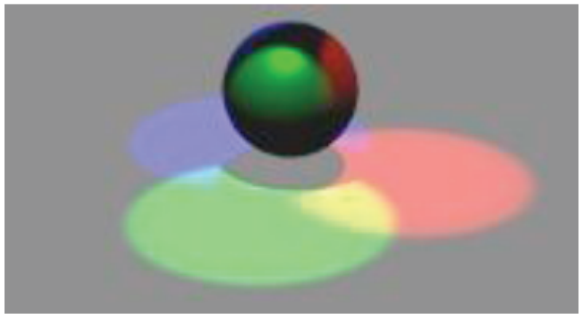
Illumination

Two Components of Illumination

- Light sources with: คุณสมบัติแหล่งกำเนิดแสง
  - Emittance spectrum (color)
  - Geometry (position and direction) ตำแหน่ง และทิศทาง
  - Directional attenuation (falloff)
- Surface properties with: คุณสมบัติของพื้นผิววัตถุ
  - Reflectance spectrum (color)
  - Geometry (position, orientation, and micro-structure)
  - Absorption



Computer Graphics Jargon

- **Illumination:** the transport of energy from light sources between points via direct and indirect paths
- **Lighting**: the process of computing the light intensity reflected from a specific 3-D point การคำนวณหาความเข้มของแสง
- **Shading**: the process of assigning a color to a pixel based on the illumination in the scene

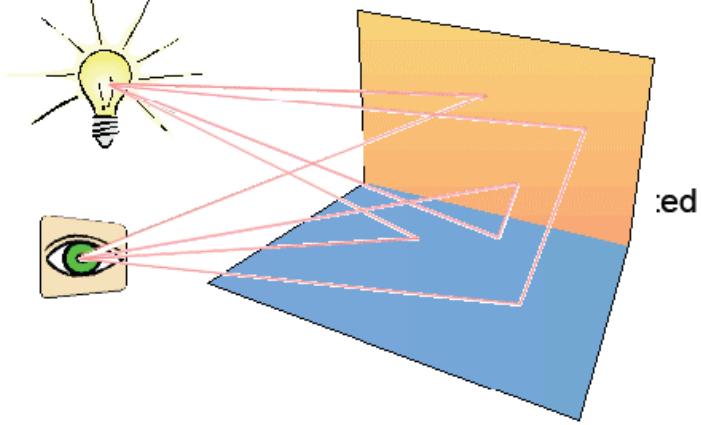
แบ่งเป็น 2 ลักษณะ

Direct and Global Illumination

ฟิสิกส์ของแหล่งกำเนิดแสง ตกกระทบกับสิ่งนั้นโดยตรง (โดยตรง)

- Direct illumination: A surface point receives light directly from all light sources in the scene
  - Computed by the local illumination model
  - Determine which light sources are visible
- Global illumination: A surface point receives light after the light rays interact with other objects in the scene

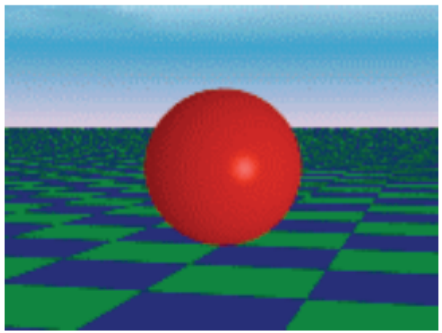
แสงตกกระทบมากกว่า 1 ชั้นไป

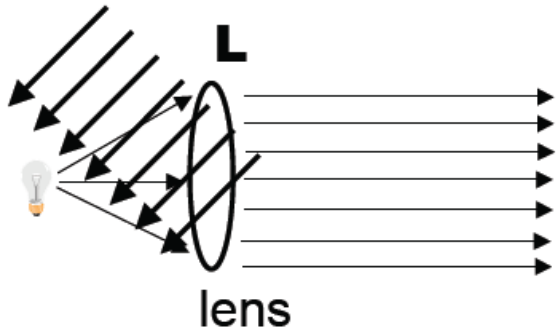


Directional Light Sources

แสงที่ออกไปในทิศทางเดียวกัน (ขนานกัน)

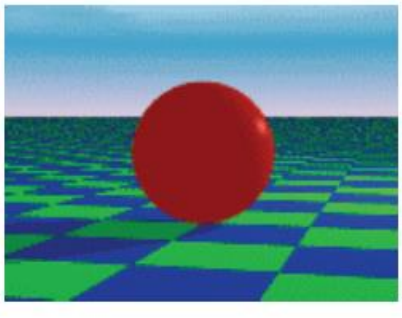
- All of the rays from a directional light source have a common direction
- The direction is a constant at every point in the scene
- It is as if the light source was infinitely far away from the surface that it is illuminating
- Examples?

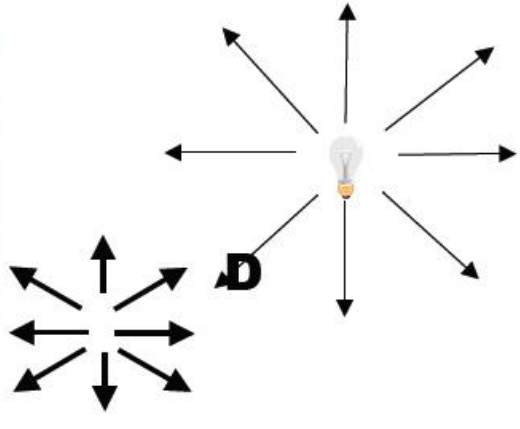




Point Light Sources แสงที่ออกมาจากจุด ทิศแสงจะแตกต่าง

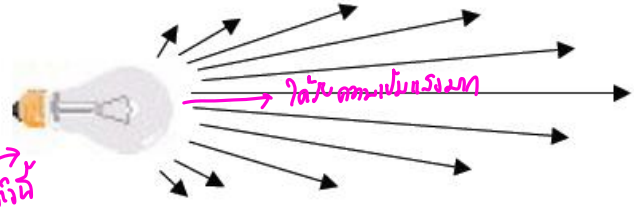
- The rays emitted from a point light radially diverge from the source
- Direction to the light changes at each point
- Examples?



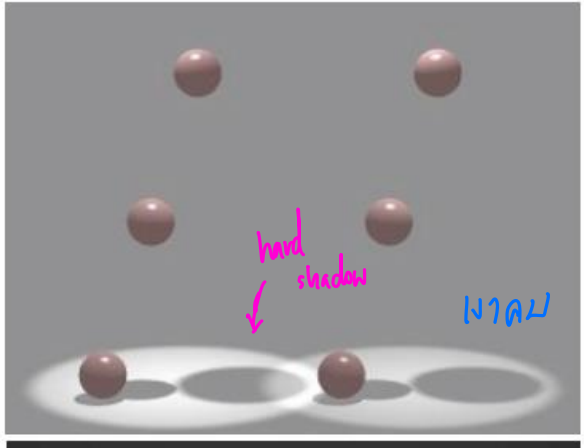


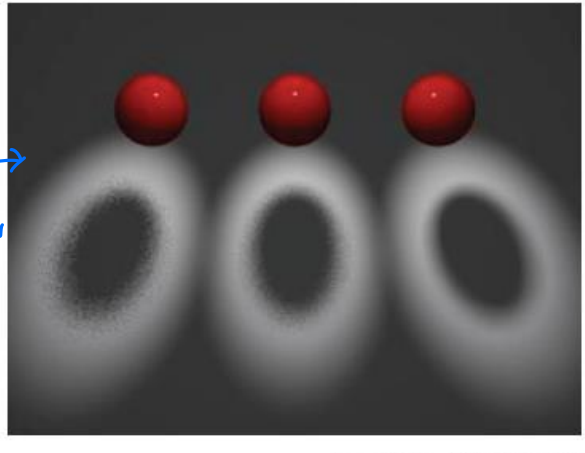
Other Light Sources

- Spotlights



- Area light sources
  - Light source occupies a 2D area (polygon)
  - Generates *soft* shadows.
- Extended light sources
  - Spherical light source
  - Generates *soft* shadows





Linearity of Light

ambien light

=

+

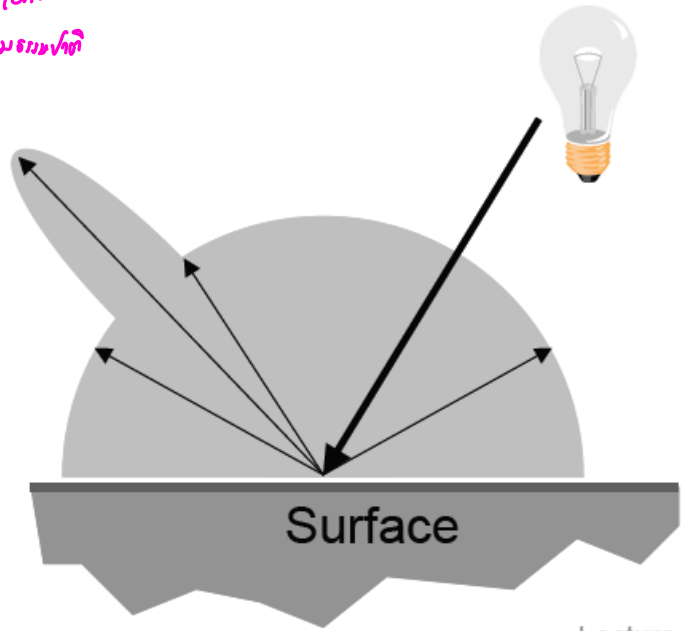
- แรงมีคุณสมบัติ รวมกันแล้วผล แรงได้ แรงออกมันได้

+

Paul Haeberli, Grafica Obscura

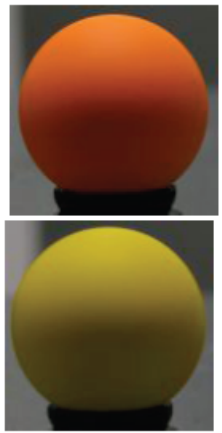
OpenGL Reflectance Model

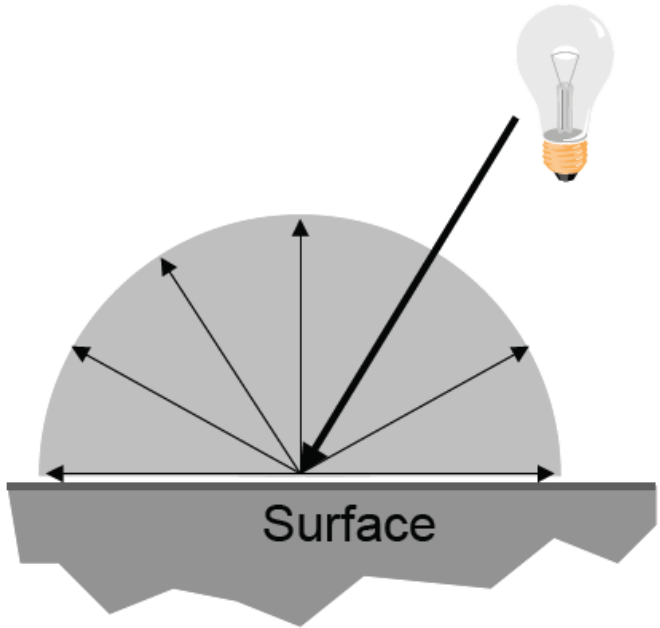
- Simple analytic model proposed by T. Phong:
  - diffuse reflection +
  - specular reflection +
  - "ambient"



Ideal Diffuse Reflectance

- Surface reflects light equally in all directions
- Why? Examples?





Lambert's Cosine Law

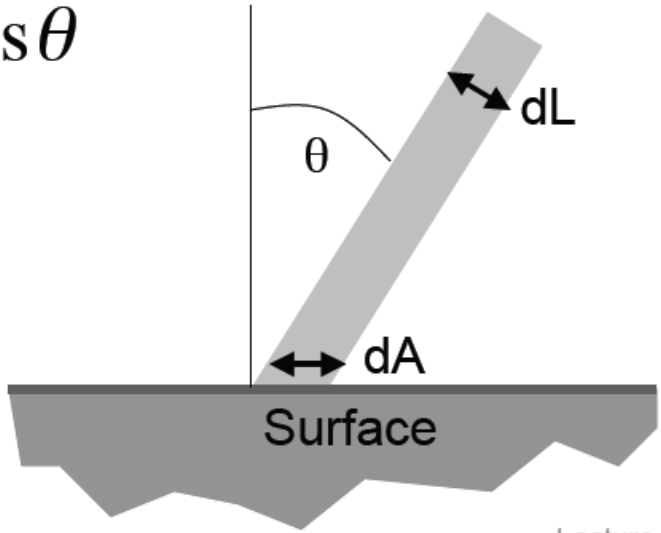
- Diffuse reflectance scales with cosine of angle

  cos θ is maximum when θ = 0°

  cos θ is zero when θ = 90°

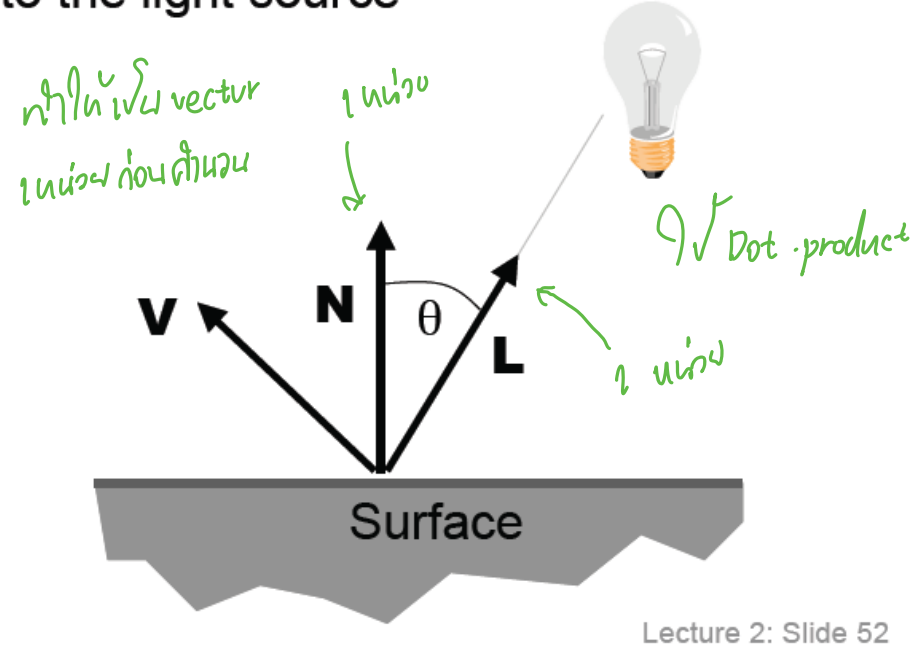
cos 0 = 1 มากที่สุด
cos > 0 ยังสะท้อนลงเรื่อย

$$dL = dA\cos\theta$$



Geometric Ingredients

- P: Point on the surface
- **N**: Normal vector at the surface point
- **V**: Vector from P to the camera / eye
- **L**: Vector from P to the light source



Ideal Diffuse Reflectance

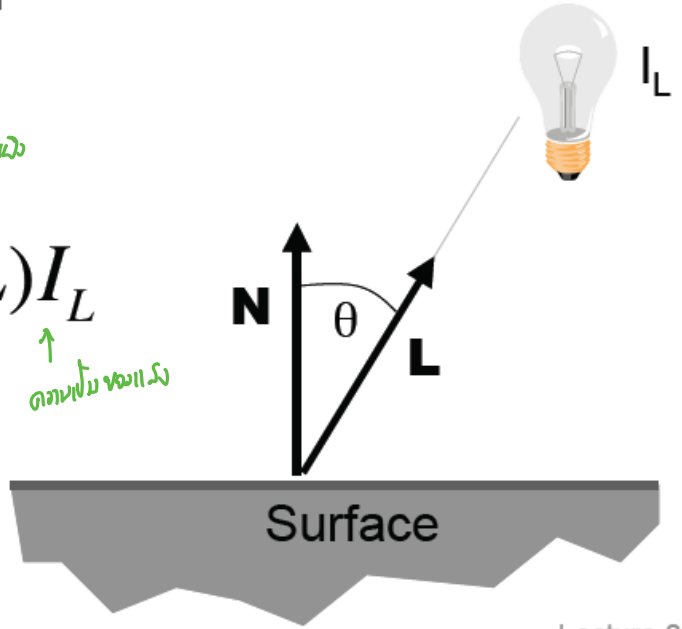
- Lambertian reflection model
  - I_L: The incoming light intensity
  - k_d: The diffuse reflection coefficient
  - N: Surface normal
  - L: Light direction

ค่าวัดประสิทธิผลพื้นผิว

$$I_d = k_d (N \bullet L) I_L$$

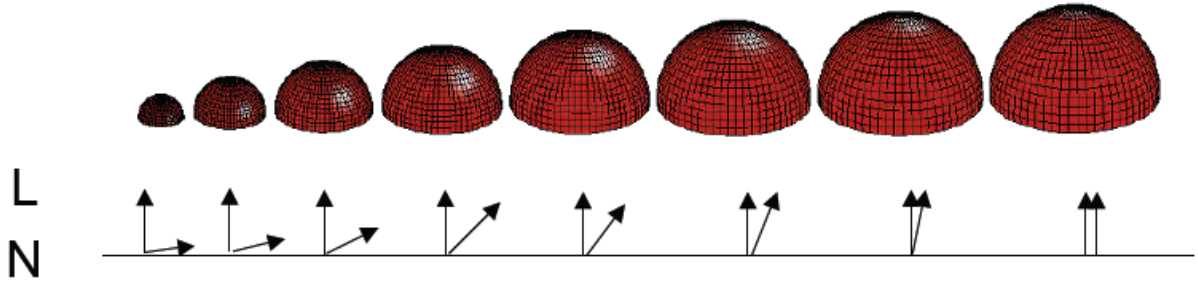
ความเข้มที่เป็น Diffuse

ความเข้มของแสง



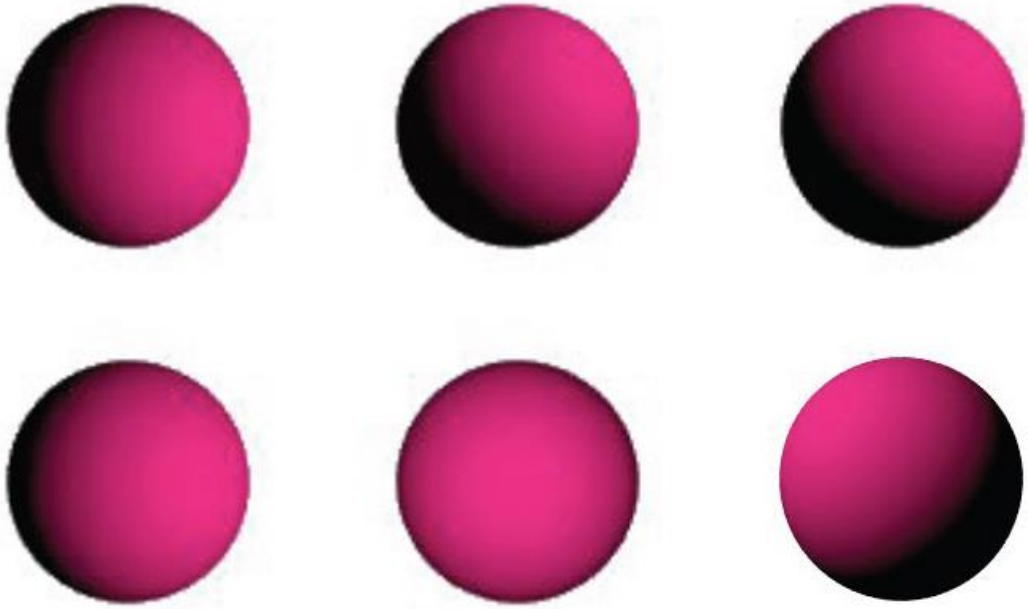
Ideal Diffuse Reflectance

- If **N** and **L** are facing away from each other, **N** • **L** becomes negative.
- Using max((**N** • **L**),0) makes sure that the result is zero.
  - From now on, we mean max() when we write •
- Do not forget to normalize your vectors for the dot product!



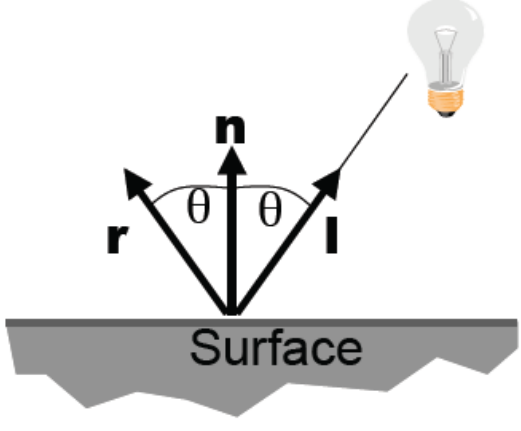
ถ้า N.L มีค่าติดลบ ให้เป็น 0 ใน code ให้ใส่ max ครอบ N.L
ค่าติดลบคือแสงส่องไม่ได้

Diffuse Reflectance Example



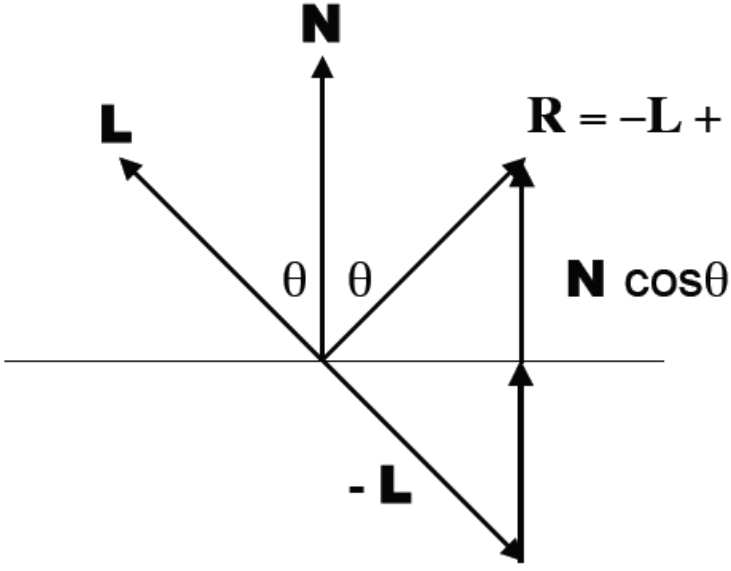
Ideal Specular Reflectance (พื้นผิวสะท้อนเงา)

- Surface reflects light only at mirror angle
- Reflection is strongest near mirror angle
- Why? Examples?



Reflection Vector R

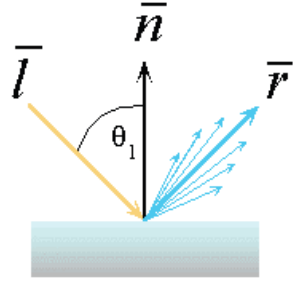
- The vector R can be computed from the incident ray direction L and the surface normal N
- Note that all vectors have unit length

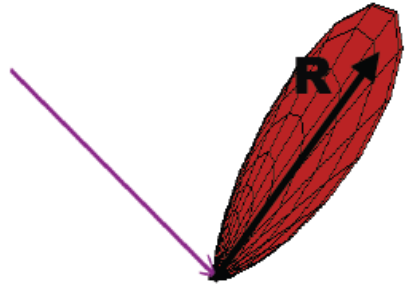


$$\mathbf{R} = -\mathbf{L} + 2\mathbf{N}\cos\theta = -\mathbf{L} + 2(\mathbf{L} \bullet \mathbf{N})\mathbf{N}$$

Non-ideal Reflectors

- Real materials deviate significantly from ideal reflectors
- Introduce an empirical model that is consistent with our experience
- The amount of reflected light is greatest in the direction of the perfect mirror reflection **R**
- The reflected light forms a "beam" pattern around this mirror direction





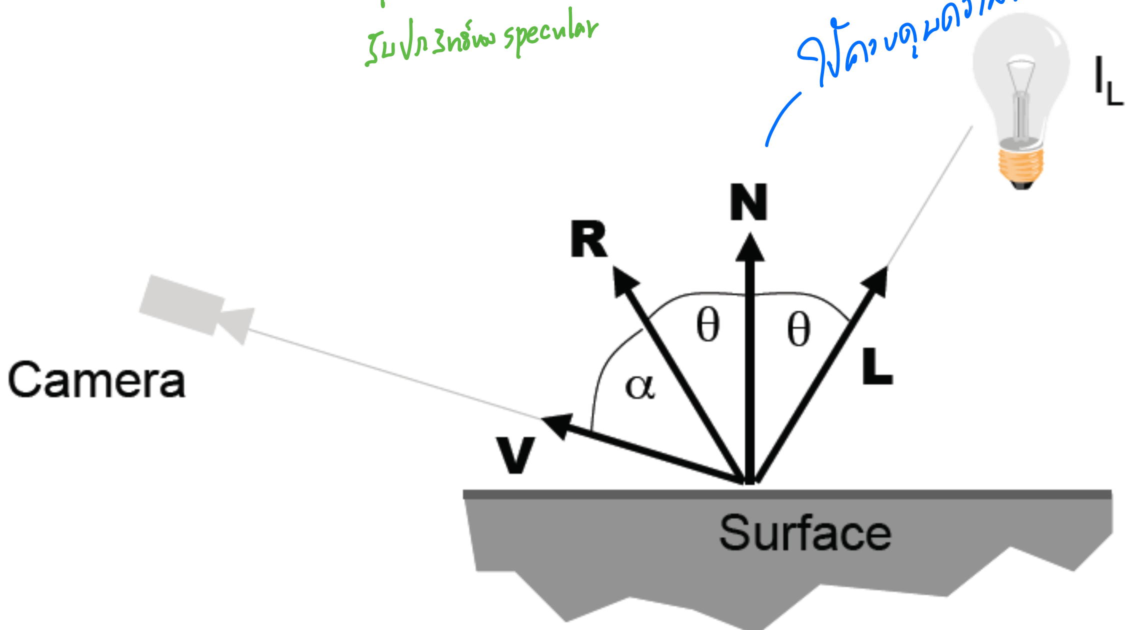
Phong Specular Reflection

shininess net
ค่าความมันวาวของพื้นผิว

$$I_s = k_s (V \bullet R)^n I_L$$

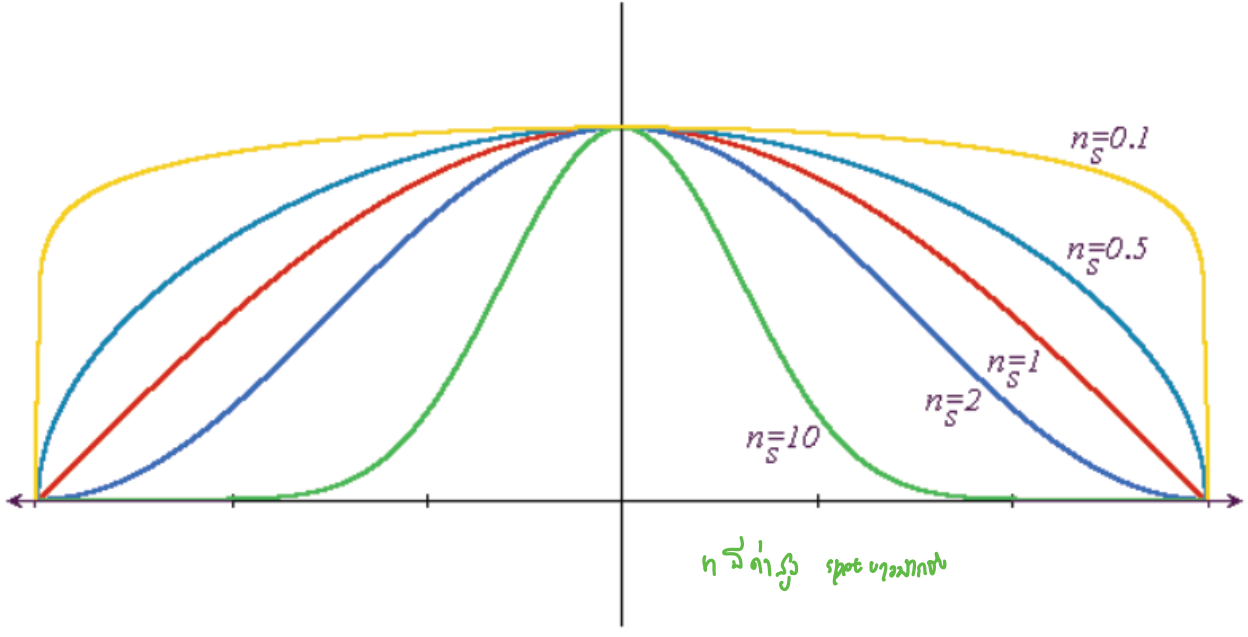
สัมประสิทธิ์ของ specular

ใช้ควบคุมความมันเงาพื้นผิวได้



Effect of n

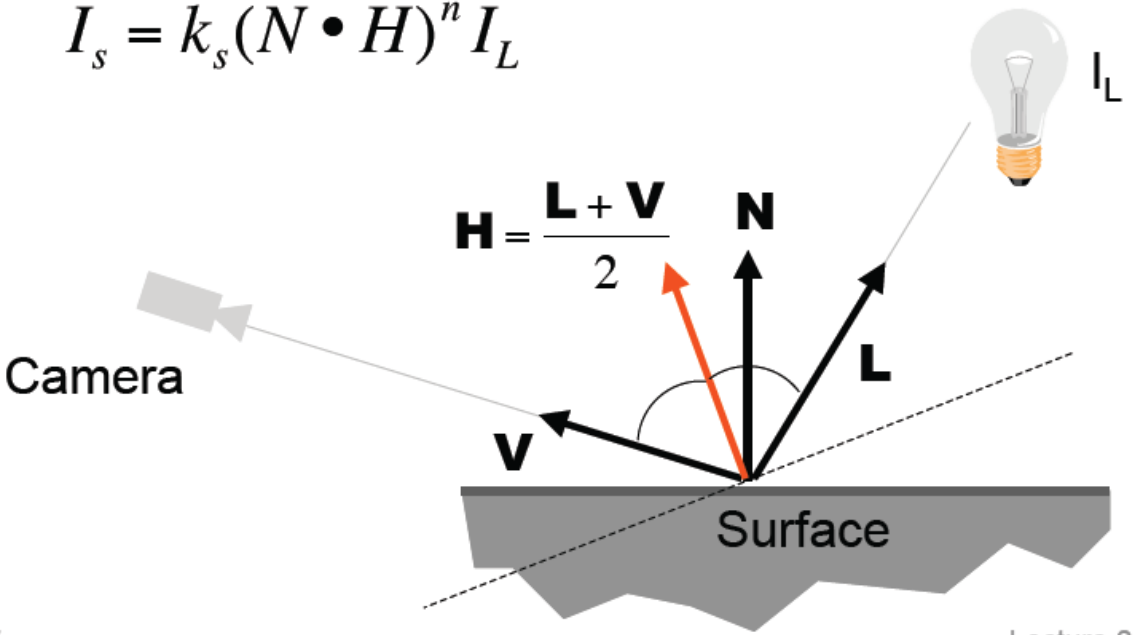
- The cosine lobe gets more narrow with increasing n.



Blinn & Torrance Variation

- Uses the halfway vector H between L and V
- H is the normal to the (imaginary) surface that maximally reflects light in the V direction

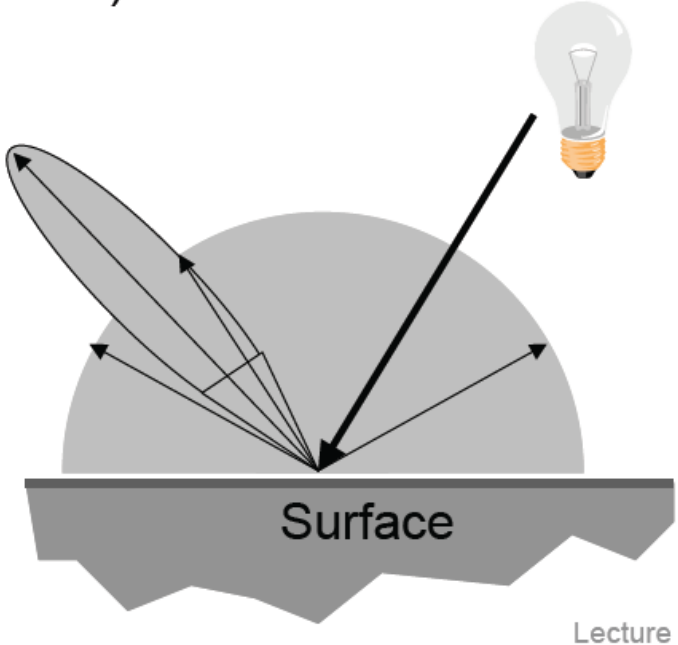
$$I_s = k_s(N \bullet H)^n I_L$$



The Phong Illumination Model

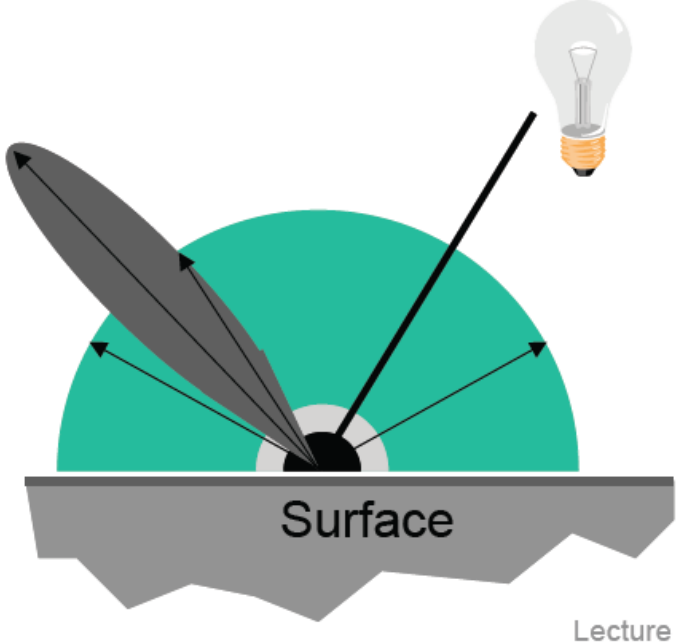
- Sum of three components:

  diffuse reflection + specular reflection + "ambient"
- Ambient represents the reflection of all indirect illumination (aka a "hack")



Phong Reflectance Model

- Simple analytical model:
  - diffuse reflection +
  - specular reflection +
  - "ambient"



Phong Reflectance Model

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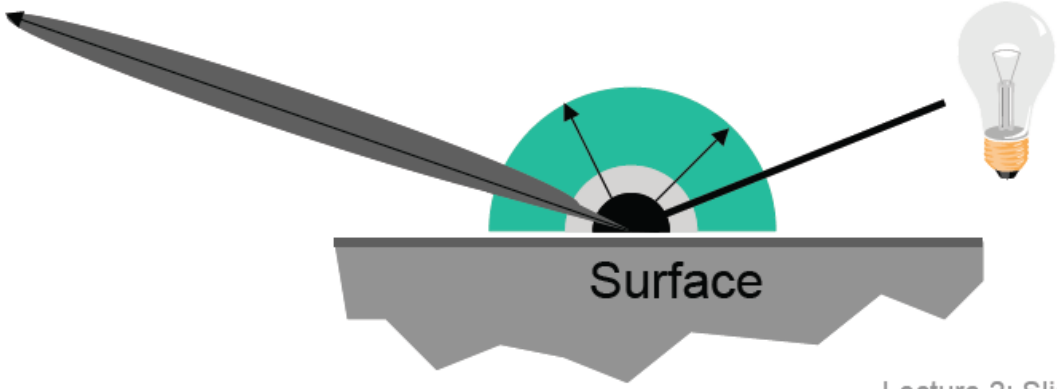
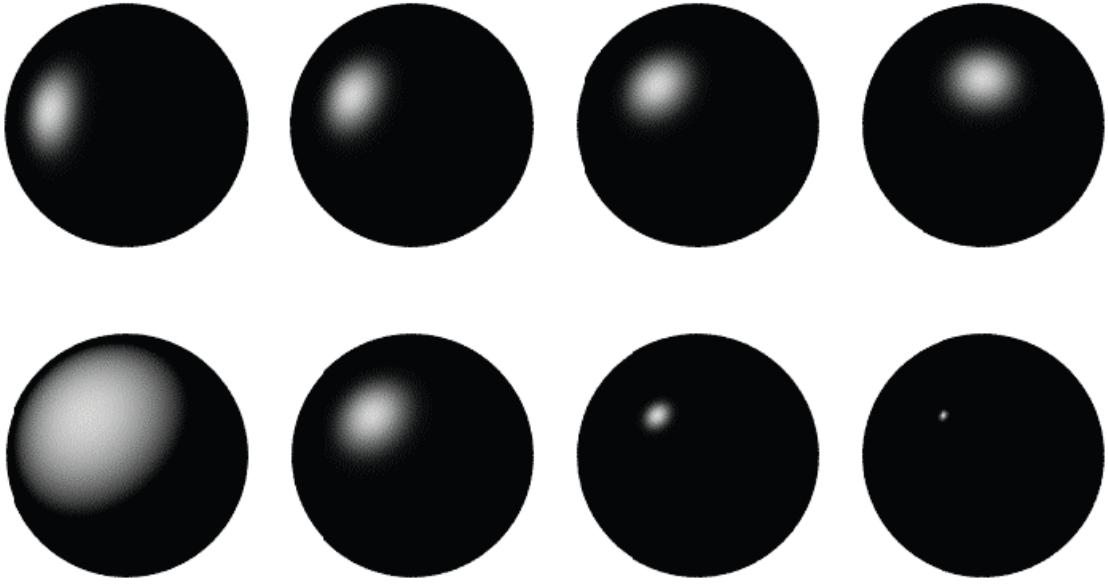


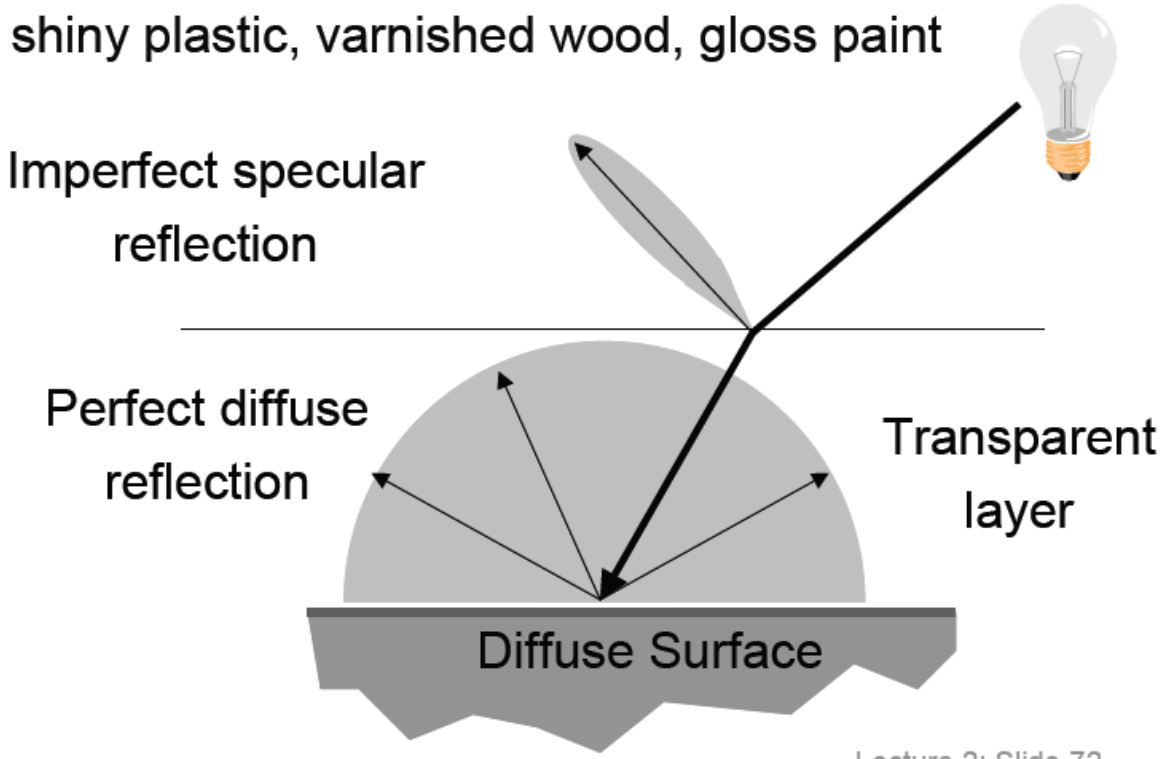
Phong Examples

- The direction of the light source and the n are varied



The Plastic Look

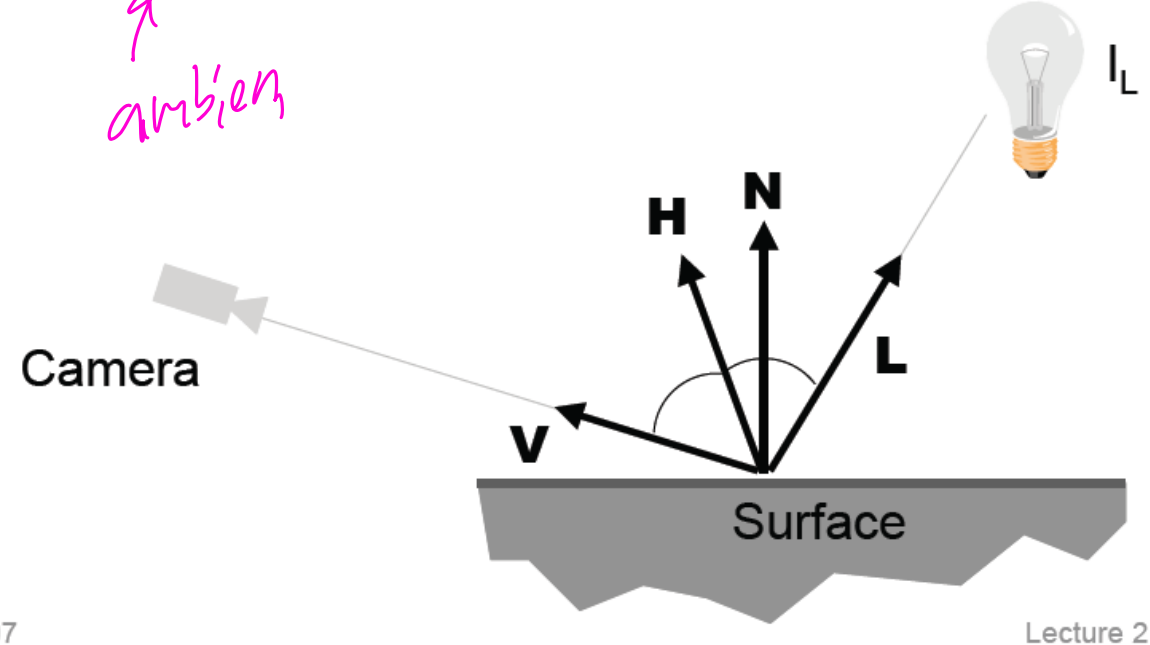
- The Phong illumination model is an approximation of a surface with a specular and a diffuse layer
  - E.g., shiny plastic, varnished wood, gloss paint



Phong Reflectance Model

- Single light source:

$$I = k_a I_a + k_d (N \bullet L) I_L + k_s (N \bullet H)^n I_L$$



Phong Reflectance Model

- Multiple light sources:

$$I = k_a I_a + \sum_i \left(k_d (N \bullet L_i) I_i + k_s (N \bullet H_i)^n I_i \right)$$