**Optical Fiber Module**  
*Student Worksheet*

**Exploration 1: Interacting Light**

In this activity you will observe the interaction of light with different materials. However, before you start your exploration, we would like you to make some predictions.

**Predict:** Predict by checking the box whether visible light will be absorbed, reflected, or transmitted through each of the materials listed in the following table.

<table>
<thead>
<tr>
<th>Absorbed</th>
<th>Reflected</th>
<th>Transmitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diamond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Use the simulation to investigate what happens to light when it interacts with different materials. Record your results using the following chart (Absorbed-A, Reflected-R, Transmitted-T):

<table>
<thead>
<tr>
<th>Absorbed</th>
<th>Reflected</th>
<th>Transmitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ink</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diamond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2) Compare your results with your initial predictions and identify the materials that have different properties from what you expected.
3) What characteristics do each group of materials have in common?

**Exploration 2: Light on a Mirror**

In this activity you will explore the path followed by a light ray when it reflects on a mirror, and compare the directions of the incident and reflected rays. However, before you start the exploration we would like you to make some predictions.

**Predict:** Light hits the surface of a mirror and is reflected. If we use arrows to represent light rays, which diagram do you think best represents the direction of the reflected light ray?

![Diagram of light rays](image)

1) Imagine that you want to send a light signal from point S to point D, but it has to strike the mirror on its way. Without changing the positions of point S and D, move the location of incident point P on the mirror to discover the shortest path. Once you find it, measure the angle of incidence and the angle of reflection with respect to the normal.

   **Angle of Incidence =** __________

   **Angle of Reflection =** __________

Move the position of points S and D in the simulation, and repeat your measurements at least two more times.
2) What can you conclude about the relationship between the angle of incidence and the angle of reflection when light hits a mirror? How do your conclusions compare with your initial predictions?

**Exploration 3: Bending Light**

In this activity you will investigate the relationship between the angle of incidence and the angle of refraction when light crosses from one transparent medium to another. However, before you proceed we would like you to make some predictions.

**Predict:** Imagine that you use a flashlight to shine light on the surface of a lake, which diagram do you think best represents what happens to light when it hits the surface?

![Diagram Options]

**Predict:** Describe what would happen if you replace water with glass.

1) Turn on the laser pointer, move it and change its orientation to investigate refraction as light passes from air to water. Use the protractor to measure the angle of incidence (qi) and the
angle of refraction (qr) with respect to a normal line to the surface. Repeat the measurement for a different orientation of the laser pointer, and then complete the following data table:

\[
\begin{array}{|c|c|c|c|c|}
\hline
\theta_i & \theta_r & n_A \sin \theta_i & n_w \sin \theta_r \\
\hline
\end{array}
\]

\[n_A = \text{index of refraction of air}\]
\[n_w = \text{index of refraction of water}\]
\[\sin = \text{sine}\]

2) Change to glass the material on the bottom of the simulation and repeat your measurements and calculations. Complete this table with your data.

\[
\begin{array}{|c|c|c|c|c|}
\hline
\theta_i & \theta_r & n_A \sin \theta_i & n_w \sin \theta_r \\
\hline
\end{array}
\]

3) Analyze and compare your results. Find the relationship between the angle of incidence and the angle of refraction.

**Exploration 4: Critical Angle**

The central goal in this exploration is to determine and compare the values of the angle for which light is reflected back into a transparent material in contact with air (critical angle). However, before you proceed we would like you to make some predictions. You can use the information from previous pages to guide your thinking.

**Predict:** Based on the values of the index of refraction for water (1.333), glass (1.45), diamond (2.417), and oil (1.5), arrange these substances in order of increasing critical angle when in contact with air:
Briefly explain your reasoning:

1) Turn on the laser pointer, move it and change its orientation to investigate refraction as light passes from water to air. Determine the minimum value of the angle of incidence for which the light ray is reflected back into the water. Remember to measure all angles with respect to the normal line. Repeat your measurements replacing water with other materials, and enter your data in the following table:

<table>
<thead>
<tr>
<th>Material</th>
<th>Critical Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
</tr>
<tr>
<td>Diamond</td>
<td></td>
</tr>
</tbody>
</table>

2) Compare your results with your initial predictions.

3) Build an explanation to justify your results.

**Exploration 4: Glass Light Guide**

In this activity you will explore the effect of the thickness of an optical fiber on its ability to guide light from one point to another.

**Predict:** Which of the following glass tubes do you think will work best as an optical fiber?
Briefly explain your reasoning.

1) Explore the effect of varying the thickness of the glass tube on the behavior of a light ray shone inside the tube. Describe what happens to the light ray as you reduce the thickness of the glass tube.

2) Explore what happens when you change the material the tube is made of. Describe the difference between the behavior of a glass tube, a water tube, and a diamond tube.

3) Compare your results with your initial predictions.

4) Explain any differences you observe between the behavior of a light ray inside the glass tube, the water tube, and the diamond tube.

Application

1) Imagine you see a coin resting at the bottom of a shallow lake. The diagram shows a light ray R traveling from the coin in water into air. When light ray R from the coin enters the air, what path will it follow?

- □ R will bend toward the Normal because the wave slows down when it enters air.
- □ R will bend toward the Normal because the wave speeds up as it enters air.
- □ R will continue in a straight line because light always travels at the same speed.
- □ R will bend away from the Normal because the wave slows down when it enters air.
- □ R will bend away from the Normal because the wave speeds up as it enters air.
2) If your eye is located at point P and you look into the mirror, which of the numbered cards can you see reflected in the mirror?

☐ 1  ☐ 2  ☐ 3  ☐ All of them

3) Which of the following figures best represents the trajectory of a beam of light as it passes through a block of glass?

☐ A  ☐ B  ☐ C  ☐ D  ☐ E

4) Susan takes a flashlight and sends a beam of light toward an inclined shiny surface as shown below. Which picture shows the correct direction of the reflected light?

☐ A  ☐ B  ☐ C  ☐ D

5) The critical angle for total internal reflection in the water-air interface is close to 48 degrees. What would a fish in a lake see if it looks upward at an angle of 60 degrees?

☐ The sky  ☐ The bottom of the lake  ☐ Its own reflection on the surface of the lake.