25SCHOOLS

FREE LEARNING NOTES FOR ZAMBIA

FORM 2

Physics

Wave motion

Lesson notes for learners · Competence-Based Curriculum

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A wave carries energy from one place to another without carrying the material itself along. You meet waves when a stone drops into a still pond and ripples spread out, when someone plucks a guitar string, and when a mobile-phone mast sends signals across a district.

AFTER THESE NOTES YOU SHOULD BE ABLE TO

- Describe a wave using amplitude, wavelength, period, frequency and wave front
- Tell longitudinal waves from transverse waves and show each with a rope or a Slinky spring
- Use $v = f\lambda$ to solve simple numerical problems
- Say how each kind of electromagnetic wave is detected, what harm it can do and how to stay safe

KEY WORDS

amplitude	the greatest distance a particle moves from its rest position, measured in metres
wavelength	the distance between two neighbouring points that are in step, such as crest to crest, in metres
period	the time for one complete oscillation, in seconds
frequency	the number of complete oscillations in one second, in hertz (Hz)
wave speed	the distance the wave travels in one second
wave front	an imaginary line or surface joining all the points that are in step
transverse wave	a wave in which particles move at right angles to the direction the wave travels
longitudinal wave	a wave in which particles move back and forth along the direction the wave travels

1 Describing a wave

Drop a stone into a still pond. Ripples spread outwards, yet the water particles only move up and down as each crest passes while the wave itself travels on. A wave transfers energy without moving matter permanently from place to place.

The size of the disturbance is the amplitude (A): the greatest distance a particle moves from its rest position, measured in metres. The amplitude is related to the energy the wave carries.

The wavelength (λ) is the distance between two neighbouring points that are in step, for example from one crest to the next, or from one compression to the next. It is measured in metres.

The period (T) is the time taken for one complete oscillation, in seconds. The frequency (f) is the number of complete oscillations in one second, in hertz (Hz). They are linked by f = 1/T.

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

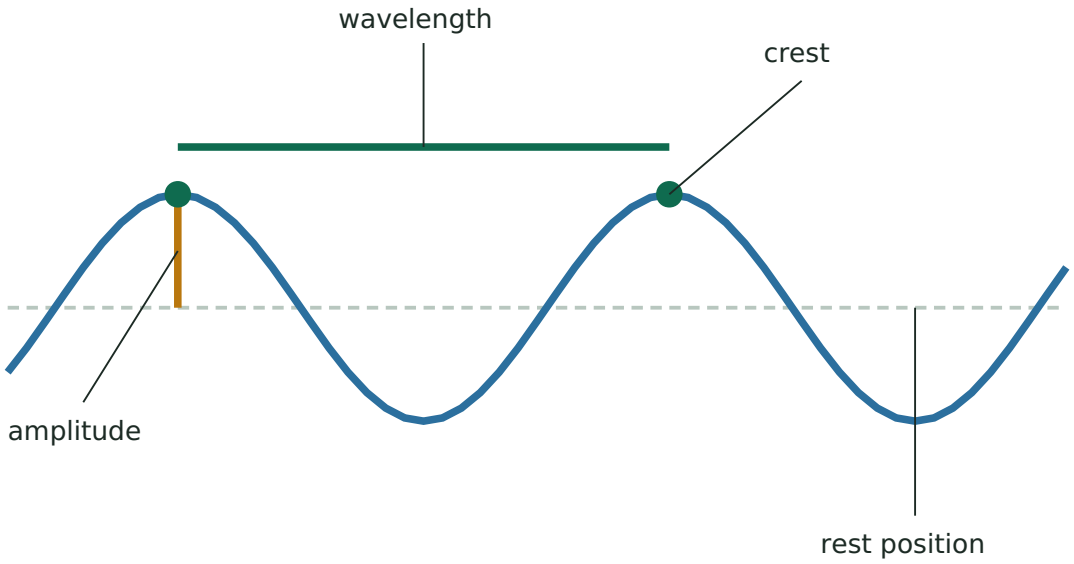

Figure 1. A transverse wave drawn with its amplitude, wavelength and crest marked

2 Transverse and longitudinal waves

In a transverse wave the particles of the medium move at right angles to the direction in which the wave travels. Shake one end of a rope up and down and a wave runs along the rope while each piece of rope moves up and down. Water waves on a ripple tank or tray show crests and troughs in the same way.

In a longitudinal wave the particles move back and forth along the direction in which the wave travels. Push and pull one end of a Slinky spring along its length. You see places where the coils are squeezed together, called compressions, and places where they are spread apart, called rarefactions.

Both kinds can be made in the classroom with a rope, a Slinky spring and a ripple tank. To measure a wave, count a known number of oscillations, time them with a stopwatch and work out the period and the frequency.

	Transverse wave	Longitudinal wave
Particles move	at right angles to the wave direction	along the wave direction
Parts of the wave	crests and troughs	compressions and rarefactions
Shown with	a rope, water in a tray	a Slinky spring pushed and pulled

Figure 2. Transverse and longitudinal waves compared

3 Wave speed and v = fλ

Wave speed (v) is the distance the wave travels in one second. Because one wavelength passes in one period, the speed is v = λ/T. Since f = 1/T, this gives the wave equation v = fλ.

The equation holds for all progressive waves in a given medium when conditions stay constant. If you know any two of v, f and λ you can find the third.

WORKED EXAMPLE

A learner makes waves on a Slinky spring. She counts 5 complete oscillations in 2.0 s and measures a wavelength of 0.40 m. Find the frequency and the wave speed.

Frequency f = number of oscillations ÷ time = 5 ÷ 2.0 = 2.5 Hz

Period T = 1 ÷ f = 1 ÷ 2.5 = 0.40 s

Wave speed v = fλ = 2.5 × 0.40 = 1.0 m/s

The wave speed is 1.0 m/s

4 Electromagnetic waves: detection, harm and safety

Different instruments detect different parts of the electromagnetic spectrum. We use the human eye for visible light. Radio waves are picked up by aerials and receivers. Infrared is detected by infrared cameras and thermometers. Other regions need other detectors, shown in the table below.

Radiation of higher frequency, that is ultraviolet, X-rays and gamma rays, is more penetrating and can ionise atoms. This can damage cells and raise the risk of cancer. Too much ultraviolet radiation from the Sun can cause sunburn and increase the risk of skin cancer. Radiation of lower frequency can cause heating effects when its intensity is high.

Two general precautions are to limit the time you are exposed and to increase your distance from the source. Near a mobile-phone mast or a hospital that uses X-rays and ultraviolet sterilisers, these precautions apply in daily life.

Region	Example of a detector
Radio waves	radio aerial and receiver
Microwaves	microwave detector
Infrared	infrared camera or thermometer
Visible light	the human eye
Ultraviolet	UV-sensitive film or detector
X-rays	X-ray film or digital detector
Gamma rays	Geiger-Müller tube or scintillation counter

Figure 3. Detectors for regions of the electromagnetic spectrum

TRY THIS

Tie one end of a long rope to a post and shake the other end up and down. Ask a friend to count the shakes in 10 seconds with a watch while you measure the distance between two neighbouring crests with a tape measure. Work out the frequency and then the wave speed using $v = f\lambda$. Try again with a Slinky or a coiled spring, pushing and pulling along its length, and draw what you see.

REMEMBER

- A wave transfers energy without moving matter permanently from place to place.
- Amplitude, wavelength, period and frequency describe a wave; $f = 1/T$.
- In a transverse wave particles move at right angles to the wave direction; in a longitudinal wave they move along it.
- The wave equation is $v = f\lambda$.
- Different regions of the electromagnetic spectrum need different detectors.
- Higher-frequency radiation is more penetrating and more hazardous; limit exposure time and keep your distance.

? Check yourself

1. Define amplitude and give its unit.
2. A wave has a period of 0.25 s. What is its frequency?
3. Name the parts of a longitudinal wave on a Slinky spring.

4. How do particles move in a transverse wave compared with the wave direction?
5. A wave has frequency 5 Hz and wavelength 0.20 m. Find its speed.
6. Which regions of the electromagnetic spectrum are more penetrating and can ionise atoms?
7. Give two general precautions against harmful electromagnetic radiation.
8. Name a detector for gamma rays.

ANSWERS

1. The greatest distance a particle moves from its rest position; metres (m).
2. f = 1/T = 1 ÷ 0.25 = 4 Hz.
3. Compressions, where the coils are squeezed together, and rarefactions, where they are spread apart.
4. At right angles to the direction in which the wave travels.
5. v = fλ = 5 × 0.20 = 1.0 m/s.
6. Ultraviolet, X-rays and gamma rays.
7. Limit the time of exposure and increase the distance from the source.
8. A Geiger-Müller tube or a scintillation counter.

Written by 25Schools to follow the Form 2 Physics syllabus of the Zambian competence-based curriculum. Free for learners to read, download and share. More notes and quizzes at 25schools.com.