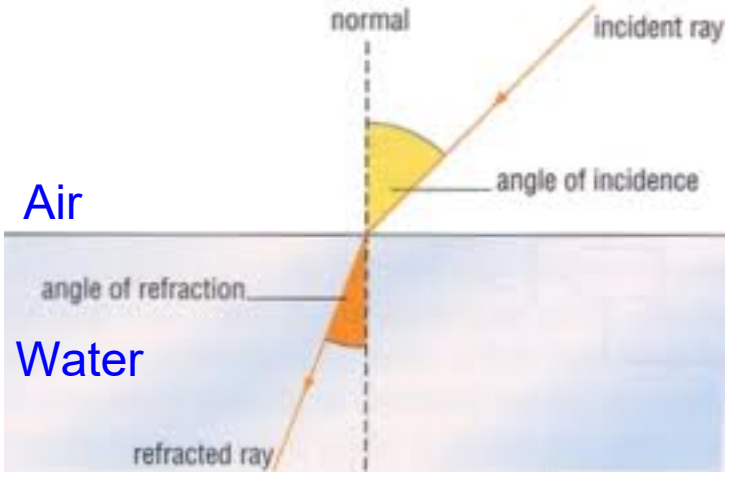
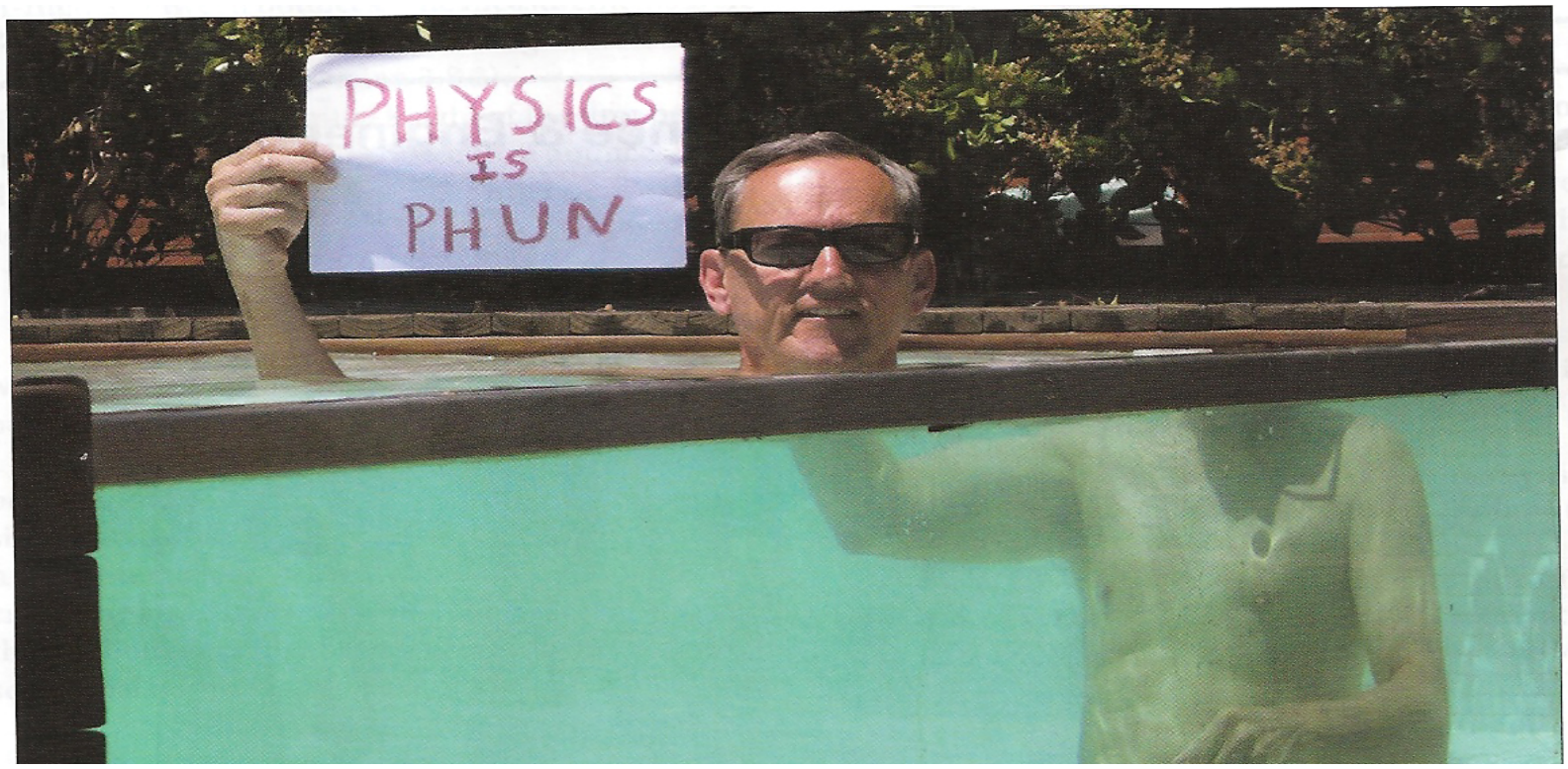
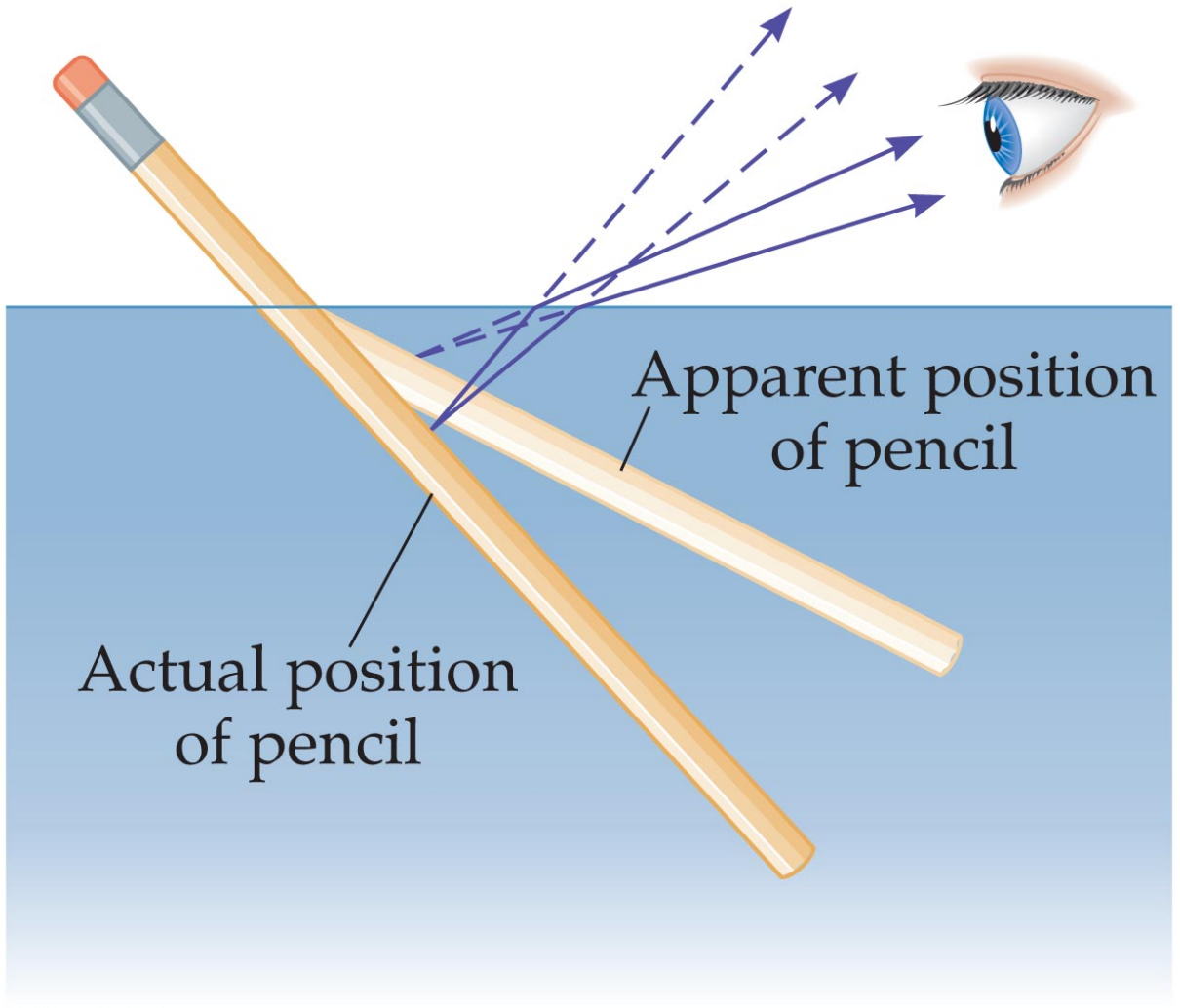
17 - Refraction

Refraction - the bending of a wave as it obliquely passes into a new medium where it travels at a different speed. Light travels fastest in a vacuum (almost the same in air) and slower in all other substances.



Revised 3.6.2021 Some diagrams from Pearson Physics by Walker. Used with permission





Index of refraction = n = (speed of light in a vacuum) / (speed of light in the substance)

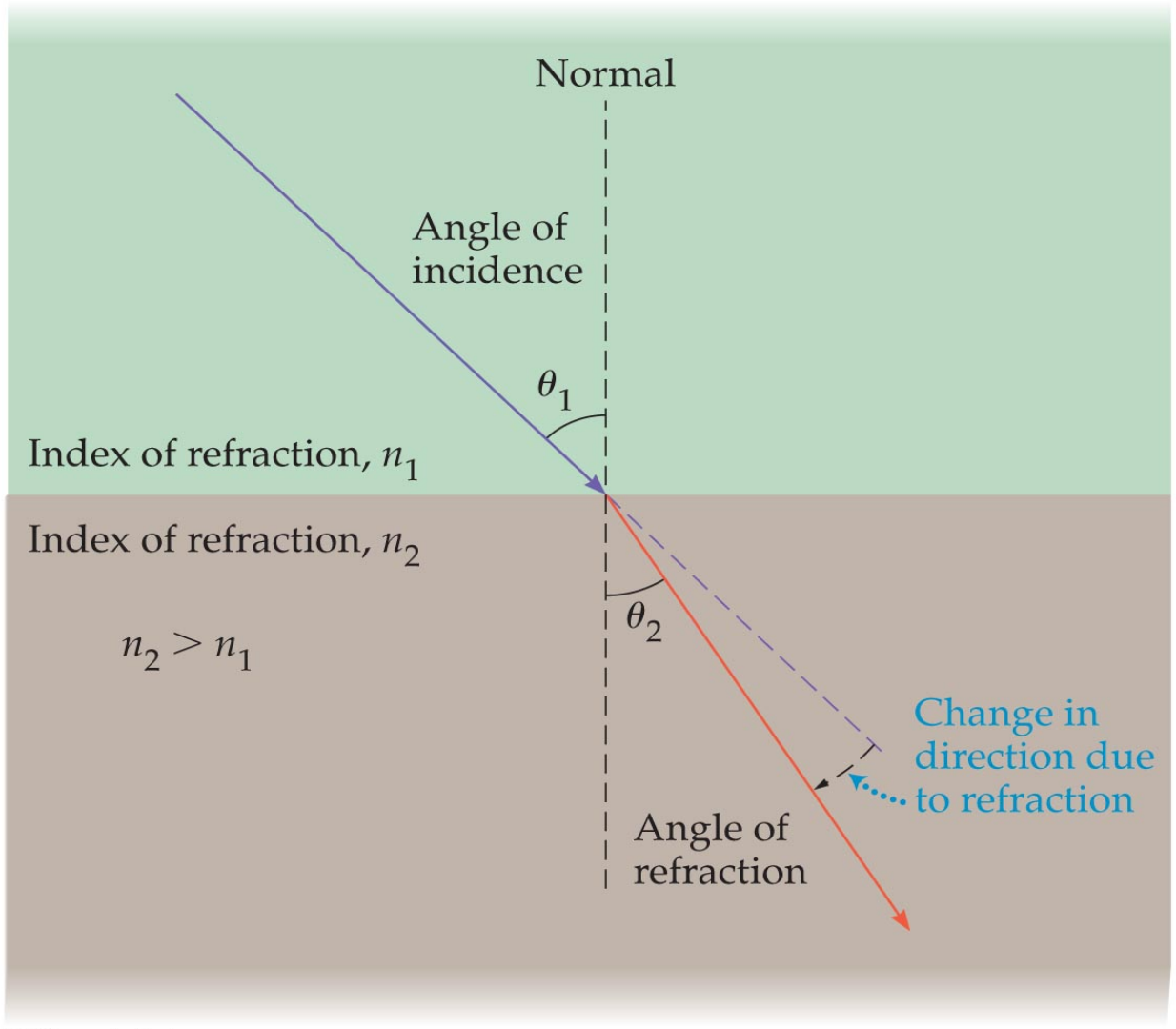
$$n=c/v$$

Table 17.1 Index of Refraction for Common Substances

	Substance	Index of refraction, *n*
SOLIDS	Diamond	2.42
	Flint glass	1.66
	Crown glass	1.52
	Fused quartz (glass)	1.46
	Ice	1.31
LIQUIDS	Benzene	1.50
	Ethyl alcohol	1.36
	Water	1.33
GASES	Carbon dioxide	1.00045
	Air	1.000293

1. What is the speed of light in Diamond?
2. What is the speed of light in water?
3. Does light travel faster in Flint Glass or in Benzene?

Snell's Law:
$n_1 \sin\Theta_1 = n_2 \sin\Theta_2$



4. Suppose light enters water from air at an angle of incidence of 20 degrees. What will be the angle of refraction to the nearest degree?
5. If light travelling in water enters air will it bend toward or away from the normal?
6. A beam of light in air enters a piece of flint glass at an angle of incidence of 40 degrees. Find the angle of refraction to the nearest degree.

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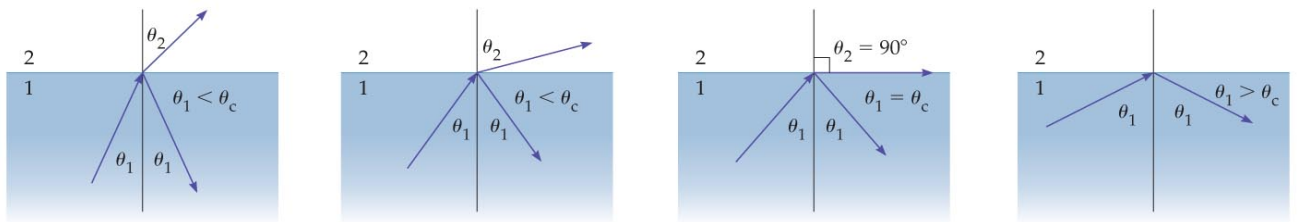
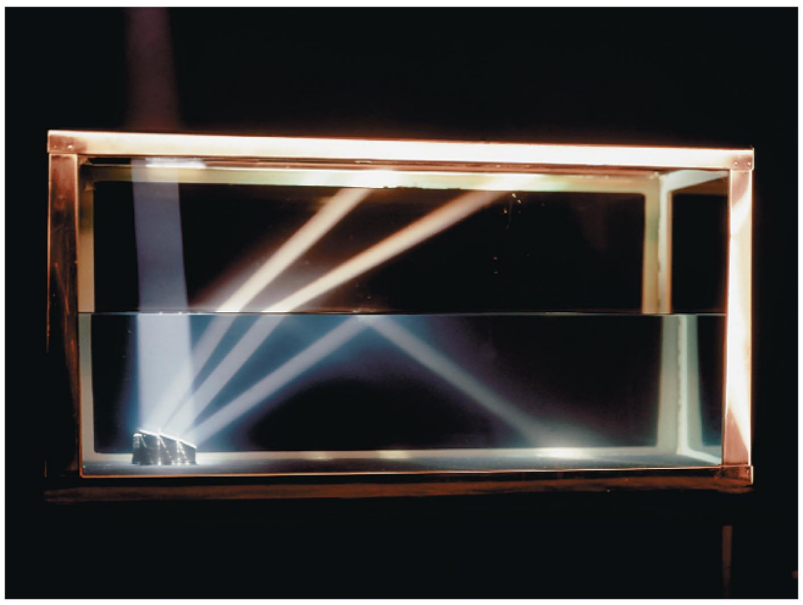
Light going from lower to higher index is bent toward the normal.
Light going from higher to lower index is bent away from the normal.

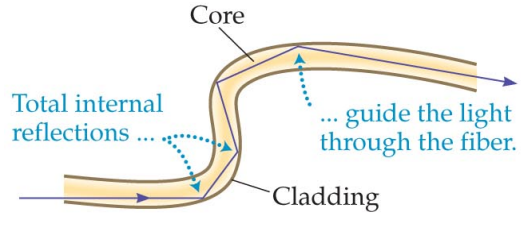
If light is going from higher to lower index and the angle of incidence is too high, then you get total internal reflection.



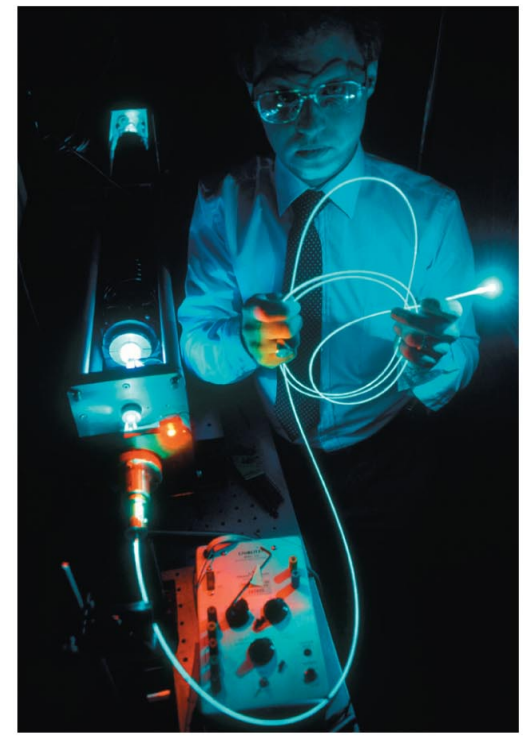
(a) Small angle of incidence **(b)** Larger angle of incidence **(c)** Refracted beam parallel to interface **(d)** Total internal reflection



Light pipe – or fiber optic cable



(a)



(b)

The speed of light in any substance depends upon the Index of Refraction of the substance.

$$N1*v1 = N2*v2$$

Table 17.1 Index of Refraction for Common Substances

	Substance	Index of refraction, *n*
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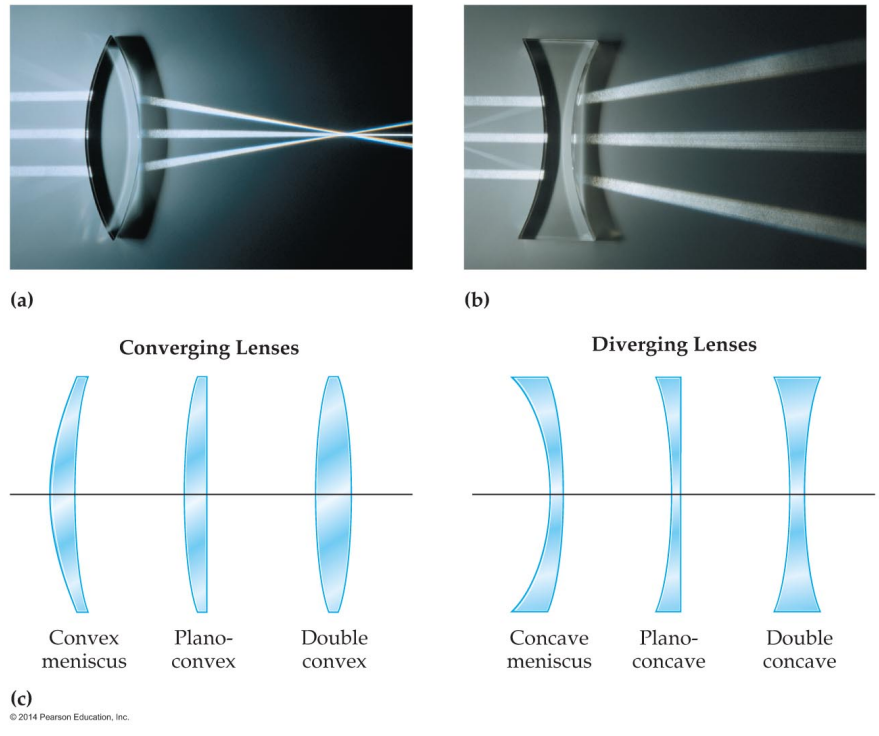
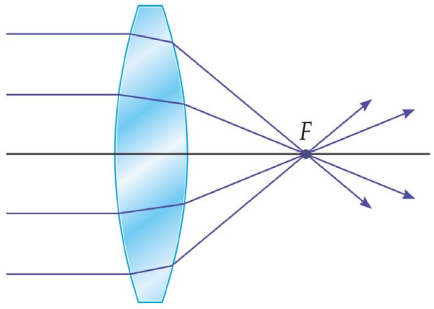
	Water	1.33
GASES	Carbon dioxide	1.00045
	Air	1.000293

7. What is the speed of light in Ice?
8. Light traveling in water enters crown glass. Does it bend toward or away From the normal?
9. Of all the substances listed above, where does light travel the slowest?
10. Of all the substances listed above, where does light travel the fastest?

Lenses bend light because of refraction



Convex (Converging) lens:
Thicker at the center than at the edges.



(a) A double-convex lens

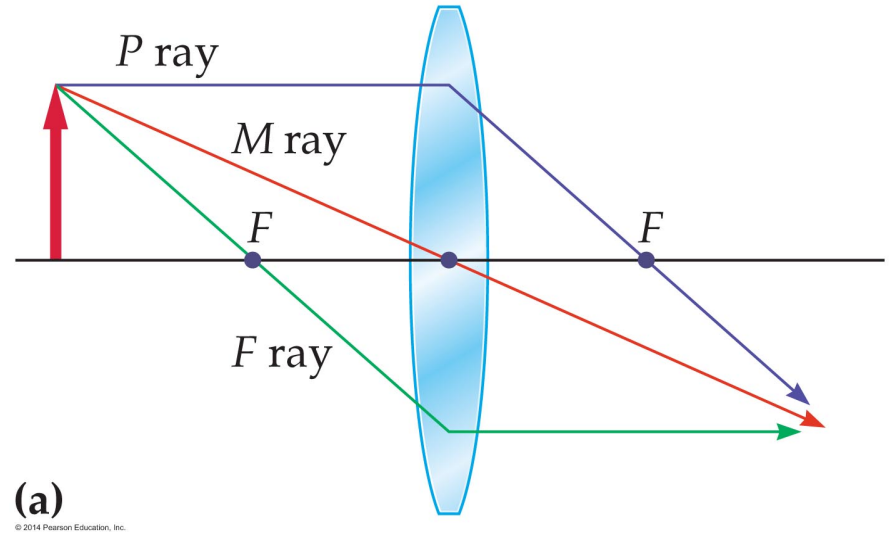
1. A ray parallel to the axis is refracted through the focus.
2. A ray through the geometric center of the lens continues straight.
3. A ray through the focus is refracted parallel to the axis.

The image is located a the intersection of the refracted rays.

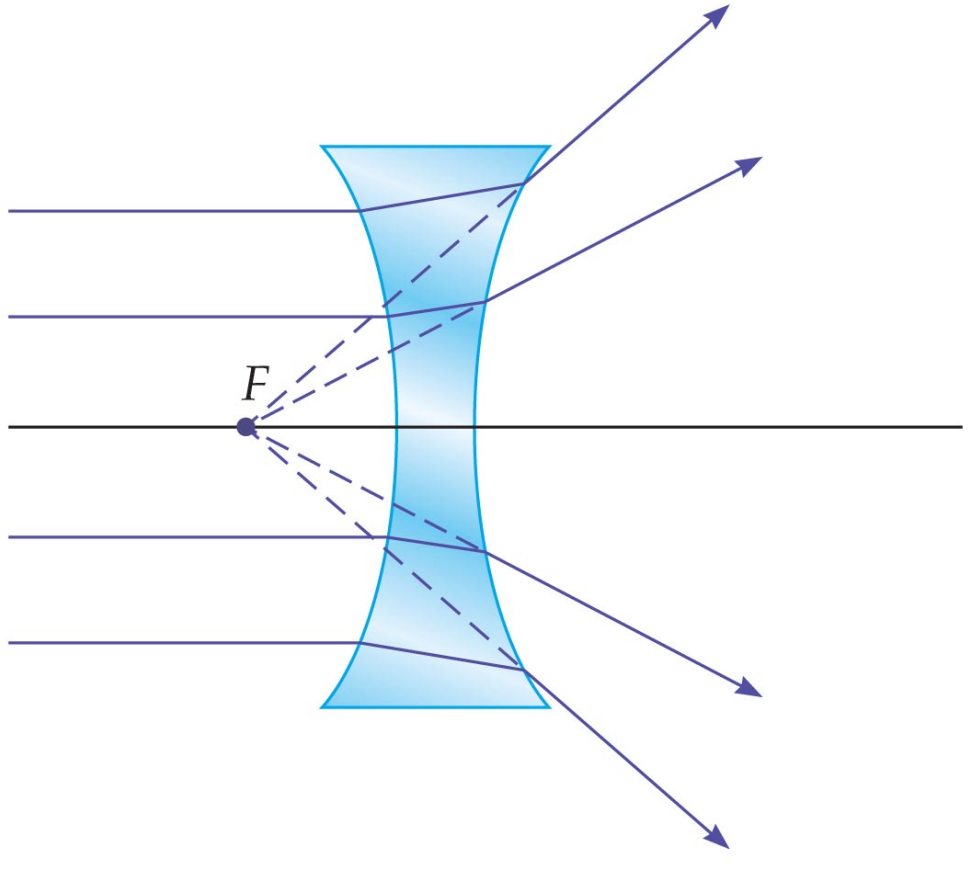
Watch this video for ray diagram construction

http://www.youtube.com/watch?v=c6mLLaqLdvg

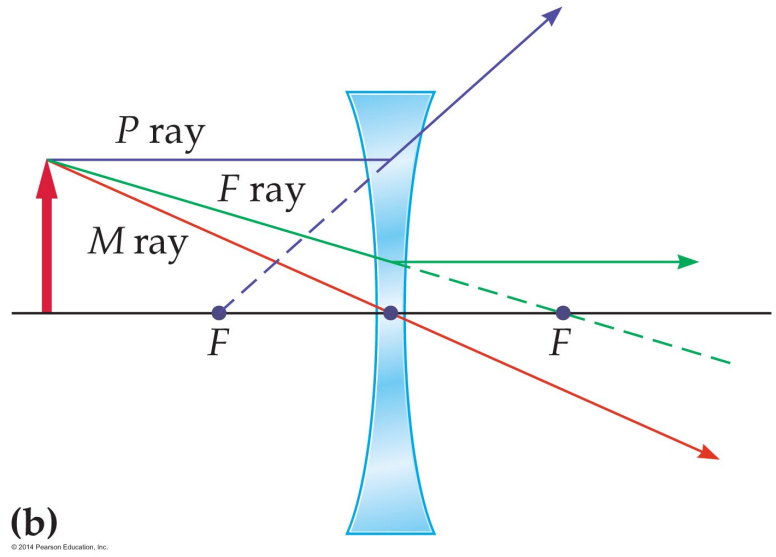
Thin Lens:
1/do + 1/di = 1/f
and
So/Si = do/di



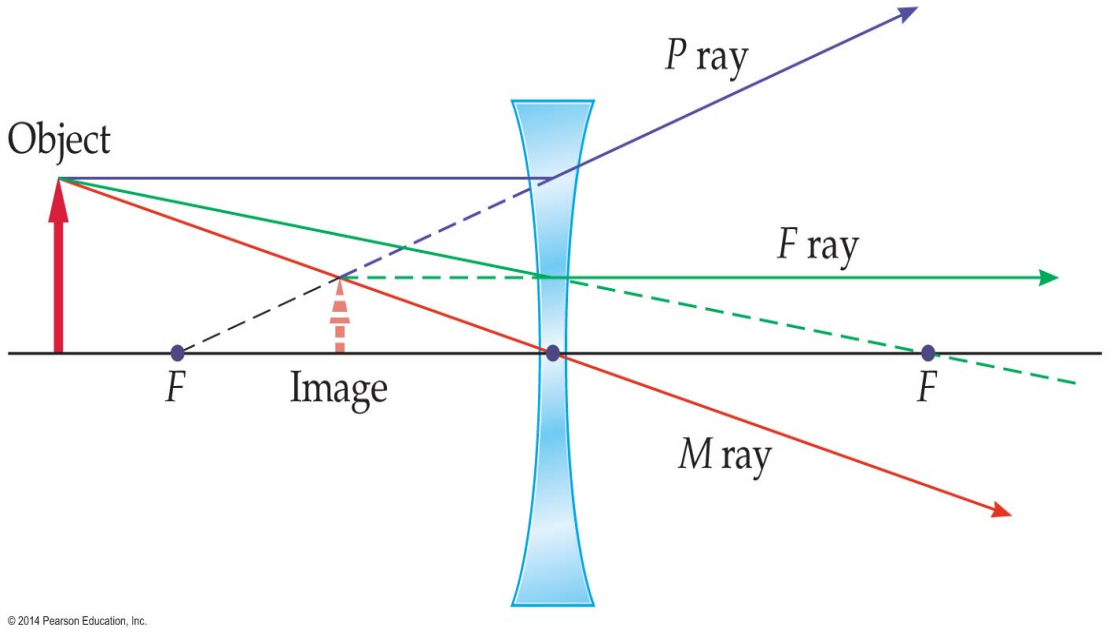
Concave (diverging) lens



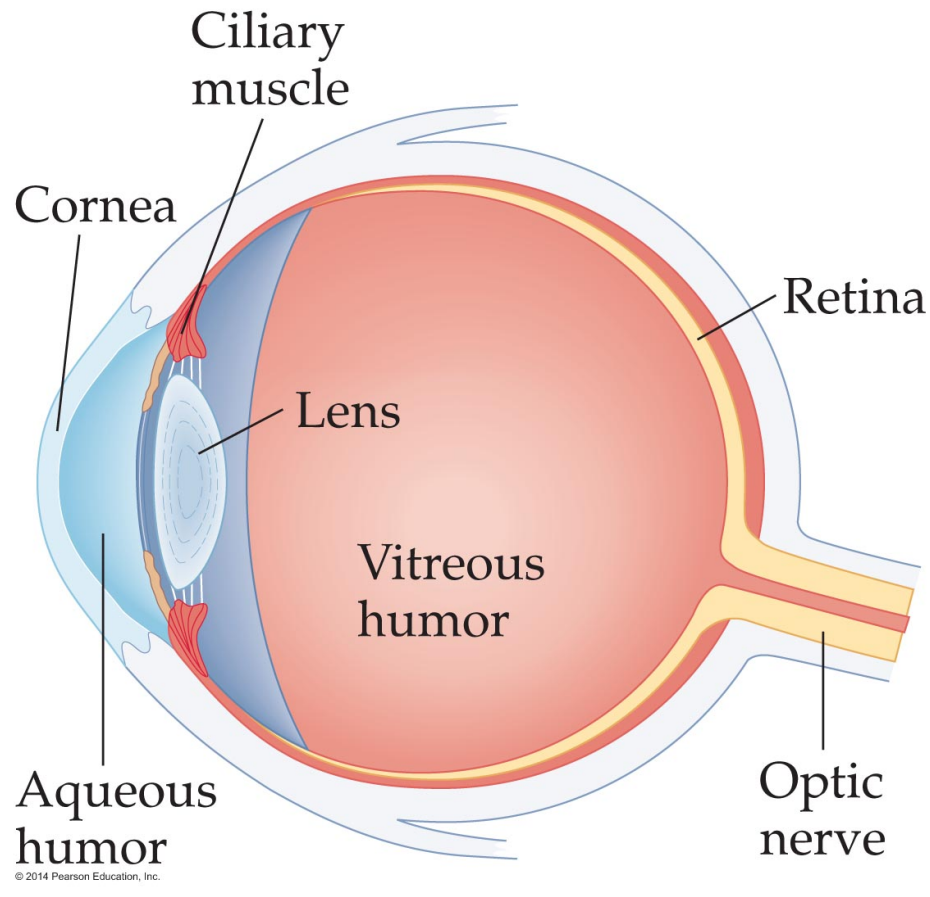
(a) A double-concave lens

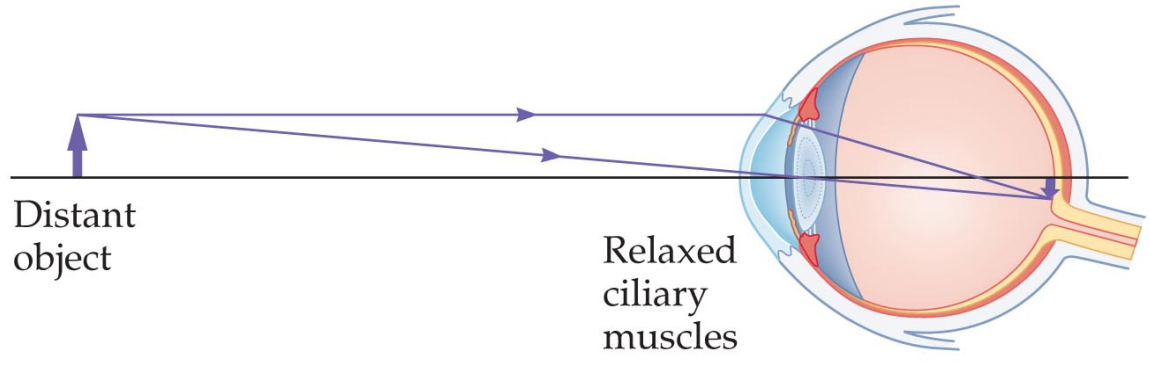


(b)

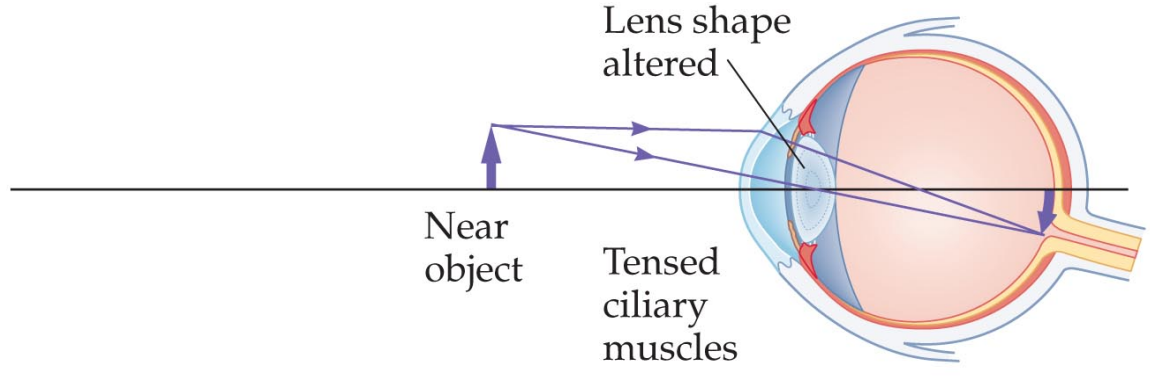


Notice the image is smaller, upright, and virtual.





(a) Viewing a distant object

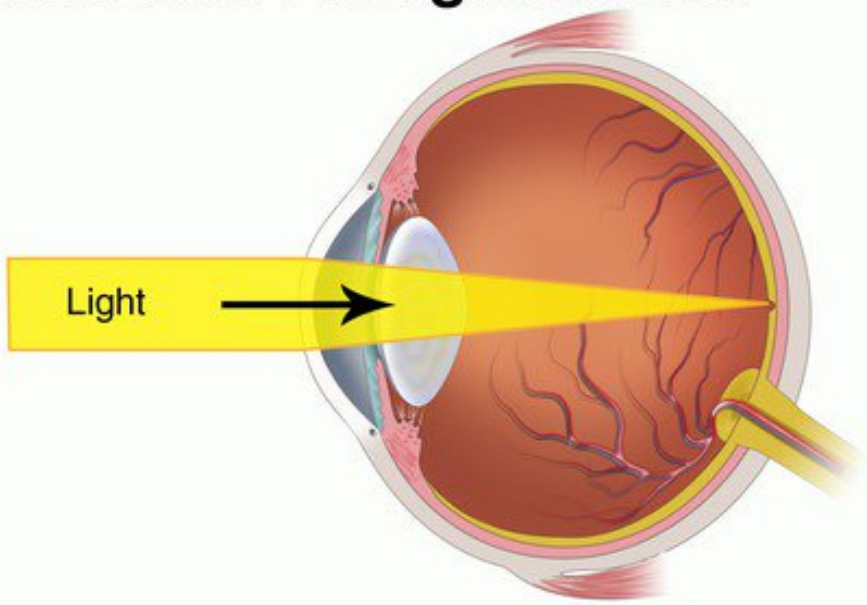


(b) Viewing a near object

Nearsightedness and Farsightedness

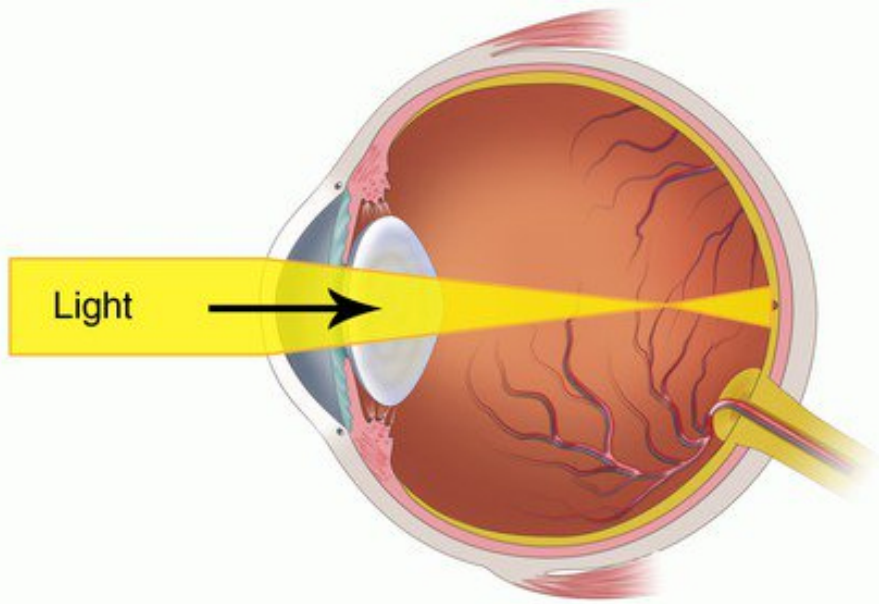
Normal Eye

The eye is the correct shape. The light rays focus on the retina.



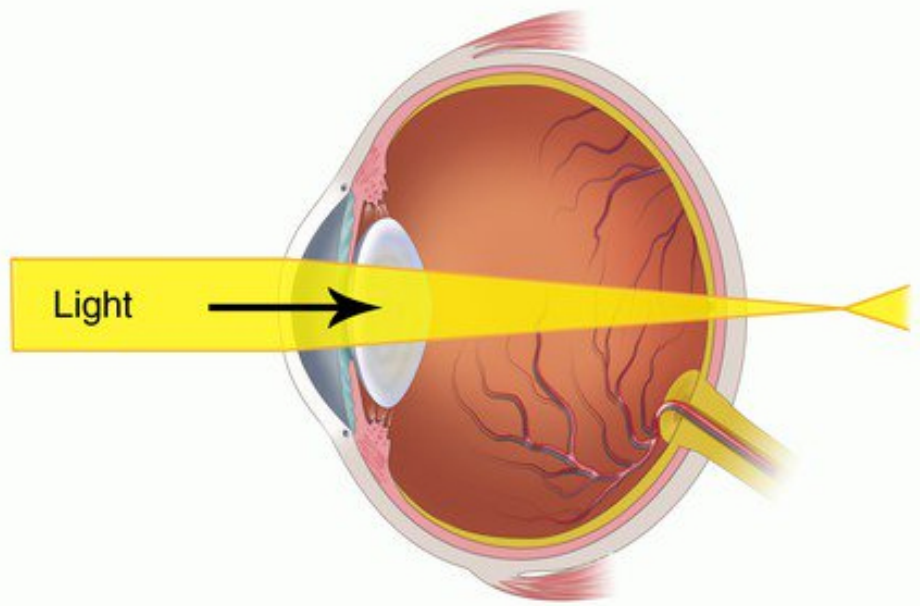
Nearsighted Eye

The eye is too long. The light rays focus in front of the retina. (Blurry at a distance)



Farsighted Eye

The eye is too short. The light rays focus behind the retina. (Blurry close up)



Dispersion: Breaking down of light into its component colors. Because different frequencies travel at different speeds in a dispersive medium (glass, for example) they bend by different amounts, and therefore travel in different directions.

http://webphysics.ph.msstate.edu/javamirror/ipmj/java/dispprizm/index.html

Chromatic aberration - distortion of colors (of an image) due to dispersion.