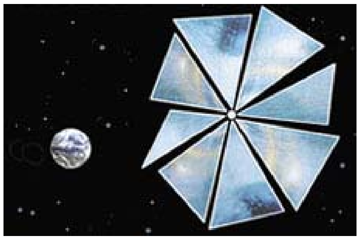
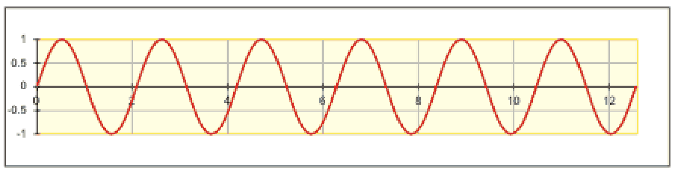


Lecture 14

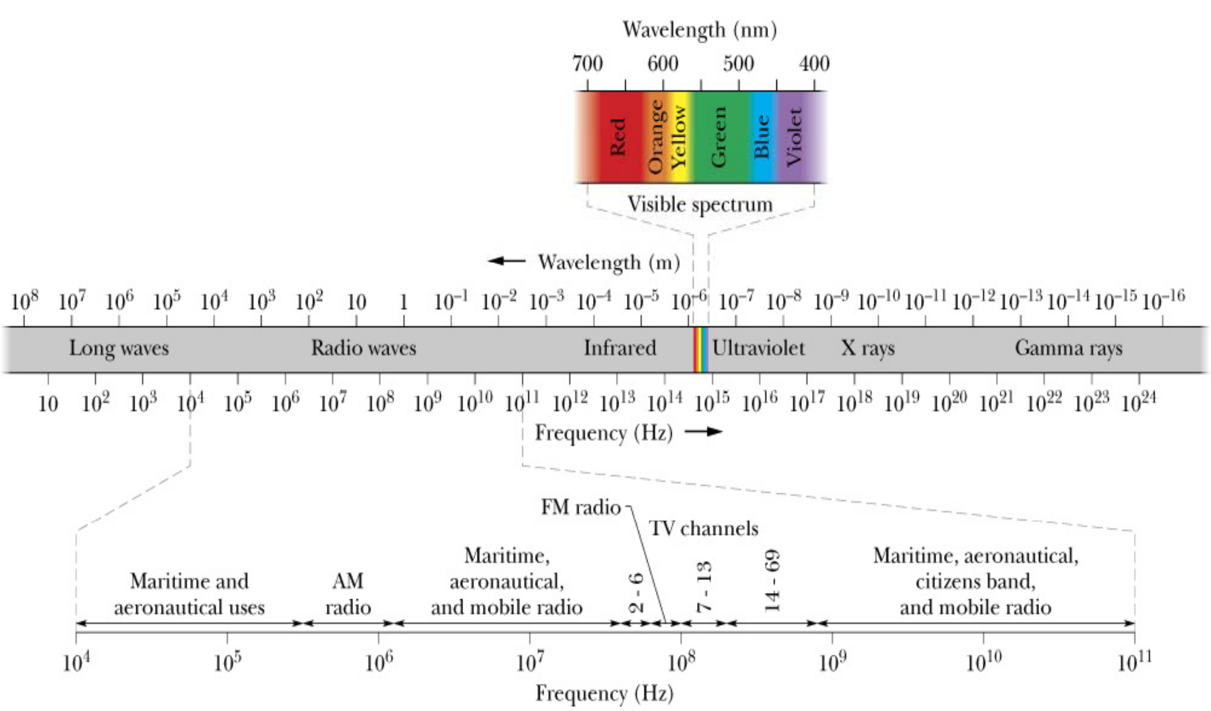
Light

http://web.njit.edu/~sirenko/

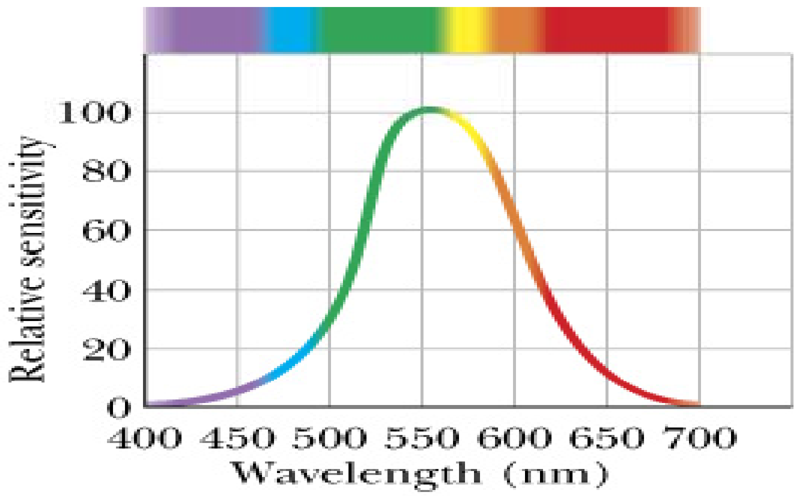
Physics 103 Spring 2012



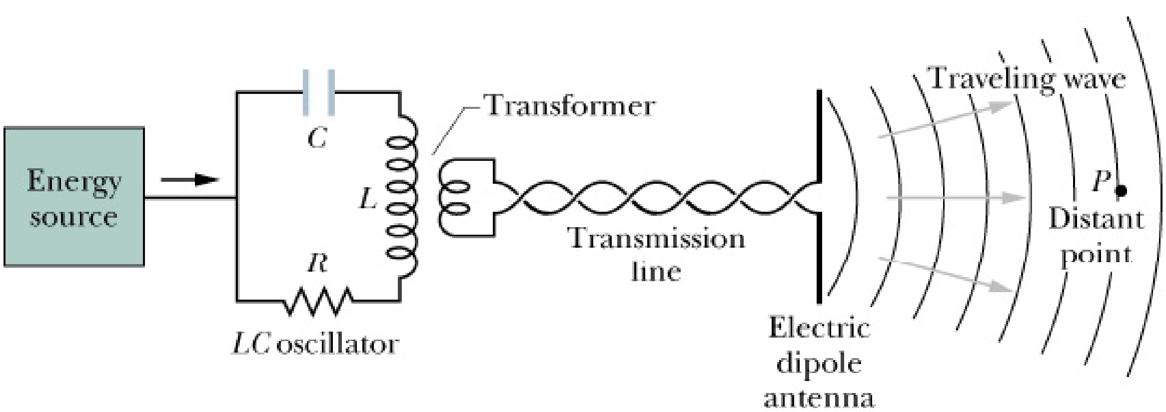
Electromagnetic Spectrum



Visible Light



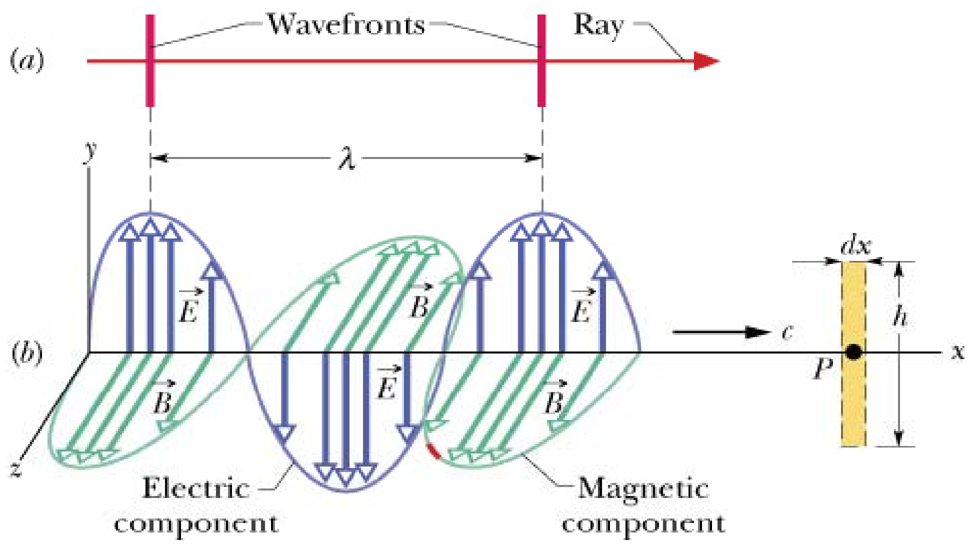
How can we produce light ?



$$\omega \; (= 1/\sqrt{LC}\,)$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \quad \text{(wave speed)}$$

What is light, anyways ?



$$c = 299792458 \text{ m / s},$$

$$3.0 \times 10^8 \text{ m/s}.$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \quad \text{(wave speed)}$$

Intensity of light

$$I = S_{avg} = \left(\frac{\text{energy / time}}{\text{area}}\right)_{avg} = \left(\frac{\text{power}}{\text{area}}\right)_{avg}.$$

$$I = S_{avg} = \frac{1}{c\mu_0}\left[E^2\right]_{avg} = \frac{1}{c\mu_0}\left[E_m^2 \sin^2(kx - \omega t)\right]_{avg}$$

$$I = \frac{1}{c\mu_0} E_{rms}^2.$$

$$c = 299792458 \text{ m / s},$$

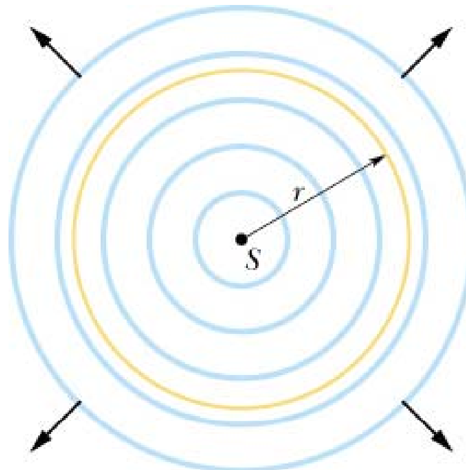
$$3.0 \times 10^8 \text{ m/s}.$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \quad \text{(wave speed)}$$

Point source of light;

Variation of Intensity with Distance

$$I = \frac{P_s}{4\pi r^2}$$



Interference of light;

Variation of Intensity at a certain Distance

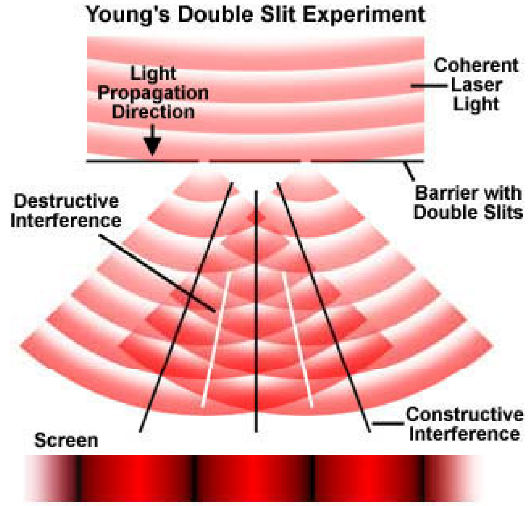
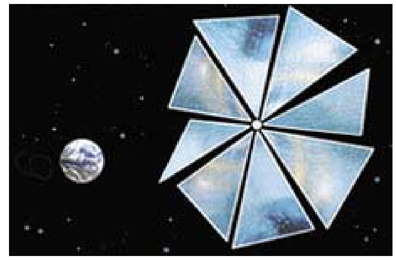


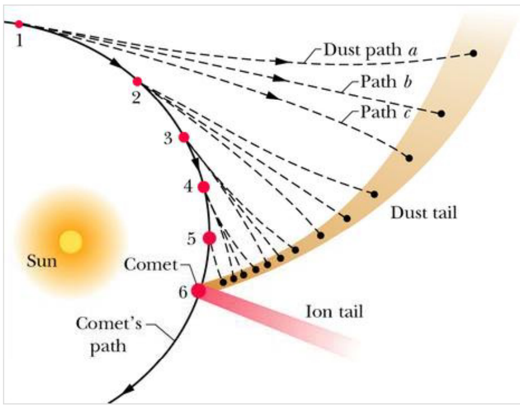
Figure 4

Light pressure



$$\Delta p = \frac{\Delta U}{c} \quad \text{(total absorption)}$$

$$\Delta p = \frac{2\Delta U}{c} \quad \text{(total reflection back along path)}$$



$$p_r = \frac{I}{c} \quad \text{(total absorption)}$$

$$p_r = \frac{2I}{c} \quad \text{(total reflection back along path)}$$

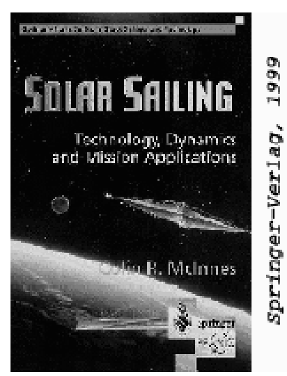
Light Sail

White Sail

Photons bounce off

Black Sail

Photons adsorbed

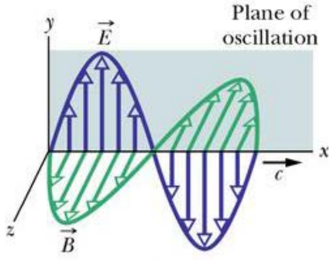


What color/material is the best for the Light Sail?

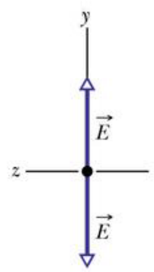
A) Black; B) Mirror-type; C) Blue; D) any

Polarization of light

Polarized light

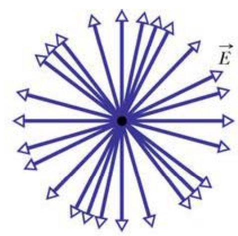


(a)

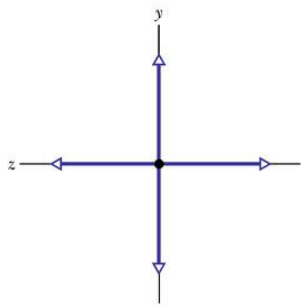


(b)

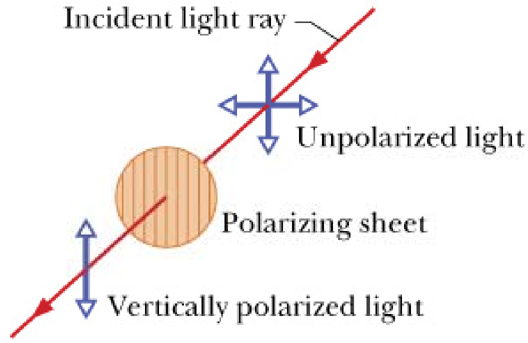
Unpolarized light



(a)

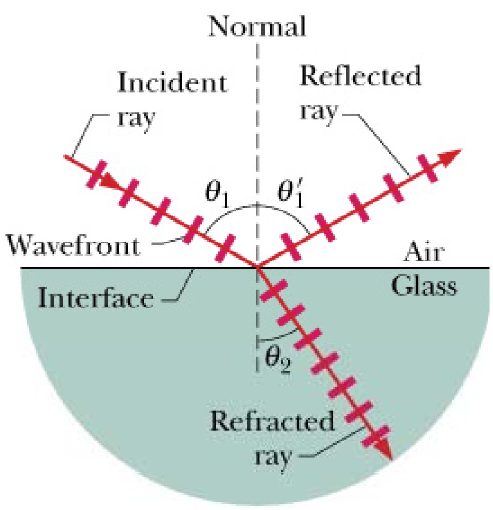


(b)




(a)
(b)

Refraction and Reflection of Light



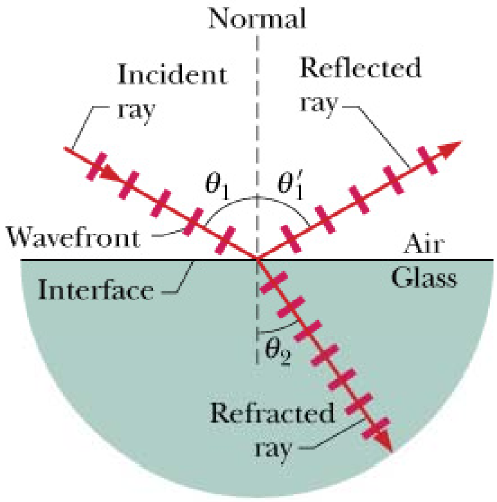
Some Indexes of Refraction[a]

Medium	Index	Medium	Index
Vacuum	Exactly 1	Typical crown glass	1.52
Air (STP)[b]	1.00029	Sodium chloride	1.54
Water (20°C)	1.33	Polystyrene	1.55
Acetone	1.36	Carbon disulfide	1.63
Ethyl alcohol	1.36	Heavy flint glass	1.65
Sugar solution (30%)	1.38	Sapphire	1.77
Fused quartz	1.46	Heaviest flint glass	1.89
Sugar solution (80%)	1.49	Diamond	2.42

$$\theta'_1 = \theta_1 \quad \text{(reflection)}.$$

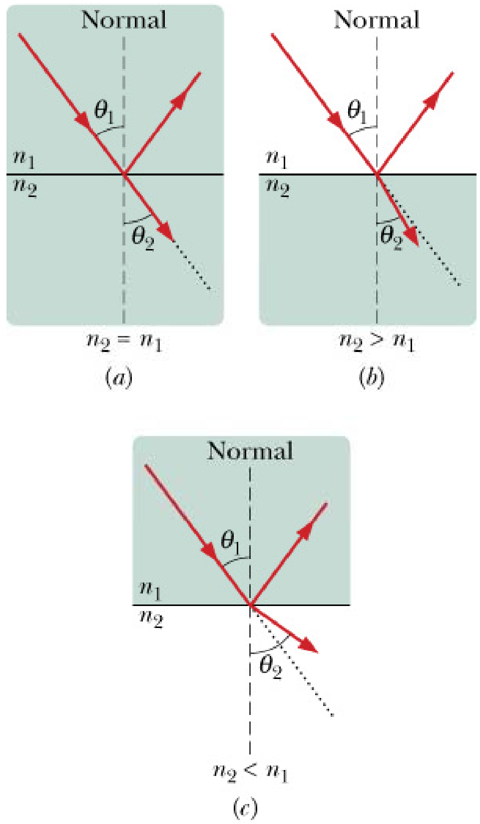
$$n_2 \sin\theta_2 = n_1 \sin\theta_1 \quad \text{(refraction)}.$$

Refraction and Reflection of Light

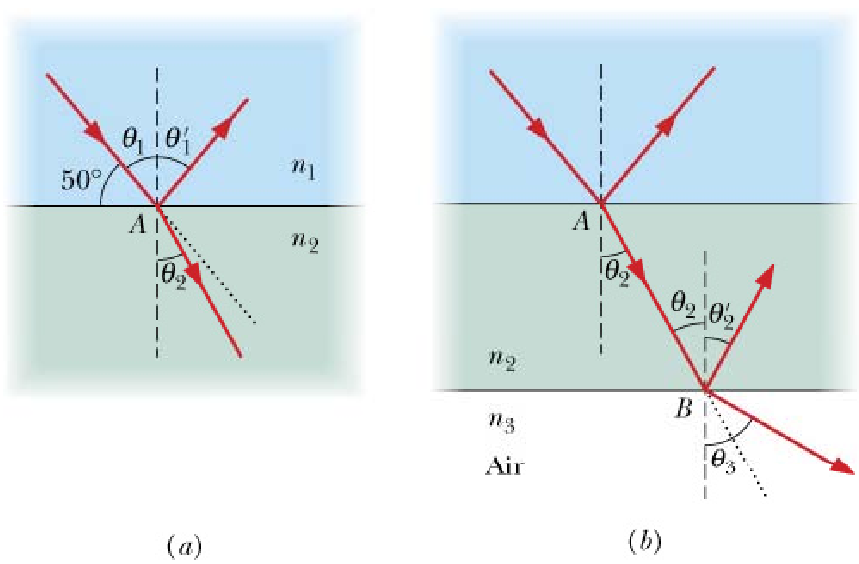


$$\theta'_1 = \theta_1 \quad \text{(reflection)}.$$

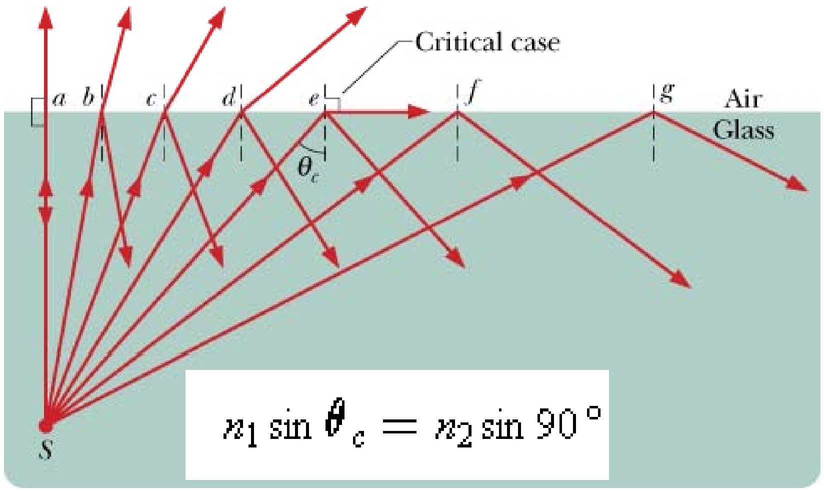
$$n_2 \sin\theta_2 = n_1 \sin\theta_1 \quad \text{(refraction)}.$$



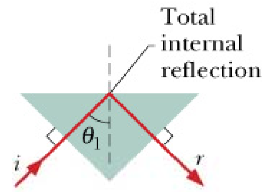
Reflection and Refraction of Light; One and two interfaces



Total internal Reflection

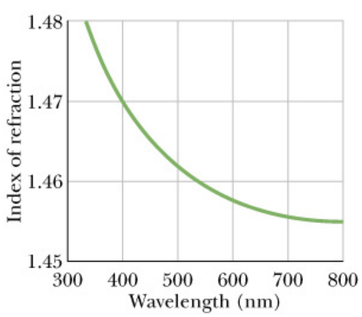


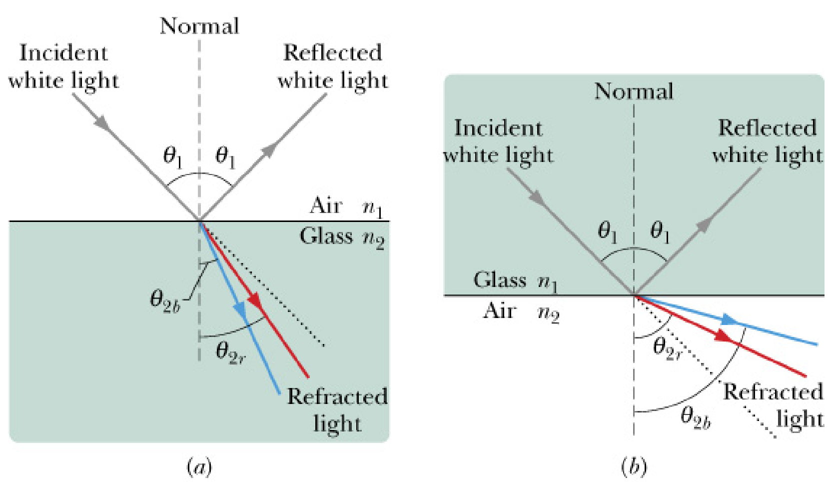
$$n_1 \sin\theta_c = n_2 \sin 90°$$



$$\theta_c = \sin^{-1}\frac{n_2}{n_1} \quad \text{(critical angle)}$$

Chromatic Dispersion of the refractive index

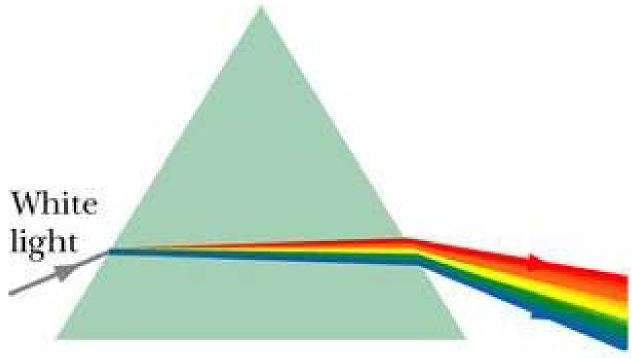




Dispersion of the refractive index:

Newton's prism

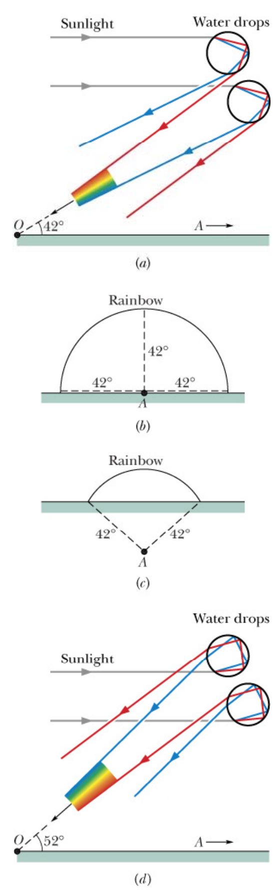

(a)



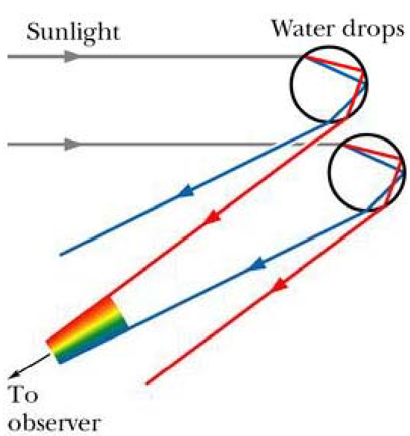
(b)

Dispersion of the refractive index:

Rainbow

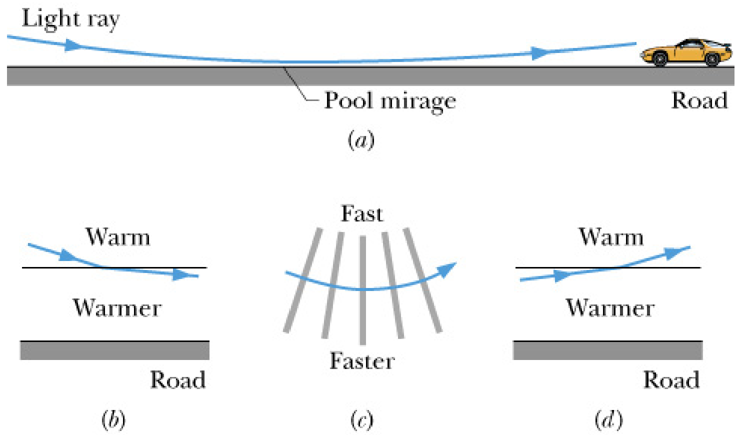



(a)

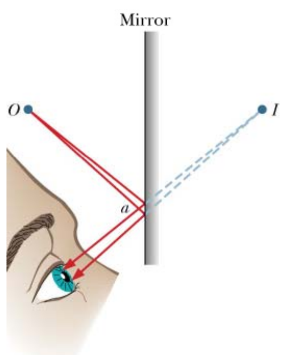


(b)

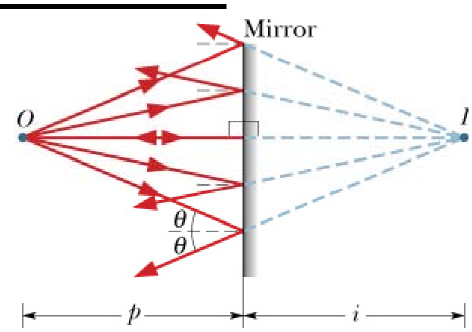
Mirages
Example of a virtual image

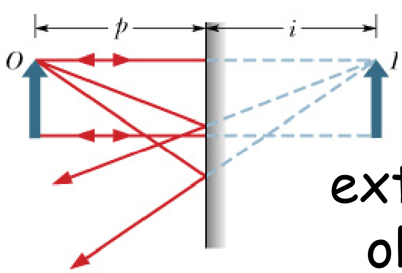


Mirror images: flat mirror

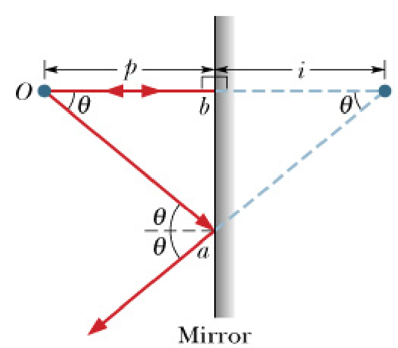


point

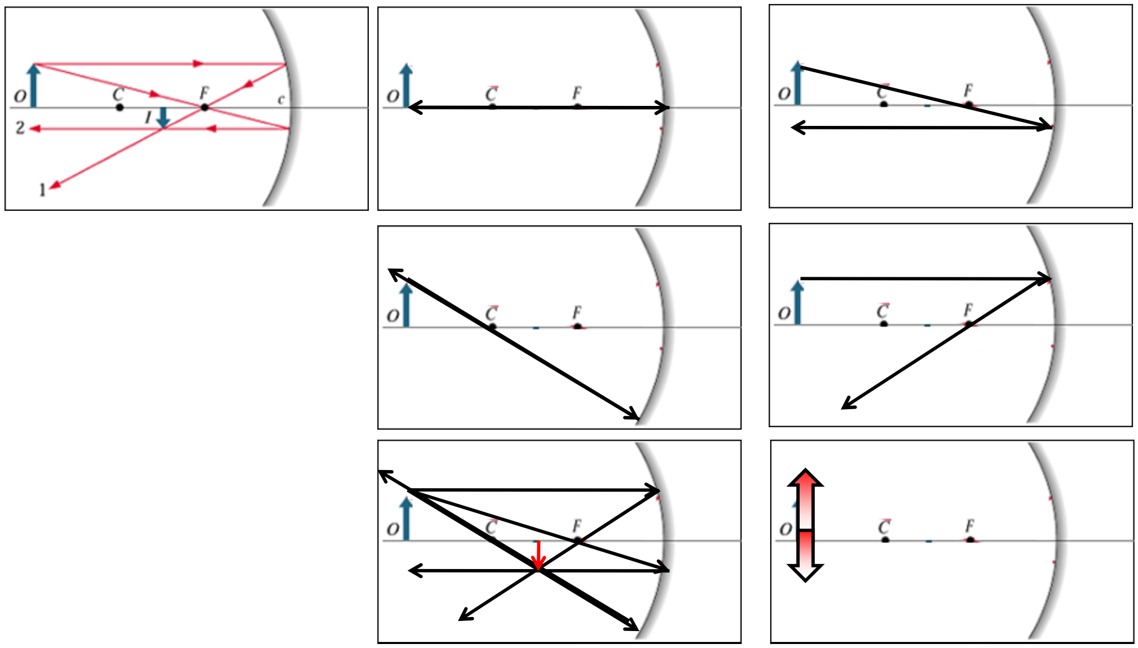




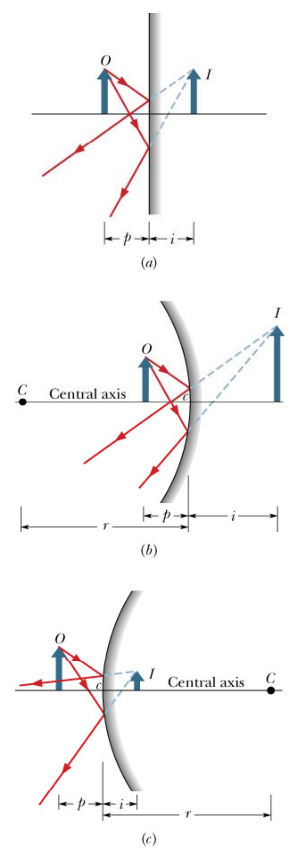
extended object



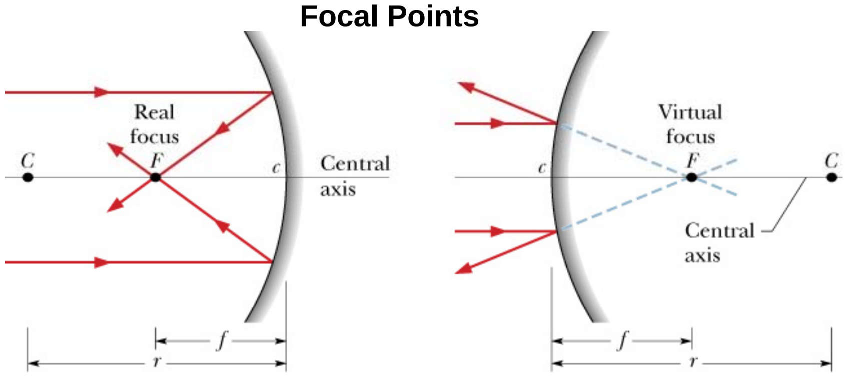
Working with Mirror images:



Mirror images:
Concave and convex mirrors



Focal Points



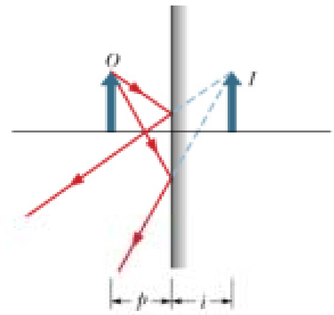
$$f = \frac{1}{2}r \quad \text{(spherical mirror)}$$

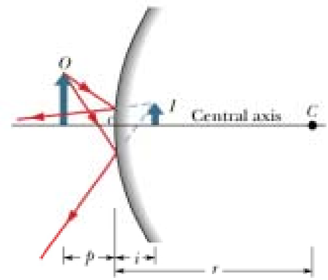
Concave mirror

Convex mirror

Mirror images: Convex mirror

For convex and plane mirrors only
a virtual image can be formed





$$f = \frac{1}{2}r \quad \text{(spherical mirror)}$$

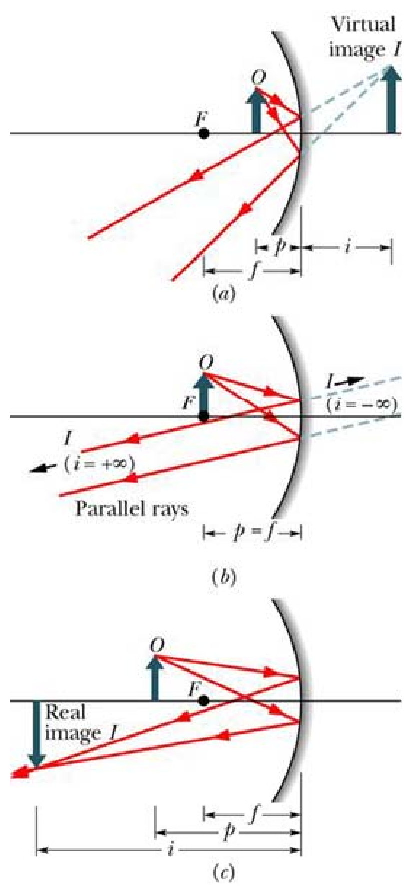
$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f} \quad \text{(spherical mirror)}.$$

$$|m| = \frac{h'}{h} \quad \text{(lateral magnification)}.$$

$$m = -\frac{i}{p} \quad \text{(lateral magnification)}.$$

i of a virtual image is negative

Mirror images: Concave mirror



Real images form on the side of a mirror where the object is, and virtual images form on the opposite side.

$$f = \frac{1}{2}r \quad \text{(spherical mirror)}$$

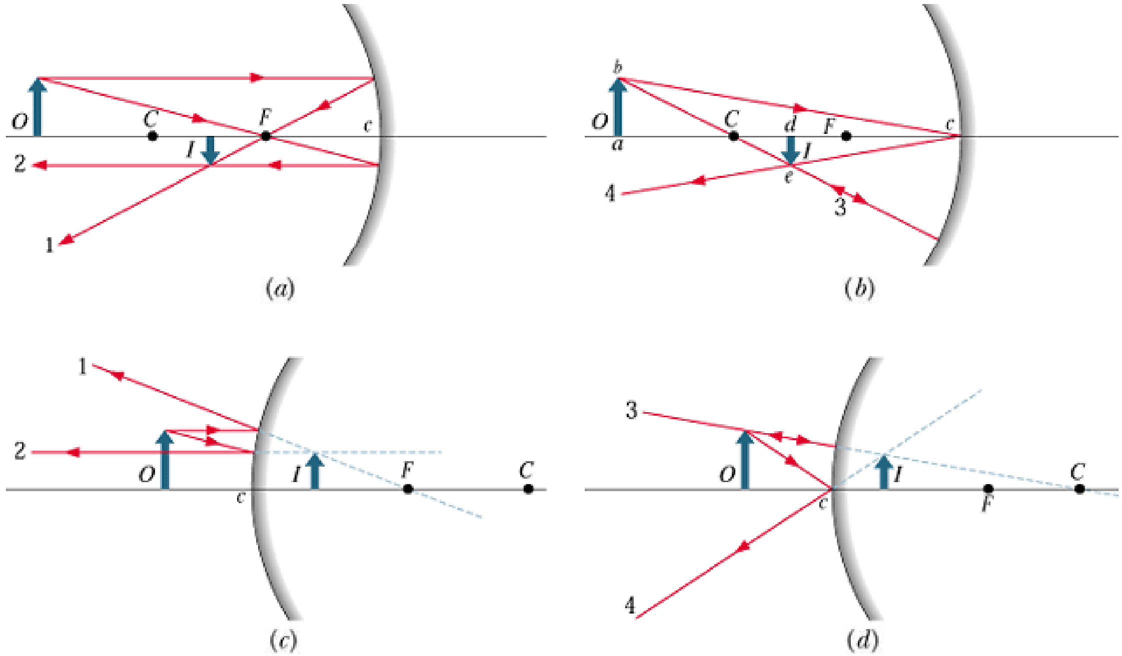
$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f} \quad \text{(spherical mirror)}.$$

$$|m| = \frac{h'}{h} \quad \text{(lateral magnification)}.$$

$$m = -\frac{i}{p} \quad \text{(lateral magnification)}.$$

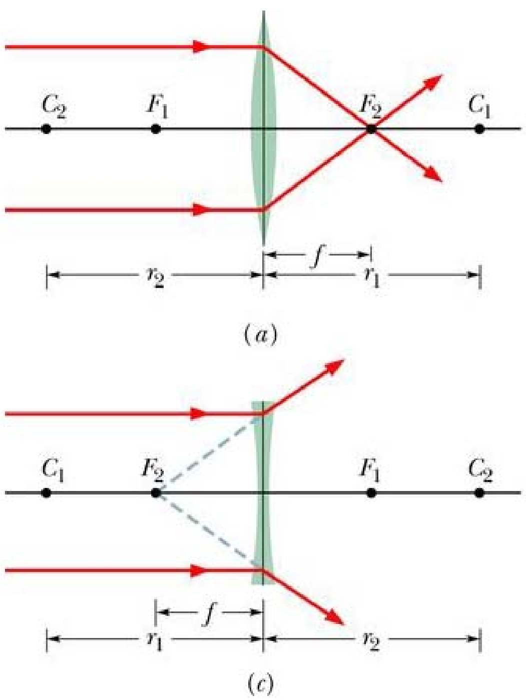
i of a real image is positive
i of a virtual image is negative

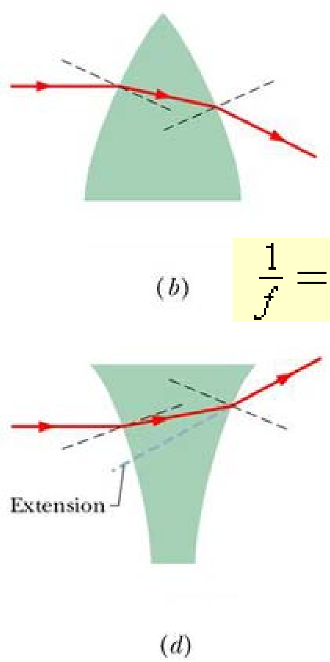
Working with Mirror images:



Thin Lenses

$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad \text{(thin lens in air)}$$



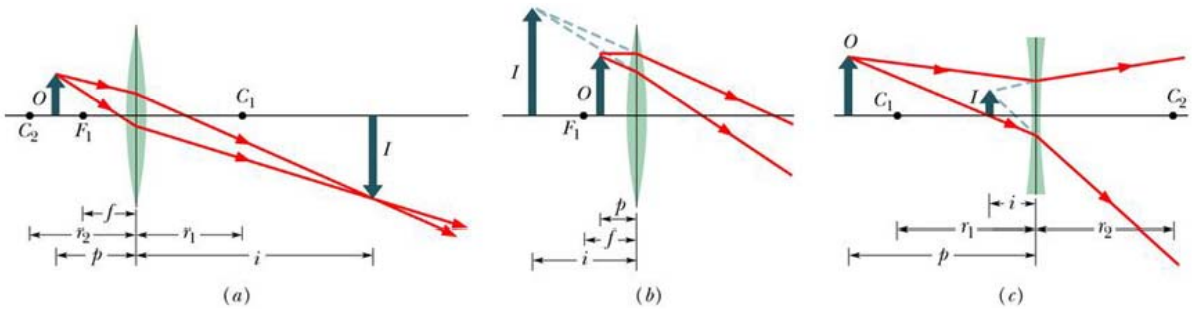


$$\frac{1}{f} = \frac{1}{p} + \frac{1}{i} \quad \text{(thin lens)}.$$

Thin Lenses

$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad \text{(thin lens in air)}$$

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{i} \quad \text{(thin lens)}.$$



real inverted image
Of the object further away than F from the lens

virtual image
Of the object between F and L

virtual image (always)