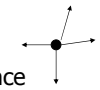
Light Sources (1)

- Illuminates other objects
- Direction is important
- For modeling purposes, a material may be *emissive* without being a light source
- Point source – all directions
  - Sun, light bulb, etc.
  - Treatment may depend on distance
    - E.g., the sun is not a point source on the earth



1

Light Sources (2)

- Spotlights
  - Subset of point sources
  - Angle of source is limited
  - May be brighter at the center

- Distributed source – uniform direction
  - E.g., fluorescent
  - May just be large relative to scene
  - Distance may make all rays look parallel

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Ambient Light

- General background illumination
  - Light without obvious source or direction
    - Multiple reflections from other objects
- General brightness in a scene
- Denoted by I_a

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Diffuse Reflection

- All objects reflect and scatter incident light
- Objects differ in brightness
  - Even under the same illumination
- Diffuse model
  - Light is reflected and absorbed
  - Surface coefficient $0 \le k_d \le 1$
  - $I_{ambdiff} = k_d I_a$

Shiny

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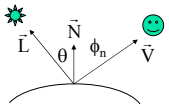
Diffuse Reflection from Light Sources

- Lambertian/Ideal model
- Intensity depends on
  - Source Intensity: I_l
  - Diffusion Coefficient: k_d
  - Source Position



$$I_{viewed} = k_d I_l \cos\theta$$
$$I_{viewed} = k_d I_l (\hat{N} \cdot \hat{L})$$

Not a function of φ_n

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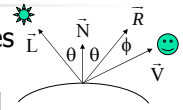
Specular Reflection

- Shiny or reflective surfaces
  - E.g., polished metal
- Light is narrowly reflected
- If the observer varies from the reflection
  - Little illumination is seen
  - Unless diffuse or ambient reflection is included



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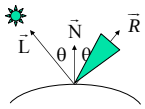
Phong Model (1)

- Mixes specular reflection with diffusion
- Control reflection in a cone
  - About the ideal reflection
  - Use a factor: n_s
    - $n_s \rightarrow \infty$ Ideal reflector
    - $n_s \rightarrow 1$ Diffuse reflector
  - Often called a specular highlight



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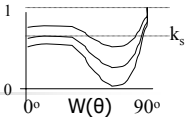
Phong Model (2)

- $I_{spec} = W(\theta) I_l [\cos\varphi]^{n_s}$
- Sometimes $W(\theta) = k_s$

$$I_{spec} = k_s I_l \left[\hat{V} \cdot \hat{R}\right]^{n_s}$$

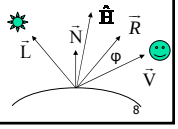
$$\hat{R} = (2\hat{N} \cdot \hat{L})\hat{N} - \hat{L}$$

- Half-Way vector simplification
  - Not equivalent; approximate
  - Efficiency: H constant when source/viewer are far
  - Orienting N to H would give maximum specular reflection



$$\hat{H} = \frac{\hat{L} + \hat{V}}{\left|\hat{L} + \hat{V}\right|}$$

$$I_{spec} = k_s I_l \left[\hat{N} \cdot \hat{H}\right]^{n_s}$$



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Attenuation

- Intensity declines with distance in a point source

$$I \propto \frac{1}{d^2}$$

- Typical model

$$I \propto \frac{1}{a_0 + a_1 d + a_2 d^2}$$

Smoother drop-off, acts more like a source with volume.

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Color

- Straightforward extension
- Each surface has 3 reflectivity coefficients
  - Red, Green, Blue
- Each source has 3 intensities
  - Red, Green, Blue
- NOTE: A human eye's cone cells have Red, Green, and Blue pigments

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Multiple Sources

- Independent using superposition
- Net effect: Visible color is
  - emissive color +
  - general ambient color +
  - For each source
    - Ambient, diffuse, and specular components
    - Adjusted for position and attenuation

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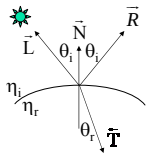
Transparent Surfaces

- Reflection and refraction
- Transparency factor k_t



$$\sin\theta_r = \frac{\eta_i}{\eta_r}\sin\theta_i$$

$$\vec{T} = \left(\frac{\eta_i}{\eta_r}\cos\theta_i - \cos\theta_r\right)\vec{N} - \frac{\eta_i}{\eta_r}\vec{L}$$

HB2: p. 510; HB3: p. 577

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