A-LEVEL PHYSICS • EXERCISE SHEET

7.1 Progressive waves

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

Objective

Build the skills to answer exam questions on **progressive waves** —the wave terms, the wave equation, the CRO, and intensity.

You must be able to:

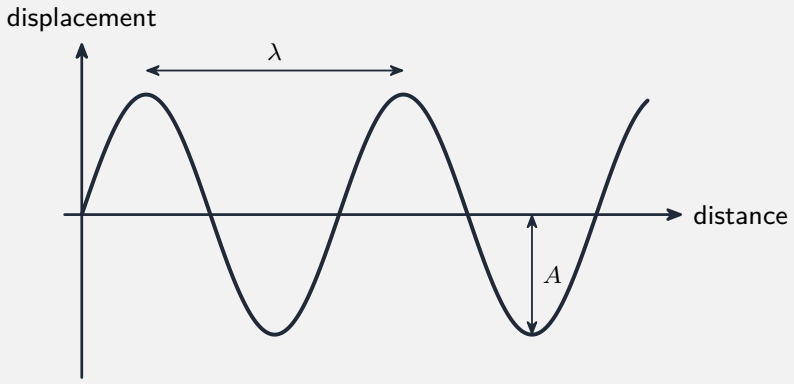
- use **displacement, amplitude, wavelength, period, frequency, phase difference**
- derive and use the **wave equation** $v = f\lambda$
- read a **CRO** trace and use **intensity** $\propto$ amplitude^2

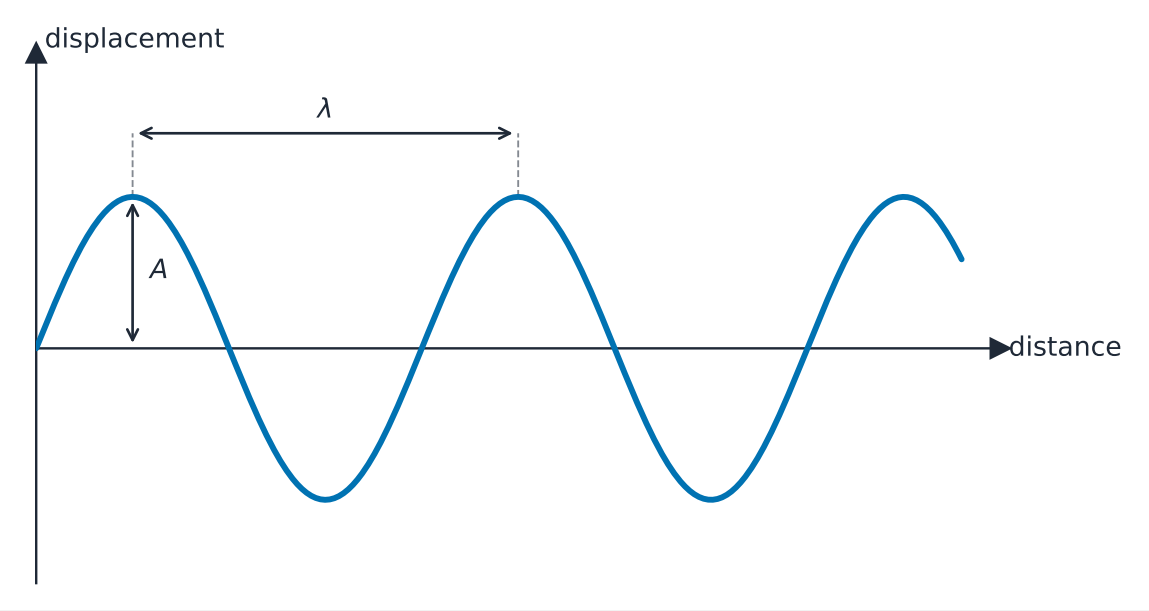
1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Wave terms

A progressive wave carries **energy** without moving matter overall:





A snapshot of a progressive wave

- **amplitude** A —maximum displacement; **wavelength** λ —distance between points in phase; **period** T —time for one cycle; **frequency** $f = 1/T$.
- points $\frac{1}{2}\lambda$ apart are **out of phase** (π); points λ apart are **in phase**.

Wave equation

In one period T the wave moves one wavelength, so $v = \lambda/T = f\lambda$.

CRO and intensity

Read the **period** from the screen: (cycles' width in divisions) $\times$ time-base. Then $f = 1/T$. **Intensity** $= \dfrac{\text{power}}{\text{area}}$ and intensity $\propto A^2$ —so doubling the amplitude makes the intensity **four times** larger.

2 Practice

Now apply the methods above.

2.1 Define **amplitude** and **wavelength**. [2]

2.2 A wave has frequency 50 Hz and wavelength 6.0 m. Find its **speed**. [2]

2.3 State the relationship between **period** and **frequency**. [1]

2.4 Two points on a wave are **half a wavelength** apart. State their **phase difference**. [1]

3 Exam-style questions

3.1 A wave travels at 340 m s^{-1} with frequency 170 Hz. Its wavelength is: [1]

- **A** 0.50 m
- **B** 2.0 m
- **C** 2.0 cm
- **D** 5.8×10^4 m

3.2 On a CRO the time-base is 5 ms per division, and one complete cycle of the trace spans 4 divisions. Calculate the **period** and the **frequency**. [3]

3.3 Derive the wave equation $v = f\lambda$ from the definitions of speed, frequency and wavelength. [2]

3.4 The amplitude of a wave is **doubled**. State what happens to its **intensity**. [1]

3.5 Two points on a progressive wave are a distance $\lambda/4$ apart. State their **phase difference** in radians. [1]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **7.1 Progressive waves** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/22 N25 —Q4 (progressive waves)
- 9702/21 J25 —Q5 (wave quantities)
- 9702/24 N25 —Q4 (wave equation and intensity)
- 9702/11 J25 —Q26 (phase difference)

Solutions

2.1 Amplitude —the maximum displacement from the rest position; **wavelength** —the shortest distance between two points oscillating **in phase**.

2.2 $v = f\lambda = 50 \times 6.0 = 300$ m s^{-1}.

2.3 $f = 1/T$.

2.4 π radians (or 180°) —exactly out of phase.

3.1 B —$\lambda = v/f = 340/170 = 2.0$ m.

3.2 $T = 4 \times 5$ ms $= 20$ ms $= 0.020$ s; $f = 1/T = 1/0.020 = 50$ Hz.

3.3 In one period T the wave moves one wavelength λ, so $v = \lambda/T$; since $f = 1/T$, $v = f\lambda$.

3.4 It becomes **four times** larger (intensity $\propto A^2$).

3.5 $\dfrac{\pi}{2}$ radians (or 90°) —a quarter wavelength is a quarter of a cycle.