Refraction of Light

11.1 – Refraction - PRACTICE PROBLEMS

1. What is the index of refraction of a solid in which the speed of light is 1.943 x 10^8 m/s?
2. Determine the speed of light in diamond.
3. What is the speed of light in glycerin?
4. Determine the time taken for light to travel a distance of 3500 km along the core of an optical fiber.
5. Determine the change in the speed of light as it passes from ice into water.

11.2 - PRACTICE PROBLEMS – Snell’s Law of Refraction

6. Light travels from air into a material at an angle of incidence of 59°. If the angle of refraction is 41°, what is the index of refraction of the material? Identify the material by referring to Table 11.1, Index of Refraction of Various Substances.
7. A beam of light travels from air into a zircon crystal at an angle of 72.0°. What is the angle of refraction in the zircon?
8. What is the angle of incidence of light traveling from air into ethyl alcohol when the angle of refraction is 35°?
9. A beam of light passes from air into ethyl alcohol at an angle of incidence of 60.0°. What is the angle of refraction?
10. A beam of light passes from ethyl alcohol into air. The angle of refraction is 44.5°. Determine the angle of incidence.

11.3 - PRACTICE PROBLEMS – Refraction Effects

11. A girl is holding a clear, thin plastic bag of water that contains a goldfish. If she looks directly at the goldfish when it is 15 cm away from the side through which she is looking at it, how far away from the plastic will the fish appear to be?
12. A worker is looking down at a sample of radioactive waste that is encased in a rectangular glass block. The sample appears to be 0.55 m below the top surface of the glass. What is the actual depth of the sample in the glass block?
13. Light enters the side of a Plexiglas™ prism, which has an apex angle of 30.0°, at an angle of incidence of 45.0°. Determine the angle of deviation for the light after it has passed through the prism.
14. Light leaves the second interface of a crystal glass prism, which has an apex angle of 60.0°, at an angle of refraction of 45°. (a) Determine the angle of incidence for the light as it first entered the prism. (b) Determine the angle of deviation for the light after it has passed through the prism.
11.4 - PRACTICE PROBLEMS – Total Internal Reflection

15. Determine the critical angle for ethyl alcohol.

16. The critical angle for a new kind of plastic in air is 40°. What is the critical angle for this plastic if it is immersed in water?

17. Optical fibers, made of a core layer surrounded by cladding, trap transmitted light by ensuring that the light always strikes the core-cladding interface at an angle greater than the critical angle. Calculate the critical angle between the core-cladding interface.

18. While swimming in a friend’s pool, you allow yourself to slowly sink to the bottom exactly 3.0 m from the edge of the pool. As you sink you fix your gaze on the edge. Calculate how deep your eyes must be below the surface for total internal reflection to occur.

Problem Tip: When using Snell’s law to determine the critical angle for a transparent material, the value for the sine of the angle of refraction will always be unity (one), because the maximum angle of refraction is 90°.

Numerical Answers to Practice Problems

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<thead>
<tr>
<th></th>
<th>1.54</th>
<th>10. 31.0°</th>
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<tbody>
<tr>
<td>2</td>
<td>1.24 x 10⁸ m/s</td>
<td>11. 11 cm</td>
</tr>
<tr>
<td>3</td>
<td>2.04 x 10⁸ m/s</td>
<td>12. 0.84 m</td>
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<tr>
<td>4</td>
<td>1.8 x 10⁻² s</td>
<td>13. 18.1°</td>
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<tr>
<td>5</td>
<td>It slows by 1.5 %</td>
<td>14. (a) 56° (b) 41°</td>
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<tr>
<td>6</td>
<td>1.31, ice</td>
<td>15. 47.2°</td>
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<tr>
<td>7</td>
<td>29.7°</td>
<td>16. 58.9°</td>
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<tr>
<td>8</td>
<td>51°</td>
<td>17. 78.5°</td>
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<tr>
<td>9</td>
<td>39.5°</td>
<td>18. 2.6 m</td>
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