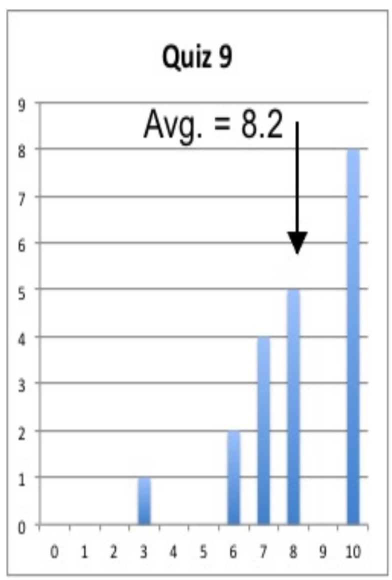
April 24, 2013 Physics 132 Prof. E. F. Redish

- **Theme Music:**
  Arvo Pärt
  Spiegel im Spiegel
  (Mirror in Mirror)

- **Cartoon:**
  Virgil Partch

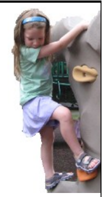
4/24/13 Physics 132 **1**

	9.1	9.2.1	9.2.2	9.3
A	0%	85%	10%	10%
B	10%	10%	60%	85%
C	90%	0%	20%	10%
D	0%	5%	5%	0%
E	0%	0%	5%	0%



4/24/13 Physics 132 **2**

Foothold Ideas 1:
The Physics



- Certain objects (the sun, bulbs,…) give off light.
- Through empty space (or ~air) light travels in straight lines.
- Each point on an object scatters light, spraying it off in all directions.
- A polished surface reflects rays back again according to the rule: *The angle of incidence equals the angle of reflection*.

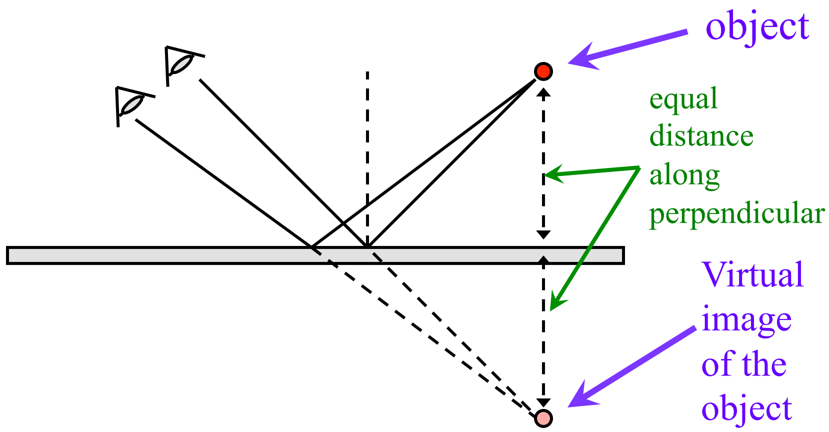
4/24/13 Physics 132 **3**

Foothold Ideas 2:
The Psycho-physiology

- We only see something when light coming from it enters our eyes.
- Our eyes identify a point as being on an object when rays traced back converge at that point.

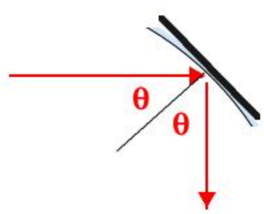
4/24/13 Physics 132 **4**

Where does an object seen in a mirror appear to be?



4/22/13 Physics 132 **5**

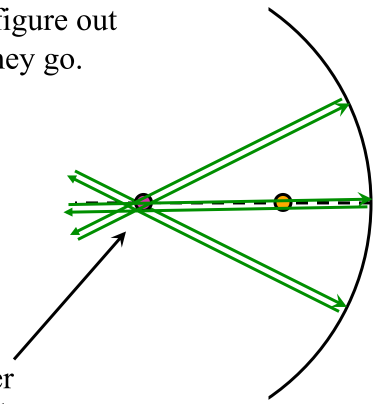
What happens when a ray hits a curved mirror?



4/24/13 Physics 132 **7**

A Spherical Mirror: Central Rays

A few rays are easy to figure out where they go.



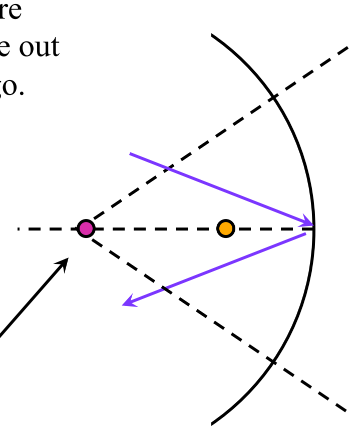
All rays satisfy the "angle of incidence = angle of reflection" measured to the normal to the surface

All rays through the center strike the mirror perpendicular to the surface and bounce back along their incoming path.

4/24/13 Physics 132 **8**

A Spherical Mirror: Central Ray

A few rays are easy to figure out where they go.



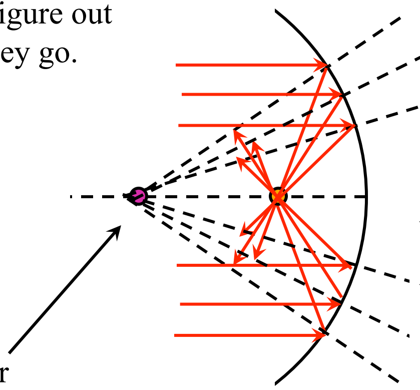
All rays satisfy the "angle of incidence = angle of reflection" measured to the normal to the surface

The ray hitting the central line of the diagram is particularly simple.

4/24/13 Physics 132 **9**

A Spherical Mirror: Parallel Rays

A few rays are easy to figure out where they go.



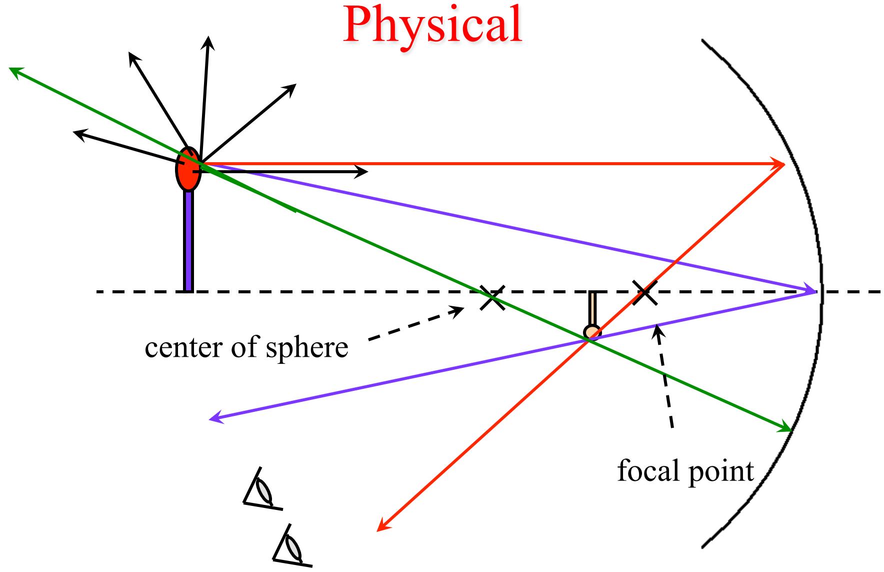
center of sphere

All rays satisfy the "angle of incidence = angle of reflection" measured to the normal to the surface

All rays parallel to and near an axis of the sphere reflect through a single point on the axis (the focal point)

4/24/13 Physics 132 **10**

Images in a Spherical Mirror: 1
Physical



4/24/13 Physics 132 **11**

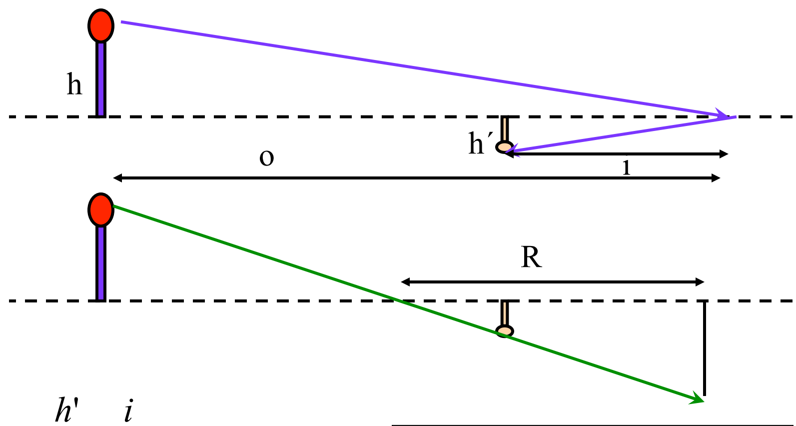
Kinds of Images: Real

- In the case of the previous slide, the rays seen by the eye do in fact converge at a point.
- When the rays seen by the eye do meet, the image is called *real*.
- If a screen is put at the real image, the rays will scatter in all directions and an image can be seen on the screen, just as if it were a real object.

Reading questions

- What is the difference between the image points and the focal point? Is the distance of the real image interpreted by our brain, or does it have a measurable distance from the mirror like the image and focal point?
- Other then the three light rays mentioned in the reading, do the other light rays also line up on the image point? So if we know the ray parallel to the center line, the ray that bounces off the center point of the mirror and the ray with no incidence, can we see how every light ray will bounce off a mirror if they all go through the image point?

Mathematical



$$\frac{h'}{h} = \frac{i}{o}$$

$$\frac{h'}{h} = \frac{R - i}{o - R}$$

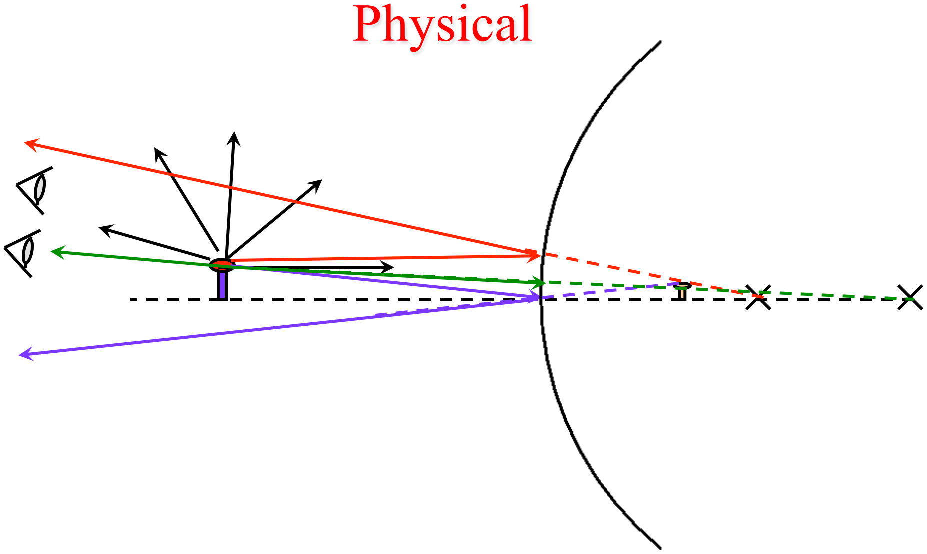
$\Longrightarrow$

$$\frac{1}{f} = \frac{1}{i} + \frac{1}{o} \qquad f = R/2$$

4/24/13 Physics 132 **14**

Images in a Spherical Mirror: 2

Physical

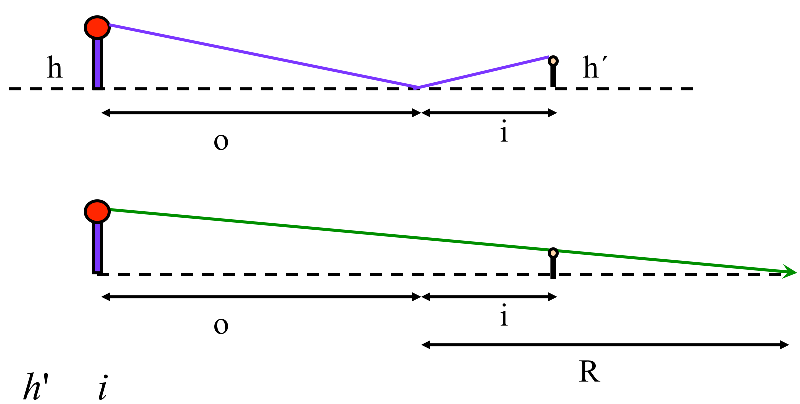


4/24/13 Physics 132 **15**

Kinds of Images: Virtual

- In the case of the previous slide, the rays seen by the eye do not converge at a point.
- When the rays seen by the eye extrapolate to a point but don't actually meet, the image is called *virtual*.
- In our case, the convergence point is behind the mirror.
- If we look at the virtual image from behind the mirror, what will we see?

Mathematical



$$\frac{h'}{h} = \frac{i}{o}$$

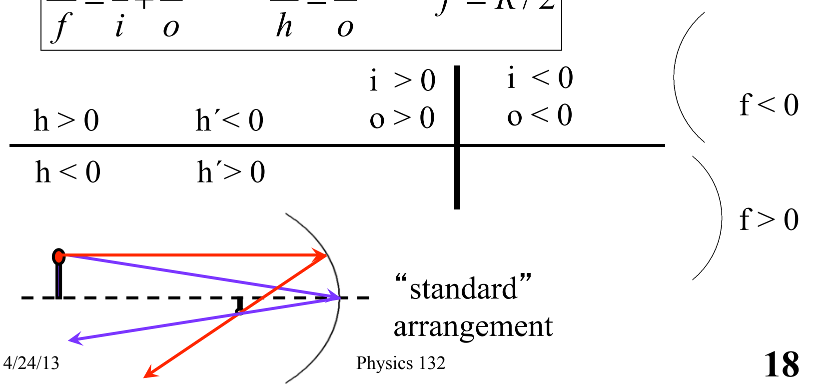
$$\frac{h'}{h} = \frac{R-i}{R+o}$$

$$\Rightarrow \quad \boxed{\frac{1}{f} = \frac{1}{i} - \frac{1}{o} \qquad f = R/2}$$

Unifying Equation for Mirrors

- If we treat our mirror quantities as “signed” and let the signs carry directional information, we can unify all the situations in a single set of equations.

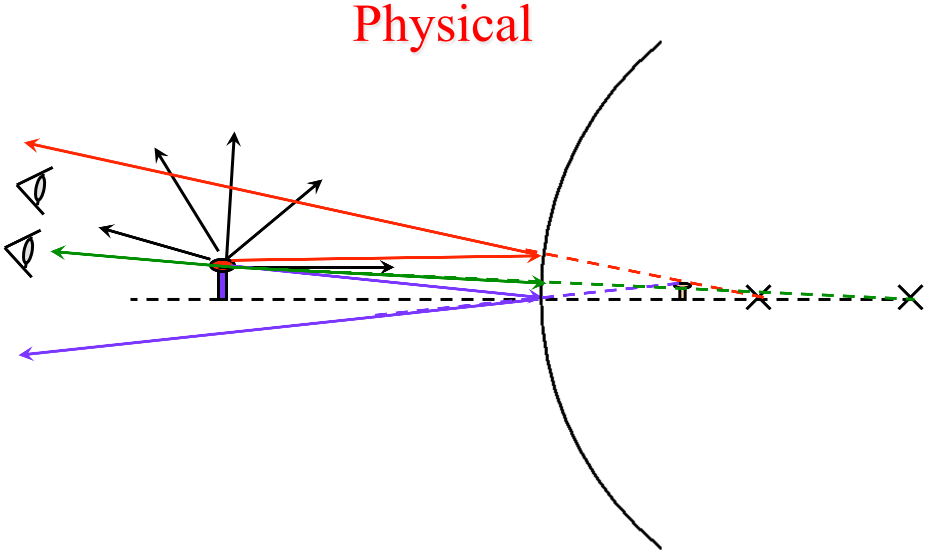
$$\frac{1}{f} = \frac{1}{i} + \frac{1}{o} \qquad \frac{h'}{h} = \frac{i}{o} \qquad f = R/2$$



4/24/13 Physics 132 **18**

Images in a Spherical Mirror: 2

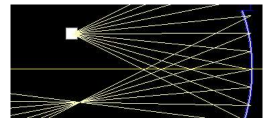
Physical

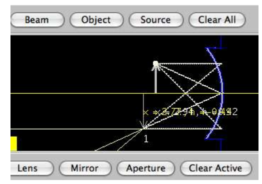


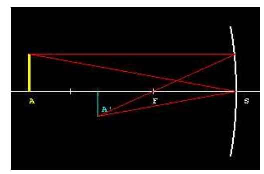
4/24/13 Physics 132 **19**

Simulations

- Overview (lots of rays)
  - http://webphysics.davidson.edu/applets/Optics/prb1.html
- Optics bench (3 rays)
  - http://webphysics.davidson.edu/physlet_resources/dav_optics/Examples/optics_bench.html
- In French (2 rays)
  - http://www.univ-lemans.fr/enseignements/physique/02/optigeo/mirspher.html







4/24/13 Physics 132 **20**