



# **=EQUALS=**

**A Club of Investigation and  
Discovery**

[www.equalsclub.com](http://www.equalsclub.com)

## **SOME QUESTIONS**

If I shout “Knock Knock” in outer space, what would you answer with?

What happens to the speed of sound as the temperature decreases?

What happens to the speed of sound as the altitude increases?

The speed of sound is about 343 meters / second. What is this in miles / second?

Light travels at about 186,000 miles / second. I see a lightning bolt, and count five seconds. How far away did the lightning strike?

## USING THE SPREADSHEET

complete the table below:

<b>From</b>	<b>at this Angle of Incidence</b>	<b>Through</b>	<b>with this Angle of Refraction</b>
Vacuum	45	Air	
Air	30	Water	
Air		Diamond	18
Water	20		17
	40	Diamond	24

<b>Material</b>	<b>Speed of Light (relative to vacuum)</b>	<b>Speed of Sound (meters / second)</b>
Vacuum	1.000000	0
Air	1.000277	343
Ice	1.310000	3,152
Water	1.333333	1,482
Glass	1.550000	5,640
Diamond	2.417000	12,000

# The Speed of Light

The speed of light is 186,000 miles per second, in a vacuum.

In a vacuum, there are no molecules.

Light travels fastest when there are no molecules.

Most things are composed of differing amounts of molecules.

When light goes through mediums with molecules, the speed of light changes.

# The Bent Pencil

Light encounters  
few molecules in  
air.

Light encounters  
many molecules  
in water.

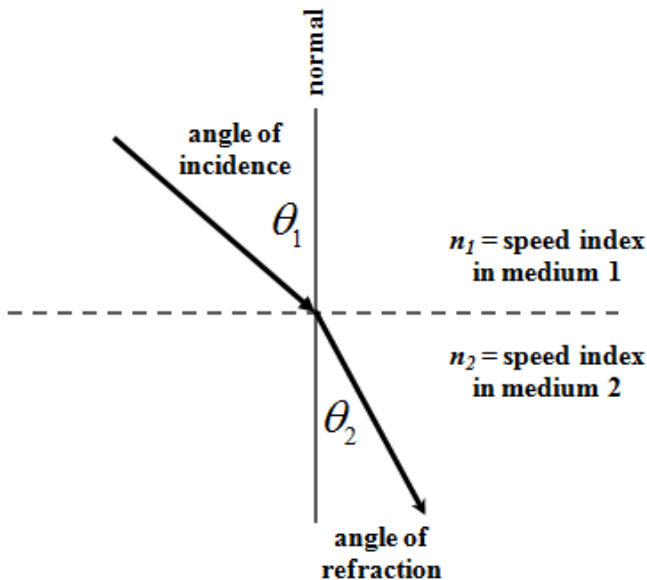
The speed of light  
is faster than air  
than in water.

What we see  
depends on light  
moving from the  
object to our eyes.

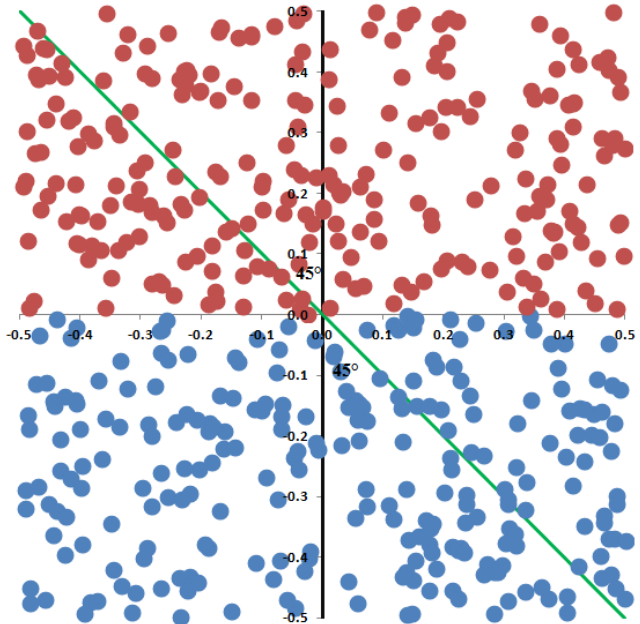
**The pencil looks  
bent in water.**

# SNELL'S LAW

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

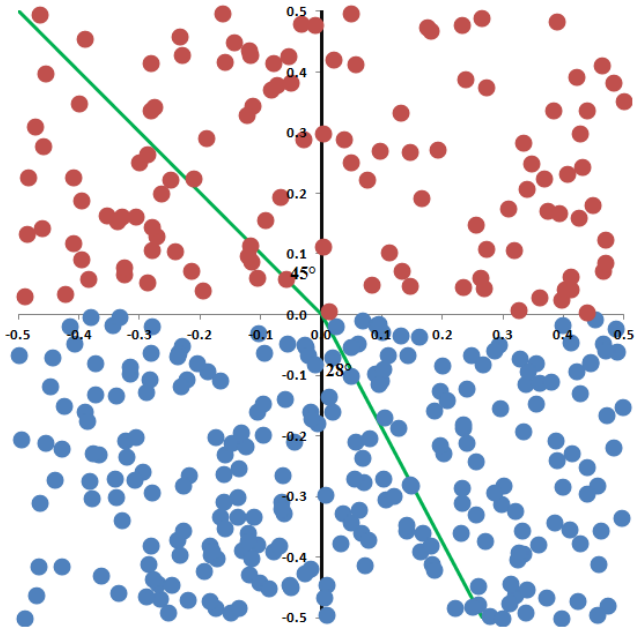


Light traveling from air through more air, at an angle of incidence of  $45^\circ$ ,



*continues in a straight line ...*

**Light traveling from air through water, at an angle of incidence of  $45^\circ$ ,**



*bends towards the normal line*

# Thunder and Lightning

Sound is the bumping of molecules against one another.

Sound is like a rumor - needing many people to spread it.

SOUND travels fastest when it encounters **MANY** molecules.

LIGHT travels fastest when it encounters **FEW** molecules.

**I see lightning much faster than I hear thunder.**



## Solving for the Angle of Refraction ( $\theta_2$ ), Given Everything Else

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



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



$$\sin^{-1} \left[ \frac{n_1}{n_2} \sin \theta_1 \right] = \theta_2$$