

REFRACTION AND SNELL'S LAW

Review Questions

1. Does a light ray traveling from one medium into another always bend toward the normal?
2. As light travels from a vacuum ($n = 1$) to a medium such as glass ($n > 1$), does its wavelength change? Does its speed change? Does its frequency change?
3. What is the relationship between the speed of light and the index of refraction of a transparent substance?
4. Why does a clear stream always appear to be shallower than it actually is?
5. What are the three conditions that must be met for refraction to occur?

Conceptual Questions

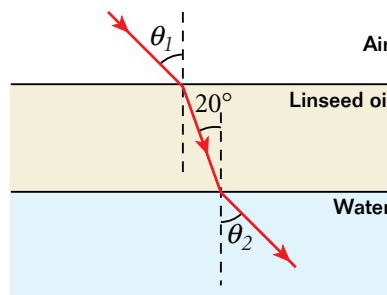
6. Two colors of light (X and Y) are sent through a glass prism, and X is bent more than Y. Which color travels more slowly in the prism?
7. Why does an oar appear to be bent when part of it is in the water?
8. A friend throws a coin into a pool. You close your eyes and dive toward the spot where you saw it from the edge of the pool. When you reach the bottom, will the coin be in front of you or behind you?
9. The level of water ($n = 1.33$) in a clear glass container is easily observed with the naked eye. The level of liquid helium ($n = 1.03$) in a clear glass container is extremely difficult to see with the naked eye. Explain why.

Practice Problems

For problems 10–14, see Sample Problem A.

10. Light passes from air into water at an angle of incidence of 42.3° . Determine the angle of refraction in the water.

11. A ray of light enters the top of a glass of water at an angle of 36° with the vertical. What is the angle between the refracted ray and the vertical?
12. A narrow ray of yellow light from glowing sodium ($\lambda_0 = 589 \text{ nm}$) traveling in air strikes a smooth surface of water at an angle of $\theta_i = 35.0^\circ$. Determine the angle of refraction, θ_r .
13. A ray of light traveling in air strikes a flat 2.00 cm thick block of glass ($n = 1.50$) at an angle of 30.0° with the normal. Trace the light ray through the glass, and find the angles of incidence and refraction at each surface.
14. The light ray shown in the figure below makes an angle of 20.0° with the normal line at the boundary of linseed oil and water. Determine the angles θ_1 and θ_2 . Note that $n = 1.48$ for linseed oil.



RAY DIAGRAMS AND THIN LENSES

Review Questions

15. Which type of lens can focus the sun's rays?
16. Why is no image formed when an object is at the focal point of a converging lens?