{L})}_{\text{diffuse reflection}} + f_{att} \underbrace{I_s K_s (\hat{R} \cdot \hat{V})^n}_{\text{specular reflection.}} \quad \text{----- (x)}$$

$$\Rightarrow I = I_a K_a + \underbrace{I_s}_{} \cdot f_{att} \left[\left(K_d (\hat{N} \cdot \hat{L}) \right) + \left(K_s (\hat{R} \cdot \hat{V})^n \right) \right] \quad \text{---- (x)}$$

in some cases this can also be written as I_p which is the intensity of source light.