3.1 Wave properties and the EM spectrum

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

Objective

Build the skills to answer exam questions on **properties of waves and the electromagnetic spectrum** : transverse and longitudinal waves, amplitude, wavelength, frequency and period, $v = f\lambda$, the Doppler effect, and the uses and dangers of electromagnetic waves.

You must be able to:

- describe transverse and longitudinal waves
- use $v = f\lambda$ and $f = 1/T$
- give uses and dangers of electromagnetic waves
- measure the speed of water waves in a ripple tank

1 Key knowledge and worked examples

Waves

idea	equation or rule
wavelength λ	distance from one crest to the next (m)
frequency f	number of waves passing a point each second (Hz)
wave speed	$v = f \times \lambda$
period	$f = 1 \div T$
EM spectrum, long to short wavelength	radio, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays; all travel at the same speed in a vacuum
Doppler effect	a moving source makes waves shorter in front of it and longer behind it

Worked example 1: wave speed. A wave has frequency 50 Hz and wavelength 0.30 m. Find its speed.

1. Known: $f = 50$ Hz; $\lambda = 0.30$ m.
2. Rule: $v = f\lambda$.
3. Numbers: 50×0.30.
4. Result: 15 **m/s**.

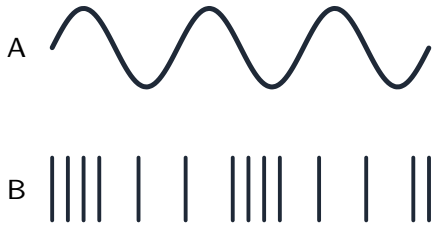
Worked example 2: period. A sound has frequency 200 Hz. Find its period.

1. Known: $f = 200$ Hz.
2. Rule: $T = 1 \div f$.
3. Numbers: $1 \div 200$.
4. Result: 0.005 **s** (5 ms).

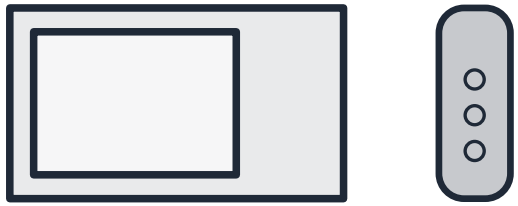
Answer shapes: convert cm to m before you use $v = f\lambda$.

2 Practice

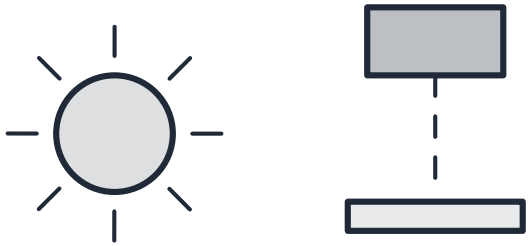
2.1 Give **one** difference between transverse and longitudinal waves, and an example of each. [2]



2.2 Give **one** use of microwaves and **one** use of infrared. [2]

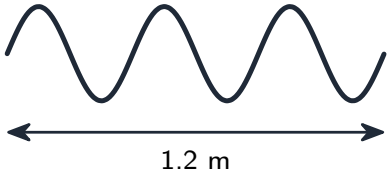


2.3 Give **one** harmful effect of ultraviolet radiation, and **one** of X-rays. [2]

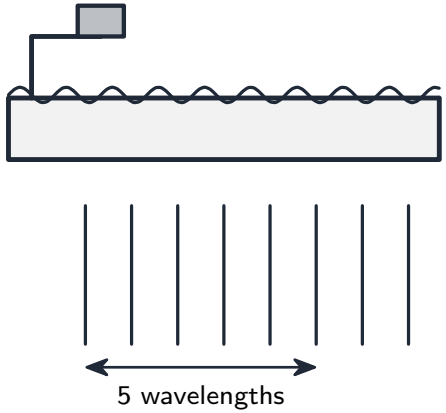


3 Exam-style questions

3.1 A student moves one end of a rope up and down 5.0 times a second. Three complete waves fit along 1.2 m of rope. Calculate the wave speed. [3]



3.2 A student uses a ripple tank to study water waves. She counts 10 waves passing a point in 4.0 s. She measures the distance across 5 wavelengths as 15 cm.



(a) Calculate the frequency of the waves. [2]

(b) Calculate the speed of the waves in m/s. [3]

(c) The dipper is now moved slowly to the right while it makes waves. Describe and explain how the wavelength in front of it changes. [3]

(d) Describe how to measure the speed of water waves in a ripple tank as accurately as possible. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- transverse: vibrations at right angles to the direction of travel, e.g. light, water waves
- longitudinal: vibrations along the direction of travel, e.g. sound

2.2

- microwaves: heating food, or satellite and phone communication
- infrared: remote controls, heaters, thermal imaging cameras

2.3

- ultraviolet: damage to skin cells (sunburn, skin cancer) or eyes
- X-rays: mutation of cells, which can cause cancer

3.1

- $\lambda = 1.2 \div 3 = 0.40$ m
- $v = 5.0 \times 0.40$
- **2.0** m/s

3.2

(a) $10 \div 4.0 =$ **2.5** Hz

(b) $\lambda = 15 \div 5 = 3.0$ cm $= 0.030$ m; $v = 2.5 \times 0.030 =$ **0.075** m/s

(c) the wavelength in front is shorter; the source moves forward between making each wave; so the crests are closer together in front (the Doppler effect)

(d) points to include:

- set the motor to a steady frequency; shine a lamp above so wave shadows fall on paper below (K)
- count the waves passing a point in a measured time (e.g. 10 s) and find f (K)
- measure the length of several wavelengths with a ruler and divide to find λ (App)
- or use a stroboscope to "freeze" the waves (App)
- calculate $v = f\lambda$ (K)
- measuring many waves reduces the uncertainty; repeat and find a mean (An)

Levels: **5–6** a full, logical answer with correct physics and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.

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