Illumination Modeling
CS 385 (Computer Vision)

Course Instructure
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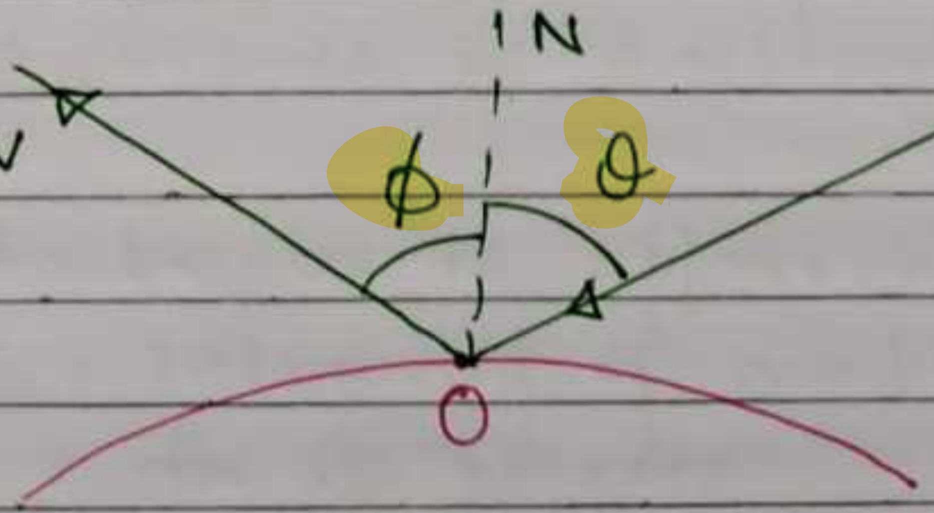
April 25, 2025

Illumination is defined using 3 parameters

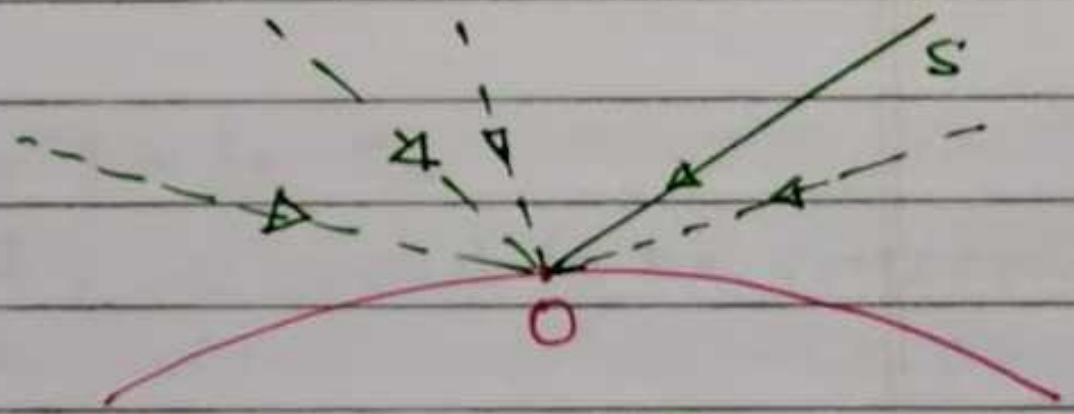
1. Surface normal
2. Source (light) direction
3. Viewing direction.

θ : angle bet. surface (N) normal & light source direction (S)

ϕ : angle bet. surface normal & viewer direction (V)



CASE I



CASE II.

S, N, V may not lie on the same plane.

$\theta, \phi < \pi/2$ or $90°$

Light may come from many directions (multiple sources, inter-reflections - AMBIENCE)

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Illumination consists of 3 parts
(a) Ambient reflection (b) Diffuse reflection and
(c) Specular reflection.

ASSUMPTIONS FOR MODELLING

1. Media is uniform bet. object space and projection plane.
2. Objects are opaque.
3. Inter-reflections approximated by ambient light.
4. Point light source.
5. Simple color model.

AMBIENT LIGHT / REFLECTION

There can be many shiny objects in the scene, and light from them can get reflected on the object although they may not get reflected to the viewer. More the objects in a 3D scene, more the inter-reflections. And these inter-reflected rays create a scenario called Ambience or Ambient illumination.

Ambience is approximated by $I = I_a . K_a$

I_a = intensity of ambient light, assumed to be constant for all objects.

K_a = ambient reflection co-efficient, and is a property of the material. $0 \leq K_a \leq 1$.

And throughout the scene I_a will be the same.

DIFFUSE REFLECTION

Diffuse reflection is a property of the surface. And from you view the object, you will observe the same illumination.

Such surfaces are known as diffused surfaces or Lambertian surfaces. Ex: dull, matte surfaces, chalk, snow, movie screens, uniformly painted walls, etc.

These surfaces appear equally bright from all viewing angles bcoz they reflect light with equal intensity in all directions. Illumination depends on angle θ.

In a movie theatre, wherever you are in the hall, you will be able to see almost similar brightness on the screen given constant radial distance.

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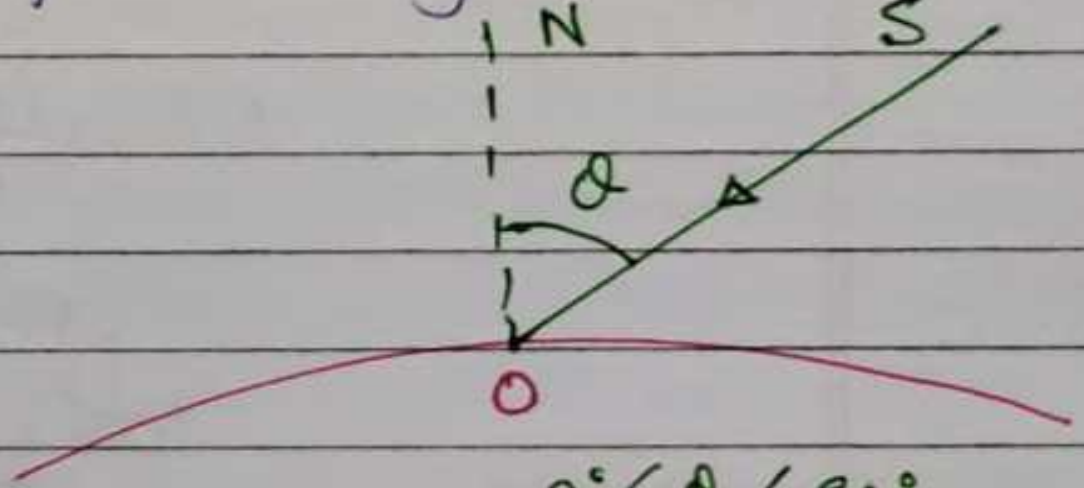
Therefore for a Lambertian surface the amount of light seen by the viewer is independent of the viewer's direction and is given by

$$I = I_s . K_d . \cos\theta$$



$0° \le \theta \le 90°$

I_s = point light source intensity.

K_d = material's diffuse reflection co-efficient.

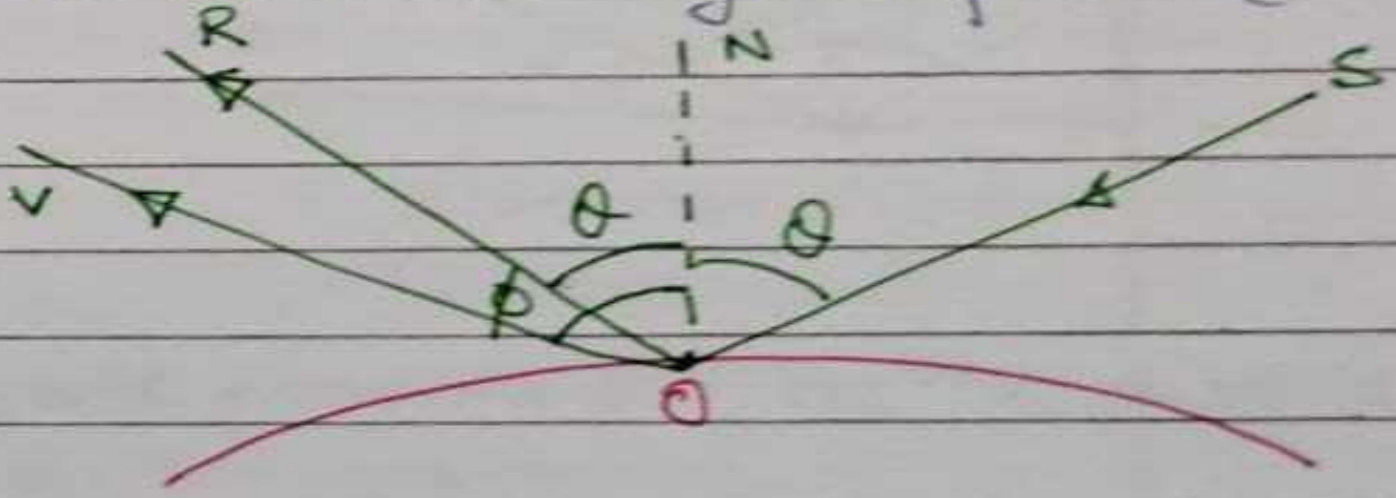
$0 \le K_d \le 1$

We can also write $I = I_s . K_d . \vec{N} . \vec{S}$ or $I = f_{att} . I_s . K_d . \vec{N} . \vec{S}$

where fatt takes into account the effect of distance i.e. when you are viewing an object from a closer range it appears much brighter than when you are away.

SPECULAR REFLECTION

Specular reflection tries to model shiny surfaces (ex: mirror). In case of a mirror, whatever light falls on the surface, gets reflected along a particular direction, say R (reflection vector).



Shiny surfaces reflect light unequally in different directions. Mirror is an example of a perfect shiny surface. Other examples of shiny (imperfect) surfaces are shiny plastic, gold or silver plated metal surfaces.

It is to be noted that R, S, N lie on the same plane & V can be anywhere in the 3D space.

PHONG'S ILLUMINATION MODEL

$$I_\lambda = I_{a\lambda} \cdot K_a \cdot O_{d\lambda} + f_{att} \cdot I_{p\lambda}\left[K_d O_{d\lambda} \cos\theta + K_s O_{s\lambda} \cos^m \alpha\right]$$

$I_{a\lambda}$ = object's ambient intensity

K_a = ambient reflection co-efficient.

$O_{d\lambda}$ = object's diffuse colour.

$I_{p\lambda}$ = point light source intensity.

K_d = diffuse reflection co-efficient

K_s = specular reflection co-efficient $0 \le K_s \le 1$

$O_{s\lambda}$ = objects specular colour.

α = angle between R and V.

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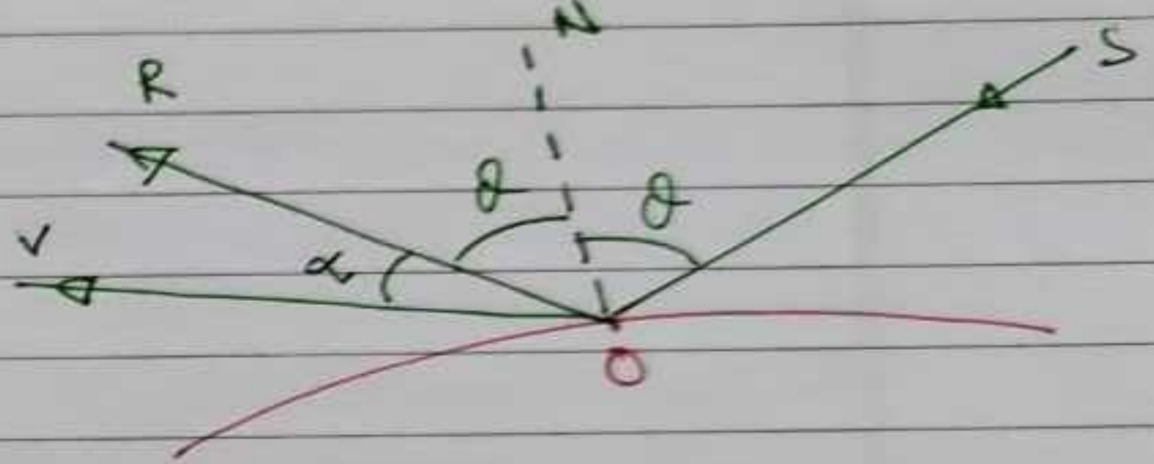
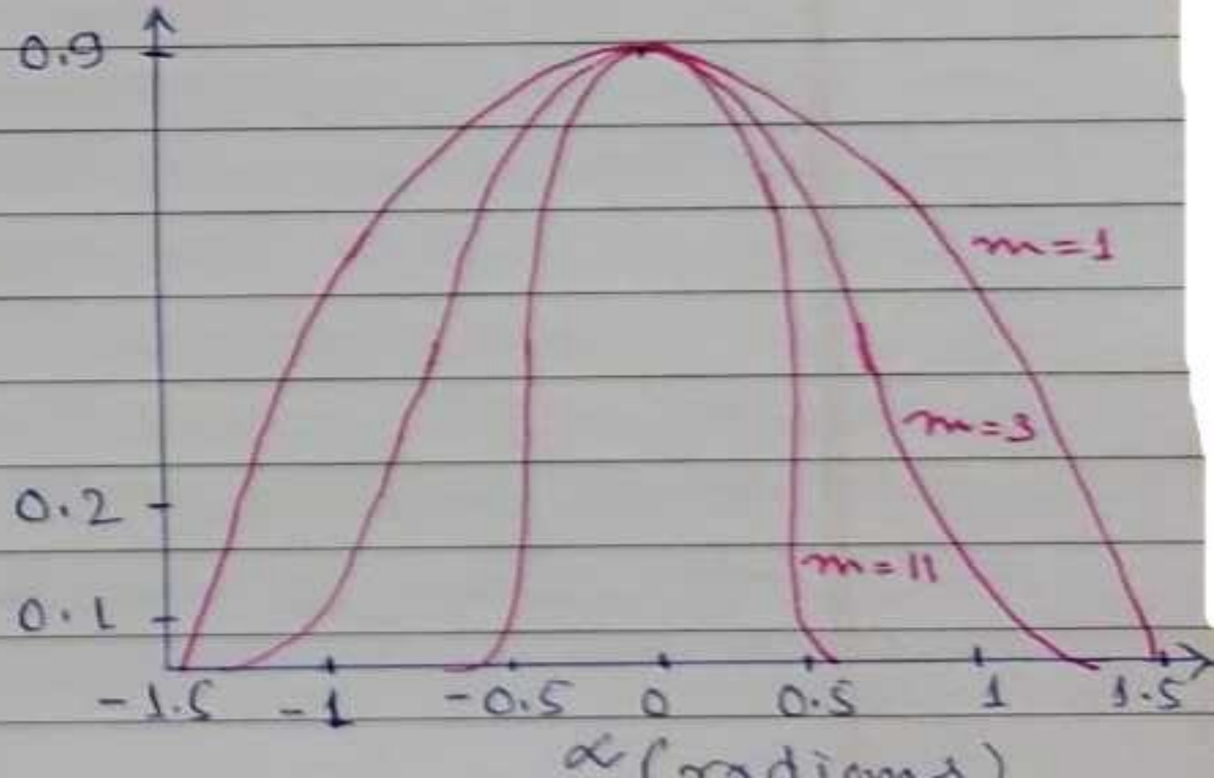


R is the direction in which majority of light will be reflected, incase of an imperfect shiny object. The angle 'α' takes into account the remaining amount of light dissipitated arround R. $\cos^m\alpha$ models the dissipation arround R.



As we raise m, the curve becomes narrower $\cos\alpha$ representing limited dissipation of light along R.