REFLECTION AND REFRACTION

OBJECTIVE:
To verify the law of reflection, Snell's law for refraction and to experimentally determine the index of refraction for glass and water.

APPARATUS:
- Hartl disc with accessories mounted horizontally
- Collimated incandescent lamp or laser
- Semi-circular plastic tray, Semi-circular piece of glass
- Small beaker

INTRODUCTION:
In this experiment you will use a collimated lamp or laser and single slit on the rim of the Hartl disc to produce a single ray of light, visible on the surface of the disc. The ray is made to impinge on the center of the flat side of a semi-circular glass element at the center of the Hartl disc. Here the incident ray is split into a reflected ray and a refracted ray, both of which should also be visible on the surface of the Hartl disc. Figure 1 shows the arrangement.

The ray traveling in the glass eventually hits the semi-circular glass-air interface, but it does not bend any further because it approaches that surface from the center of the circle, along a radius, and therefore strikes it perpendicularly. Now all three angles, the angle of incidence, $\theta_1$, of reflection $\theta'_1$, and of refraction $\theta_2$, can be read directly from the angle scale on the outer edge of the Hartl disc.

For a series of various incident angles, you will record the angles of reflection and refraction.

Snell's law states:

$$ n_1 \sin(\theta_1) = n_2 \sin(\theta_2) \quad \text{Equation 1} $$

where $n_1$ is the index of refraction of air (1.0) and $n_2$ is the index of refraction of glass.

If we write equation 1 as:

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

A graph of $\sin \theta_1$ versus $\sin \theta_2$ should be a straight line with a slope equal to $\frac{n_2}{n_1} = \frac{n_2}{1.0} = n_2$.

The same procedure is repeated for water in a semi-circular plastic container. However, in this case, the refracted ray has gone through the plastic container as well, which has its own index of refraction. The plastic, if not taken into account, is therefore a source of error. However, the displacement of the beam should be small as the plastic wall is very thin. For this experiment we will ignore its effect.
REFLECTION AND REFRACTION

PROCEDURE:
1. Place the glass semi-circle in the position outlined at the center of the Hartl disc. The flat edge should be perpendicular to the double zero line running across the disc and right on the 90° line. (So the flat surface points towards 0°)

Warning: Laser light is damaging to the eye. Laser light entering the eye directly or off a reflective surface can cause permanent eye damage. To see the laser light hold a small piece of paper in front of the beam to determine its direction.

2. Turn on the laser, turn off the room lights and position the laser close to the edge of the Hartl disc so that it shines toward the glass semi-circle.

3. Adjust the aim of the light beam so that the ray travels along the line at 0° and strikes the center of the flat glass side. .

4. You can turn the disk that the glass lies upon by turning the handle underneath the Hartl table. Adjust the angle of the light source as well as the Hartl table to get the best incident and reflected rays. To make sure you are hitting the surface of the glass perpendicularly, look for a reflected beam off the glass, it should travel directly back to the light source.

5. If necessary repeat steps 3 and 4 for best alignment and visibility. Alignment is key to getting accurate results.

6. Take readings of \( \theta_1 \), \( \theta_1' \), and \( \theta_2 \) for \( \theta_1 = 10°, 20°, 30°, 40°, 50°, 60° \) and 70°. Use a piece of paper or the white movable screen provided to see the rays.

7. Replace the glass with the semi-circular plastic container, making sure that it is centered along the 90° line, perpendicular to the 0° line.

8. Use the small beaker to bring the water and fill the container half full.

9. Repeat steps 2 - 5 with the water filled semi-circle in place of the glass one. Don't worry if the refracted ray is not very clear.

10. Take readings of \( \theta_2 \) for \( \theta_1 = 10°, 20°, 30°, 40°, 50°, 60° \) and 70°. Use a piece of paper, as described in step 6, to read the angle of refraction

* You can just enter the angles into graphical analysis and it can find the sine of the angles for you. To do this, you must set graphical analysis for degrees instead of radians in the file menu. Then use a calculated data column to have it calculate \( \sin(\Theta_1) \) and \( \sin(\Theta_2) \). Ask a fellow student or the lab assistant for help if you need it.
## Refraction and Reflection Lab Sheet 1

### Data Table:

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### Calculations: Show all work include answers on results table

1. Use **Graphical Analysis** to plot graphs of \( \sin \theta_1 \) versus \( \sin \theta_2 \) for both trials (on the same page).
   
   Find the index of refraction of glass and for water using the slopes of the graphs and compare (using percent error equation) these experimental values to their theoretical values of \( n_{\text{glass}} = 1.52 \) and \( n_{\text{water}} = 1.33 \).

### Results Table:

<table>
<thead>
<tr>
<th></th>
<th>Experimental Value</th>
<th>Theoretical Value</th>
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### Conclusion: Turn in: Lab Sheet 1 and Graph