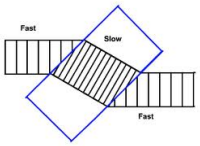
Chapter 26 -

Refraction and Lenses

demo - broken glass, fish tank

Refraction

- Bending of light due to change in medium
- Wave changes speed
- One part speeds up/slows down before the other = BENDS

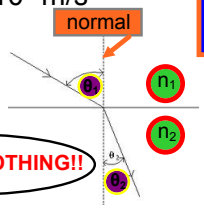


Snell's Law

- $n_1 \sin\theta_1 = n_2 \sin\theta_2$
- $n = c/v$
- $c = 3 \times 10^8$ m/s
- $n \geq 1$

n = index of refraction

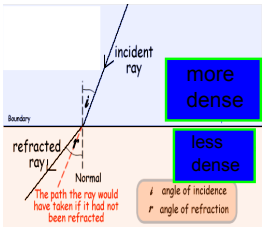
BIGGER difference in n = MORE bending

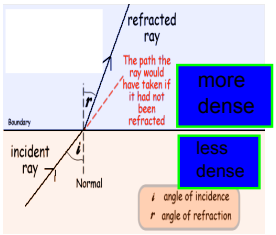


units for n - NOTHING!!

N ⟶ n = "bends TOWARDS normal"

n ⟶ N = "bends AWAY from normal"

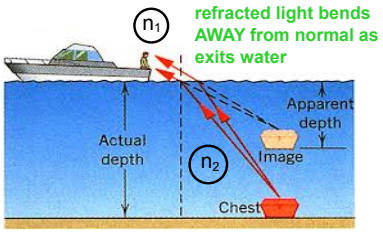




Apparent Depth - refracted light causes object to appear at a different location

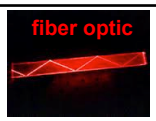
d' = d(n_1/n_2)

- **ratio of n_1/n_2 alters amount of difference**

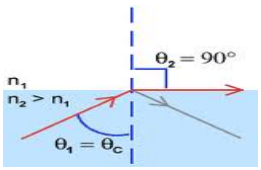


demo - waterfall of fire, plastic, fiber optics

Total Internal Reflection



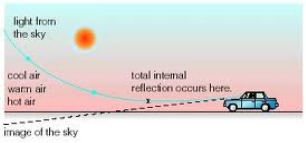
- When all the light is reflected and NONE is refracted OUT of medium 1
- Can only happen from MORE dense to LESS dense
- $\theta_r = 90^o$
- $\theta_c = \theta_i$ = critical angle



Critical Angle Formula

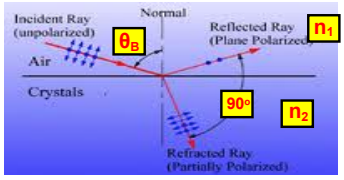
Mirages

- Due to various refraction indices of cold and hot air
- Sky light refracted onto ground = looks like water



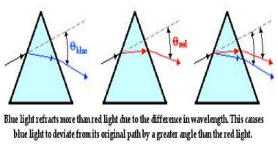
Brewster's Angle

- Angle where reflected light is polarized
- Refracted ray and reflected ray are 90°
- $\tan\theta_B = n_2/n_1$



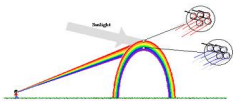
Dispersion

- Separation of color due to difference in n's
- High f = more interaction with molecules = higher n = more bending
- ex. Blue light bends more than Red light



Blue light refracts more than red light due to the difference in wavelength. This causes blue light to deviate from its original path by a greater angle than the red light.

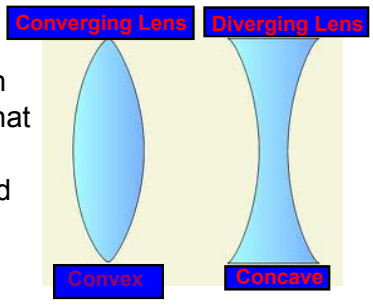
Prisms - note CANNOT be rectangular!!



Rainbows - note sun is BEHIND viewer

Lenses

- Refract light
- Like mirrors, can create images that can be real or virtual, magnified of demagnified
- CANNOT be rectangular!!!



Ray Diagram Rules are the same as mirrors:

1) A ray **parallel** to the optical axis bends through **focus TWO**

2) A ray passing through **focus ONE** exits **parallel** to optical axis

3) A ray passing through **CENTER OF LENS** does **NOT BEND**

Equations are the same

$1/d_o + 1/d_i = 1/f$

$m = -d_i/d_o = h_i/h_o$

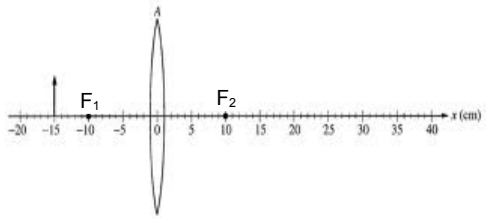
*** all measurements are relative to optical axis***

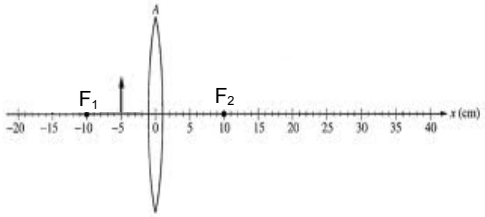
there are now TWO foci, but all our lenses have $f_1 = f_2$ (There are just TWO surface bending the light)

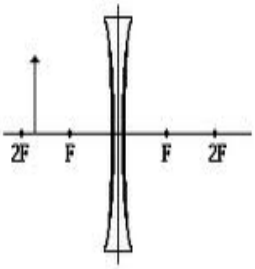
d_o = distance to object
d_i = distance to image
f = focal length = R/2
h_i = height of image
h_o = height of object
m = magnification

Sign Conventions

- same as mirrors BUT...
- light is supposed to go through
- **"right side" is opposite object = +**
- **"wrong side" is same as object = -**





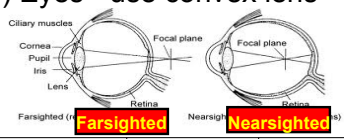


Optical Devices

Problems with eyes:

refractive index of eyeglasses = 1/f of lens

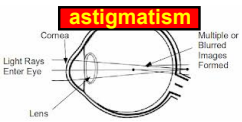
1) Eyes - use convex lens



Farsighted

Nearsighted

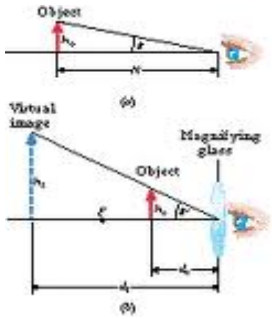
astigmatism



NAME	CAUSE	PROBLEM	CORRECTED BY
Nearsighted	long eyeball	image in front of retina	concave lens
Farsighted	short eyeball	image in back of retina	convex lens
Astigmatism	barrel shaped cornea	rays don't all cross at one spot	curve of glasses (contacts not as well)

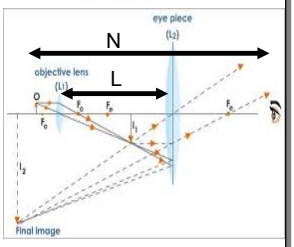
2) Magnifying glasses MUST be CONVEX lens

- M = magnification
- **$M = \theta'/\theta = (1/f - 1/d_i)N$**
- θ' = angular distance to image in radians
- θ = angular distance to object in radians
- N = distance from eye to object = "near" point



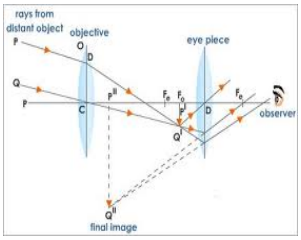
3) Compound Microscope - uses TWO convex lenses

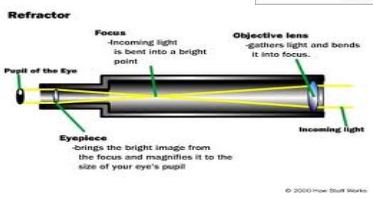
- **$M = -(L-f_e)N/f_o f_e$**
- f_e = eyepiece focal length
- f_o = objective focal length
- L = distance between lenses
- N = Near point
- M = greatest when f_o and f_e are smallest and L is greatest



4) Telescope

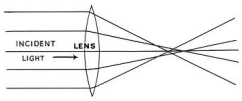
- **$M = -f_o/f_e = \theta'/\theta$**
- M is greatest when f_o is BIG and f_e is small





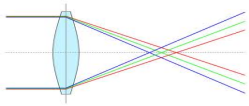
Lens problems

1) Spherical aberration



> Due to different thickness at edges, refracts different amounts

2) Chromatic aberration



> Due to different n's for different colors = refract differently and separate

*****both corrected with extra lenses******