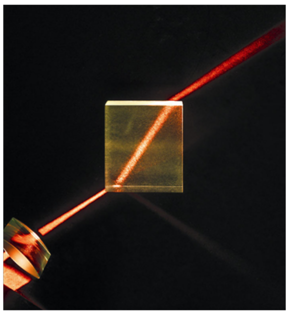
5.A.3 - Refraction



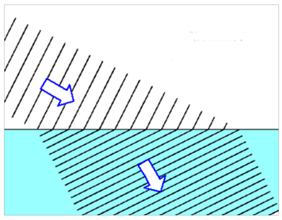
Refraction

Demo: Pencil in water. Ever seen something like this?

Changing wave direction at the boundary between materials is <u>Refraction</u>. Note wave front compression.

Caused by speed of light differences through different media: light is fastest in a vacuum, and slower through <u>optically dense</u> materials.

Analogy: a car's tires in the soft snow at the road's edge pull towards the ditch.



Index of Refraction (n)

Comparison of light speeds in different media.

$n = \frac{c}{v}$	n = index of refraction c = vacuum light speed (3.00 E 8 m/s) v = speed of light in medium (m/s)
AP Equation	

Table 5.A.2 lists indices (Resources 8).

Light's frequency when passing into different media is **<u>unaltered:</u>** wavelength & speed change.

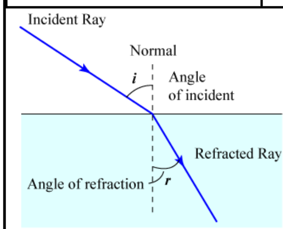
Wavelength shortens when light travels slower, and lengthens when going faster:

$n = \frac{\lambda}{\lambda_m}$	n = Index of Refraction λ = Wavelength in vacuum (m) λ_m = Wavelength in medium (m)

Law of Refraction

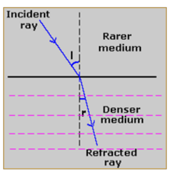
<u>Angle of refraction</u>: angle a light beam deflects from its path at a boundary; given in <u>Snell's Law</u>:

$n_1 \sin\theta_1 = n_2 \sin\theta_2$	θ_1 = angle of incidence θ_2 = angle of refraction n_1 = index of refraction (material 1) n_2 = index of refraction (material 2)
AP Equation	

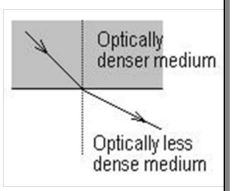


Relationships

If the 2nd medium has a higher index (more optically dense) than 1st, light refracts toward the normal.



If the 2nd medium has a lower index (less dense) than 1st, light refracts away from the normal.

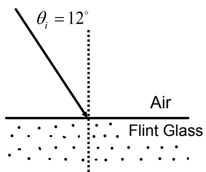


Example 1 A

What is the angle of refraction of light entering a piece of flint glass (use resources for n) from air at a 12° incident angle?

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_2 = \sin^{-1}\left(\frac{n_1 \bullet \sin}{n_2}\right) = \sin^{-1}\left(\frac{1.0 \bullet \sin 12^\circ}{1.66}\right) = 7.2^\circ$$



Example 2

What is the velocity of light in flint glass?

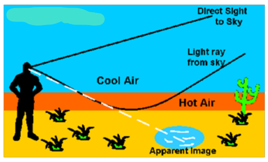
$$n = \frac{c}{v}$$

$$v = \frac{c}{n} = \frac{3.00E8\,m/s}{1.66} = 1.80E8\,m/s$$

Special Effects

Refraction plays a part in the optical world around us.

Mirage: Air next to a hot surface is less dense than the air above, so light refracts upwards.

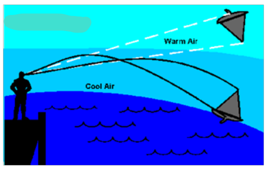


Special Effects

Fata Morgana: Seen in winter during temperature inversions.

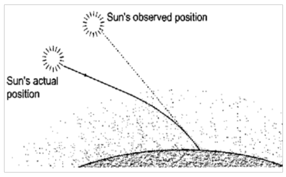
Light turns towards the medium with higher density.

As light gets to the inversion layer, it refracts downwards: distant objects appear giant!



Other Special Effects

Stars twinkle as their light passes through the atmosphere's layers.
The sun and moon appear in the sky before they actually rise due to atmospheric refraction.

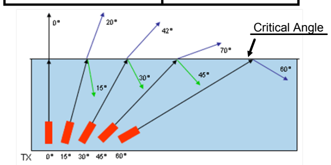


Total Internal Reflection

When light passes from an optically dense medium to a lesser one, it deflects away from the normal.

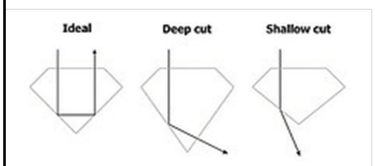
If the angle is great enough (the critical angle (θ_c), light undergoes total internal reflection, and doesn't pass into the second medium.

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



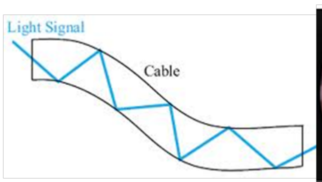
Diamonds!

Internal reflection increases diamonds' brilliance. Diamond has a very high index of refraction: gem cutters take advantage of this by designing diamonds so light entering them comes out the front – thus making the gem more beautiful.



Fiber Optics

Internal reflection is used in fiber optics. Light is mov
through ahighly optically conductive fiber.



This is used in communications, as well as surgeries where fiber optic instruments are used to see into bodie during arthroscopic surgery!

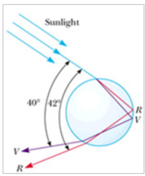
Fiber optics demo - water into container.

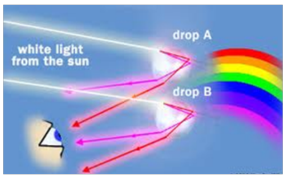
Dispersion

As EM frequency increases, so does index of refraction. Ex: violet light refracts more than red.

Ex: as sunlight enters raindrops it separates into its components, making a rainbow.

Called <u>dispersion,</u> this is caused by frequencies of light having different speeds through a medium.





Homework

5.A.3 Booklet Problems.
Due: Next Class.

Unit 5.A Review Problems Due: