Refraction

***Available equipment**: Large mirror, ruler, tape, laser pointer, ruler, protractor(optional), rectangular and circular vessels with transparent walls (clear plastic or glass boxes, cylindric glass or vase).*

<u>Optional</u>: A packages of Jello®, or package of clear gelatin (Knox® brand is easy to find in supermarkets)

Part 1. Refraction

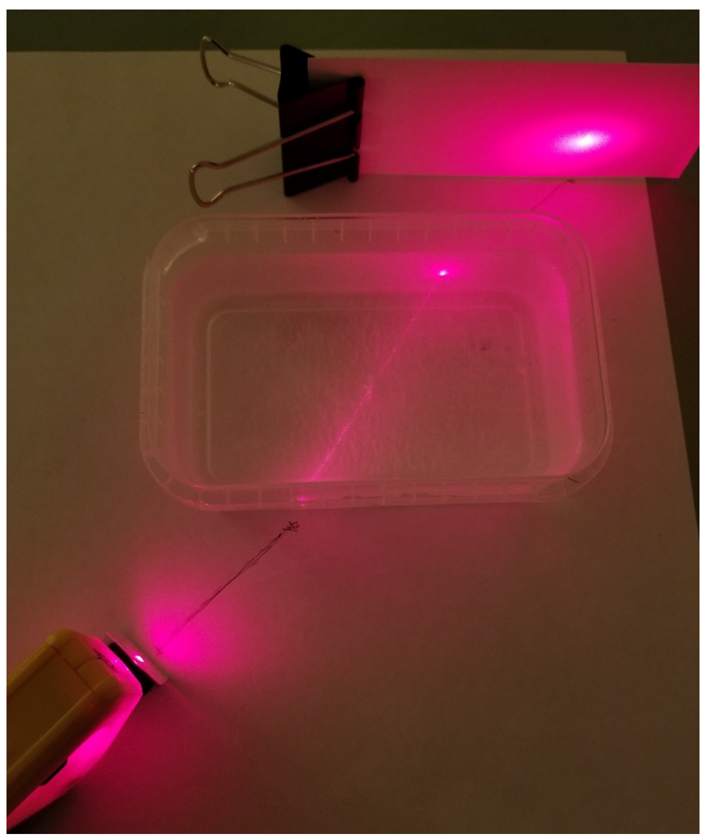
As you have seen, the direction of light propagation changes abruptly when light encounters a reflective surface. The direction also changes abruptly when light passes across a boundary between two different media of propagation, such as between air and acrylic, or between glass and water. In this case, the change of direction is called Refraction.

A simple law characterizes the behavior of a refracted ray of light. According to the Law of Refraction, also known as Snell's Law:

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

The quantities n_1 and n_2 are constants, called indices of refraction, that depend on the two media through which the light is passing. The angles θ_1 and θ_2 are the angles that the ray of light makes with the normal to the boundary between the two media. <u>Refractive index of air is 1.</u>

Objective: In this experiment you have to determine the refractive index of water or Jello by using Snell's law.



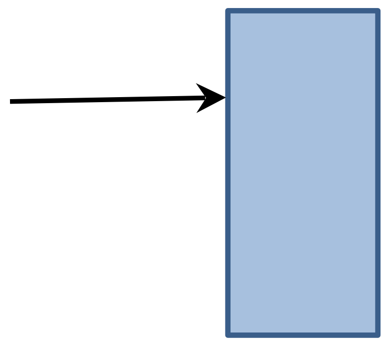
You will need a rectangular or circular vessel with transparent walls to fill it with water or use a Jello or gelatin. Place the laser pointer so it passes through water. Can you see the beam? If you use water may add a small pinch of dry milk or flour to make the laser beam visible.

You will need a rectangular or circular vessel with transparent walls to fill it with water or use a Jello or gelatin. Place the laser pointer so it passes through water. Can you see the beam? If you use water may add a small pinch of dry milk or flour to make the laser beam visible. You can place a white paper as a screen and another piece of paper underneath the set-up to draw the lines. You can trace the beam by drawing lines from the source to a point where the beam strikes the vessel and where it strikes the screen (see the figure)

Qualitative experiments.

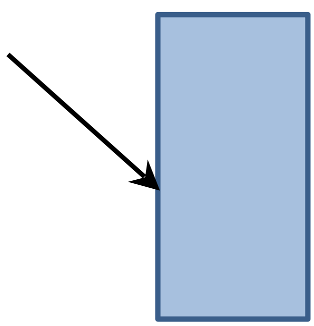
Hint: Draw normal lines to surfaces at a point where the beam strikes it.

1. A beam of light hits a wall of a rectangular prism as shown in the figure. Use your previous knowledge to predict the direction of the beam inside of the prism and after it passes through the prism.



   Perform the testing experiment. Did the results match your prediction?

2. A beam of light hits a wall of a rectangular prism. Use your previous knowledge to the direction of the beam inside of the prism and after it passes through the prism. Mark all important angles.

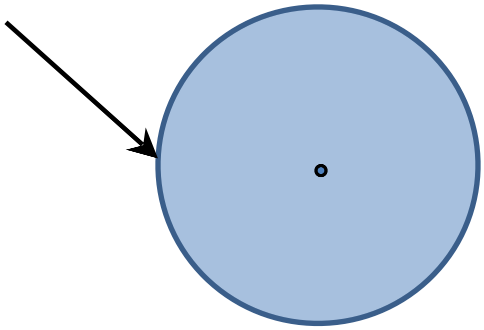


(When estimating refraction, draw the ray through the surface as if it did not bend – then bend it toward or away from the normal as required. (Must always cross the normal)

Perform the testing experiment. Did the results match your prediction?

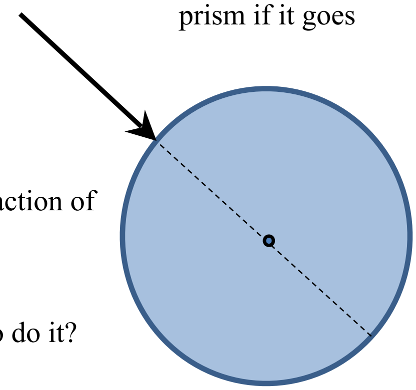
3. Predict what will happen when a beam of light that hit a circular prism Hint: remember that normal line to a circular surface goes through its center.

   Test your prediction



4. Predict what will happen when a beam of light that hit a circular prism if it goes through the center of the circle.

   Test your prediction



Measurements of index of refraction.

Perform several different measurements to determine the index of refraction of water and compare the results.

1. What values do you need to measure and how are you going to do it? What mathematical procedure should you use to determine the refraction index? Think about minimizing the uncertainty of your measurements.
   Think how to make the set-up stable, how to fix the laser pointer and how to do the measurements

   Hint: place a piece of paper under the vessel with water so you can mark the places where the beam gets in and gets out of the water. Also, it may help to draw a line around the vessel.

2. Briefly describe your experimental procedure. Attach the photo of your set-up

3. Perform the experiment for one angle, record data and evaluate the index of refraction. Show your calculations.

4. Does the measured index have a reasonable value? Is it greater or lesser than 1?

5. Can you claim that the measured index of refraction does not depend on angle of incidence? How can you test it?

6. Perform several other measurements and record them. Use these values to find the average value of refraction index.

7. Evaluate the uncertainty.

8. Report the measured index of refraction in the appropriate format, including uncertainty. What units does it have?

   n = ______________________

9. Is it comparable to the accepted values of refractive index of water (1.33) or Jello (1.2)?