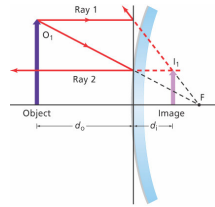


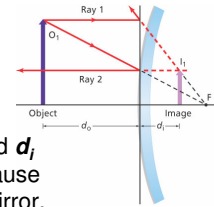
## Convex Mirrors

- a reflective surface with edges that curve away from the observer.
- (the outer surface of the spoon)



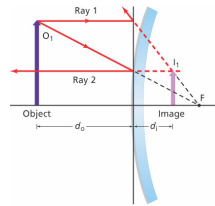
## Convex Mirrors

- Rays reflected from a convex mirror always diverge. Thus, convex mirrors form virtual images.
- Points  $F$  and  $C$  are behind the mirror.
- In the mirror equation,  $f$  and  $d_i$  are negative numbers because they are both behind the mirror.



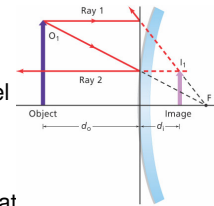
## Convex Mirrors

- The figure uses two rays, but remember that there are an infinite number of rays.
- Ray 1 approaches the mirror parallel to the principal axis.
- The reflected ray is drawn along a sight line from  $F$  through the point where ray 1 strikes the mirror.



## Curved Mirrors

- Ray 2 approaches the mirror on a path that, if extended behind the mirror, would pass through  $F$ .
- The reflected part of ray 2 and its sight line are parallel to the principal axis.
- The two reflected rays diverge, and the sight lines intersect behind the mirror at the location of the image.



## Convex Mirrors

- the image is always a virtual image that is upright and smaller than the object.
- If you know the diameter of an object, you can multiply by the magnification fraction to see how the diameter changes.
  - You will find that the diameter is smaller, as are all other dimensions.
- This is why the objects appear to be farther away than they actually are for convex mirrors.

## Convex Mirrors



- By forming smaller images, convex mirrors enlarge the area, or field of view.
- The center of this field of view is visible from any angle of an observer off the principal axis of the mirror; thus, the field of view is visible from a wide perspective.
- For this reason, convex mirrors often are used in cars as passenger-side rearview mirrors.

## Convex Mirrors

<http://www.freewebs.com/michellemarie88/tripphoto.htm>

## Convex Mirror

## Refraction of Light

- Refraction
  - Change in direction of waves** at the boundary between two different media
  - is the **bending of the path of a light wave** as it passes across the boundary separating two media.
  - is caused by the **change in speed** experienced by a wave when it changes medium.

<http://www.glenbrook.k12.il.us/gbssci/Phys/Immedia/optics/bp.html>

## Refraction of Light

<http://www.glenbrook.k12.il.us/gbssci/Phys/Immedia/optics/bp.html>

## Refraction of Light

- Light bends toward the normal as it moves from air to glass; bends away as it moves from glass to air
- This bending of light makes objects appear to be shifted from their actual locations

## Refraction of Light

- The **index of refraction (n)** for a substance is the **ratio** of the speed of light **in a vacuum (c)** to the speed of light **in that substance (v)**.

$$n = \frac{c}{v}$$

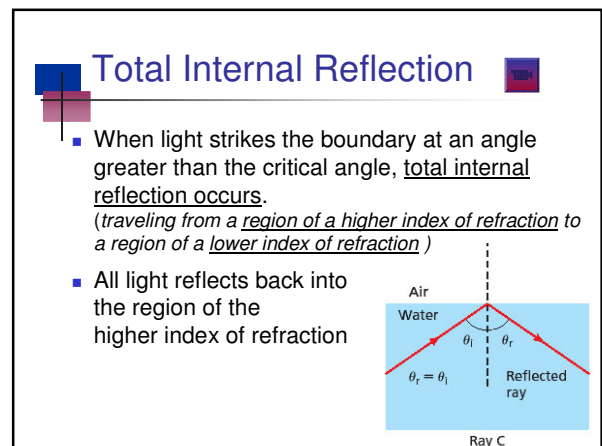
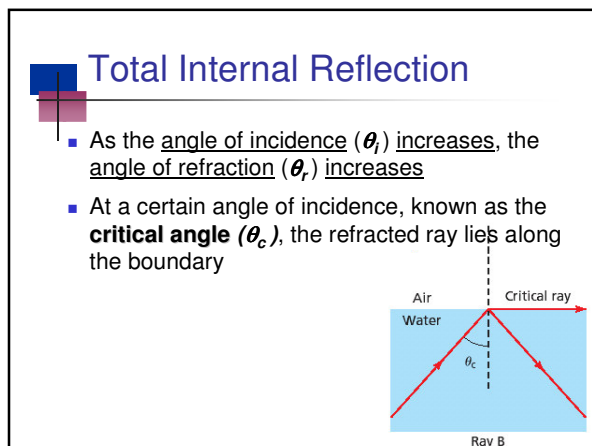
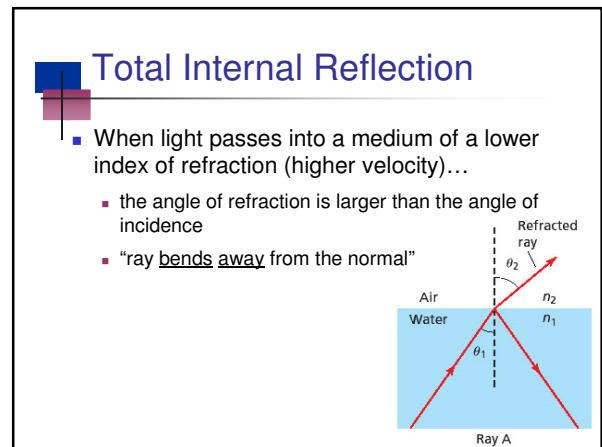
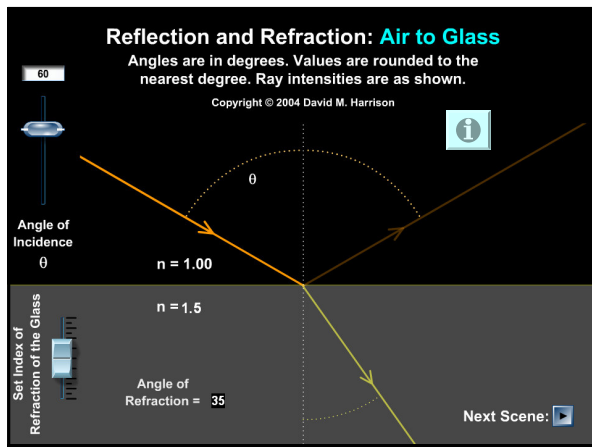
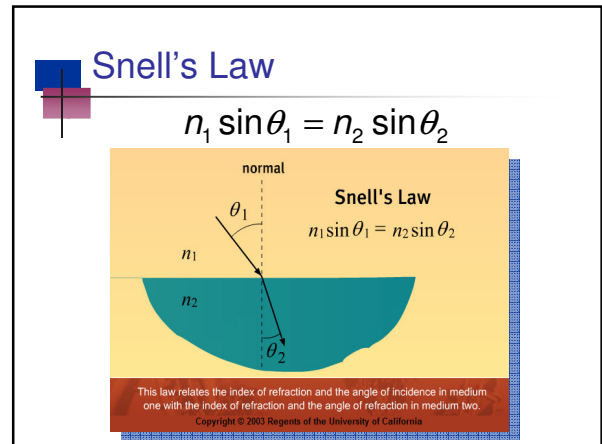
index of refraction =  $\frac{\text{speed of light in a vacuum}}{\text{speed of light in medium}}$

- For a given medium (air, water, glass, etc):
  - the higher the index of refraction, the slower the speed of light is in that medium**

## Indices of Refraction $n = \frac{c}{v}$

Solids at 20°C		Liquids at 20°C	
	<i>n</i>		<i>n</i>
Cubic zirconia	2.20	Benzene	1.501
Diamond	2.419	Carbon disulfide	1.628
Fluorite	1.434	Carbon tetrachloride	1.461
Fused quartz	1.458	Ethyl alcohol	1.361
Glass, crown	1.52	Glycerine	1.473
Glass, flint	1.66	Water	1.333
Ice (at 0°C)	1.309		
Polystyrene	1.49	Gases at 0°C, 1 atm	
Sodium chloride	1.544		<i>n</i>
Zircon	1.923	Air	1.000 293
		Carbon dioxide	1.000 450

\*measured with light of vacuum wavelength = 589 nm



## Total Internal Reflection

- Use Snell's law:  $n_1 \sin \theta_1 = n_2 \sin \theta_2$

and substitute  $\theta_1 = \theta_c$  and  $\theta_2 = 90^\circ$ , then...

$$\sin \theta_c = \frac{n_2}{n_1}$$

[Examples:](#)

