## Solutions

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

**2.1**

- any two: they are **transverse**; they travel at the **same speed** $c$ in a vacuum; they can travel through a vacuum

**2.2**

- $c = \mathbf{3.0 \times 10^8}\ \dfrac{\text{m}}{\text{s}}$

**2.3**

- **400** nm to **700** nm

**2.4**

- radio waves < visible light < X-rays

**2.5**

(a) 3 cm is between 1 mm and 10 cm: **microwaves**

(b) 500 nm is between 400 nm and 700 nm: **visible** light

(c) 0.1 nm is between 0.01 nm and 10 nm: **X-rays**

**3.1 D**

- $\gamma$-rays have the highest frequency (shortest wavelength) on the EM spectrum

**3.2**

- **ultraviolet** has the higher frequency
- on the spectrum UV is **closer to the high-frequency end** (shorter $\lambda$) than infrared

**3.3**

- $\lambda = c/f$

$$\lambda = \frac{c}{f} = \frac{3.0 \times 10^8\ \dfrac{\text{m}}{\text{s}}}{100 \times 10^6\ \text{Hz}} = \mathbf{3.0}\ \text{m}$$

**3.4**

(a) Rearrange $c = f\lambda$ for the wavelength:

$$\lambda = \frac{c}{f} = \frac{3.0 \times 10^8\ \text{m s}^{-1}}{1.5 \times 10^{15}\ \text{Hz}} = 2.0 \times 10^{-7}\ \text{m} = \mathbf{200}\ \text{nm}$$

(b) 200 nm is between 10 nm and 400 nm, so it is ultraviolet

**3.5**

- the pulse covers the width **twice** (there and back)

$$d_{\text{total}} = ct = (3.0 \times 10^8\ \frac{\text{m}}{\text{s}})(8.4 \times 10^{-6}\ \text{s}) = 2520\ \text{m}$$

$$\text{width} = \tfrac{1}{2} d_{\text{total}} = \tfrac{1}{2} \times 2520\ \text{m} = \mathbf{1.3 \times 10^3}\ \text{m}$$

- assumption: light travels in a straight line at $c$ through air (air treated as a vacuum)