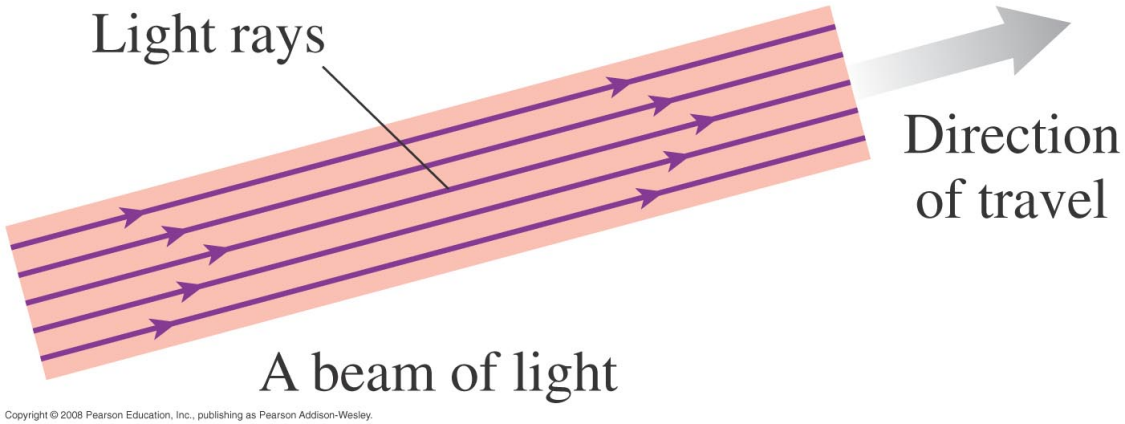
Ray Optics

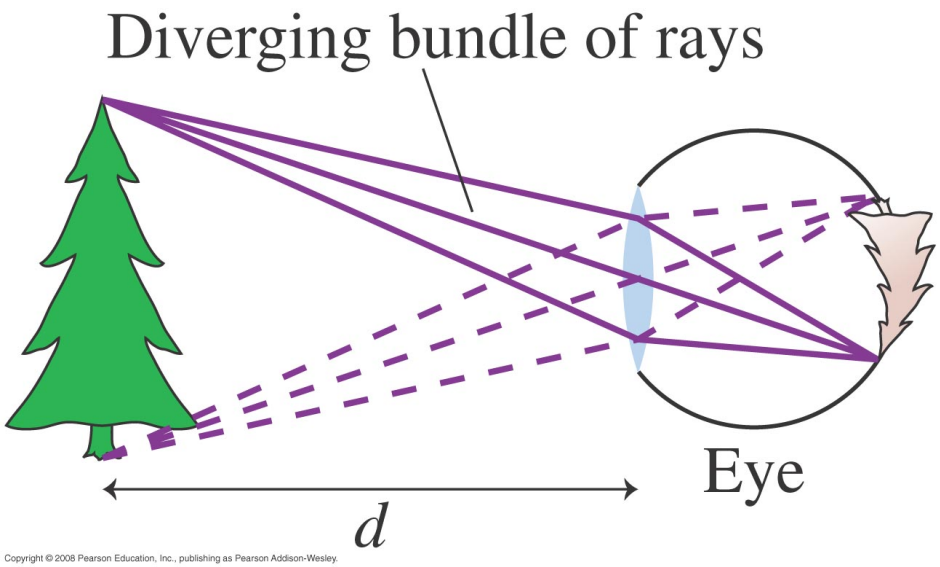


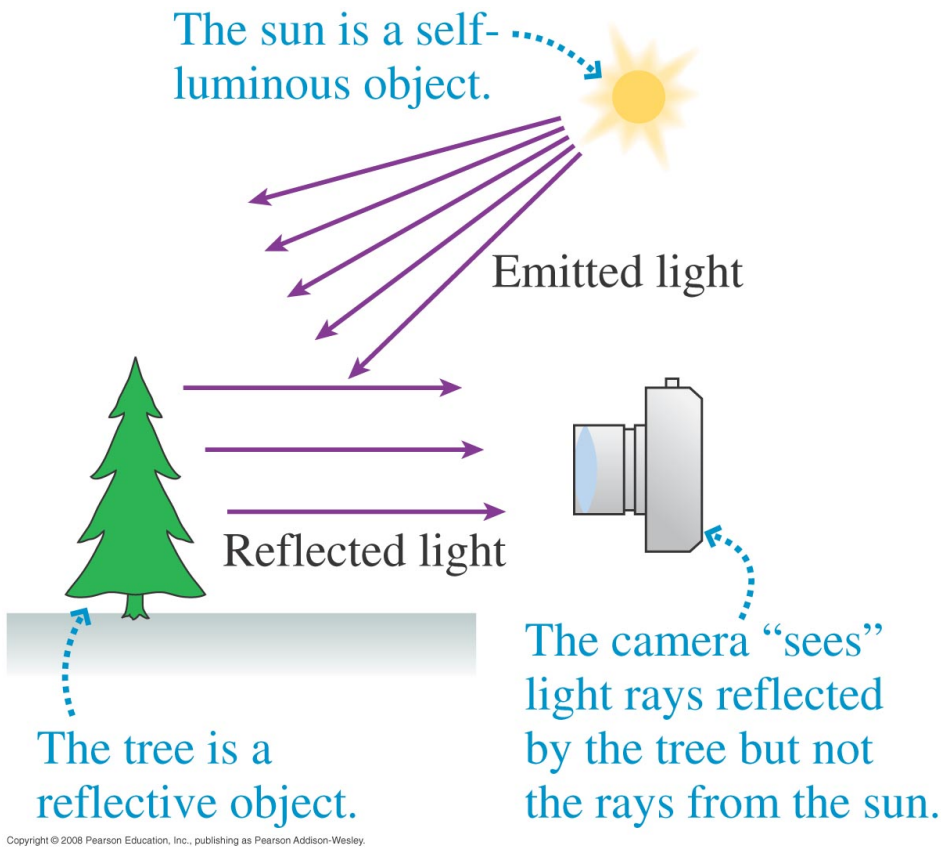
The Ray Model of Light - Chapter 23

When apertures are big ($> 1mm$), light travels in a straight line. A light ray is a line in a direction along which light energy is flowing. It is an idea, not a thing. Some properties:

- Light rays travel in straight lines
- Light rays can cross
- Light rays travel forever unless they interact with matter
- An object is a source of light rays

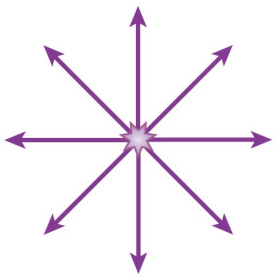
Seeing Objects



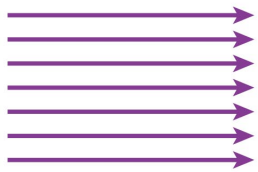


You can see an object because it either produces its own light (eg. the sun) or reflects light. The diverging bundles of rays are then focused by a lens onto your retina and your brain turns the pattern into an image.

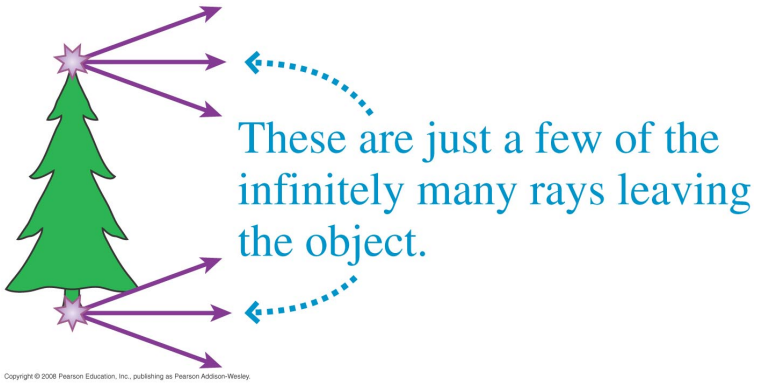
Ray Diagrams



Point source

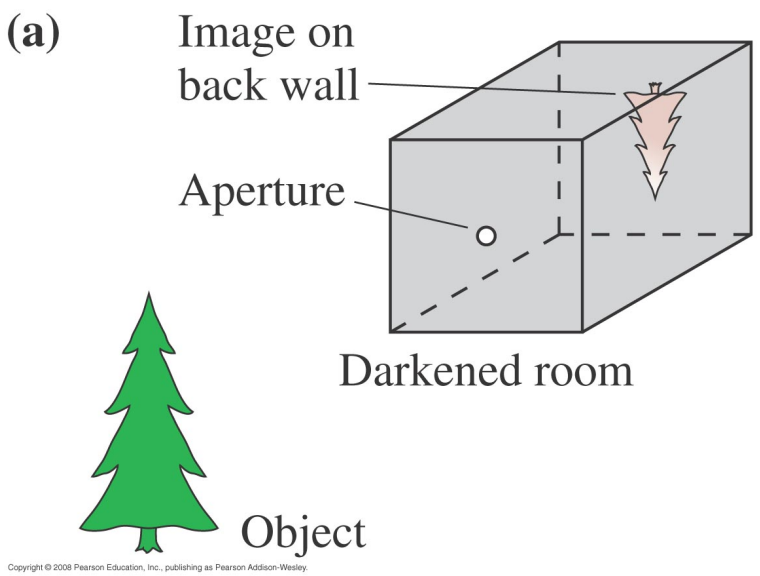


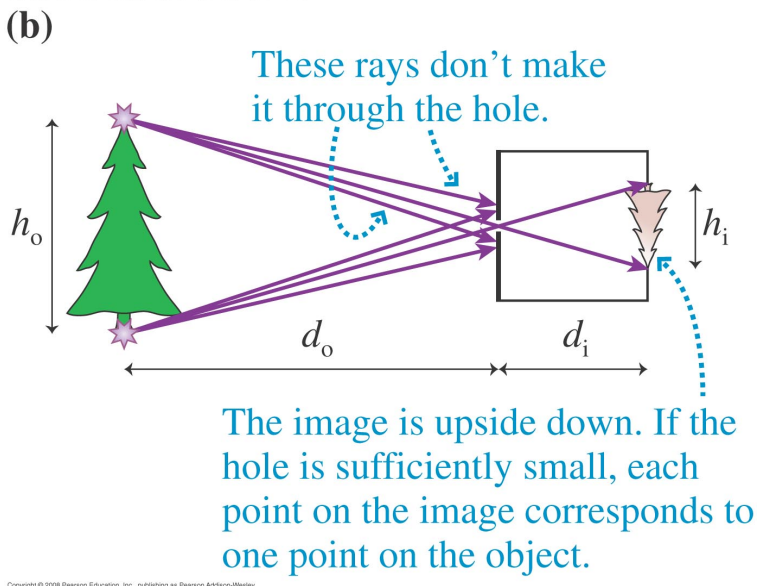
Parallel bundle



- Divergent rays from a point source are emitted in all directions.
- A parallel bundle of rays could be from a laser beam or just a very distant object (eg. star).
- A ray diagram is a simplification in which we draw just a few representative rays.
- We use a ray diagram to figure out the size, orientation, etc. of an image. Please remember that it is just a simplification, not the whole picture....

Apertures

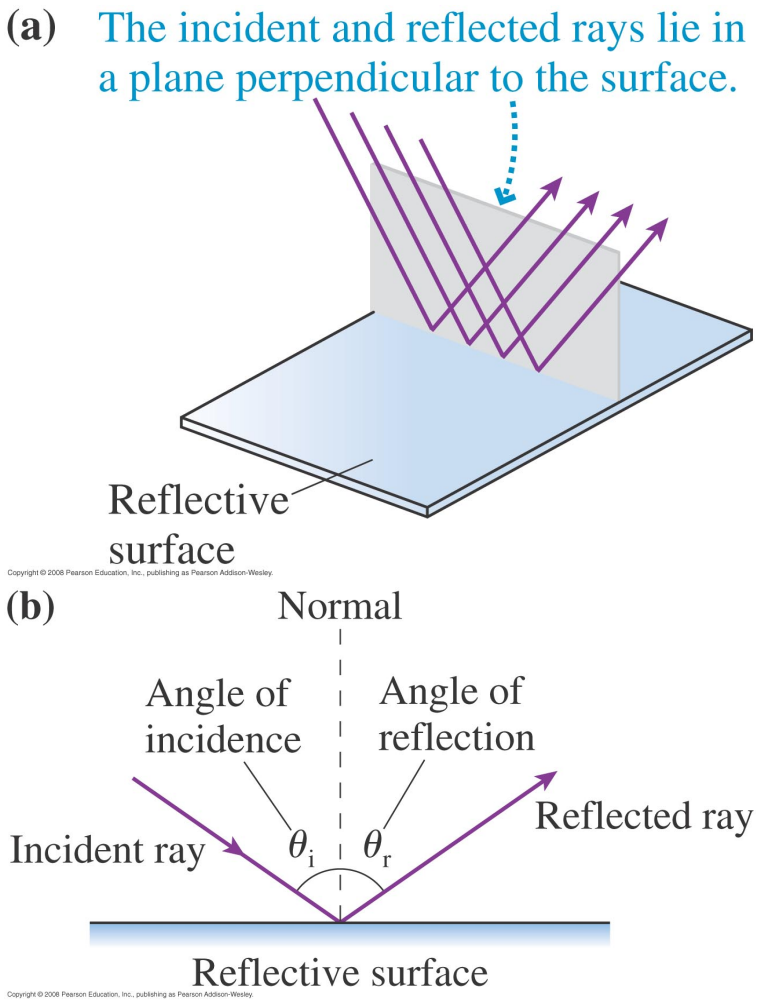




- A camera obscura is an example of what happens when light passes through a circular aperture.
- We can understand what is going on with a simple ray diagram.
- Each point on the object is reflecting light rays, but most are blocked.
- The geometry shows us that the image will be upside-down.
- The aperture allows rays from the same point to enter at slightly different angles (fuzzy image).
- The image heights go like:

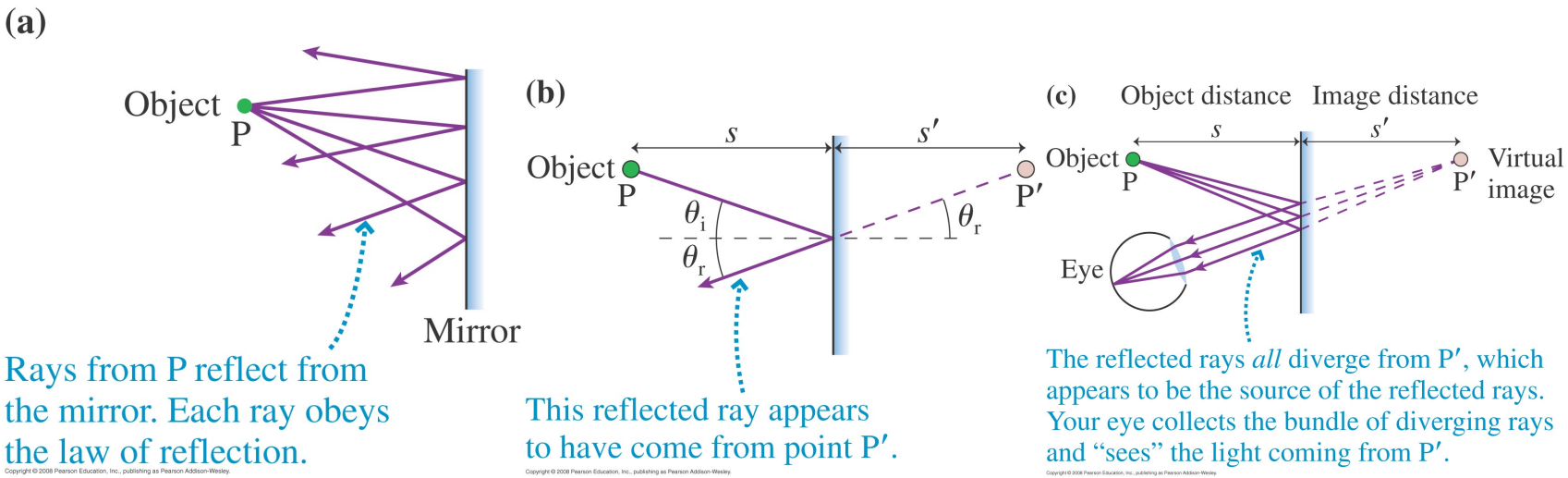
$$\frac{h_i}{h_o} = \frac{d_i}{d_o}$$

Reflection



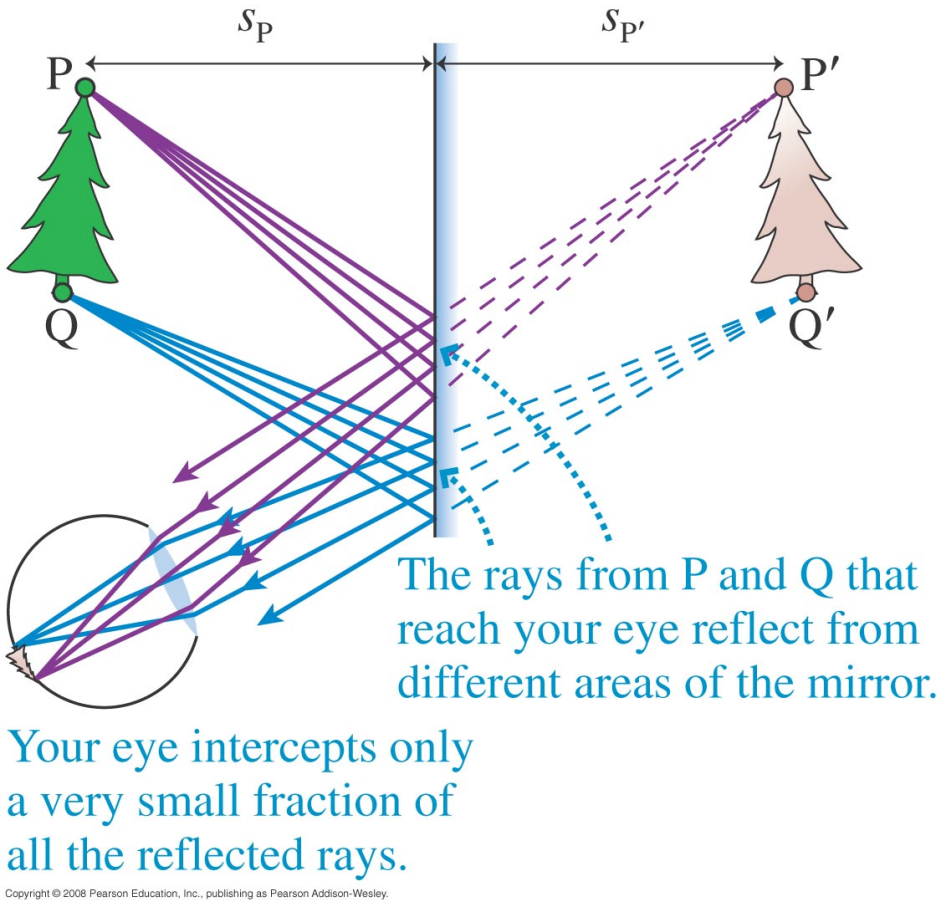
- Reflection from a mirror is called specular reflection
- Incident and reflected rays lie in a plane perpendicular to the surface.
- Lower-left: a single ray represents a bundle of parallel rays "stacked" behind one another.
- The angle of incidence (θ_i) is the angle between the incoming ray and a line perpendicular to the surface.
- The angle of reflection (θ_r) is the angle between the reflected ray and a line perpendicular to the surface.
- The incident and reflected rays are in the same plane and $\theta_i = \theta_r$

The Plane Mirror



- Every ray from point *P* gets reflected such that $\theta_r = \theta_i$
- All of the rays from point *P* that reach your eye appear to come from point *P′*
- The mirror forms a virtual image of point *P* at *P′*

An Extended Object in a Plane Mirror

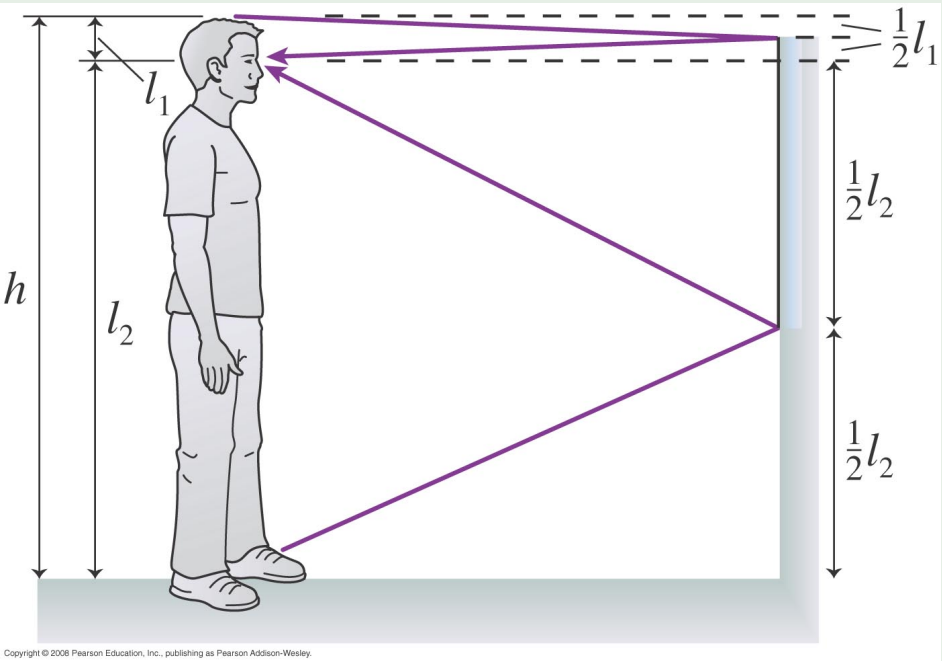


- For an extended object, each point on the object has a reflected image in the mirror.
- Rays diverge from the object and strike every point on the mirror, only a few of the rays enter your eye

How High is the Mirror?

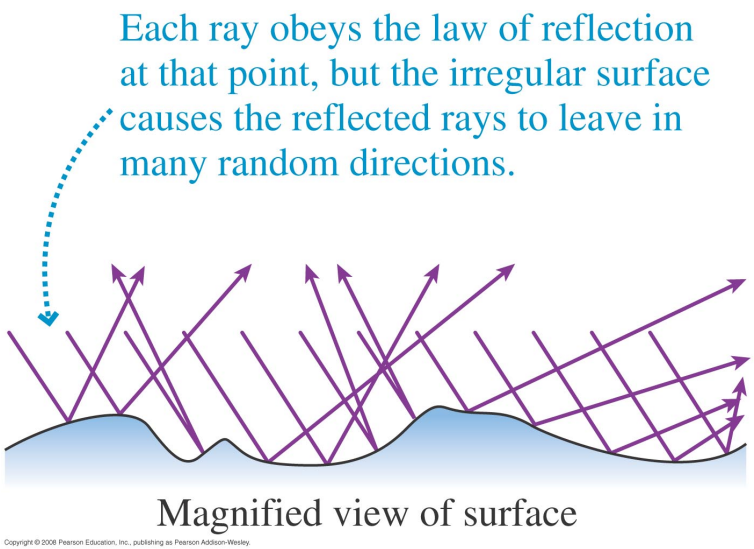
Example 23.2: How High is the Mirror?

If your height is h, what is the shortest mirror on the wall in which you can see your full image? Where must the top of the mirror be hung?



- The minimum size is $h/2$, which only works if the top of the mirror is midway between your eyes and the top of your head.
- Your distance from the mirror does not matter in answering this question!!
- Left and right is not reversed in a mirror, rather it reverses front and back!

Diffuse Reflection



- Mirrors and specular reflection are interesting. However, you see most objects around you via diffuse reflection.
- Reflection from any rough surface will be diffuse.
- The law of reflection is the same, but the surface is rough and the scattering is randomized by the surface roughness.
- Mirrors are special in that they are exceptionally smooth.