Light at the Boundary

Trace how light reflects and refracts.

PHY.4.7 "Explain the laws of reflection and refraction and apply Snell's law to describe the relationship between the angles of incidence and refraction."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the two rules that link angles, then circle the three refractive-index values. Use your marks to predict reflected and refracted paths.

A Beam at the Aquarium

1. At an aquarium, a narrow beam of light strikes the water's surface. Some light returns to the air, and some passes into the water. To describe either path, imagine a normal, a line perpendicular to the surface where the beam hits. The angle of incidence is measured between the incoming beam and the normal, not between the beam and the surface. The returning beam is reflected. The law of reflection says its angle from the normal equals the angle of incidence. The incoming beam, reflected beam, and normal all lie in one plane.

2. The beam that enters the water is refracted: its direction changes because light travels at a different speed there. A material's refractive index, written as n, describes this speed difference. At a given boundary, Snell's law links the angles: $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$. Here, θ_1 is the angle of incidence, and θ_2 is the angle of refraction. The subscripts identify the materials the light travels through before and after crossing the boundary. For the calculations on this sheet, use these approximate refractive indices: air, 1.00; water, 1.33; and glass, 1.50.

3. To predict a refracted path, first identify the material the light leaves and the material it enters. Next, place each index and angle on the correct side of Snell's law. Finally, calculate the unknown angle, measured from the normal. If light enters a material with a higher refractive index, the refracted beam bends toward the normal. If it enters one with a lower index, the beam bends away from the normal. A reflected beam can leave the same boundary at the same time, but its angle follows the law of reflection, not Snell's law.

2 ANSWER WITH EVIDENCE

Use the passage

1. A beam strikes a flat mirror at 25° from the normal. What is its angle of reflection? Explain how you know.

2. A beam travels from air into water at 30° from the normal. Use Snell's law to find its angle of refraction to the nearest degree. Does it bend toward or away from the normal?

3. A beam travels from water into air at 30° from the normal. Use Snell's law to find its angle of refraction to the nearest degree. Does it bend toward or away from the normal?

4. Two beams strike boundaries at the same angle from the normal. One travels from air into water, and the other travels from air into glass. Which refracted beam will be closer to the normal? Explain using Snell's law.

3 YOUR TURN

Your own words

Create a new example in which light travels from glass into water at 20° from the normal. State the reflected angle, use Snell's law to calculate the refracted angle to the nearest degree, and explain which way the refracted beam bends.

Light at the Boundary

PART 1 · READ AND MARK

Underline the two rules that link angles, then circle the three refractive-index values. Use your marks to predict reflected and refracted paths. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	A beam strikes a flat mirror at 25° from the normal. What is its angle of reflection? Explain how you know.	**25° from the normal, because the angle of reflection equals the angle of incidence.**
2	A beam travels from air into water at 30° from the normal. Use Snell's law to find its angle of refraction to the nearest degree. Does it bend toward or away from the normal?	**$1.00 \sin(30°) = 1.33 \sin(\theta_2)$, so $\theta_2 \approx 22°$. It bends toward the normal.**
3	A beam travels from water into air at 30° from the normal. Use Snell's law to find its angle of refraction to the nearest degree. Does it bend toward or away from the normal?	**$1.33 \sin(30°) = 1.00 \sin(\theta_2)$, so $\theta_2 \approx 42°$. It bends away from the normal.**
4	Two beams strike boundaries at the same angle from the normal. One travels from air into water, and the other travels from air into glass. Which refracted beam will be closer to the normal? Explain using Snell's law.	**The beam entering glass will be closer to the normal. For the same incident angle and starting index, glass's higher refractive index requires a smaller refracted angle.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The reflected angle is 20° from the normal because it equals the angle of incidence. For the refracted beam, Snell's law gives $1.50 \sin(20°) = 1.33 \sin(\theta_2)$. The angle of refraction is about 23° from the normal. The beam bends away from the normal because it enters water, which has a lower refractive index than glass.

Accept angles within 1° of the stated rounded answers. In Part 3, the reflected and refracted angles must both be measured from the normal.