Super Gelatin

Activity:

Materials Checklist:

- [ ] Gelatin sample (red, yellow, or clear)
- [ ] Laser pointer and binder clip
- [ ] One sheet of graph paper
- [ ] Protractor
- [ ] Pencil
- [ ] Scientific calculator

Explore

Your challenge is to find the index of refraction for your gelatin sample.

Identify the variables

What variable are you trying to find?

What variables do you already know, and what variables can you control?

What variables can you measure?

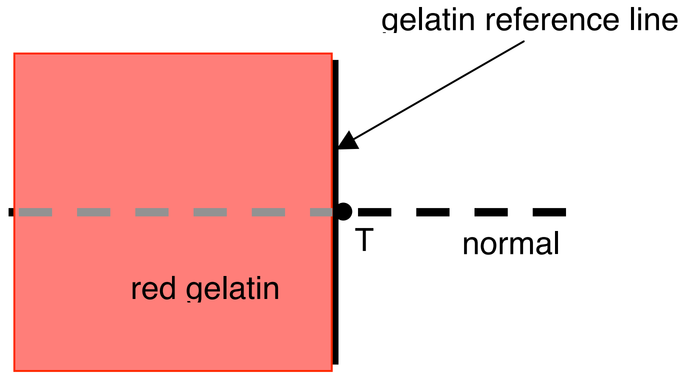
Here's the relationship between the variables expressed mathematically as the Law of Refraction, or Snell's Law:

$$n_{air} \sin(\theta_i) = n_{gel} \sin(\theta_r)$$

Set up the experiment

A. Set up your graph paper to test the gelatin

1. Draw a vertical line to represent the surface of the gelatin sample. Mark the midpoint.
2. Draw a long horizontal normal dashed line through the midpoint.
3. Mark the point where the normal meets the surface of the gelatin. Label it "T" for target.



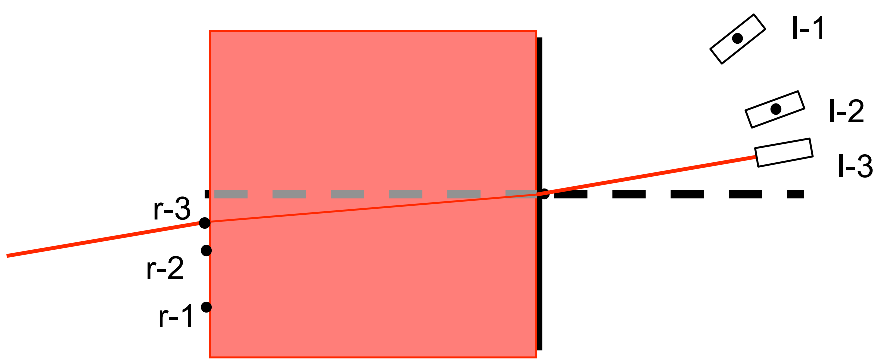
B. Prepare the gelatin sample for testing

1. Trim the wax paper around the edges of the gelatin.
2. Place the gelatin sample (on wax paper) on the graph paper. Align one side on the vertical line.

Your laser can cause permanent eye retina damage. Always be aware exactly where the laser is pointed. As you set up the laser, point it in a safe direction.

C. Mark the incident and refracted light rays

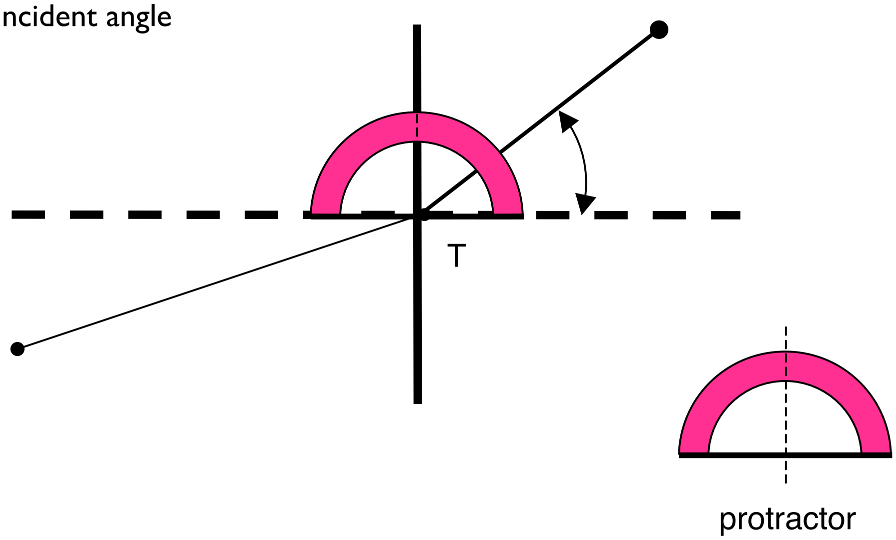
1. Pick three positions to fire the beam into the gelatin above the normal and below the normal, for a total of six positions.
2. Stand the laser and point it at the gelatin.



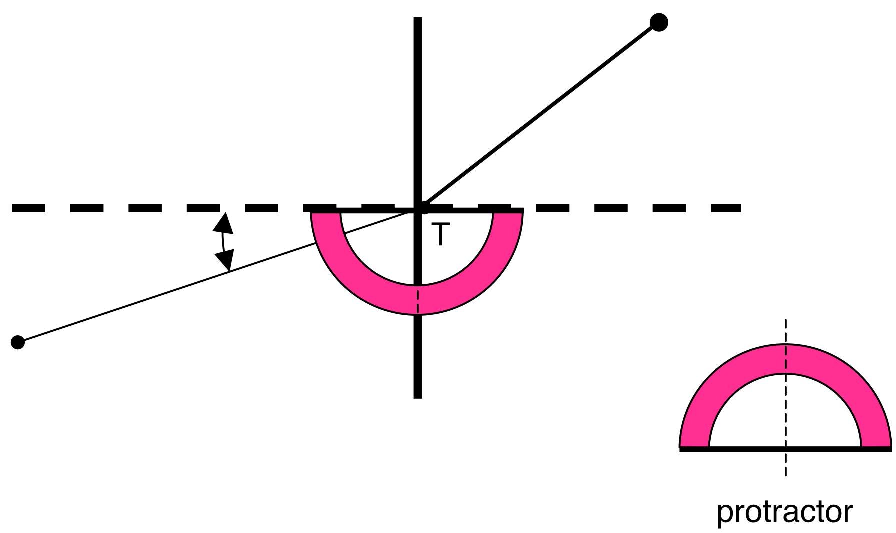
3. Clamp the laser "on" then align the beam so that it enters the gelatin directly over point "T."
4. Carefully hold down the laser pointer with one finger, and trace the sides of the binder clip on the graph paper. Label it "i-1." Later, you will use these reference lines to mark the position of the laser beam.
5. Mark the location where the refracted beam exits the gelatin. Label it "r-1."
   - ⋆ Be careful not to nudge the gelatin. If you accidentally move the gelatin a bit, just re-align it with the vertical line. Or, you may decide to redo your measurements.
6. Move the laser to a new incident beam position.
7. Repeat the above steps (2 – 6) for the remaining positions.

8. Remove the gelatin from the graph paper.
9. At each of the incident beam positions, mark a midpoint between the reference lines.
10. Lightly draw a line segment between each incident beam point (i-1, i-2, i-3 …) and the point "T."
11. Measure the angle between each incident line and the normal. Write down your data in you data table.
    - ⋆ Alternative: measure the x and y coordinates for the point, with "T" as the origin.
12. Lightly draw a line segment between each refracted beam point (r-1, r-2, r-3 …) and "T."
13. Measure the angle between the refracted line and the normal. Write down your data in your data table.
    - ⋆ Alternative: measure the x and y coordinates for the point, with "T" as the origin.

Measure the incident angle



Measure the refraction angle



D. Plot your data

1. What variables should you plot?

Think about what you are trying to find (n_{gel}), and the mathematical relationship among the variables:

$$n_{air} \sin(\theta_i) = n_{gel} \sin(\theta_r)$$

You already know $n_{air} = 1$, and have just measured six different values for θ_i and θ_r .

$\sin(\theta_i) = n_{gel} \sin(\theta_r)$ looks like an equation for a line $y = mx$, where m is the slope. In this case, the x-axis represents the values for $\sin(\theta_r)$ and on the y-axis are values for $\sin(\theta_i)$.

2. Calculate the sine of each angle using the sine function on your scientific calculator.
   Alternative method: express $\sin(\theta)$ geometrically, in terms of x and y.
   x and y are the coordinates for each incident or refracted point on the graph paper, with "T" as the origin.

3. Plot your $[\sin(\theta_r), \sin(\theta_i)]$ coordinate pairs on the graph paper below your data sheet.

4. Draw a straight line that best fits the data points.

Explain

1. As the angle of incidence changes, what happens to the refraction angle?

2. What does the slope of your best fit line represent?

3. List at least three reasons why do you think the data points do not perfectly line up.

4. What value did you find for the gelatin index of refraction?

Elaborate: The super in Super Gelatin

By experiment, you know the index of refraction for your sample of gelatin. But what else does that number mean?

If you think of light as an electromagnetic wave (composed of electric and magnetic fields), you can mathematically model light as a wave. Three basic properties of a wave are:

Wavelength (λ or lamda) is the distance between electric or magnetic wave maximum expressed in meters (m). This is distance over one period, or oscillation, of the wave.

Frequency (ν or nu) cycles or oscillations per second, expressed in units called Hertz (Hz).

Velocity (**V**) expressed in meters per second (m/s)

For a light wave, these three properties are related:

$$v = \lambda\nu = \frac{c}{n}$$

"c" is the speed of light in a vacuum (a constant), and "n" is the index of refraction for the medium light is traveling through.

The light's frequency does not change as it enters the gelatin – that is set by the source emitting the light. But what does change in the medium is the index of refraction. As a result, how does the wavelength and speed of the light change as it travels through the gelatin?

Gelatin Stack

Given the following situation, formulate a hypothesis and design an experiment to test it.

The three gelatin samples are stacked one on top of the other. What path do you think the laser beam will take through the gelatin stack?