



ANSWER BOOK

Progressive waves

Waves · Year 12

AQA 3.3.1.1 · CIE 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5, 7.1.6, 7.1.7
OCR A 4.4.1(a), 4.4.1(b)(i), 4.4.1(b)(ii), 4.4.1(c), 4.4.1(d), 4.4.1(g)

19 questions · 52 marks

NAVY EDITION

SECTION A · Warm-up

- A1** A progressive wave transfers energy (and information) through the medium (1). The particles oscillate about fixed equilibrium positions; they do not travel with the wave (1). [2]
- A2** $c = f\lambda = 50 \times 6.0$ (1) [2]
 $c = 300 \text{ m s}^{-1}$ (1)
- A3** $f = 1/T = 1/0.020$ (1) [2]
 $f = 50 \text{ Hz}$ (1)
- A4** The maximum displacement of a particle of the medium from its equilibrium (rest) position (1). [1]
- A5** The repeat time is the period of the wave (1). $f = 1/T = 1/0.25 = 4.0 \text{ Hz}$ (1). [2]
- A6** π rad (the points are in antiphase) (1). [1]

SECTION B · Standard

- B1** $\lambda = c/f = 340/170$ (1) [2]
 $\lambda = 2.0 \text{ m}$ (1)
- B2** $f = c/\lambda = (3.0 \times 10^8)/(600 \times 10^{-9})$ (1) [2]
 $f = 5.0 \times 10^{14} \text{ Hz}$ (1)
- B3** (a) $c = f\lambda = 25 \times 1.2$ (1) [3]
 $c = 30 \text{ m s}^{-1}$ (1)
 (b) $T = 1/f = 1/25 = 0.040 \text{ s}$ (1)
- B4** Phase difference = $(\Delta x/\lambda) \times 360^\circ$ (1) [3]
 $= (0.75/1.0) \times 360^\circ$ (1)
 $= 270^\circ$ (1)
- B5** $\lambda = c/f = 1500/(120 \times 10^3)$ (1) = 0.0125 m (= 12.5 mm) (1). [2]
- B6** Amplitude = half the trough-to-crest distance = $24/2 = 12 \text{ mm}$ (1). Wavelength = crest-to-crest distance = 0.80 m , so $c = f\lambda = 5.0 \times 0.80$ (1) = 4.0 m s^{-1} (1). [3]

B7 $f = 1/T = 1/(25 \times 10^{-6}) = 4.0 \times 10^4 \text{ Hz (40 kHz) (1)}$. $\lambda = c/f = 1480/(4.0 \times 10^4) \text{ (1)} = 0.037 \text{ m (1)}$. [3]

SECTION C · Stretch

C1 (a) $f = 20/10 = 2.0 \text{ Hz (1)}$ [4]
 (b) $c = f\lambda = 2.0 \times 3.0 \text{ (1)}$
 $c = 6.0 \text{ m s}^{-1} \text{ (1)}$
 (c) $T = 1/f = 0.5 \text{ s (1)}$

C2 $\pi/2 \text{ rad}$ is a quarter of a cycle (1) [4]
 separation $= \lambda/4 = 2.4/4 = 0.60 \text{ m (1)}$
 For 3.0 m : $\Delta x/\lambda = 3.0/2.4 = 1.25 \text{ cycles (1)}$
 phase difference $= 1.25 \times 360^\circ = 450^\circ$, equivalent to 90° (1)

C3 Each particle oscillates about its own fixed equilibrium position (1), passing energy to the next particle (1). It is this disturbance (energy) that moves forward through the medium; the particles themselves only move back and forth and stay in the same average place (1). [3]

C4 Phase difference $= (\Delta x/\lambda) \times 360^\circ = (1.8/2.4) \times 360^\circ \text{ (1)} = 270^\circ \text{ (3}\pi/2 \text{ rad) (1)}$. [3]
 Antiphase requires $180^\circ \text{ (}\pi \text{ rad)}$, so the student is not correct: P is three-quarters of a cycle out of phase with Q (1).

C5 $\lambda = c/f = (3.0 \times 10^8)/(9.4 \times 10^9) \text{ (1)} = 0.032 \text{ m} = 3.2 \text{ cm}$, which is about 3 cm (1) . $T = 1/f = 1/(9.4 \times 10^9) \text{ (1)} = 1.1 \times 10^{-10} \text{ s (1)}$. [4]

C6 The displacement–distance graph is a snapshot of every point at one instant, so its repeat distance gives the wavelength λ (1). The displacement–time graph follows one point, so its repeat time gives the period T (1). The frequency follows from $f = 1/T$ (1) and the speed from $c = f\lambda$ (or $c = \lambda/T$) (1). The distance graph carries no time information, so it cannot give T or f (1). The time graph carries no distance information, so it cannot give λ ; only the two graphs together supply both quantities needed for the speed (1). [6]