Wave motion

Lesson plan and teacher's notes · Form 2 Physics · 1 period of 40 minutes

School	(write school name)	**Teacher**	(write name)
Date	(date)	**Class**	Form 2
Subject	Physics	**Enrolment**	Boys ___ Girls ___ Total ___
Time	40 minutes	**Topic**	Wave motion

Learners describe a wave using amplitude, wavelength, period, frequency and wave front, tell transverse from longitudinal waves, use v = fλ to solve problems, and state how electromagnetic waves are detected and how to stay safe. The lesson uses ripples in a pond, a rope, a Slinky spring and a mobile-phone mast.

Specific outcomes

By the end of the lesson, learners should be able to:

1. Define amplitude, wavelength, period, frequency and wave front
2. Tell transverse from longitudinal waves and show each with a rope or Slinky
3. Use f = 1/T and v = fλ to find an unknown quantity
4. State two precautions against harmful electromagnetic radiation

Prior knowledge

- Vibration and oscillation of a pendulum or spring
- The unit second and the unit metre
- Rearranging a simple equation

Teaching and learning materials

- chalk and board
- a rope or a long piece of string
- a Slinky spring, or a coiled wire if none is available
- a basin of water and a small stone
- a watch or phone with a stopwatch

References

Ministry of Education (CDC) Form 2 Physics syllabus and module; 25Schools learners' note: Wave motion.

Lesson development

Stage and time	Teacher activities	Learner activities
Introduction 5 min	Drop a stone into a basin of water. Ask what moves outwards and whether the water itself travels. Write wave on the board.	Watch the ripples and say what travels and what stays near its place.
Development: describing a wave 12 min	Draw one wave and mark amplitude, wavelength and crest. Define period, frequency and wave front and show f = 1/T. Link amplitude to the energy carried.	Copy the diagram and label it. Count oscillations of a swinging object for ten seconds to find frequency.
Development: two kinds of wave 8 min	Shake a rope up and down for a transverse wave, and push and pull a Slinky for a longitudinal wave. Name compressions and rarefactions.	Make each wave in pairs and say which way the particles move compared with the wave direction.
Development: wave speed 10 min	Derive v = fλ from v = λ/T and f = 1/T. Work the Slinky example, then one more on the board.	Work two numerical examples and show every line of working with units.
Conclusion 5 min	Name two precautions against harmful radiation. Ask two learners to say them in their own words and set the homework.	Answer and copy the homework.

Teacher's content notes

Read these before the lesson. They are what you need to know, not what to copy onto the board.

Describing a wave

A wave transfers energy without moving matter permanently from place to place. Amplitude is the greatest distance a particle moves from rest, in metres. Wavelength is the distance between two neighbouring points in step, in metres. Period is the time for one oscillation, in seconds. Frequency is the number of oscillations in one second, in hertz. f = 1/T.

Wave front

A wave front is an imaginary line or surface joining all the points that are vibrating in step.

Two kinds of wave

In a transverse wave the particles move at right angles to the direction of travel, as on a shaken rope or water in a ripple tank. In a longitudinal wave they move back and forth along the direction of travel, as in a pushed Slinky with compressions and rarefactions.

Wave speed

One wavelength passes in one period, so v = λ/T. Because f = 1/T, v = fλ. If you know any two of v, f and λ you can find the third.

Electromagnetic waves: detection and safety

Different instruments detect different parts of the spectrum; the human eye detects visible light and a Geiger-Müller tube or scintillation counter detects gamma rays. Ultraviolet, X-rays and gamma rays are more penetrating and can ionise atoms, damaging cells and raising the risk of cancer. Limit the time of exposure and increase the distance from the source.

Questions to ask during the lesson

Question	Expected answer
A girl drops a stone into a pond and sees ripples spread out while a leaf on the water only bobs up and down. (a) Say what the wave carries. (b) Say what the leaf shows about the water. (c) Name the kind of wave.	(a) Energy. (b) The water particles move up and down but do not travel with the wave. (c) A transverse wave.
A learner counts 6 complete oscillations of a pendulum in 3.0 s. (a) Find the frequency. (b) Find the period. (c) Give the unit of each.	(a) 6 ÷ 3.0 = 2 Hz. (b) 1 ÷ 2 = 0.5 s. (c) Hertz and seconds.
A student makes waves on a rope with frequency 5 Hz and a wavelength of 0.20 m. (a) Write the equation to use. (b) Find the wave speed. (c) Give the unit.	(a) v = fλ. (b) 5 × 0.20 = 1.0 m/s. (c) Metres per second.
A teacher says the amplitude of one wave is larger than another. (a) Define amplitude. (b) Give its unit. (c) Say what a larger amplitude shows about the energy.	(a) The greatest distance a particle moves from its rest position. (b) Metres. (c) The wave carries more energy.

Worked examples for the board

Example 1: Slinky waves

A learner counts 5 complete oscillations in 2.0 s and measures a wavelength of 0.40 m. f = 5 ÷ 2.0 = 2.5 Hz. T = 1 ÷ 2.5 = 0.40 s. v = fλ = 2.5 × 0.40 = 1.0 m/s.

Example 2: finding the wavelength

A wave has speed 12 m/s and frequency 3 Hz. From v = fλ, λ = v ÷ f = 12 ÷ 3 = 4 m.

Example 3: staying safe

A family lives near a mobile-phone mast. The two general precautions are to limit the time of exposure and to increase the distance from the source.

Board plan

Write the title and wave. Left: a drawn transverse wave with amplitude, wavelength and crest marked. Centre: the equations f = 1/T and v = fλ with units. Right: transverse and longitudinal waves compared. Bottom: two precautions against harmful radiation.

Feature	Transverse	Longitudinal
Particle motion	At right angles to wave direction	Back and forth along wave direction
Shows	Crests and troughs	Compressions and rarefactions
Made with	A rope shaken up and down	A Slinky pushed and pulled

Transverse and longitudinal waves compared

Mistakes to expect

Learners often think	Put it right
The water travels with the wave.	The wave carries energy while the water particles move up and down only. Show a floating piece of paper that bobs but stays in place.
A larger wavelength means a larger frequency.	At a fixed speed, a longer wavelength means a lower frequency, because v = fλ.
Only transverse waves carry energy.	All waves transfer energy. Longitudinal waves such as sound do too.

Differentiation

Learners who struggle

Give learners the three equations on a card and a table with columns for v, f and λ. Let them fill in the knowns first and then choose the equation.

Learners who finish early

Ask learners who finish early to show that doubling the frequency at constant speed halves the wavelength, using v = fλ.

Hearing or visual impairment

For learners with hearing impairment, write each equation and word on the board and demonstrate each wave visibly. For learners with visual impairment, let them hold the rope or the Slinky and feel the wave pass along it, and describe each step aloud.

No projector, no printing

Use a basin of water, a rope and a coil of wire in place of a ripple tank and Slinky. A watch or phone gives the timing, and all diagrams are drawn on the board.

If time is short

Teach the description of a wave and v = fλ with the Slinky example. Leave transverse and longitudinal waves and electromagnetic safety as homework reading.

Evaluation

Question or task	A correct answer shows

A learner shakes a Slinky and counts 8 complete oscillations in 4.0 s, and measures a wavelength of 0.50 m. (a) Find the frequency. (b) Find the period. (c) Find the wave speed.	(a) 8 ÷ 4.0 = 2 Hz. (b) 1 ÷ 2 = 0.5 s. (c) v = fλ = 2 × 0.50 = 1.0 m/s.
A student pushes and pulls one end of a long spring and sees coils squeezed together in some places and spread apart in others, while another student shakes a rope up and down. (a) Name the places where coils are squeezed. (b) Name the places where they are spread. (c) Say which of the two is a transverse wave and give the reason.	(a) Compressions. (b) Rarefactions. (c) The rope, because its particles move at right angles to the direction of travel.
A family lives near a mobile-phone mast and the hospital nearby uses X-rays, and the learner wants to stay safe. (a) Name two precautions. (b) Say which of ultraviolet, X-rays and gamma rays can ionise atoms. (c) Name one harm they can do.	(a) Limit the time of exposure and increase the distance from the source. (b) All three. (c) Damage cells and raise the risk of cancer.

Homework

A learner shakes a rope in the school yard and sees that a wave on the rope has a period of 0.20 s and a wavelength of 0.30 m. (a) Find the frequency. (b) Find the wave speed. (c) Say what the wavelength becomes if the frequency is doubled and the speed stays the same, and give its value.

Extra practice with answers

Question	Answer
1. A wave has a period of 0.25 s. (a) Find its frequency. (b) The wavelength is 2 m; find the speed. (c) Say what happens to the frequency if the period doubles.	(a) 1 ÷ 0.25 = 4 Hz. (b) 4 × 2 = 8 m/s. (c) It halves.
2. A wave of frequency 10 Hz has wavelength 0.50 m. (a) Find the speed. (b) Find the period. (c) Name the equation used for the speed.	(a) 10 × 0.50 = 5 m/s. (b) 1 ÷ 10 = 0.10 s. (c) v = fλ.
3. A learner at the school tank sends waves across the water, and she measures that the wave travels at 8 m/s with a wavelength of 2 m. (a) Find the frequency. (b) Find the period. (c) Rearrange the equation used.	(a) 8 ÷ 2 = 4 Hz. (b) 1 ÷ 4 = 0.25 s. (c) f = v ÷ λ.
4. A learner pushes a Slinky along its length and sees coils squeeze and spread. (a) Name the squeezed places. (b) Name the kind of wave. (c) Say how the particles move compared with the wave direction.	(a) Compressions. (b) Longitudinal. (c) Back and forth along the direction of travel.
5. A hospital uses X-rays and warns patients and staff about exposure. (a) Say whether X-rays are more or less penetrating than visible light. (b) Name one harm. (c) Name two precautions.	(a) More penetrating. (b) Damage to cells and raised risk of cancer. (c) Limit the time of exposure and increase the distance from the source.

6. A learner spends many hours in strong sunshine without cover and gets sunburn. (a) Name the radiation that caused it. (b) Name a greater risk from too much of it. (c) Say how to reduce the exposure.

(a) Ultraviolet radiation. (b) Skin cancer. (c) Limit the time in the Sun or stay away from direct sunlight.

Answers to the learners' check-yourself questions

1. Define amplitude and give its unit.
   The greatest distance a particle moves from its rest position; metres (m).
2. A wave has a period of 0.25 s. What is its frequency?
   f = 1/T = 1 ÷ 0.25 = 4 Hz.
3. Name the parts of a longitudinal wave on a Slinky spring.
   Compressions, where the coils are squeezed together, and rarefactions, where they are spread apart.
4. How do particles move in a transverse wave compared with the wave direction?
   At right angles to the direction in which the wave travels.
5. A wave has frequency 5 Hz and wavelength 0.20 m. Find its speed.
   v = fλ = 5 × 0.20 = 1.0 m/s.
6. Which regions of the electromagnetic spectrum are more penetrating and can ionise atoms?
   Ultraviolet, X-rays and gamma rays.
7. Give two general precautions against harmful electromagnetic radiation.
   Limit the time of exposure and increase the distance from the source.
8. Name a detector for gamma rays.
   A Geiger-Müller tube or a scintillation counter.

Teacher's reflection

What went well:

What I will change next time:

Learners who need follow-up: