ISTA 352

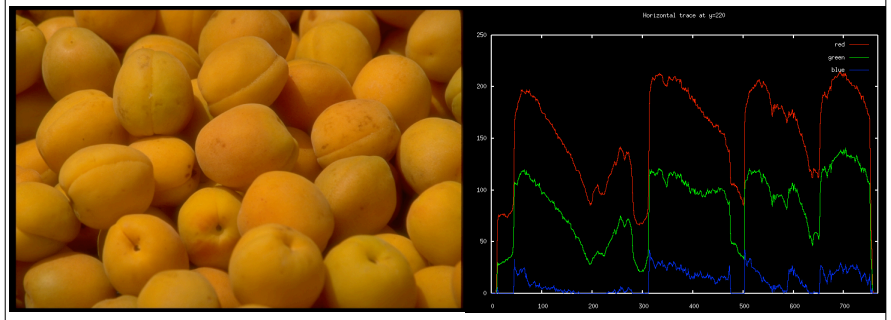
Lecture 24

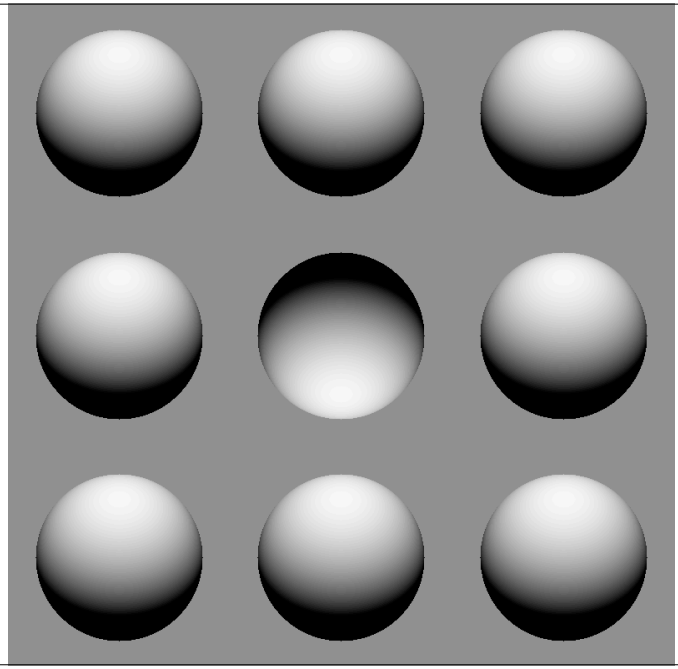
Light interacting with the world

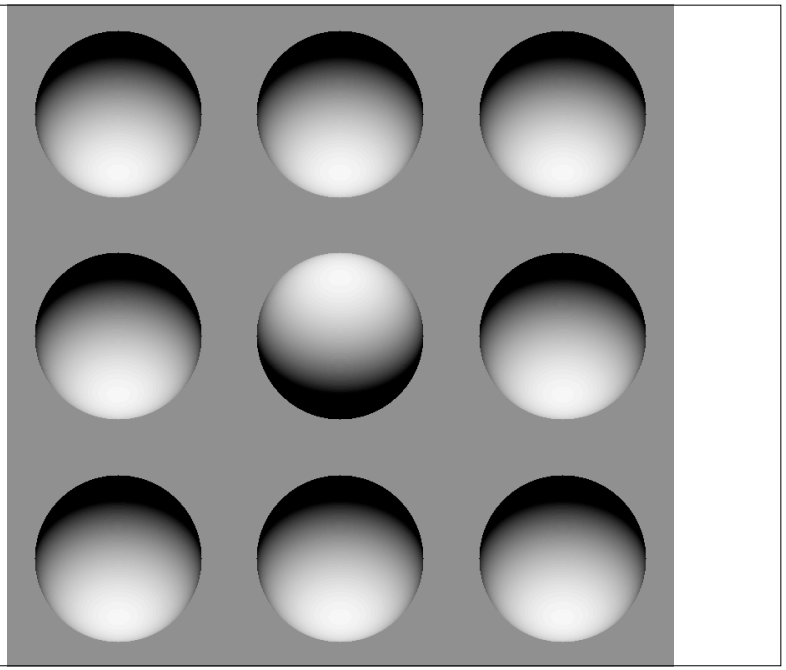
Administrivia

- I will accept questions for the bonus assignment through the weekend. (We are late getting the video up).
- Homework 3B due Sunday Oct 21

Interpreting shading

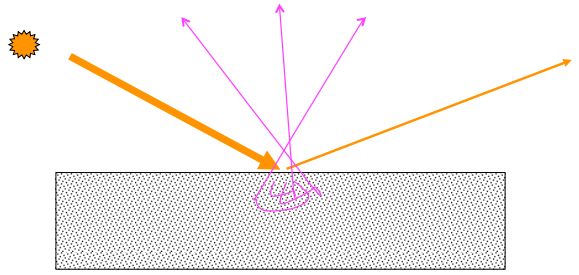






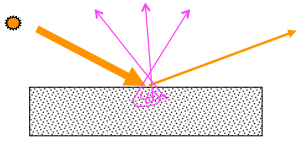
Light interacting with the world

- The light captured by camera caries information about what is in the world **because** what is in the world interacts with it differently depending on 1) surface properties; and 2) geometry.
- Many effects when light strikes a surface. It could be:
  - absorbed
  - transmitted
  - reflected
  - scattered (in a variety of directions!)



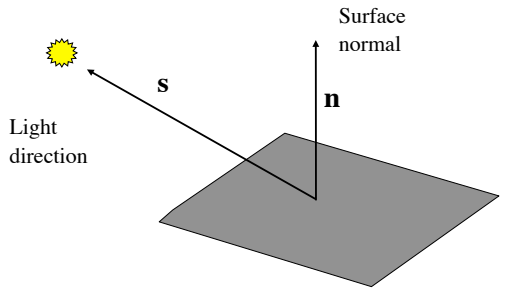
Lambertian surfaces

- Simple special case of reflectance: ideal diffuse or matte surface--e.g. cotton cloth, matte paper.
- Surface appearance is independent of viewing angle.
- Typically such a surface is the result of lots of scattering---the light "forgets" where it came from, and it could end up going in any random direction.



- What counts is how much light power reaches the surface

Lambertian Reflection

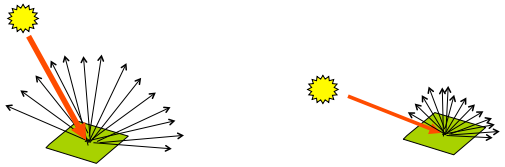


Brightness is proportional to **n•s**

Lambertian Reflection

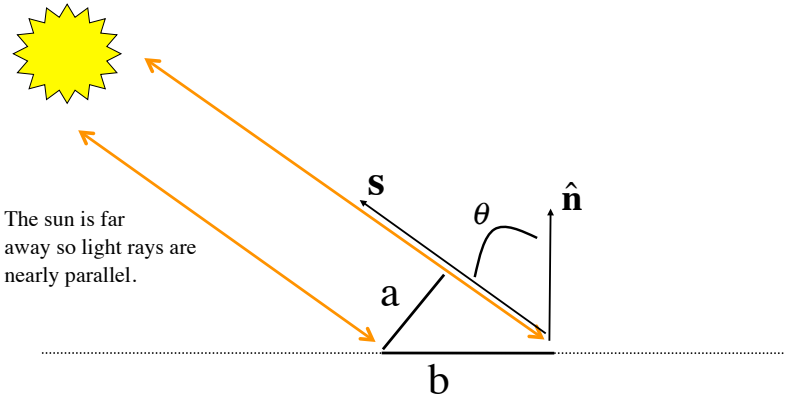
Why is brightness proportional to **n•s** ?

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 received is reduced (foreshortened) by a factor of the cosine of the angle.



The same light spread over a, giving intensity, i_a, is also spread over b, giving intensity, i_b. This means that:

$$a \bullet i_a = b \bullet i_b$$

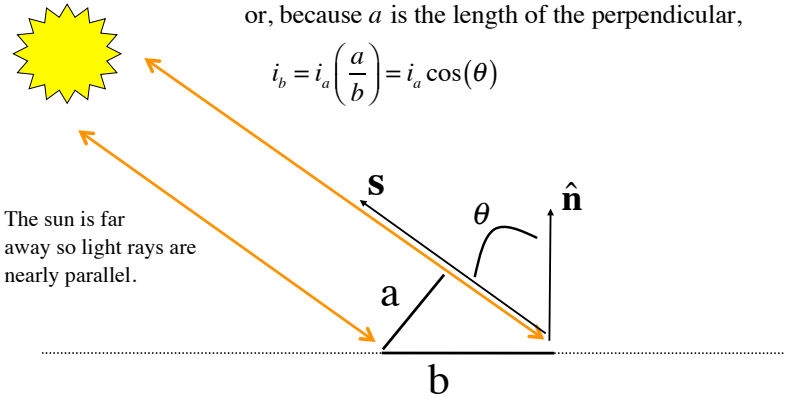


The same light spread over a, giving intensity, i_a, is also spread over b, giving intensity, i_b. This means that:

$$a \bullet i_a = b \bullet i_b$$

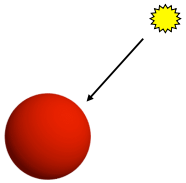
or, because a is the length of the perpendicular,

$$i_b = i_a\left(\frac{a}{b}\right) = i_a \cos(\theta)$$



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).

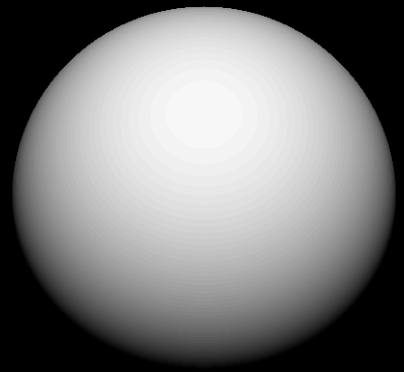


Sun is in front of page--I don't know how to draw that!

- Question: Is the moon a Lambertian reflector?

The moon
Distant light source (sun)

Lambertian reflection
Distant light source

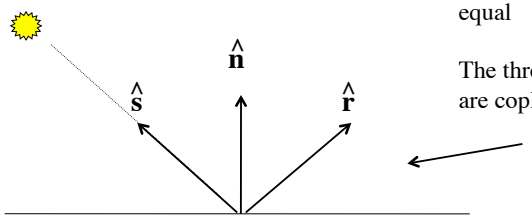


Ideal Mirrors

The opposite extreme case from Lambertian is a mirror.

Instead of going every way equally, the reflected light goes exactly one way.

Reflection Direction



The two angles are equal

The three vectors are coplanar!

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

multiplying both sides by $\mathbf{n}$

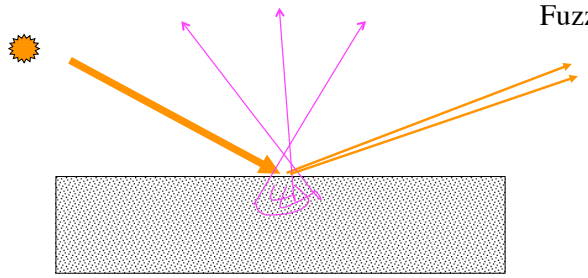
$$\hat{\mathbf{n}} \bullet \hat{\mathbf{s}} + \hat{\mathbf{n}} \bullet \mathbf{r} = k \implies k = 2\hat{\mathbf{n}} \bullet \hat{\mathbf{s}}$$

plug k into first formula.

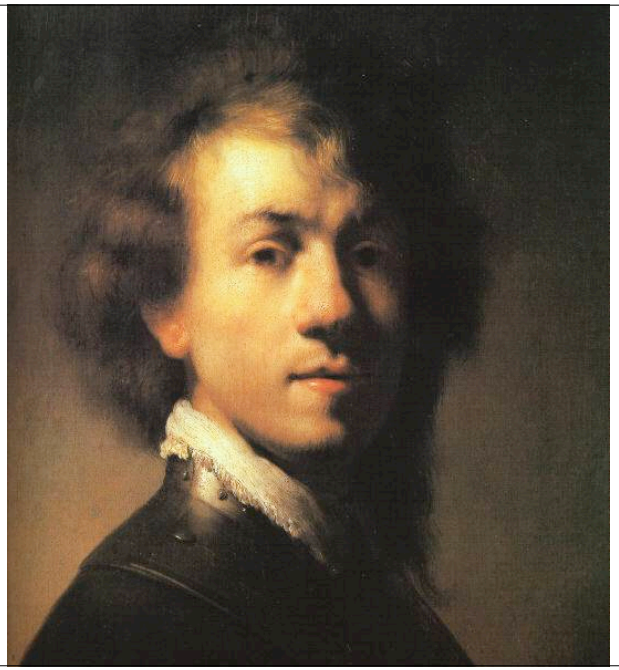
$$So \quad \hat{\mathbf{r}} = 2(\hat{\mathbf{n}} \bullet \hat{\mathbf{s}})\hat{\mathbf{n}} - \hat{\mathbf{s}}$$

Optional--Just in case you need it for something!

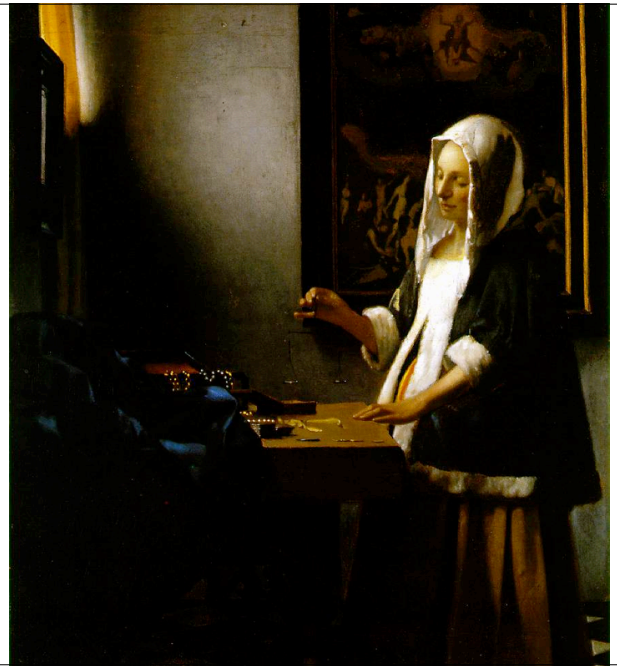
Specularities



Fuzzy mirror

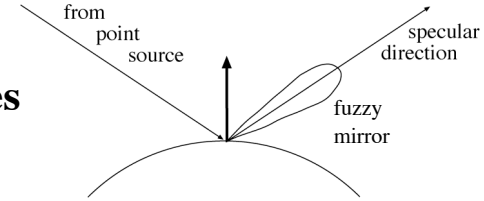


Rembrandt, *Self Portrait*
1629; Oil on canvas; The Mauritshuis, The Hague



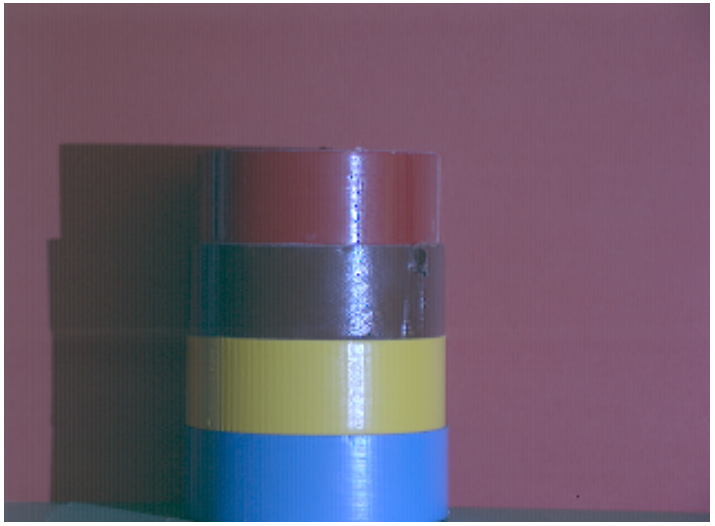
Vermeer, *Young Woman with a Water Pitcher*
c. 1664-65;

Specular surfaces



- Important point: The specular part of the reflected light usually carries the color of the **light**
- Technically, this is the case for dielectrics--plastics, paints, glass.
- Important exception is metals (e.g. gold, copper)

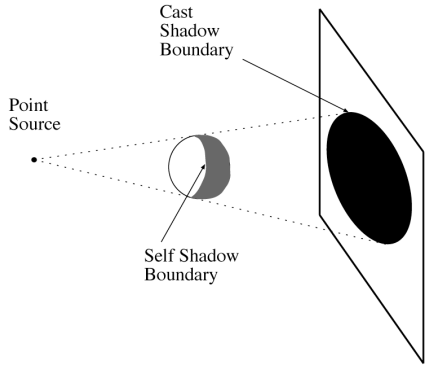
Dielectric Specularities



Shadows

Shadows cast by a point source

- A point that can't see the source is in its shadow
- For point sources, the geometry is simple
- For extended sources, we have an **umbra** (points seeing no light), and a **penumbra** (seeing some parts of the light but not all)



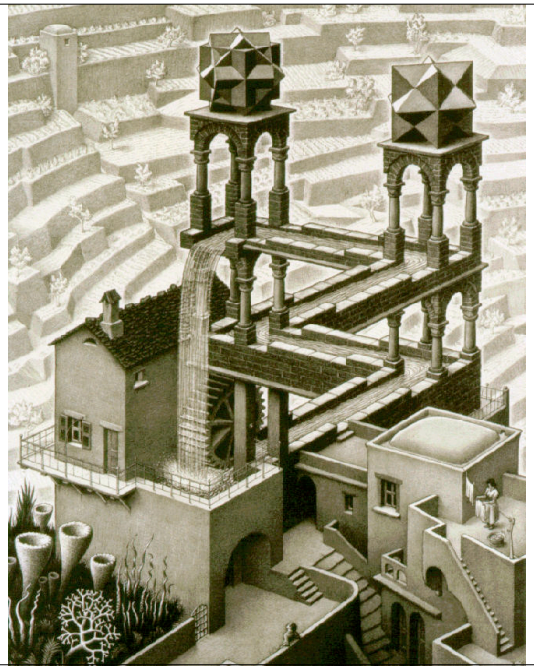
The Shadow Identification Problem

Shadows in paintings

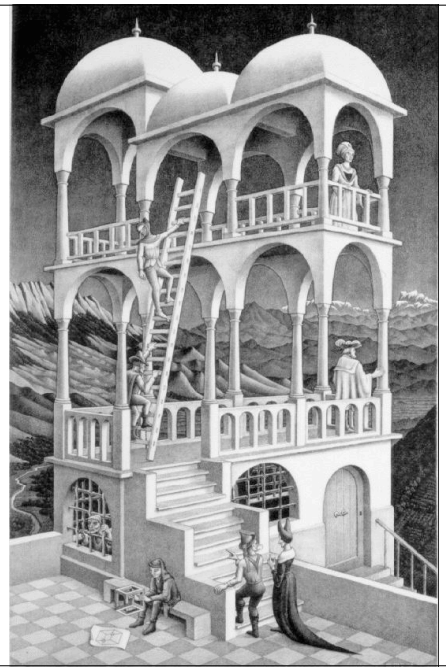
Shadows in paintings

- Shadows help the 3D illusion a lot, but they need not be mathematically correct or consistent
- The human vision system uses shadows as cues, but does not seem to care much about global consistency
  - Perhaps too hard to compute to evolve?
  - Evolving to be able to verify that the real world is "real" might not make a lot of sense
  - Figuring out why shadows are where they are, or whether they are missing, as an exercise can be hard (try it at home!)

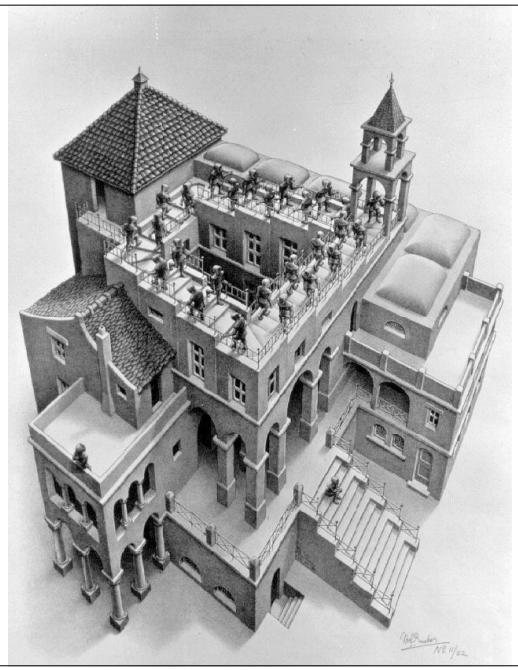
More examples of locally reasonable, globally inconsistent



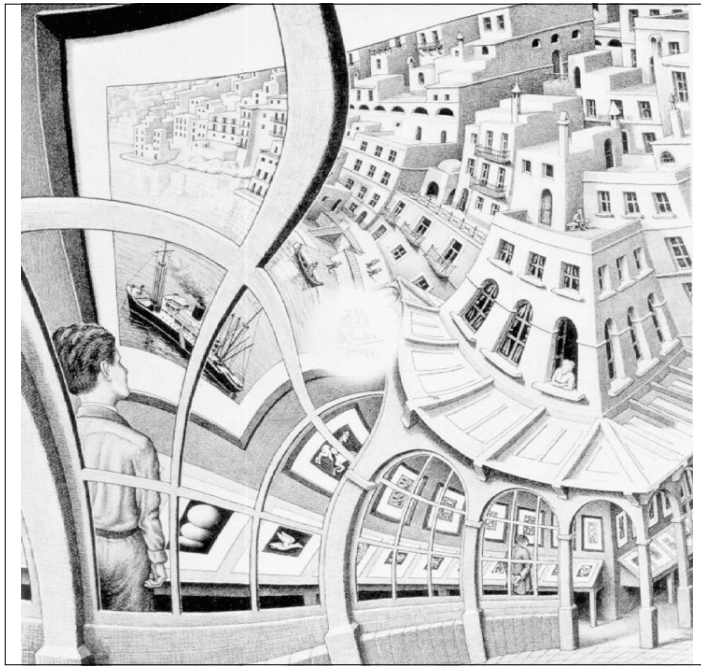
M.C.Escher,
Waterfall, 1961



M.C.Esher, *Belvedere*, 1960



M.C.Esher, *Ascending and Descending*, 1960



M.C.Esher, *Print Gallery*, 1956