Lambertian surfaces and albedo

- We will refer later to "radiosity" as a unit to describe light leaving the surface taken as whole
  - Technically, it is the total power leaving a point on the surface, per unit area on the surface (Wm^{-2})
- Recall that for a Lambertian surface, the direction that light leaves is irrelevant (because it is uniform).
- Percentage of light leaving the surface compared with that falling onto it, is often called diffuse reflectance, or *albedo* for a Lambertian surface.

Lambertian surfaces

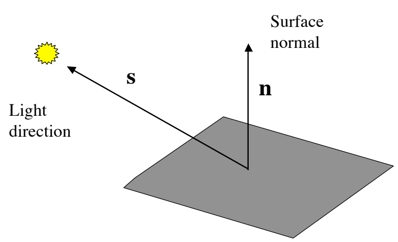
The Lambertian assumption leads to very simple rule to shade an object. Specifically, we attenuate brightness by

$$\mathbf{n} \cdot \mathbf{s}$$

Surface normal ↗ (n) Light source direction ↖ (s)

Must know this

Lambertian Reflection



Brightness is proportional to **n•s**

Comments on light source direction

The direction to a nearby light changes as you move around in the scene.

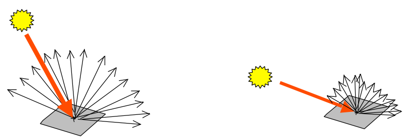
If we say a light source is "at infinity", we mean that it is so far away that only the direction is important.

Example: On the scale of a city, the sun is at infinity.

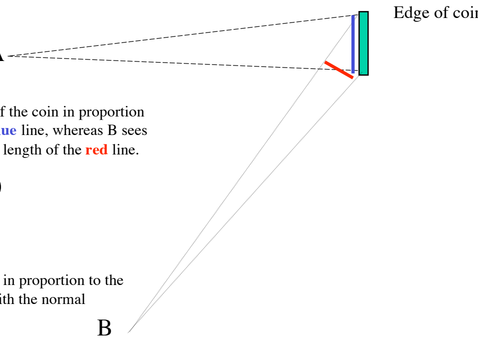
Lambertian Reflection

Why is brightness proportional to **n•s** ?

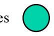
Intuitive argument: The surface scatters light in all directions equally, but as the angle of the light becomes oblique, the amount of light per unit area is reduced (foreshortening) by a factor of the cosine of the angle.



Foreshortening illustrated



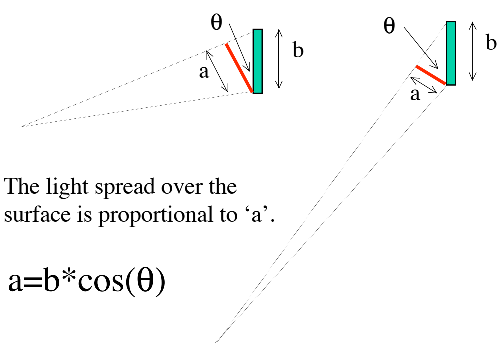
A sees the diameter of the coin in proportion to the length of the **blue** line, whereas B sees it in proportion to the length of the **red** line.

Further, A sees 

But B sees 

The foreshortening is in proportion to the cosine of the angle with the normal (next slide)

Foreshortening illustrated

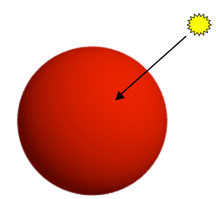


The light spread over the surface is proportional to ‘a’.

$a=b*\cos(\theta)$

Lambertian surfaces

- Surface brightness is only a function of the foreshortening of the incident light (the more oblique it is, the less bright the surface).



Lambertian Reflection

Most the world is not Lambertian

Lambertian assumption failures

Rough surfaces--important example--the moon is not Lambertian

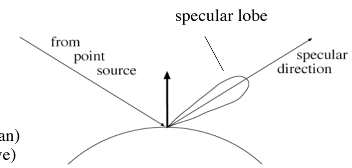
Dielectrics (plastics, many paints)

Metallic surfaces

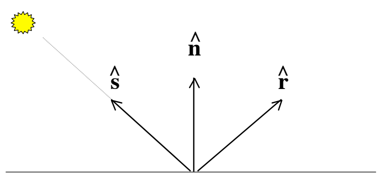
Skin

Specular surfaces

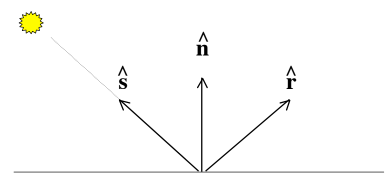
- Another important class of surfaces is specular (mirror-like).
  - specular surfaces reflect a significant amount of energy in the specular (mirror) direction
  - produces “highlights”
- Two related cases
  - a perfect mirror
  - a fuzzy mirror
- Typically there is a diffuse (Lambertian) component as well (effects are additive)



Computing reflection (specular) direction



Computing reflection (specular) direction



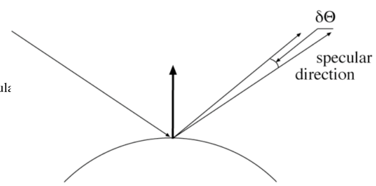
$\hat{\mathbf{s}} + \hat{\mathbf{r}} = k\hat{\mathbf{n}}$ and $\hat{\mathbf{n}} \bullet \hat{\mathbf{s}} = \hat{\mathbf{n}} \bullet \hat{\mathbf{r}}$

$\hat{\mathbf{n}} \bullet \hat{\mathbf{s}} + \hat{\mathbf{n}} \bullet \hat{\mathbf{r}} = k \Rightarrow k = \mathbf{2}\hat{\mathbf{n}} \bullet \hat{\mathbf{s}}$

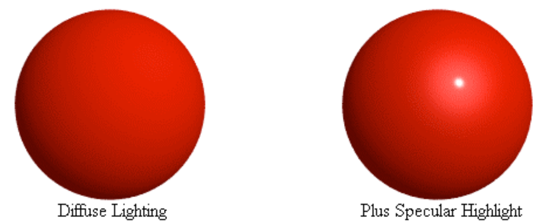
So $\hat{\mathbf{r}} = \mathbf{2}(\hat{\mathbf{n}} \bullet \hat{\mathbf{s}})\hat{\mathbf{n}} - \hat{\mathbf{s}}$

Phong's model of specularities

- There are very few cases where the exact shape of the specular lobe matters.
- Typically:
  - very, very small --- mirror
  - small -- blurry mirror
  - bigger -- see only light sources as "specula
  - very big -- faint specularities
- Phong's model
  - reflected energy falls off with



$$\cos^n(\delta\vartheta)$$



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