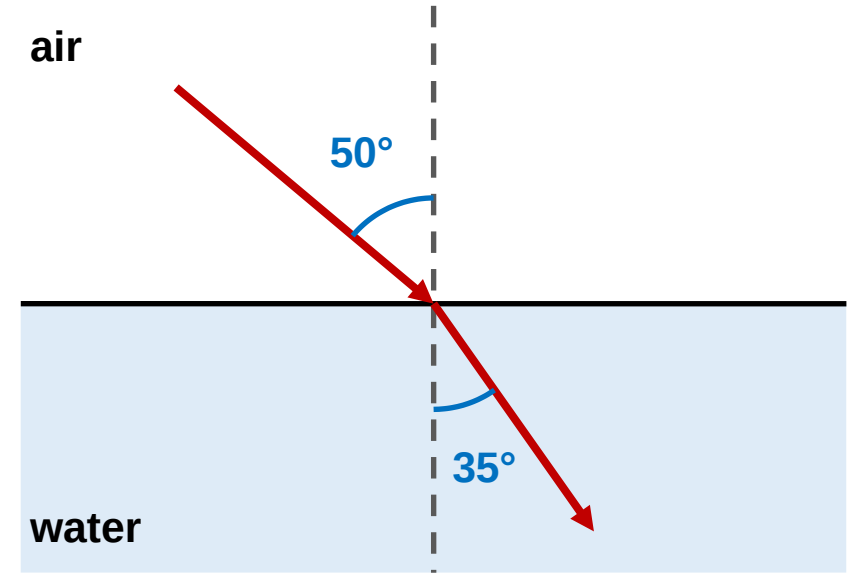


Essential Question

Why does a straw look bent in a glass of water?

What Is Refraction?

- New material, new speed
- The speed change bends light
- Bending happens at the boundary



slower in water: bends toward the normal

Index of Refraction

$$n = c / v$$

vacuum
 $n = 1.00$

water
 $n = 1.33$

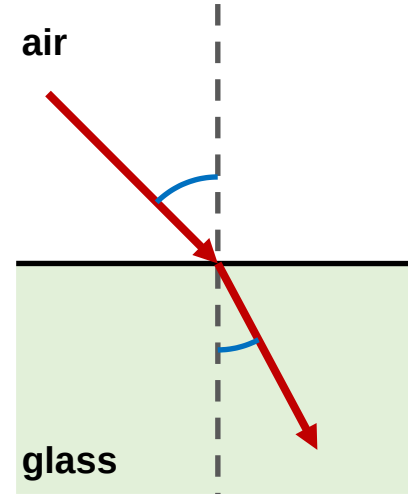
glass
 $n = 1.50$

diamond
 $n = 2.42$

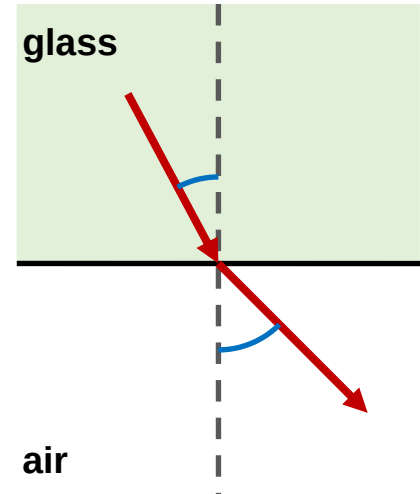
bigger n = slower light

Toward or Away from the Normal

- Slows down: toward normal
- Speeds up: away from normal
- Along the normal: no bend



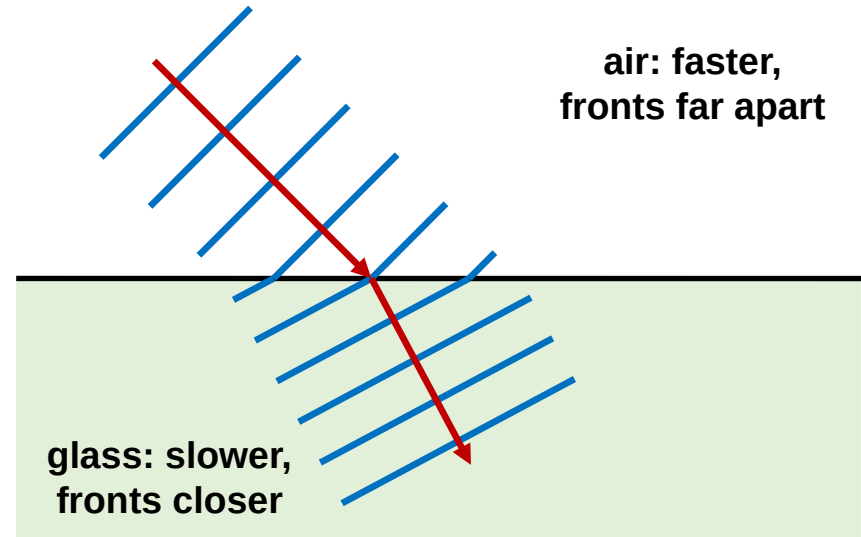
slows down:
toward normal



speeds up:
away from normal

Why Light Bends

- Wave fronts slow down in glass
- One side slows down first
- Like a wagon rolling onto grass



Snell's Law

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

 n_1

index, medium 1

 θ_1

angle in medium 1

 n_2

index, medium 2

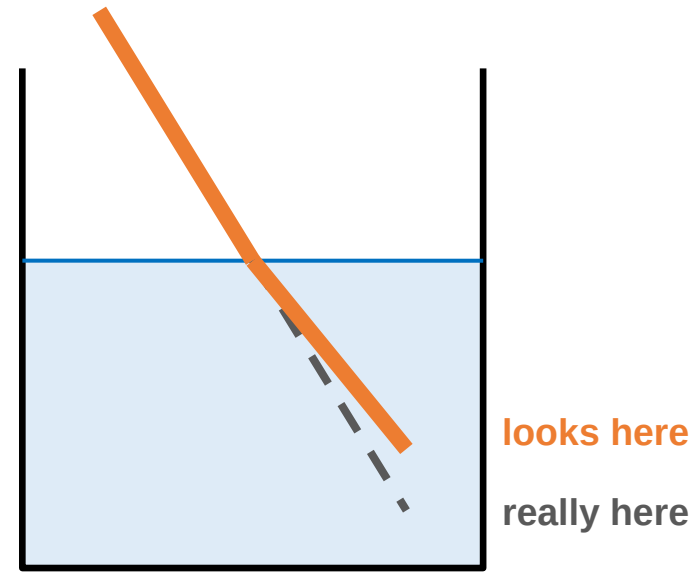
 θ_2

angle in medium 2

angles measured from the normal

The Bent Straw

- Light bends leaving the water
- Your brain traces rays straight back
- Underwater part looks shallower



the straw looks bent at the surface

Example: Light in Water

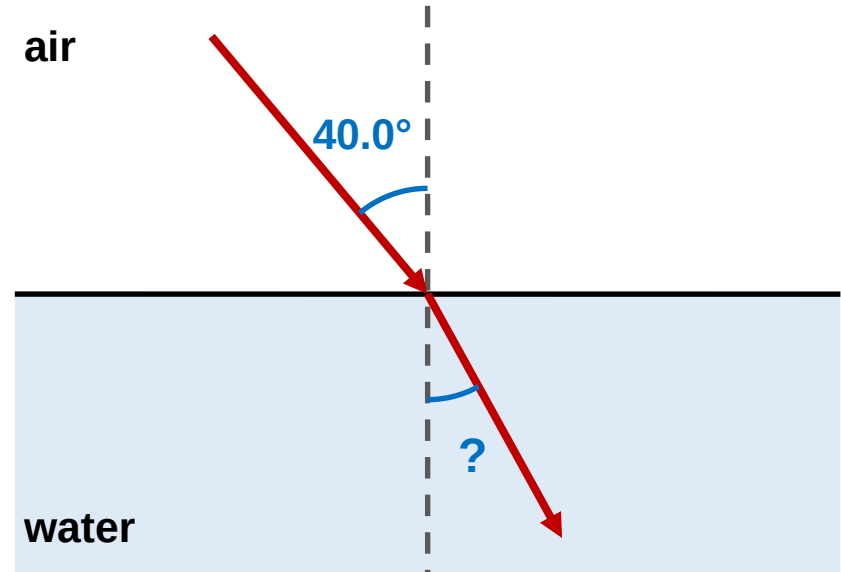
Water has an index of refraction of 1.33. How fast does light travel in water?

Example: Finding the Index

Light travels through a clear plastic at 2.00×10^8 m/s. What is the plastic's index of refraction?

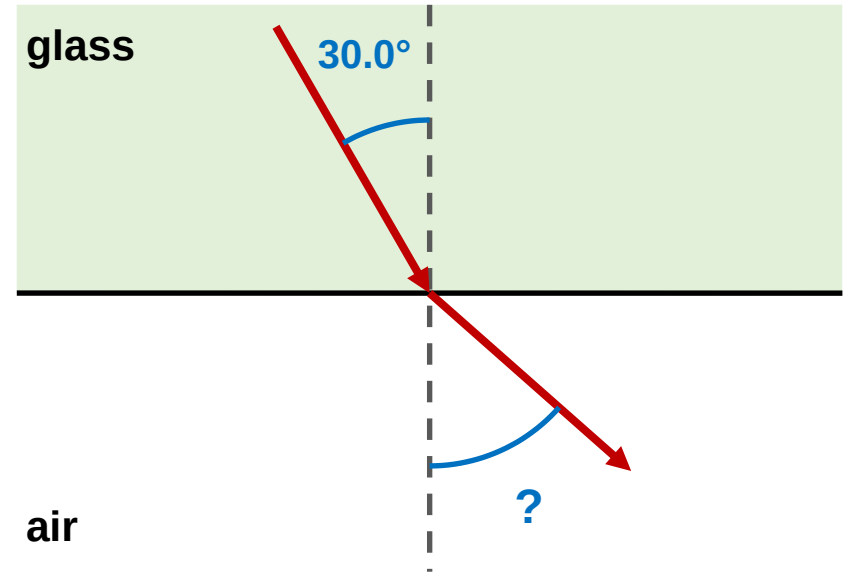
Example: Into Water

Light in air ($n = 1.00$) hits the surface of water ($n = 1.33$) at 40.0° from the normal. What is the angle of refraction?



Example: Out of Glass

Light inside a glass block ($n = 1.50$) hits the surface at 30.0° from the normal and passes into air ($n = 1.00$). What is the angle in the air?



Big Ideas

- Speed change at a boundary bends light
- $n = c/v$; bigger n , slower light
- Slower: toward normal. Faster: away
- $n_1 \sin \theta_1 = n_2 \sin \theta_2$