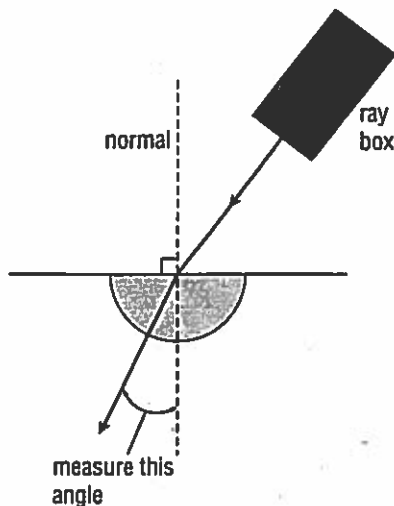**SUGGESTED ANSWERS**

WHAT DO YOU REMEMBER?

1. Direct an incident light ray at the centre of the flat side of a semicircular block of a transparent material. Draw the normal to the flat side at the point where the light ray hits and measure the angle between the normal and the refracted ray.


2. Light travels at a slower speed in material B.

3. The light always bends toward the normal when it slows down travelling into another medium.

4. The material with an index of refraction of 2.30 will refract light the most because it has the highest index of refraction of the four, meaning that it is more optically dense and causes the greatest slowdown.

5. 90°

6. 24.6°

7. The actual position of the object is deeper than its apparent depth.

8. If an observer is looking at an area with a very large number of raindrops, sunlight coming from behind the observer can enter the drops, get dispersed into a spectrum, and then bounce back towards the observer to create a visible rainbow.

9. (a) The diagram should show the ray bending toward the normal, then exiting the glass turning away from the normal parallel to its original path.

   (b) When the light ray enters the glass, it slows down and is refracted toward the normal. When the light ray leaves the glass, it speeds up and bends away from the normal, following a path that is parallel to its original path in air.

   (c) The angle of refraction cannot reach 90° because this would result in total internal reflection, and that is not possible when light travels into a medium with a higher index of refraction.
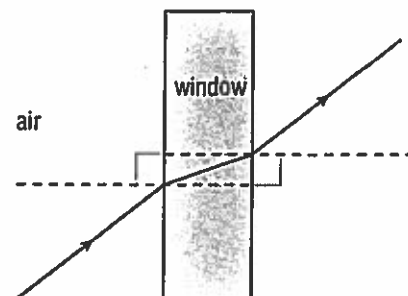
WHAT DO YOU UNDERSTAND?

(10.) (a) medium A

(b) medium A

(c) The ray will always bend toward the normal and have a smaller angle in the medium with a higher index of refraction.

(11.) Refraction would not occur if light had the same speed in air and glass because refraction is caused by a change in speed when light passes from one medium into another.

(12.) (a) Light entering a triangular prism can undergo total internal reflection and follow the same path it would if mirrors were placed there instead.

(b) Mirrored surfaces absorb a little of the light that falls on them whereas prisms absorb virtually no light, thus producing brighter images. Also, mirrored surfaces deteriorate over time, but prisms do not.

13. A rainbow is a virtual image. Dispersed light rays of different colours exit raindrops, and an observer's eyes and brain trace these rays backwards to form a virtual image.

(14.) The air over the hot asphalt gets increasingly cooler farther away from the asphalt, which creates a gradual increase in the air's index of refraction. Light from the sky enters the warmer air over the asphalt and, due to the lower index of refraction, is refracted more and more until it is internally reflected to form a virtual image of the sky on the asphalt.
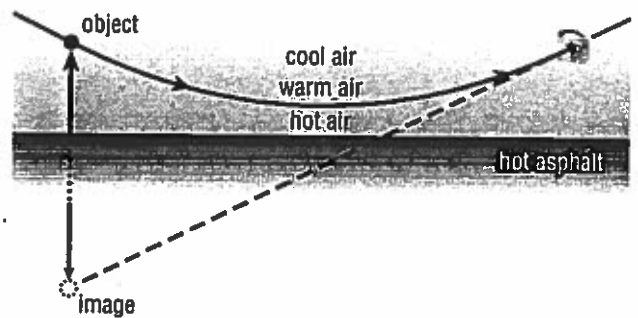
SOLVE A PROBLEM

(15.) $n_{\text{carbon disulfide}} = \dfrac{3.00 \times 10^8 \text{ m/s}}{1.84 \times 10^8 \text{ m/s}} = 1.63$

(16.) $n_{\text{arg}} = \dfrac{3.00 \times 10^8 \text{ m/s}}{1.47 \times 10^8 \text{ m/s}} = 2.04$

(17.) $n_{\text{fluoride}} = \dfrac{3.00 \times 10^8 \text{ m/s}}{2.10 \times 10^8 \text{ m/s}} = 1.43$

(18.) $v_{\text{veg. oil}} = \dfrac{3.00 \times 10^8 \text{ m/s}}{1.47} = 2.04 \times 10^8 \text{ m/s}$

(19.) $v_{\text{flint glass}} = \dfrac{3.00 \times 10^8 \text{ m/s}}{1.65} = 1.82 \times 10^8 \text{ m/s}$

(20.) $v_{\text{zircon}} = \dfrac{3.00 \times 10^8 \text{ m/s}}{1.92} = 1.56 \times 10^8 \text{ m/s}$

CREATE AND EVALUATE

21. (a) The light is reflected from wall to wall inside the fibre, traveling in straight lines between the reflections.

(b) Compared to copper cable, fibre-optic cable allows communications systems to run at higher speeds, and fibre-optic signals can travel longer distances without having to be boosted. Also, fibre-optic cables are less costly to maintain and are less affected by interference from radios, motors, and nearby cables.