SCHOOL OF
COMPUTER SCIENCE

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BACHELOR OF TECHNOLOGY in
COMPUTER SCIENCE & ENGINEERING

Computer Graphics Presentation

Illumination Parts:- Lambert's Law
(Ambient Light, Specular Light, Diffuse Reflection

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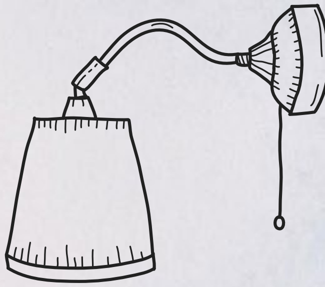
ILLUMINATION MODEL

Introduction

- A **projection** describes only where an object has to be drawn on the projection plane.
- The **determination of visible surfaces** also focused only on the question which objects should be drawn and which ones are hidden from view by others.
- The information where an object should be drawn on the projection plane **is not at all sufficient for a realistic representation** of a 3D scene.
- Realistic displays of a scene are obtained by generating perspective projections of objects and by applying natural lighting effects to the visible surfaces.



ILLUMINATION MODEL

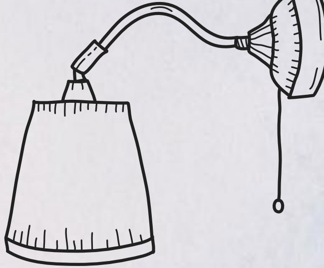
- Also called a lighting model or shading model
- Model for calculating light intensity at a single surface point.
- This is used to calculate the intensity of light that we should see at a given point on the surface of an object.

SURFACE RENDERING METHODS

- Also called surface-shading methods.
- Defined as a procedure for applying a lighting model to obtain pixel intensities for all the projected surface positions in a scene.

AMBIENT LIGHT (I_a)

- Ambient light has no spatial or directional characteristics.
- The amount of ambient light incident on each object is a constant for all surfaces and over all directions.
- The intensity of the reflected light for each surface depends on the optical properties of the surface; that is, how much of the incident energy is to be reflected and how much absorbed.
- We can set the level for the ambient light in a scene with parameter I_a and each surface is then illuminated with this constant value.
- The reflected intensity of Iamb of any point on the surface is $$I_{amb} = K_a I_a$$
- This is a simple way to model the combination of light reflections from various surfaces to produce a uniform illumination called the ambient light, or background light.



DIFFUSE REFLECTION (K_d)

- Diffuse reflections are constant over each surface in a scene, independent of the viewing direction.
- If there is a light source then different objects should have different intensities based on distance and orientation with respect to light source and viewer's position.
- A point on a diffuse surface appears equally bright from all viewing position because it reflects light equally in all directions.
- The fractional mount of the incident light that is diffusely reflected can be set for each surface with parameter kd, the diffuse-reflection coefficient, or diffuse reflectivity.
- Parameter kd is assigned a constant value in the interval 0 to 1, according to the reflecting properties we want the surface to have.
- If a surface is exposed only to ambient light, we can express the intensity of the diffuse reflection at any point on the surface as

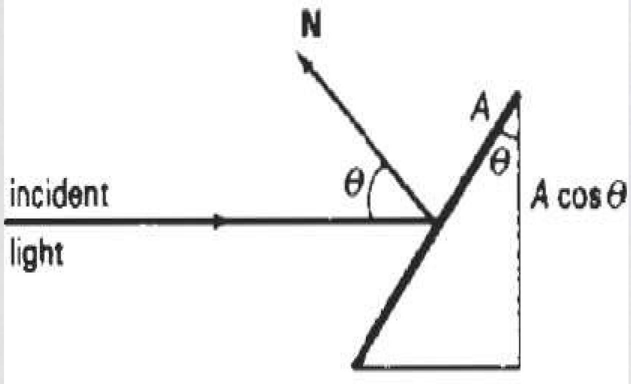
$$I_{ambdiff} = k_d I_a$$

❖ (where Kd is the diffuse-reflection coefficient)

DIFFUSE REFLECTION (K_d)

- If we denote the angle of incidence between the incoming light direction and the surface normal as , then the projected area of a surface patch perpendicular to the light direction is proportional to cos .
- If I_L is the intensity of the point light source, then the diffuse reflection equation for a point on the surface can be written as

$$I_{l,diff} = K_d \, I_l \cos\theta$$



DIFFUSE REFLECTION (K_d)

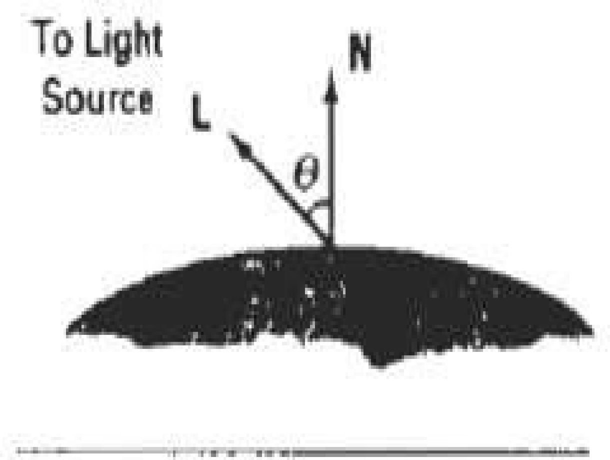
- If N is the unit normal vector to a surface and L is the unit direction vector to the point light source from a position on the surface

- (Fig. 14-9), then cos = N.**L** and the diffuse reflection equation for single point-source illumination is $I_{l,diff} = K_d\, I_l\, (N.L)$

- We can **combine the ambient and point source intensity** calculations to obtain an expression for the total diffuse reflection.

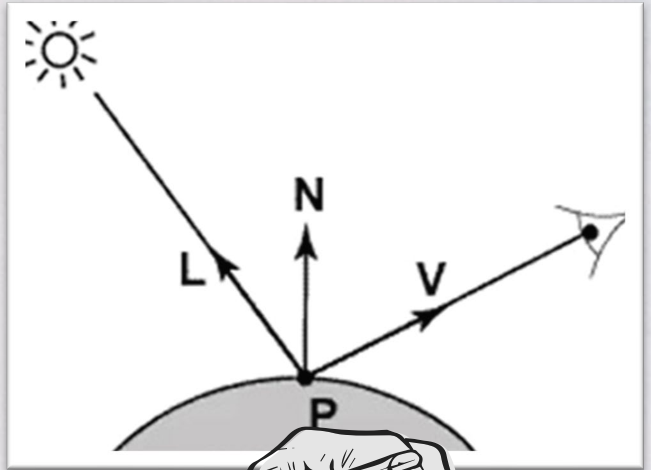
- In addition, many graphics packages introduce **an ambient-reflection coefficient ka to modify the ambient light intensity Ia**, for each surface.

$$I_{diff} = k_a\, I_a + k_a\, I_l\, (N.L)$$



LAMBERTS LAW

Angle of incident between the unit light source direction vector L and there unit vectors normal N



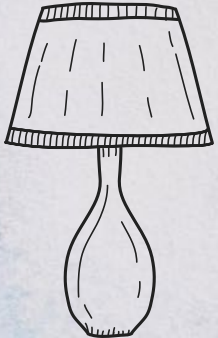
- This law states that when light falls obliquely on a surface, the illumination of the surface is directly proportional to the cosine of the angle (q) theta between the direction of the incident light and the surface normal N.

- **If I_L is the intensity of the point light source then, the diffuse reflection equation for a point on the surface can be written as**

$$I_{L,diff} = K_d \, I_L \, (N.L)$$

OR

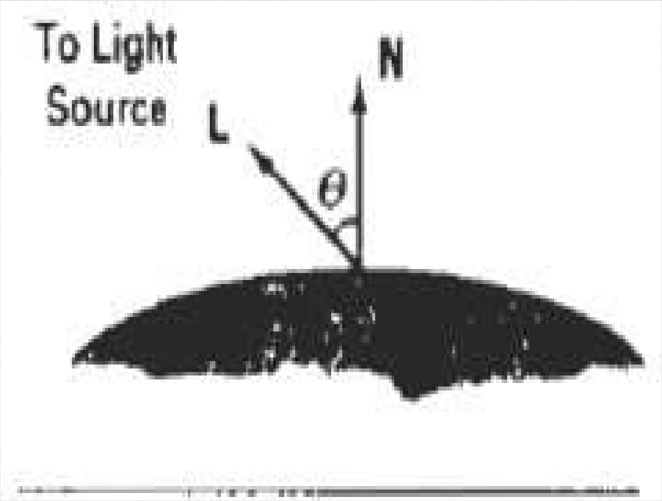
$$I_{L,diff} = K_d \, I_L \cos\theta$$



DIFFUSE REFLECTION (K_d)

- If light source is at infinite distance from the object then L will be the same for all points on the object, the light source becomes a directional light source

$$I_{diff} = k_a I_a + k_a I_1 \text{ (N.L)}$$

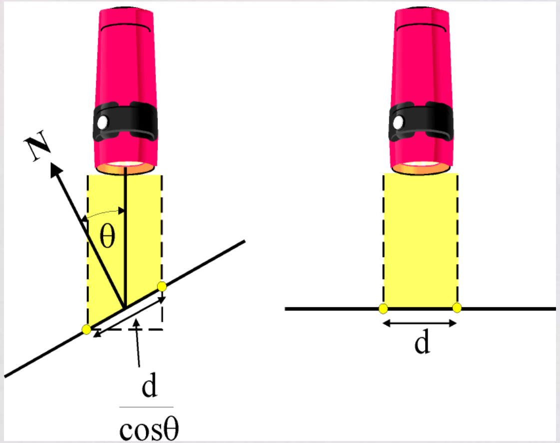


LAMBERTS LAW

- A surface which is oriented perpendicular to a light source will receive more energy (and thus appear brighter) than a surface oriented at an angle to the light source.
- The irradiance E is proportional to $\frac{1}{area}$
- As the area increase the irradiance decreases therefore:

$$E = \frac{d\Phi}{dA_{\perp}} = \frac{\cos\theta \, d\Phi}{dA} = \frac{\cos\theta \, \Phi}{4\pi r^2}$$

As θ increases, the irradiance and thus the brightness of a surface decreases by cos θ



LAMBERTIAN ILLUMINATION MODEL

- Intensity of reflected light depends on:
  - The angle the light rays make with the surface of the object $\boldsymbol{\theta}$
  - And the reflectivity (*“colour”*) of the object surface (***k_d***)
  - The original colour of the light (***L***)

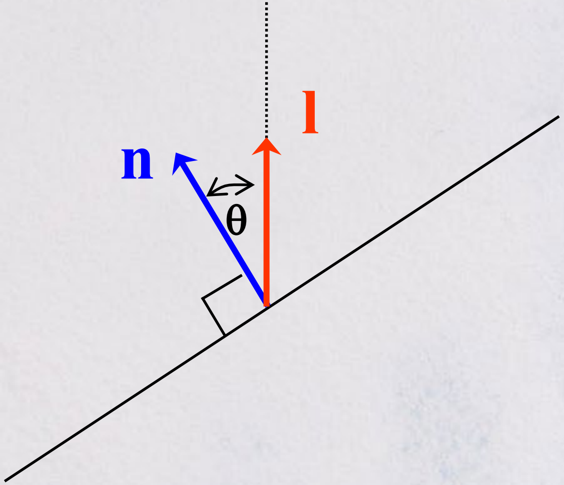
Graphical programs calculate light at each point using a simple formula

$$I_d = L \times k_d \times \cos\theta$$

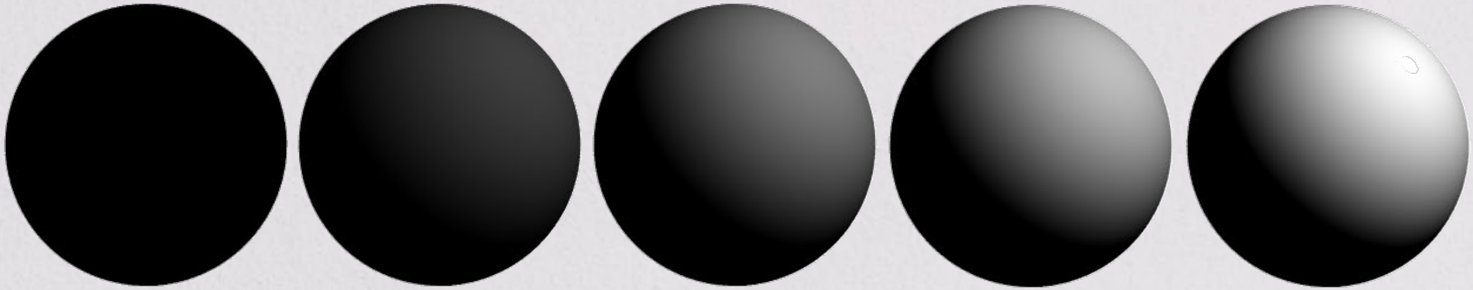
θ is the angle between the normal and the light direction.

so $$I_d = L \times k_d \times (\mathbf{l} \bullet \mathbf{n})$$

Where **l** and **n** are unit vectors



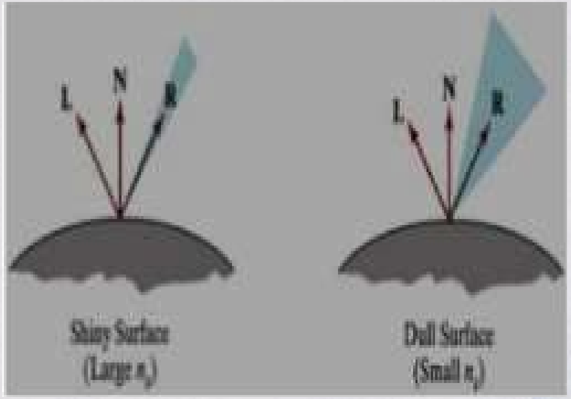
DIFFUSE REFLECTION



- The spheres above are lit by diffuse (k_d) values of 0.0, 0.25, 0.5, 0.75, 1 respectively

SPECULAR REFLECTION

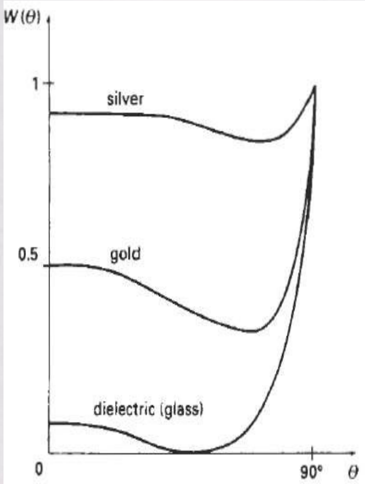
- When we look at an illuminated shiny surface, such as polished metal, an apple, or a person's forehead, we see a highlight, or bright spot, at certain viewing directions.
- This phenomenon, called *specular reflection*, is the result of total, or near total, reflection of the incident light in a concentrated region around the specular reflection angle.
- In this figure, we use **N** unit normal surface vector R to represent the unit vector in the direction of **ideal specular reflection.**
- **L to represent the unit vector directed toward the point light source.**
- **V** as the unit vector pointing to the **viewer** from the surface position.



SPECULAR REFLECTION

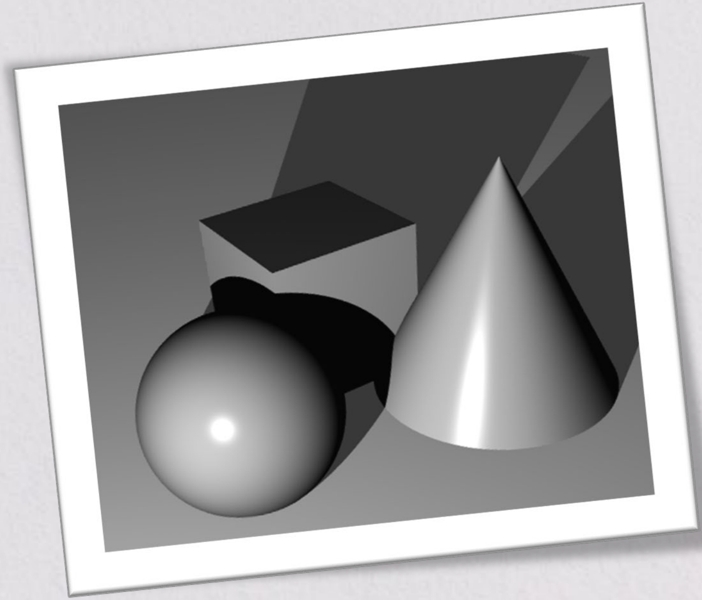
- The intensity of specular reflection depends on the **material properties of the surface and the angle of incidence**, as well as other factors such as the polarization and color of the incident light.
- We can approximately model monochromatic iintensity for each specular variations using a **specular-reflection coefficient, W(θ),** surface.

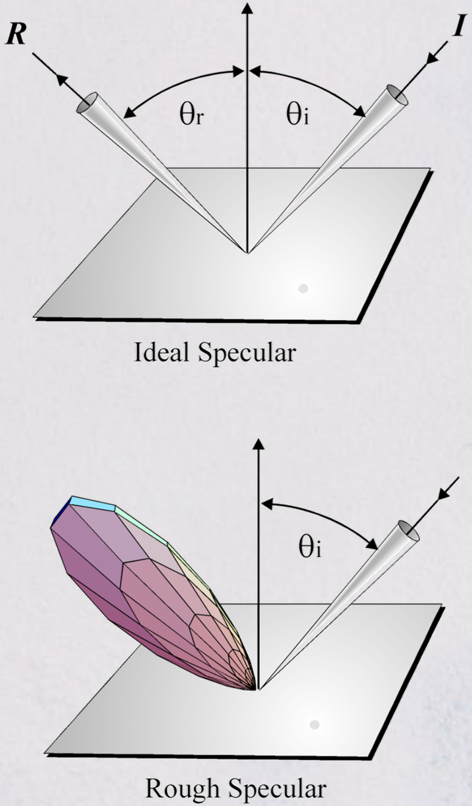
$$I_{spec} = W(\theta)\, I_1\, COS^{ns}\, \phi$$



specular-reflection coefficient, W(q) for different materials

SPECULAR HIGHLIGHTS





Thank You

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