inkPhysics

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)
$c = 300\ \text{m s}^{-1}$ (1) [2]

A3 $f = 1/T = 1/0.020$ (1)
$f = 50$ Hz (1) [2]

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). $f = 1/T = 1/0.25 = 4.0$ Hz (1). [2]

A6 π rad (the points are in antiphase) (1). [1]

SECTION B · Standard

B1 $\lambda = c/f = 340/170$ (1)
$\lambda = 2.0$ m (1) [2]

B2 $f = c/\lambda = (3.0 \times 10^8)/(600 \times 10^{-9})$ (1)
$f = 5.0 \times 10^{14}$ Hz (1) [2]

B3 (a) $c = f\lambda = 25 \times 1.2$ (1)
$c = 30\ \text{m s}^{-1}$ (1)
(b) $T = 1/f = 1/25 = 0.040$ s (1) [3]

B4 Phase difference $= (\Delta x/\lambda) \times 360°$ (1)
$= (0.75/1.0) \times 360°$ (1)
$= 270°$ (1) [3]

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 mm (1). Wavelength = crest-to-crest distance = 0.80 m, so $c = f\lambda = 5.0 \times 0.80$ (1) $= 4.0\ \text{m s}^{-1}$ (1). [3]

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

SECTION C · Stretch

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

C2 $\pi/2$ rad is a quarter of a cycle (1) [4]
separation = $\lambda/4 = 2.4/4 = 0.60$ m (1)
For 3.0 m: $\Delta x/\lambda = 3.0/2.4 = 1.25$ cycles (1)
phase difference = $1.25 \times 360° = 450°$, 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 = $(\Delta x/\lambda) \times 360° = (1.8/2.4) \times 360°$ (1) = 270° ($3\pi/2$ rad) (1). Antiphase requires 180° (π rad), so the student is not correct: P is three-quarters of a cycle out of phase with Q (1). [3]

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