Phys 2426 2014-11-19

Index of Refraction

I told you: $v_{light} = c = 3 \times 10^8 \ m/s$

Actually, $v_{light} = c$ only in a vacuum

Materials slow light by a factor of n.

n = index of refraction $\quad v = \frac{c}{n}$

As light changes materials, f = const.

$v = f\lambda \qquad \lambda_n = \frac{\lambda_0}{n}$

Every n is > 1. Generally $1 < n < 5$

Ex: $n_{air} = 1.003$

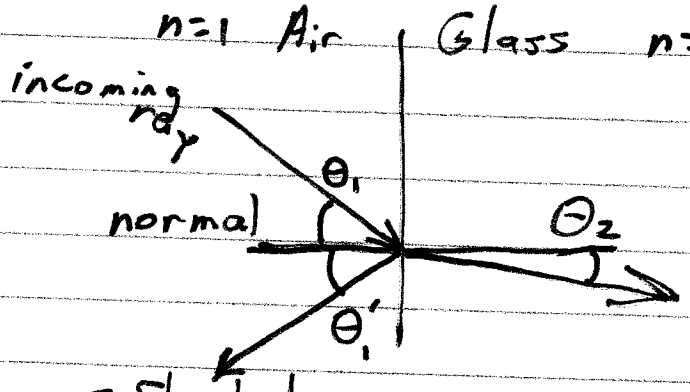
$n_{water} = 1.33$

$n_{glass} = 1.5$

Ex: Speed of light under water

$$v = \frac{c}{n} = \frac{3 \times 10^8 \ m/s}{1.33} = 2.26 \times 10^8 \ m/s$$

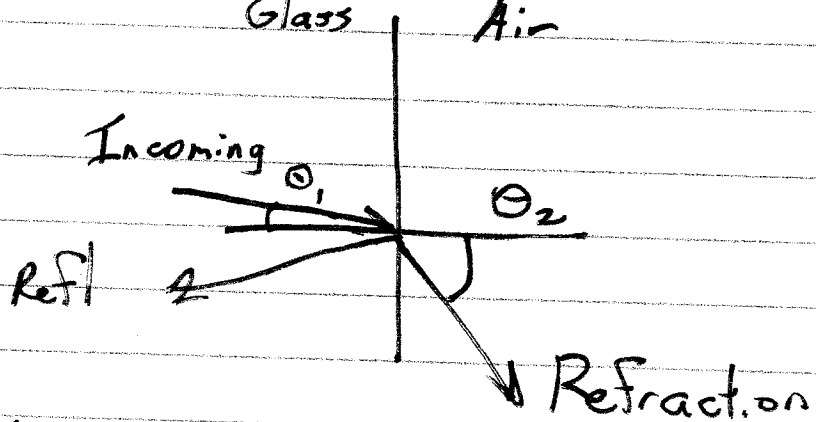
Reflection & Refraction



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

If n increases, $\sin\theta$ decr.

When light leaves the glass, it speeds up.



Note: $\sin\theta_2$ is limited to 1

Set $\sin\theta_2 = 1$ to find largest θ_1.

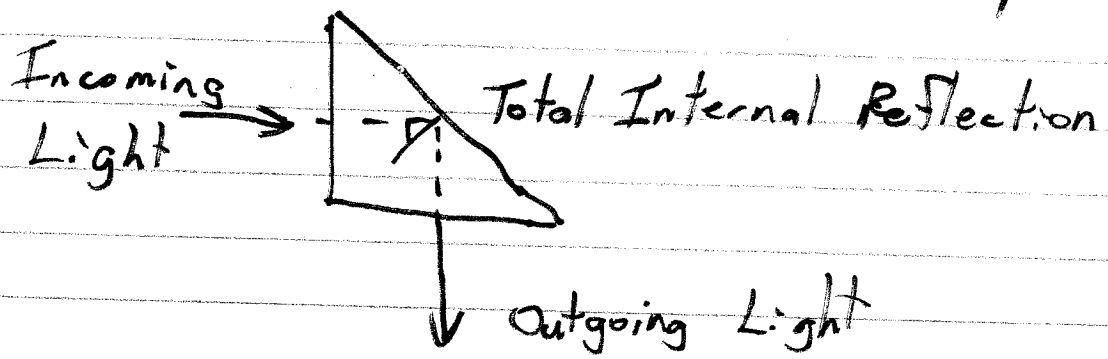
$n_1 \sin\theta_1 = n_2$

$\sin\theta_1 = n_2/n_1$ "critical angle"

Total Internal Reflection : θ_2 not allowed.

To have this, n_1 must be larger (than n_2).

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\qquad$ $\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$



$\theta_1 = 45^\circ$

$n_2 = 1$

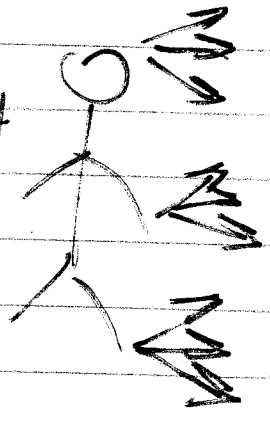
$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_1 \sin 45^\circ = (1)(1)$

$n_1 = 1.414$ at a minimum

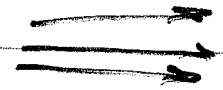
Image Formation

Every part of the object Emits light in all directions.



We will consider a point source.

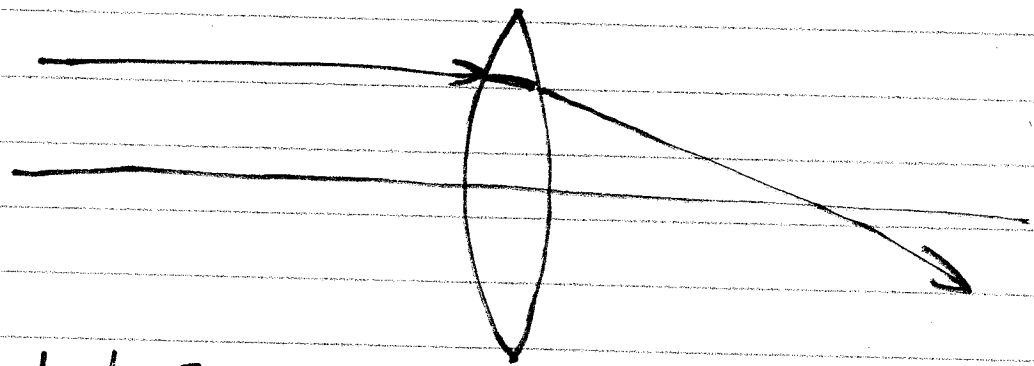
These rays are diverging



These rays are less diverging.

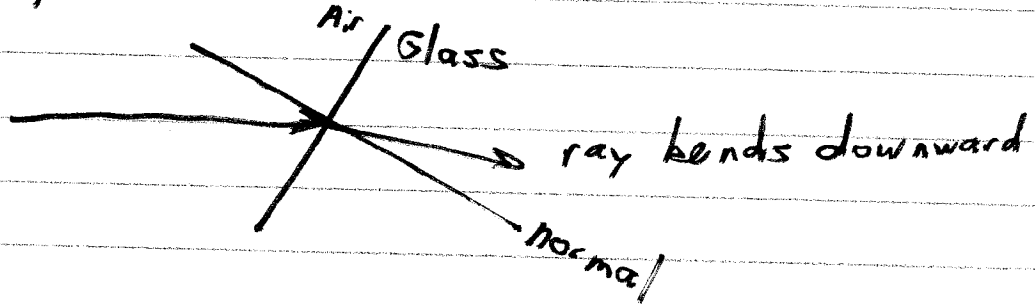
Everything we see causes diverging rays.
We control the divergence of rays to control the appearance.

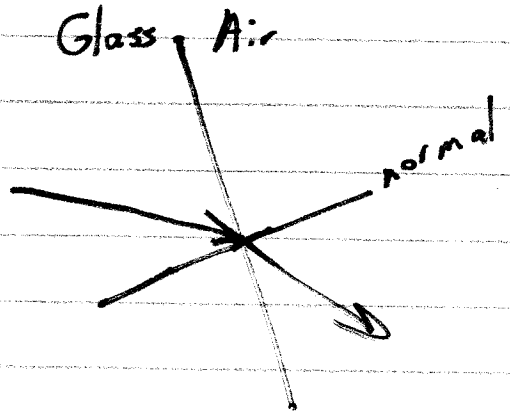
Converging Lens: Thicker in the middle.

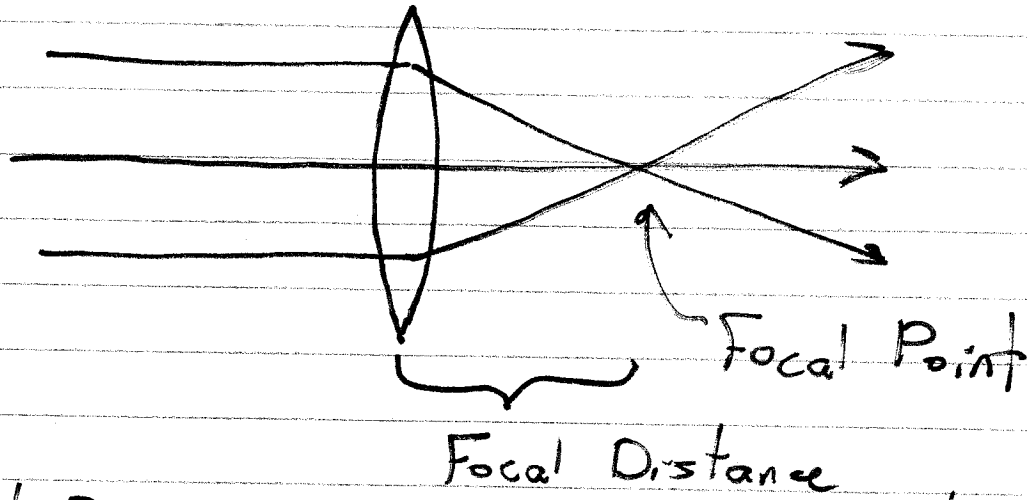


Central Ray: $\theta_1 = 0 \rightarrow \theta_2 = 0$

Upper Ray @ Front surface

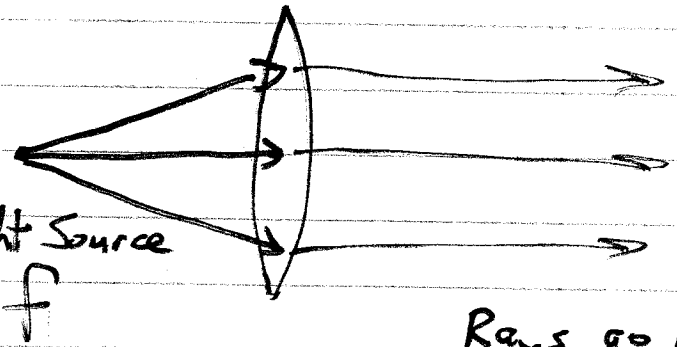






Parallel Rays are focused @ Focal Distance.

The rays can be reversed.



3 Important Rays

1. Central Ray goes straight thru middle of lens.
2. Incoming Parallel Ray bends to line up w/ focal point.
3. Focal Ray bends parallel to axis.

Measurements w/ Lenses - Distance to the current lens is the important quantity.

p - object distance

q - image distance

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Note: If $1/q = 0$, the behavior "flips".

$p = f$ is a critical point.