Module 3 · Lesson

Wave Behaviour

PH11-10

ORIENTATION

Lesson goal: explain reflection, refraction, diffraction, interference, and standing waves using the correct wave model and representation.

Students should be able to state what changes, what stays constant, and what evidence supports the explanation.

CORE CONTENT

Wave behaviour is controlled by boundary conditions and superposition. Reflection, refraction, diffraction, and interference are not interchangeable terms. Each describes a different physical interaction.

BEHAVIOUR	WHAT CHANGES	WHAT REMAINS FIXED	KEY EVIDENCE
Reflection	direction	speed in same medium, frequency	angle in equals angle out
Refraction	direction, speed, wavelength	frequency	wave bends at boundary
Diffraction	spreading pattern	frequency	greater spreading for wider wavelength or narrower gap
Interference	resultant amplitude	source frequencies	constructive or destructive pattern

Key equations and rules:

$$\theta_i = \theta_r$$

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

$$n = \frac{c}{v}$$

In refraction, the source fixes the frequency. The speed changes because the medium changes, so the wavelength must change to keep $v = f\lambda$ true.

CONCEPT CHECK

1. In reflection, angles are measured relative to:

    - A. the surface
    - B. the normal
    - C. the wave crest
    - D. the source

    Answer: B.

2. When a wave refracts at a boundary, which quantity remains constant?

    - A. frequency
    - B. speed
    - C. wavelength
    - D. direction

    Answer: A.

3. Diffraction is most pronounced when:

    - A. the gap is much larger than the wavelength
    - B. the wave has zero amplitude
    - C. the gap size is comparable to wavelength
    - D. frequency is zero

    Answer: C.

4. Short response: explain why a ray bends toward the normal when light slows down entering a higher refractive-index medium.

APPLIED PRACTICE

Worked Example

Light passes from air into glass. The incident angle is 40° to the normal. Take $n_1 = 1.00$ and $n_2 = 1.50$. Find the refracted angle.

1. State Snell's law:

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

2. Substitute:

$$1.00 \sin 40^\circ = 1.50 \sin\theta_2$$

3. Rearrange:

$$\sin\theta_2 = 0.4285$$

4. Calculate:

$$\theta_2 = 25.4^\circ$$

Final answer: the refracted angle is 25.4° to the normal. The ray bends toward the normal because light travels more slowly in glass.

Practice Problem

A light ray moves from glass with $n = 1.50$ into air with $n = 1.00$. The incident angle is 30° to the normal. Calculate the refracted angle and state whether the ray bends toward or away from the normal.

DEEP PRACTICE AND WRITING

Prompt: write a paragraph comparing reflection and refraction. Your paragraph must use the terms direction, speed, frequency, and boundary.

Strong response pattern:

1. identify the boundary interaction,
2. state the conserved quantity,
3. state the changed quantity,
4. explain the visible consequence.

MAINTENANCE LOOP

Fast retrieval:

1. Angles in reflection/refraction are measured from the _____.
2. Refraction changes speed and wavelength, but not _____.
3. Diffraction increases when gap size is closer to _____.

STUDENT WORKING