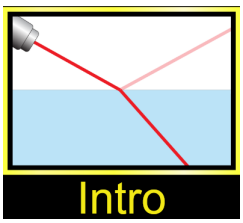
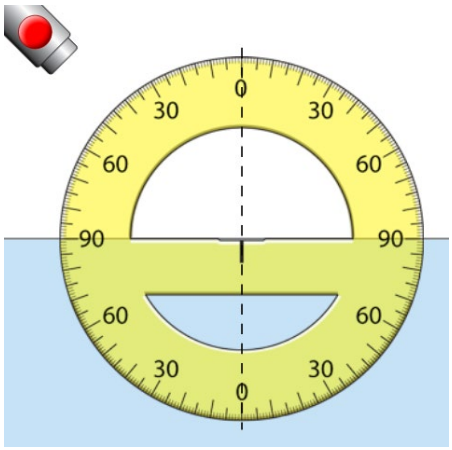
Refraction
(Using PhET Simulation "Bending Light")

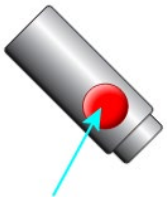
Name: _____

Setup

1. Open the simulation: https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html

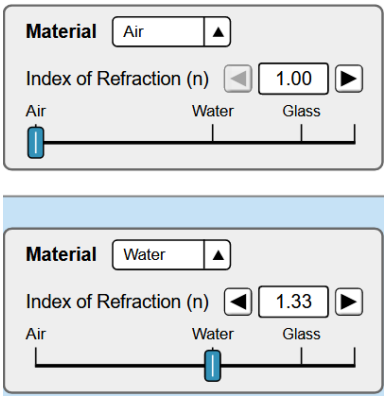
2. Select "Intro." 

3. Align the protractor with the normal and the surface. 

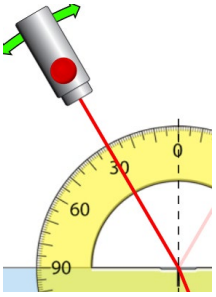
4. Turn on the "laser" by clicking on the red button. 

Part A – $n_1 < n_2$

1. Set the materials to air and water.



2. Move the "laser" such that the angle of incidence is 30°.



3. Record the angle of refraction in the table below.

4. Select 4 more angles of incident and record the angles of incident and refraction in the table.

Angle of Incidence θ_i	$\sin\theta_i$	Angle of Refraction θ_r	$\sin\theta_r$	$\frac{\sin\theta_i}{\sin\theta_r}$
30°				

5. Calculate the other values in the table.

6. Is the angle of refraction always greater than or less than the angle of incidence?

7. Calculating the index of refraction.

   (a) Calculate the average value of $\frac{\sin\theta_i}{\sin\theta_r}$.

   (b) Use the value calculated in (a) to calculate the index of refraction for water. Verify that this value matches the one given in the simulation.

8. Set the materials to air and glass.

9. Measure the angle of refraction for five different angles of incidence and record them in the following table.

Angle of Incidence θ_i	$\sin\theta_i$	Angle of Refraction θ_r	$\sin\theta_r$	$\frac{\sin\theta_i}{\sin\theta_r}$

10. Calculate the other values in the table.

11. Is the angle of refraction always greater than or less than the angle of incidence?

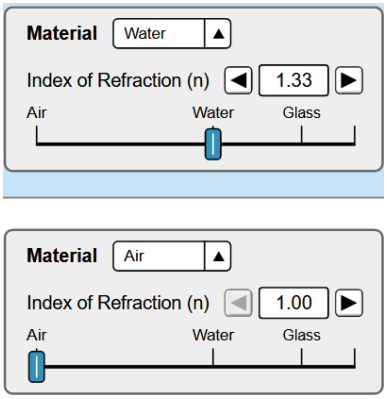
12. Calculating the index of refraction.

    (a) Calculate the average value of $\frac{\sin \theta_i}{\sin \theta_r}$.

    (b) Use the value calculated in (a) to calculate the index of refraction for glass. Verify that this value matches the one given in the simulation.

Part B – $n_1 > n_2$

1. Set the materials to water and air.



2. Measure the angle of refraction for five different angles of incidence and record them in the following table.

Angle of Incidence θ_i	$\sin\theta_i$	Angle of Refraction θ_r	$\sin\theta_r$	$\frac{\sin\theta_i}{\sin\theta_r}$

3. Calculate the other values in the table.

4. Is the angle of refraction always greater than or less than the angle of incidence?

5. Calculating the index of refraction.

   (a) Calculate the average value of $\frac{\sin \theta_i}{\sin \theta_r}$.

   (b) Use the value calculated in (a) to calculate the index of refraction for water. Verify that this value matches the one given in the simulation.

6. There is a maximum angle of incidence. This maximum angle is referred to as the critical angle.

   (a) Use the simulation to find the critical angle. _____.

   (b) This angle can be calculated by using an angle of refraction of 90°. Calculate the value of the critical angle.

7. Set the materials to glass and air.

8. Measure the angle of refraction for five different angles of incidence and record them in the following table.

Angle of Incidence θ_i	$\sin\theta_i$	Angle of Refraction θ_r	$\sin\theta_r$	$\frac{\sin\theta_i}{\sin\theta_r}$

9. Calculate the other values in the chart.

10. Calculating the index of refraction.

    (a) Calculate the average value of $\frac{\sin\theta_i}{\sin\theta_r}$.

    (b) Use the value calculated in (a) to calculate the index of refraction for glass. Verify that this value matches the one given in the simulation.

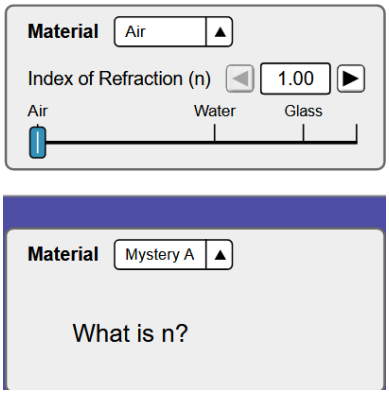
11. There is a maximum angle of incidence. This maximum angle is referred to as the critical angle.

    (a) Use the simulation to find the critical angle. _____.

    (b) This angle can be calculated by using an angle of refraction of 90°. Calculate the value of the critical angle.

Part C – Measuring the Index of Refraction of an Unknown Material.

1. Set the materials to air and Mystery A.



2. Measure the angle of refraction for five different angles of incidence and record them in the following table.

Angle of Incidence θ_i	$\sin\theta_i$	Angle of Refraction θ_r	$\sin\theta_r$	$\frac{\sin\theta_i}{\sin\theta_r}$

3. Calculate the other values in the chart.

4. Calculate the index of refraction of Mystery A.

5. Set the materials to air and Mystery B.
6. Measure the angle of refraction for five different angles of incidence and record them in the following table.

Angle of Incidence θ_i	$\sin\theta_i$	Angle of Refraction θ_r	$\sin\theta_r$	$\frac{\sin\theta_i}{\sin\theta_r}$

7. Calculate the other values in the chart.

8. Calculate the index of refraction of Mystery B.