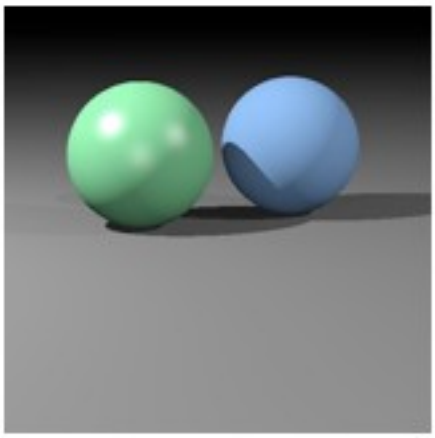
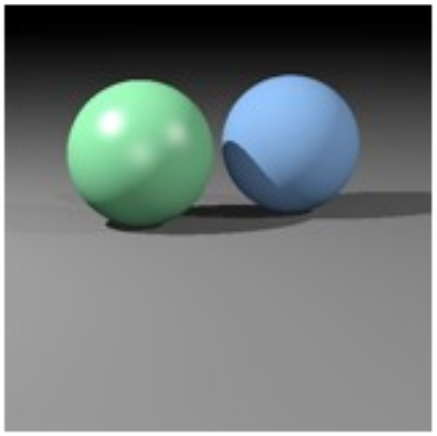
Shading



Based on slides from Marschner 2008

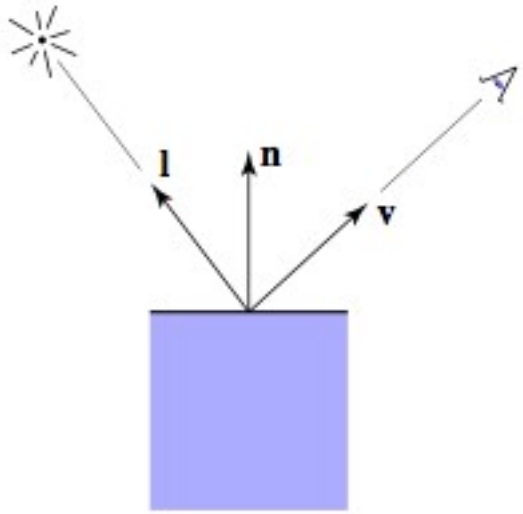
Shading

- Shading models
  - Approximate light reflection on illuminated surfaces



Shading model

- Compute light reflected toward camera / eye
  - **v** - view direction
  - **l** - light direction
  - **n** - surface normal
  - surface parameters
    - color, shininess, etc.



Shading model

- Compute light reflected toward camera / eye
  - **v** - view direction
  - **l** - light direction
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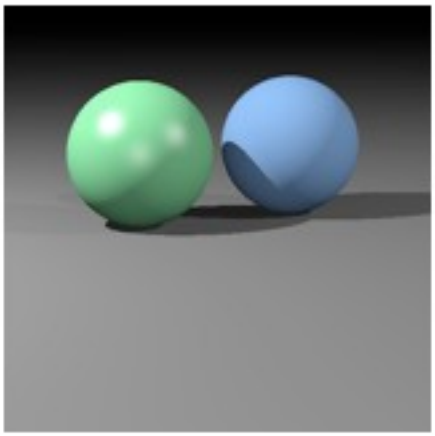
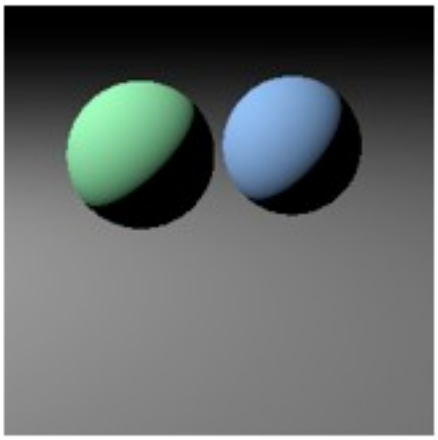


v, l, n must be normalized!!!!!!!!!

Diffuse

- Light scattered uniformly in all directions
  - surface color same for all viewing directions

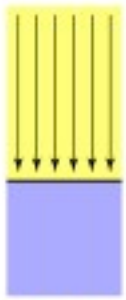


Diffuse

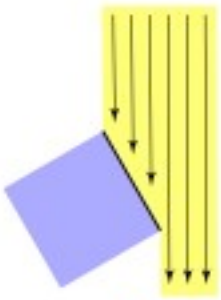
- Lambertian shading model
  - energy from light source depends on angle to light source
    - max illumination - surface directly toward light source
    - min illumination - surface tangent to light source

Diffuse

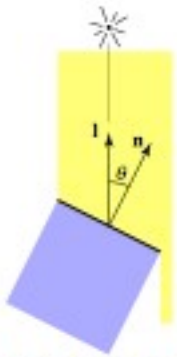
- Lambert's cosine law



Top face of cube receives a certain amount of light



Top face of 60° rotated cube intercepts half the light



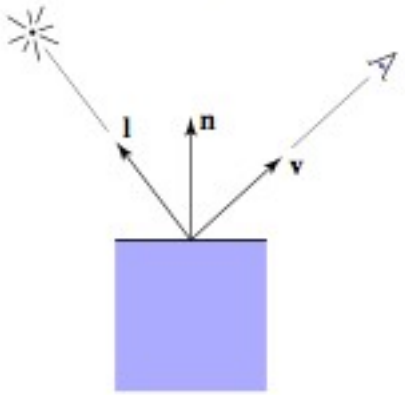
In general, light per unit area is proportional to $\cos\theta = \mathbf{l} \cdot \mathbf{n}$

Diffuse

- Lambertian shading
  - Shading independent of view direction

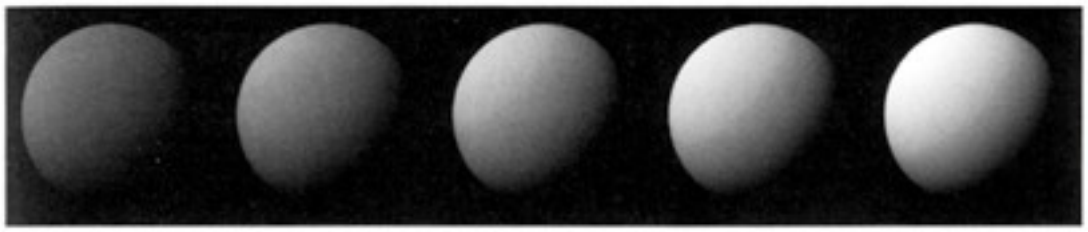
$$L_d = k_d \, I \max(0, \mathbf{n} \cdot \mathbf{l})$$

- L_d - diffusely reflected light
- k_d - diffuse coefficient
- I - illumination from source



Diffuse

- Lambertian shading
  - matte appearance

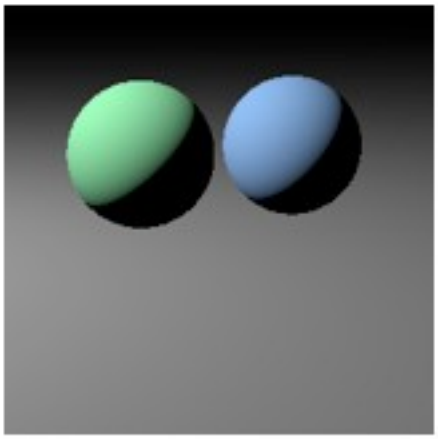


[Foley et al.]

k_d ⟶

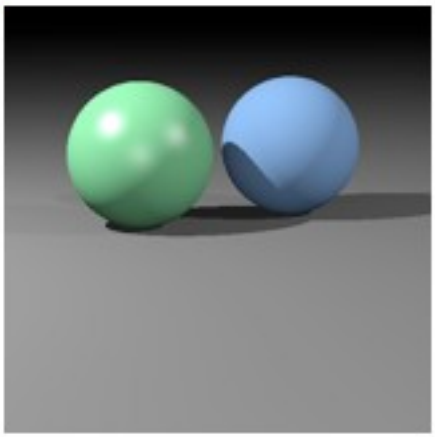
Diffuse

- Light scattered uniformly in all directions
  - surface color same for all viewing directions



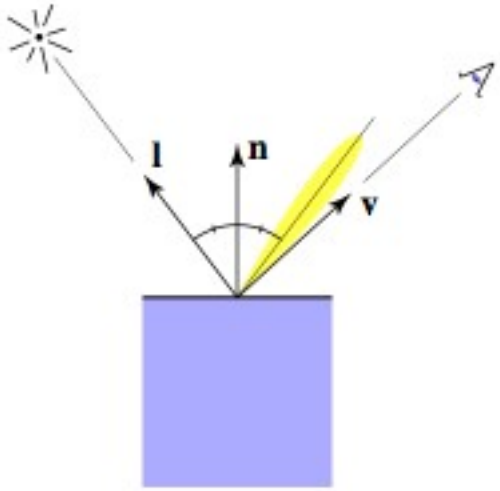
Specular

- Blinn-Phong
  - Intensity depends on view direction
  - Highlights



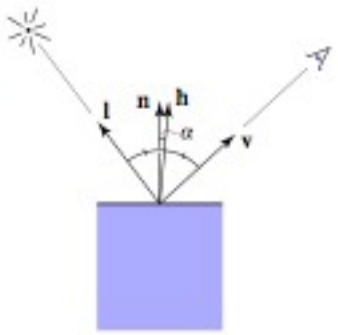
Specular

- Blinn-Phong
  - reflection brightest when $\boldsymbol{v}$ and $\boldsymbol{i}$ are symmetric across surface normal



Specular

- Blinn-Phong
  - L_s - specularly reflected light
  - k_s - specular coefficient
  - p - *Phong exponent > 1*



$$\mathbf{h} = \text{bisector}(\mathbf{v}, \mathbf{l}) \qquad L_s = k_s\, I \max(0, \cos\alpha)^p$$
$$= \frac{\mathbf{v}+\mathbf{l}}{\|\mathbf{v}+\mathbf{l}\|} \qquad = k_s\, I \max(0, \mathbf{n}\cdot\mathbf{h})^p$$

Specular

- *p - Phong exponent > 1*

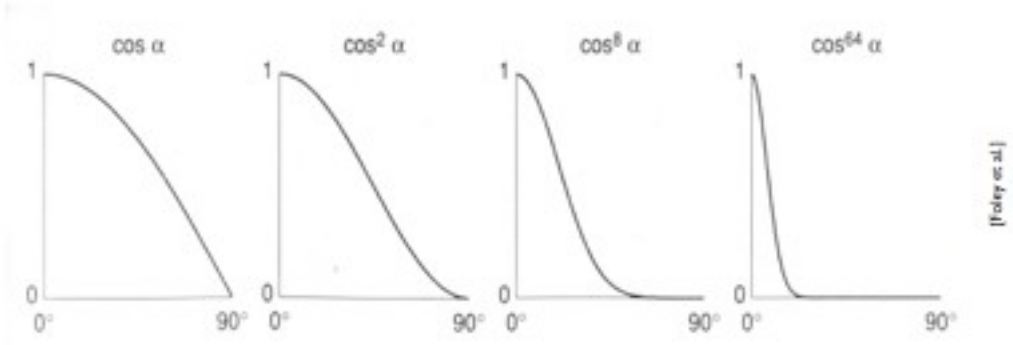
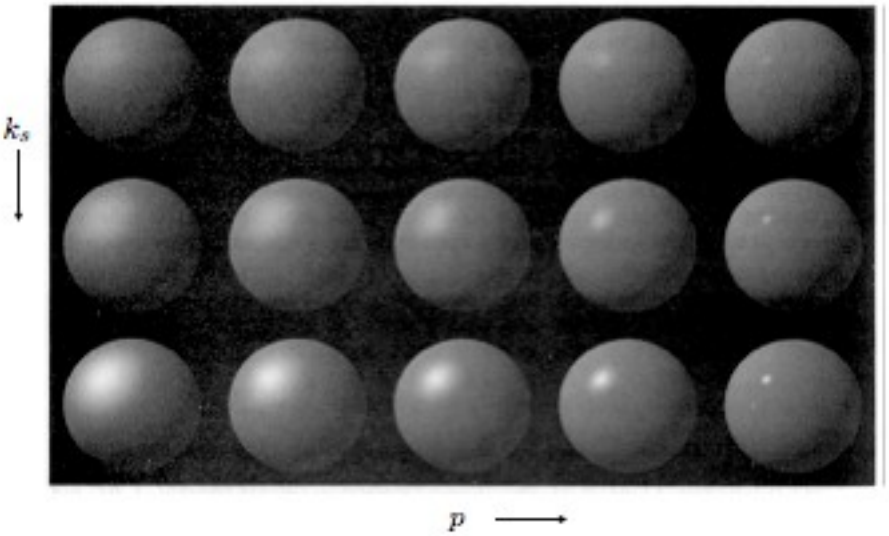


Fig. 16.9 Different values of $\cos^n \alpha$ used in the Phong illumination model.

Specular

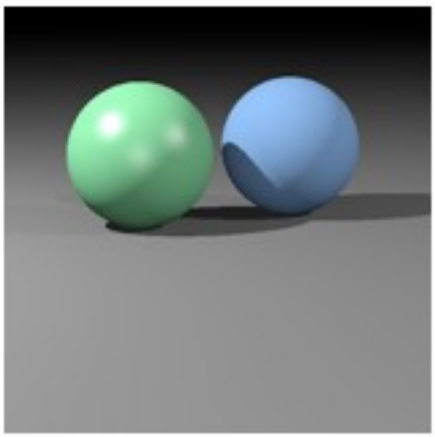


[Foley et al.]

Specular

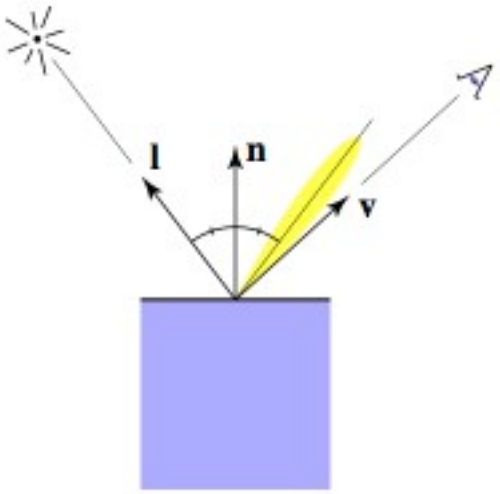
- Diffuse + Specular

$$L = k_d I max(0, n \cdot l) + k_s I max(0, n \cdot h)^p$$



Specular

- Lambertian
  - view independent
- Blinn-Phong
  - view dependent

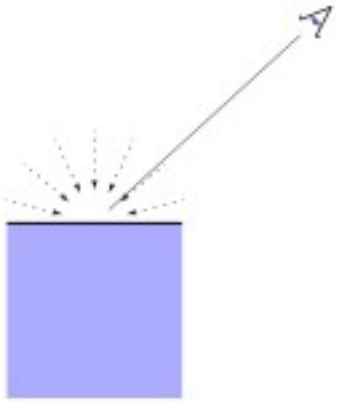


Ambient

- Independent of everything
  - add constant color
  - fill in black shadows

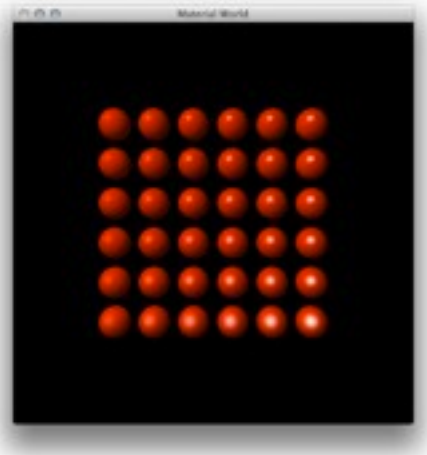
$$L_a = k_a I_a$$

- L_a - reflected ambient light
- k_a - ambient coefficient



- Ambient + diffuse + specular

$$L = L_a + L_d + L_s$$
$$= k_a I_a + k_d I \max(0, \mathbf{n} \cdot \mathbf{l}) + k_s I \max(0, \mathbf{n} \cdot \mathbf{h})^p$$



Demo

- Your task
  - Create a 5x5x5 array of spheres
  - Modify specular, diffuse, and ambient properties along each axis
  - In DropBox create a folder named "ClassWork" and submit a screenshot of your spheres