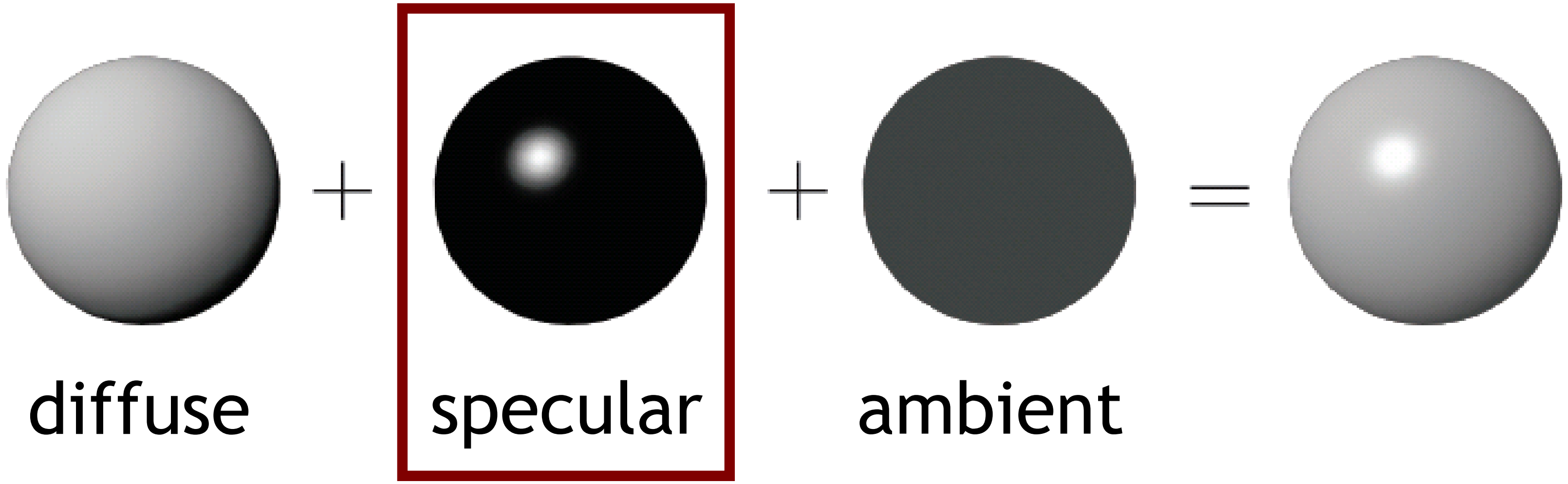
CMSC427
L08P4: Shading Local Models - Specular

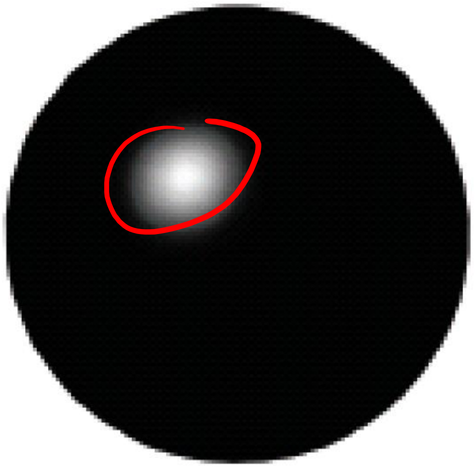
Credit: slides from Dr. Zwicker

Simplified model



Specular reflection

- Shiny or glossy surfaces
  - Polished metal
  - Glossy car finish
  - Plastics
- Specular highlight
  - Blurred reflection of the light source
  - Position of highlight depends on viewing direction



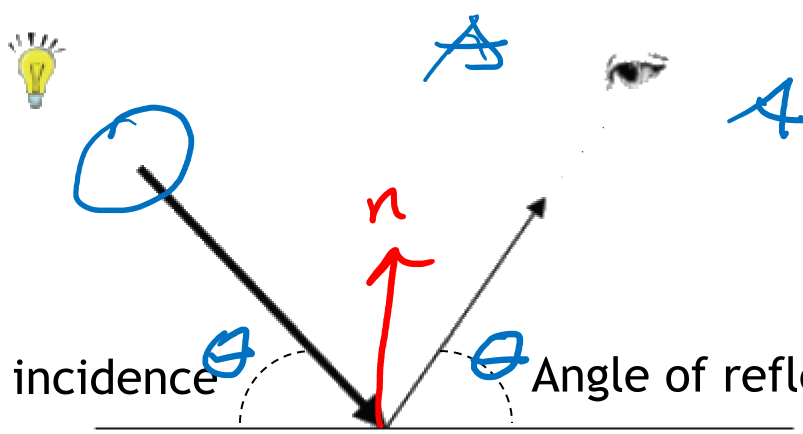
Sphere with specular highlight

Shiny or glossy materials

white

Specular reflection

- Ideal specular reflection is mirror reflection
  - Perfectly smooth surface
  - Incoming light ray is bounced in single direction
  - Angle of incidence equals angle of reflection



Angle of incidence

Angle of reflection

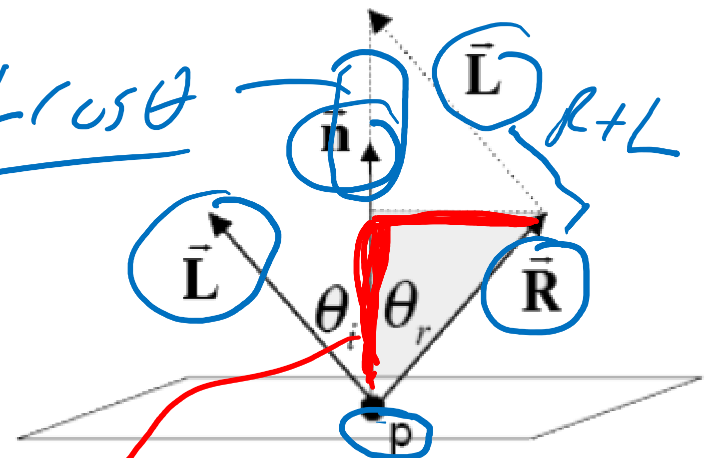
Law of reflection

- "Angle of incidence equals angle of reflection" applied to 3D vectors **L** and **R**
- Equation expresses constraints:
  1. Normal, incident, and reflected direction all in same plane (**L**+**R** is a point along the normal)
  2. Angle of incidence θ_i = angle of reflection θ_r

$$\vec{\mathbf{R}} + \vec{\mathbf{L}} = 2\cos\theta\ \vec{\mathbf{n}} = 2\left(\vec{\mathbf{L}}\cdot\vec{\mathbf{n}}\right)\vec{\mathbf{n}}$$

$$\vec{\mathbf{R}} = 2\left(\vec{\mathbf{L}}\cdot\vec{\mathbf{n}}\right)\vec{\mathbf{n}} - \vec{\mathbf{L}}$$

project R onto $\vec{n}$



$$\theta_r = \theta_i$$

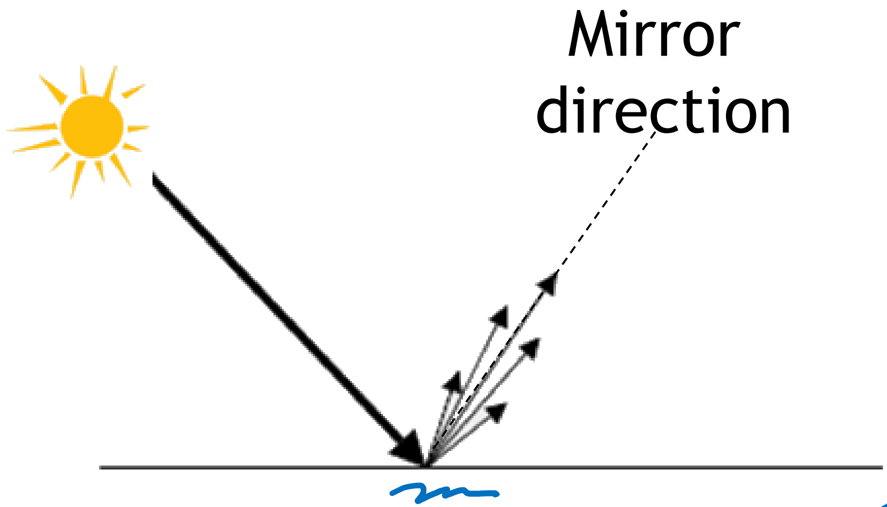
$R \sim f(\vec{n}, \vec{L})$

$|R| = |L| = |n| = 1$

$R\cos\theta = L\cos\theta$

Glossy materials

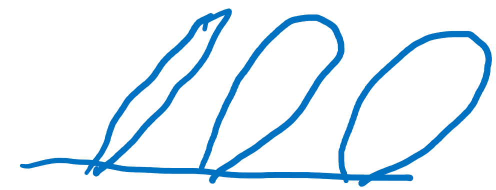
- Many materials not quite perfect mirrors
- Glossy materials have blurry reflection of light source



Glossy teapot with highlights from many light sources

Physical model

- Assume surface composed of small mirrors with random orientation (microfacets)
- Smooth surfaces
  - Microfacet normals close to surface normal
  - Sharp highlights
- Rough surfaces
  - Microfacet normals vary strongly
  - Leads to blurry highlight

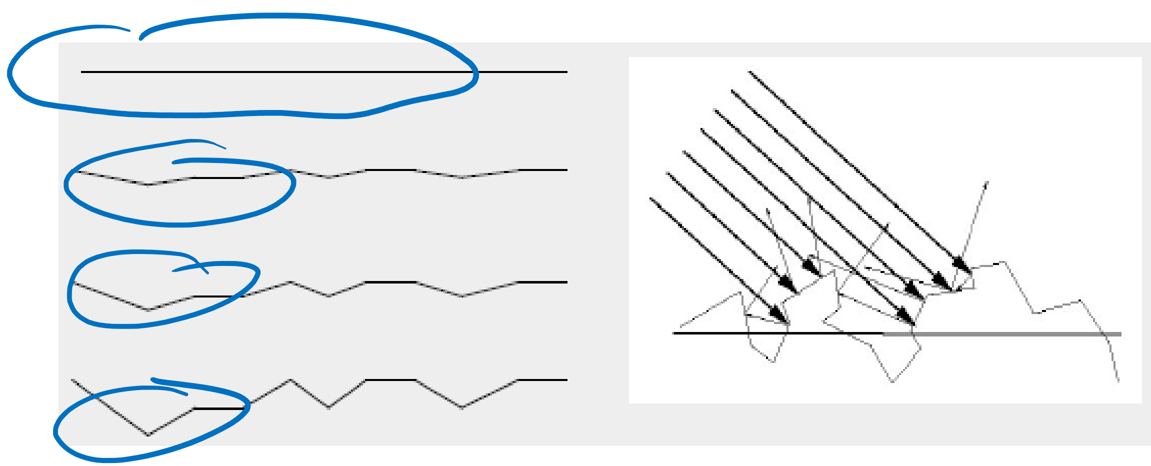


Polished

Smooth

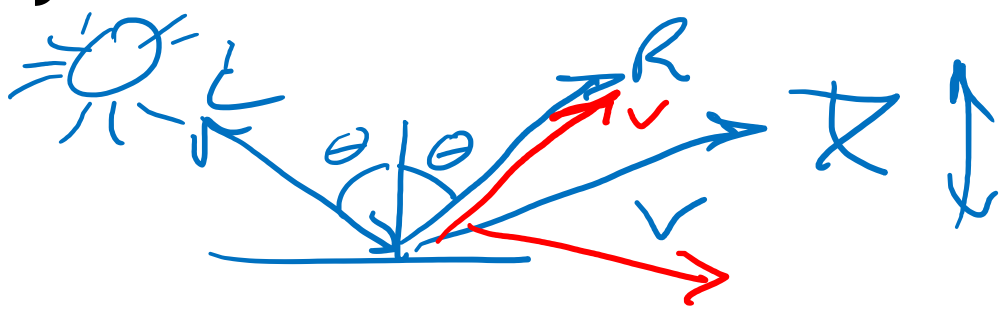
Rough

Very rough



Physical model

- Expect most light to be reflected in mirror direction
- Because of microfacets, some light is reflected slightly off ideal reflection direction

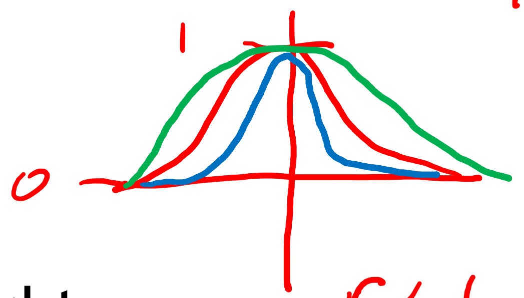


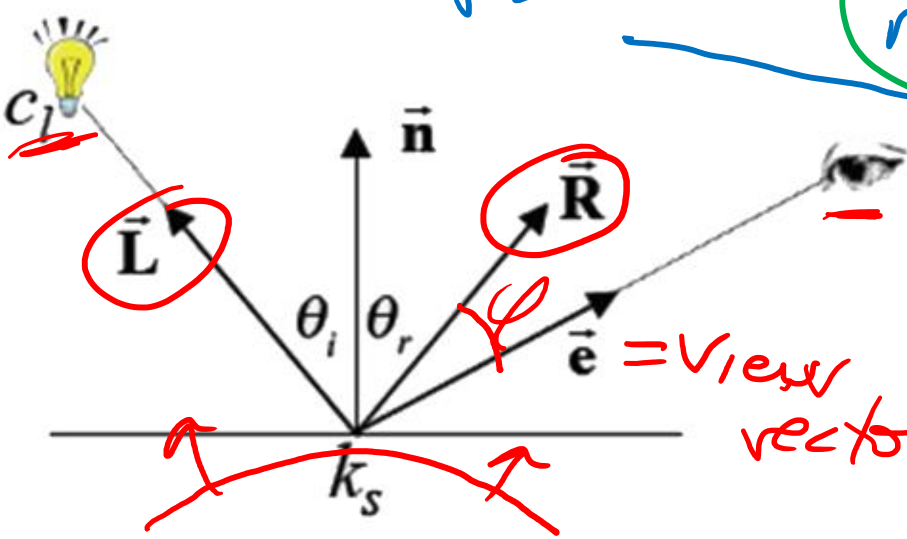
- Reflection
  - Brightest when view vector is aligned with reflection
  - Decreases as angle between view vector and reflection direction increases

Phong model

http://en.wikipedia.org/wiki/Phong_shading

- Simple “implementation” of the physical model
- Radiance of light source c_l
- Specular reflectance coefficient k_s
- Phong exponent p
  - Higher p, smaller (sharper) highlight





Reflected radiance

$$c = c_l k_s \left(\mathbf{R} \cdot \mathbf{e}\right)^p$$

Note

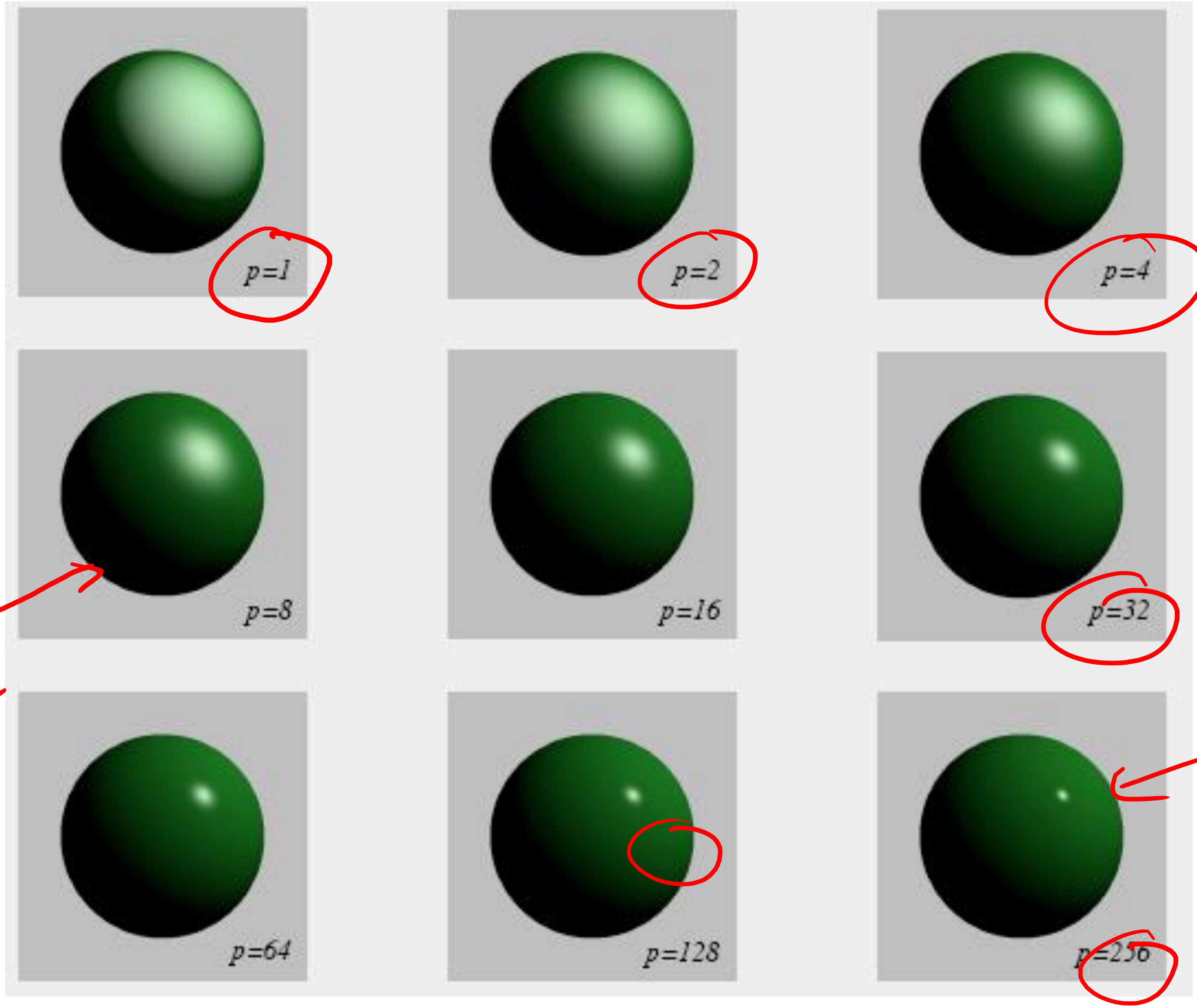
- Technically, Phong „BRDF“ is

$$c = \underbrace{c_l \cancel{(\mathbf{n} \cdot \mathbf{L})}}_{\text{Irradiance}} \underbrace{\frac{k_s (\mathbf{R} \cdot \mathbf{e})^p}{\cancel{\mathbf{n} \cdot \mathbf{L}}}}_{\text{„BRDF“}}$$

- Phong model is not usually considered a BRDF, because it violates energy conservation

http://en.wikipedia.org/wiki/Bidirectional_reflectance_distribution_function#Physically_based_BRDFs

Phong model



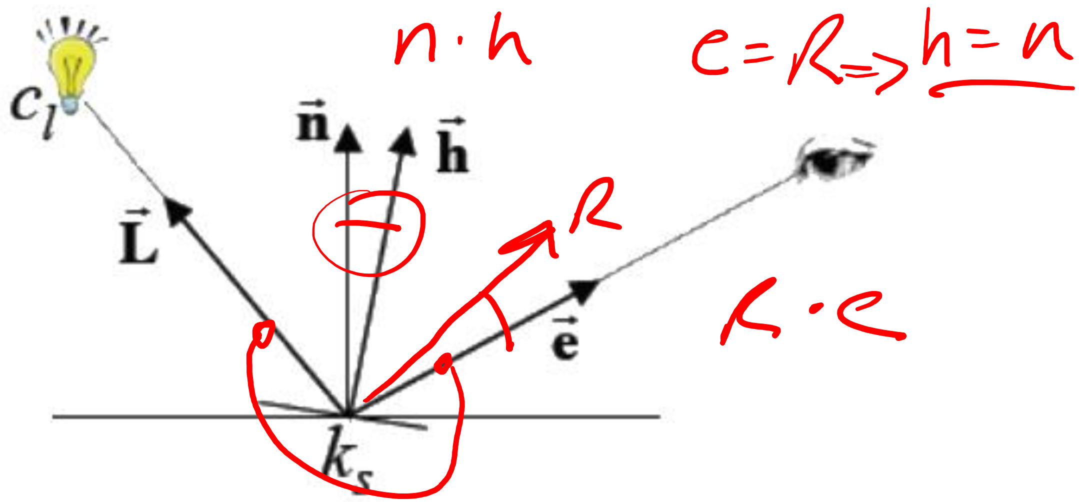
blach

Blinn model (Jim Blinn, 1977)

- Alternative to Phong model
- Define unit halfway vector

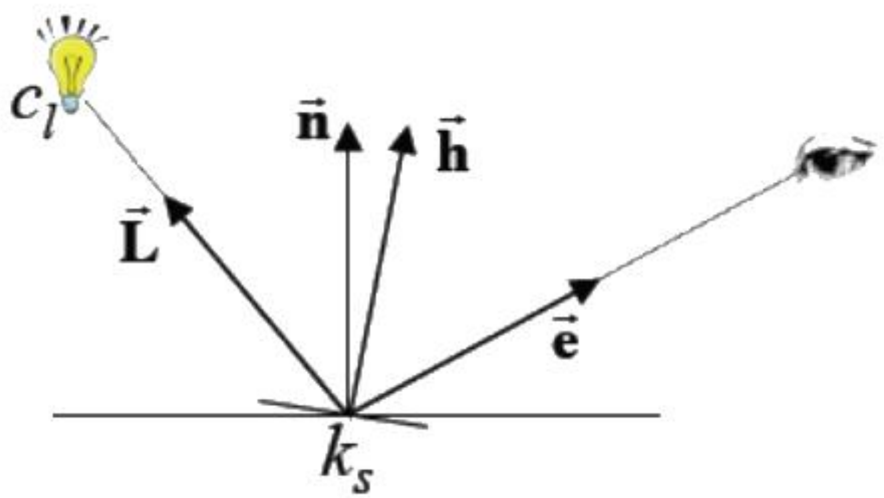
$$\mathbf{h} = \frac{\mathbf{L} + \mathbf{e}}{\|\mathbf{L} + \mathbf{e}\|}$$

- Halfway vector represents normal of microfacet that would lead to mirror reflection to the eye



Blinn model

- The larger the angle between microfacet orientation and normal, the less likely
- Use cosine of angle between them
- Shininess parameter s
- Very similar to Phong



Reflected radiance

$$c = c_l k_s \left(\mathbf{h} \cdot \mathbf{n}\right)^s$$