Solutions

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

2.1

- $v = f\lambda$

$$v = 12.5 \times 0.24 = \mathbf{3.0}\ \text{m s}^{\mathbf{-1}}$$

2.2

- $\lambda = v/f$

$$\lambda = \frac{3.0 \times 10^8}{1.2 \times 10^6} = \mathbf{250}\ \text{m}$$

2.3

- $\Delta\phi = \dfrac{x}{\lambda} \times 360°$
- $\Delta\phi = \dfrac{15}{60} \times 360° = \mathbf{90}°$

2.4

- one cycle spans $10/2 = 5.0$ divisions, so $T = 5.0 \times 0.20$ ms $= 1.0$ ms
- $f = 1/T = \mathbf{1.0 \times 10^3}$ Hz

2.5

- $I = P/A$ with $A = 1.5 \times 10^{-6}$ m^2

$$I = \frac{2.0 \times 10^{-3}}{1.5 \times 10^{-6}} = \mathbf{1.3 \times 10^3}\ \text{W m}^{\mathbf{-2}}$$

2.6

- the wave transfers energy along the spring
- each coil oscillates about its own rest position, and does not travel along with the wave

3.1 C

- $\lambda = \dfrac{360°}{\Delta\phi} \times x = 6 \times 0.12 = 0.72$ m
- **A** turns the ratio upside down

3.2 C

- intensity $\propto$ (amplitude)^2, so the intensity falls to $\left(\frac{1}{3}\right)^2 = \frac{1}{9}$
- **A** treats the intensity as proportional to the amplitude

3.3

(a) one cycle spans 2.5 divisions

- $T = 2.5 \times 0.20$ ms $= \mathbf{0.50}$ ms

(b) $f = 1/T = 1/(0.50 \times 10^{-3}) = \mathbf{2.0 \times 10^3}$ Hz

(c) amplitude = 3.0 divisions × 10 mV = **30** mV

(d) $\lambda = v/f$

$$\lambda = \frac{340}{2000} = \mathbf{0.17}\ \text{m}$$

(e) intensity $\propto$ (amplitude)^2

$$\frac{I_{\text{new}}}{I_{\text{original}}} = \left(\frac{2.0}{3.0}\right)^2 = \mathbf{0.44}$$

3.4

(a) from the graph $\lambda = 1.2$ m

$$f = \frac{v}{\lambda} = \frac{3.0}{1.2} = \mathbf{2.5}\ \text{Hz}$$

(b) **180°**, or π rad: P and R are half a wavelength apart

(c) **upwards**

- the wave moves to the right, so the crest now at P moves towards Q; drawing the wave a moment later shows the rope at Q above the axis

(d) **zero**: in a quarter of a period P moves from the crest back to its rest position

(e) intensity $\propto$ (amplitude)^2: $\left(\frac{6.0}{4.0}\right)^2 = \mathbf{2.25}$

3.5

(a) intensity is the power per unit area, where the area is at right angles to the direction of travel of the wave

(b) the power spreads over a sphere of area $4\pi r^2$

$$I = \frac{0.80}{4\pi \times 5.0^2} = \mathbf{2.5 \times 10^{-3}}\ \text{W m}^{-2}$$

(c) **10** m: twice the distance spreads the power over four times the area

(d) intensity $\propto$ (amplitude)^2, so one quarter of the intensity means half the amplitude

- amplitude = $\mathbf{a/2}$

3.6

- speed = distance ÷ time, and in one period T the wave moves one wavelength λ, so $v = \lambda/T$
- frequency is the number of oscillations per unit time, so $f = 1/T$ and $v = f\lambda$