Teacher Reference

Introduction:
In this exercise, students determine experimentally the index of refraction of a material, determine the critical angle of the material, and qualitatively investigate chromatic aberration.

Experimental goals:
After completing this experiment, students will be able to determine the index of refraction of a material experimentally, to determine the critical angle of that material, and to describe the phenomenon of chromatic aberration.

Equipment:
Optics bench. Ray Table
Light source. Ray table base
Slit Plate. Viewing Screen
Slit Mask Component Holder
Cylindrical Lens Ray Table Component Holder

Keywords:
Refraction, Snell’s Law, Critical Angle, Chromatic Aberration.

Notes:
The initial setup is very important to successful completion of this lab. If the initial ray on the ray table isn’t aligned properly, the results will not be good! This setup will not tolerate much jiggling of the table, so caution students to keep away from the tables as much as possible.

Answers:
Index of refraction exercise:
Data table with developer’s answers. Student answers should be similar:

<table>
<thead>
<tr>
<th>Angle of Incidence (θ₁)</th>
<th>Angle of Refraction (θ₂)</th>
<th>Calculated index of refraction (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10°</td>
<td>6.5</td>
<td>1.53</td>
</tr>
<tr>
<td>20°</td>
<td>13.5</td>
<td>1.46</td>
</tr>
<tr>
<td>30°</td>
<td>20</td>
<td>1.46</td>
</tr>
<tr>
<td>40°</td>
<td>26</td>
<td>1.47</td>
</tr>
<tr>
<td>50°</td>
<td>31</td>
<td>1.49</td>
</tr>
<tr>
<td>60°</td>
<td>36</td>
<td>1.47</td>
</tr>
<tr>
<td>70°</td>
<td>39.5</td>
<td>1.48</td>
</tr>
<tr>
<td>80°</td>
<td>42</td>
<td>1.47</td>
</tr>
</tbody>
</table>

The index of refraction should remain constant over all angles, but students may mistake experimental error at large and small incident angles for a change in the index. If they did their observations carefully, they will recognize this.

The index of refraction is easier to determine at incident angles that in the midrange of the measurements taken. 10° and 80° incident angles will be a bit more difficult.
The speed of light in the plastic is about 204,000,000m/s

Critical Angle exercise:
Consider the beam to be a series of wave fronts. When the lens/air interface is not normal to the beam, one side of each wave front goes from the lens to air before the other. This side increases speed, turning the wave front toward its opposite side.
Student explanations will vary.

This may be explained before the lab by using the common “marching soldiers” analogy.

The critical angle is 43°.

Chromatic Aberration exercise:
Different frequencies (colors) of light bend at different angles

Blue rays are bent more

Red rays are bent less

Camera designers would like rays of all frequencies to focus on the same point on the film if they come from a single point. Unfortunately, glass does not bend all frequencies the same amount. Lens designers use multiple element lenses with materials of different indices of refraction to correct for these errors.