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DEPARTMENT OF SCIENCES OF THE NATURE AND LIFE
1st year common core Biology

Practical work N⁰ 2 Snell's Law of Refraction

1. OBJECTIVES

The transmission of light across a boundary between two media is accompanied by a change in both the speed and wavelength of the wave. This can result in a change of direction at the boundary, a phenomenon known as refraction. In this experiment you measure the change in direction of light beams as they refract or reflect at a boundary to determine the index of refraction of a transparent object. The objectives of this experiment are as follows:

1. To measure the angles of incidence and refraction at a boundary between media
2. To observe total internal reflection at a boundary between media
3. To calculate the critical angle of a boundary between media (medium)

2. THEORY

The index of refraction is a property of transparent substances that has been independently discovered several times, but is attributed to Willebrord Snellius whose name is associated with the law. Mathematically, Snell's law describes the relationship between the angle of incidence of a beam of light as it intersects a new transparent medium and the angle of refraction as enters that transparent medium.

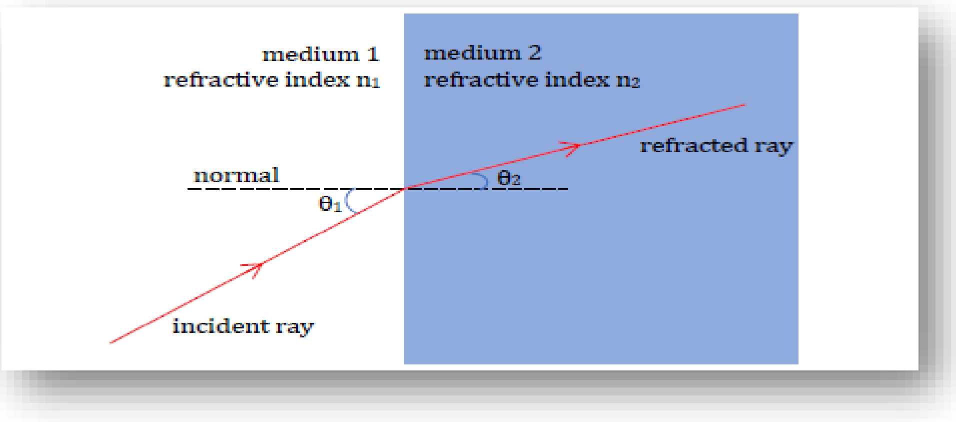


Figure 1: Refraction overview

Snell's law quantifies the relationship that is observed in Figure 1:

$$n_1 . \sin\theta_1 \; = n_2 . \sin\theta_2 \qquad 1$$

where n_1 is the index of refraction of medium 1, n_2 is the index of refraction medium 2, θ_1 is the angle that the light ray makes with respect to the normal in medium 1, θ_2 is the angle that the light ray makes with respect to the normal in medium 2.

The index of refraction of any medium (n_i) is the ratio of the speed of light in vacuum (c) to the speed of light in that medium (v_i), as shown in equation 2.

$$n_\mathrm{i} = \frac{c}{v_\mathrm{i}} \qquad 2$$

where $c \; = \; 3.00 \times 10^8 \; m/s$ (the accepted value for the speed of light in vacuum, a constant). A very good approximation for the refractive index of air is 1.00, i.e. nair=1.00.

On observation, it can easily be seen that as light travels from a lighter medium to a denser one (i.e. $n_1 < n_2$), the refracted light ray bends towards the normal. Conversely, when light travels from a denser medium to a lighter one (i.e. $n_1 > n_2$), the refracted light ray bends away from the normal.

When the refracted ray exceeds 90°, it's not refraction anymore, instead light is reflected back into the same medium it started from, and this phenomenon is known as **total internal reflection**. Note that this only happens for light traveling from a denser medium to a lighter one (see figure 2 below).

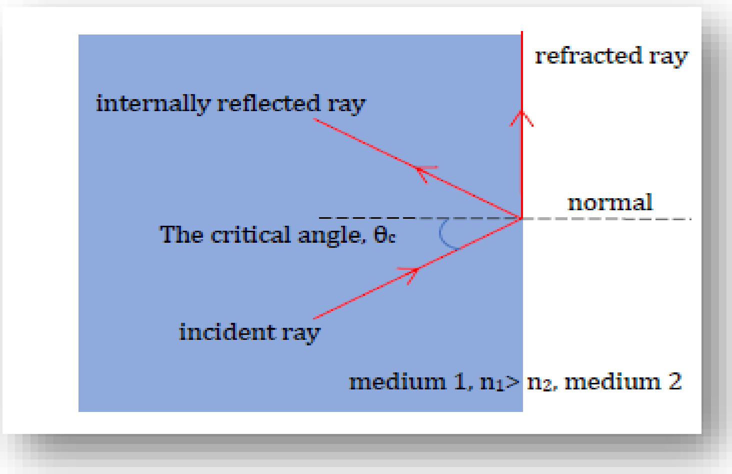


Figure 2 : Total internal reflection

The critical angle **(θc) is the angle of incidence** for which the angle of refraction is 90°. Beyond the critical angle, 100% of the incident light is reflected back into the same medium.), as shown in equation 3(see figure 2) . $n_{Glass} . \sin\theta_c = n_{air} . \sin 90^0$

$$\theta_c = \sin^{-1}\left(\frac{n_{air}}{n_{Glass}}\right) = \sin^{-1}\left(\frac{n_2}{n_1}\right) \qquad 3$$

3. Experiment

The glass used in this experiment is made of Lucite. The accepted value for the refractive index of Lucite is **1.50**. The mystery media have no accepted value for their refractive indices. It is up to the experimenter to determine their values.

Click on this link to start your experiment on refraction:

https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html

Data table

Medium	**Measurement**	**Magnitude (°)**	**Refractive index**
Air	Angle of incidence (40°< θi < 60°)		$n_a =$
Glass	Angle of refraction		
Air	Angle of incidence (60°< θi < 90°)		$n_b =$
Glass	Angle of refraction		
Glass	Critical Angle (θc)		$n_c =$
Air	Angle of incidence (θi)		$n_A =$
Mystery Medium A	Angle of refraction		
Air	Angle of incidence (θi)		$n_B =$
Mystery Medium B	Angle of refraction		

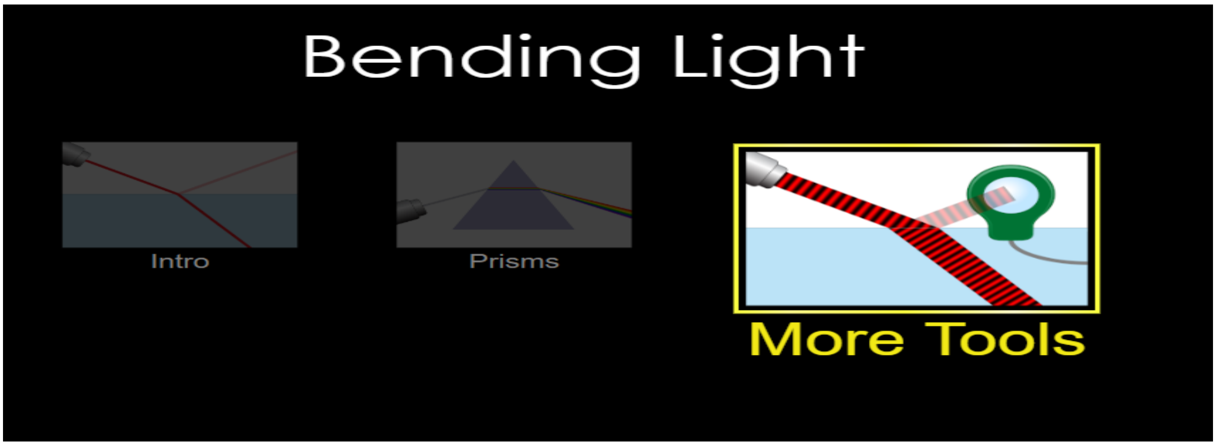
ANALYSIS (QUESTIONS) :

1. Use equation 1 to calculate the refractive index of glass in the first three scenarios on the data table ($n_a, n_b and\ n_c$).
2. Find the average experimental value for the refractive index of Lucite, $n_{average}$.
3. Calculate the error (as a percentage) in your average experimental value calculated above.
4. Calculate the speed of light in Lucite.
5. Calculate the Critical Angle of the Lucite.
6. Use equation 1 to calculate the refractive index of "Mystery A" and "Mystery B" media.
7. Conclusion

$$n_i = n_a, n_b\ or\ n_c,$$

$$\boldsymbol{Error} = \Delta \boldsymbol{n} = \boldsymbol{sup}\left|\boldsymbol{n_i} - \boldsymbol{n_{average}}\right|,$$

$$\frac{\Delta n}{n_{average}} = percentage$$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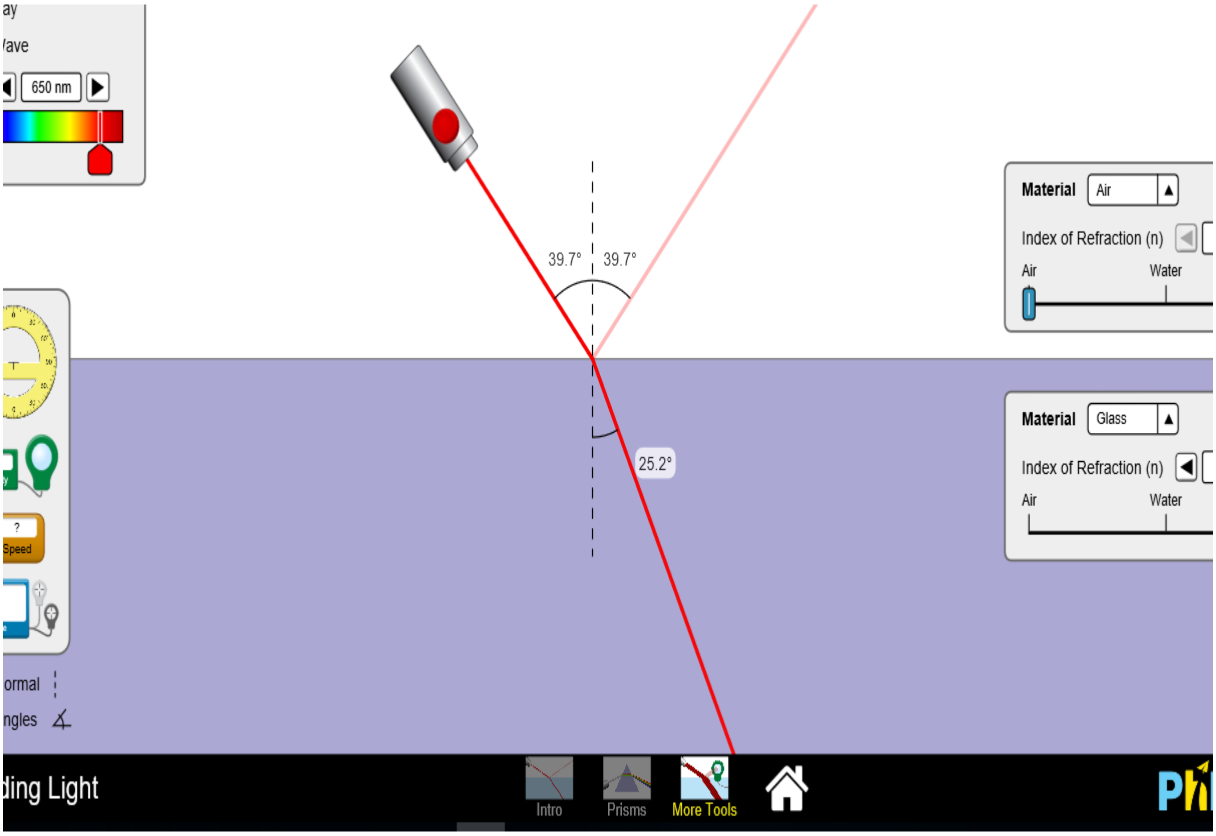
650 nm
39.7°
39.7°
25.2°
Material
Air
Index of Refraction (n)
Air
Water
Material
Glass
Index of Refraction (n)
Air
Water
Speed
Intro
Prisms
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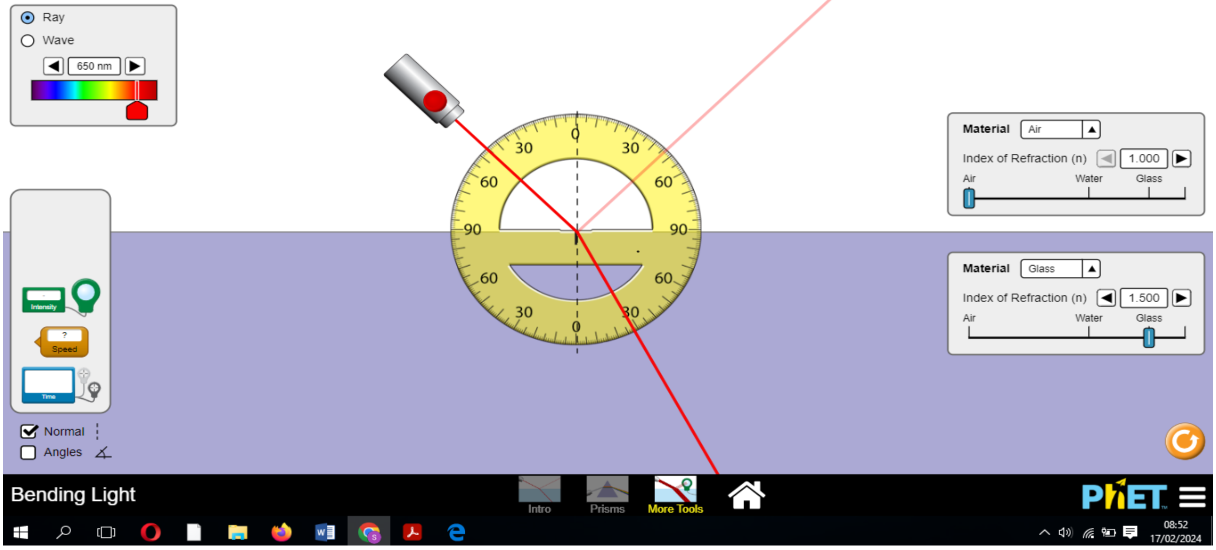
Ray
Wave
650 nm
Material
Air
Index of Refraction (n)
1.000
Air
Water
Glass
Material
Glass
Index of Refraction (n)
1.500
Air
Water
Glass
Speed
Normal
Angles
Bending Light
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