Module 3 · Lesson

Wave Properties

PH11-10

ORIENTATION

Lesson goal: define the measurable properties of a wave and use them to explain how energy is transferred without net matter transport.

Students should leave this lesson able to name the relevant quantity, state the unit, and explain whether the medium, source, or wave pattern controls it.

CORE CONTENT

A wave is a disturbance that transfers energy. In a mechanical wave, particles of the medium oscillate locally while the disturbance travels through the medium. The key distinction is that the energy propagates; the material does not travel with the same overall motion as the wave.

QUANTITY	SYMBOL	MEANING	UNIT
Amplitude	A	maximum displacement from equilibrium	m
Wavelength	λ	distance between equivalent points on successive cycles	m
Period	T	time for one complete cycle	s
Frequency	f	number of cycles per second	Hz
Wave speed	v	speed of propagation of the disturbance	m s^-1

Key equations:

$$v = f\lambda$$

$$T = \frac{1}{f}$$

At a fixed wave speed, frequency and wavelength are inversely related. If the source frequency doubles and the medium is unchanged, the wavelength halves.

Representation Notes

- Label equilibrium line, amplitude, wavelength, crest, and trough.
- For transverse waves, particle oscillation is perpendicular to wave travel.
- For longitudinal waves, particle oscillation is parallel to wave travel.
- State whether the source or medium controls the quantity being discussed.

CONCEPT CHECK

1. A wave transfers:

    - A. matter only
    - B. energy without net matter transport
    - C. frequency only
    - D. particles from source to detector

    Answer: B.

2. A wave in the same medium has its frequency doubled. What happens to its wavelength?

    - A. it doubles
    - B. it is unchanged
    - C. it halves
    - D. it becomes zero

    Answer: C.

3. Which quantity is measured in hertz?

    - A. amplitude
    - B. frequency
    - C. wavelength
    - D. wave speed

    Answer: B.

4. Short response: explain why a wave on a string can transfer energy without carrying the string along the bench.

APPLIED PRACTICE

Worked Example

A sound wave in air has frequency $512\ \text{Hz}$ and speed $346\ \text{m s}^{-1}$. Find its wavelength.

1. State the formula:

$$v = f\lambda$$

2. Rearrange:

$$\lambda = \frac{v}{f}$$

3. Substitute:

$$\lambda = \frac{346}{512}$$

4. Calculate:

$$\lambda = 0.676\ \text{m}$$

Final answer: $\lambda = 0.676\ \text{m}$. In the same medium, a higher frequency sound would have a shorter wavelength.

Practice Problem

A wave on a rope has wavelength $1.8\ \text{m}$ and frequency $4.0\ \text{Hz}$. Calculate the wave speed and state what would happen to wavelength if frequency increased while rope tension stayed the same.

DEEP PRACTICE AND WRITING

Prompt: explain why frequency, not amplitude, determines the number of cycles per second. Your answer must include one labelled wave quantity and one sentence about energy transfer.

Expected structure:

1. identify the relevant quantity,
2. relate it to the source or medium,
3. state the consequence for wavelength or energy transfer.

MAINTENANCE LOOP

One-minute retrieval:

1. State the units for A, λ, T, f, and v.
2. Complete: at fixed wave speed, increasing frequency causes wavelength to _____.
3. Explain why this does not mean the medium travels faster.

STUDENT WORKING
