

Wavelength, frequency and how waves behave

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer shows the formula, the substitution and the result with its unit. Check that your units match before you substitute, and compare your reasoning for explain questions with the key ideas given. A slightly different rounding in the last digit is fine.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS4-1, GCSE P6

Problem 1 Classify the waves

(a) **Transverse**. (b) **Longitudinal**, since the vibration is parallel to the travel direction. (c) **Transverse**. (d) **Transverse**.

Problem 2 Reading a wave graph

1. Amplitude = maximum displacement = **3 cm**.
2. The pattern repeats every 12 cm (0 cm to 12 cm), so wavelength = **12 cm**.

Problem 3 Frequency and period

- (a) $f = 1 / T = 1 / 0.050 = \mathbf{20 \text{ Hz}}$
(b) $T = 1 / f = 1 / 4.0 = \mathbf{0.25 \text{ s}}$

Problem 4 First wave speed

$$v = f \lambda = 50 \times 0.30 = \mathbf{15 \text{ m/s}}$$

Problem 5 Law of reflection

The angle of incidence equals the angle of reflection. The angle of reflection is **35°**, and the angle between the incident and reflected rays is $35^\circ + 35^\circ = \mathbf{70^\circ}$.

Problem 6 Waves on a rope

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

Problem 7 Wi-Fi wavelength

$$f = 2.4 \text{ GHz} = 2.4 \times 10^9 \text{ Hz}$$
$$\lambda = v / f = 3.0 \times 10^8 / 2.4 \times 10^9 = 0.125 \text{ m} = \mathbf{12.5 \text{ cm}}$$

Problem 8 Radio station

$$f = 96.3 \times 10^6 \text{ Hz}; \lambda = 3.0 \times 10^8 / 96.3 \times 10^6 = 3.115 = \mathbf{3.1 \text{ m}}$$

Problem 9 A buoy on Lake Victoria

$$1. f = 20 / 50 = \mathbf{0.40 \text{ Hz}}$$

$$2. T = 1 / 0.40 = \mathbf{2.5 \text{ s}}$$

$$3. v = f \lambda = 0.40 \times 6.0 = \mathbf{2.4 \text{ m/s}}$$

Problem 10 Displacement-time graph

$$1. \text{ Amplitude} = \mathbf{4 \text{ cm}}$$

$$2. \text{ Four complete waves in } 1.0 \text{ s: } T = 0.25 \text{ s and } f = \mathbf{4.0 \text{ Hz}}$$

$$3. v = f \lambda = 4.0 \times 0.30 = \mathbf{1.2 \text{ m/s}}$$

Problem 11 Into shallow water

$$1. \text{ Deep: } v = 5.0 \times 3.0 = 15 \text{ cm/s. Shallow: } v = 5.0 \times 2.0 = \mathbf{10 \text{ cm/s.}}$$

$$2. \text{ The frequency stays at } \mathbf{5.0 \text{ Hz}}; \text{ it is set by the source.}$$

Problem 12 Which gap spreads the waves?

The **1 cm gap**. Diffraction is greatest when the gap is smaller than or about the same size as the wavelength. The 20 cm gap is ten times the wavelength, so the waves pass through almost unchanged.

Problem 13 Seismic waves

P arrive after $420 / 6.0 = 70 \text{ s}$. S arrive after $420 / 3.5 = 120 \text{ s}$. Difference = $120 - 70 = \mathbf{50 \text{ s}}$.

Problem 14 Spot the error

The wave speed depends on the rope (and its tension), not on the frequency. Since $v = f \lambda$ with v fixed, doubling f halves the wavelength. **The speed stays the same.**

Problem 15 Stadium wave

$$\text{Speed} = \text{distance} / \text{time} = 400 / 25 = \mathbf{16 \text{ m/s.}}$$

$$\lambda = v / f = 16 / 0.80 = \mathbf{20 \text{ m}}$$

Problem 16 Deep and shallow

$$1. \lambda = v / f = 0.24 / 6.0 = 0.040 \text{ m} = \mathbf{4.0 \text{ cm}}$$

2. $v = f \lambda = 6.0 \times 0.030 = \mathbf{0.18 \text{ m/s}}$
3. $0.18 / 0.24 = \mathbf{0.75}$, which is also 3.0 cm / 4.0 cm

Problem 17 A tsunami

1. $f = 220 / 200\,000 = 1.1 \times 10^{-3} \text{ Hz}$; $T = 1 / f = 909 \text{ s} = \mathbf{15 \text{ minutes}}$ (15.2 min).
2. The frequency stays $1.1 \times 10^{-3} \text{ Hz}$, so $\lambda = 22 / 1.1 \times 10^{-3} = 2.0 \times 10^4 \text{ m} = \mathbf{20 \text{ km}}$. The energy is squeezed into shorter waves, which grow taller.

Problem 18 Two barriers

1. Angle to the normal = $90^\circ - 40^\circ = \mathbf{50^\circ}$.
2. The reflected path leaves at 40° to barrier 1. In the triangle formed with the two barriers (angles 90° and 40°), the path meets barrier 2 at $180^\circ - 90^\circ - 40^\circ = 50^\circ$ to its surface, so the angle of incidence is $90^\circ - 50^\circ = \mathbf{40^\circ}$.
3. The final wave travels back parallel to the incoming wave, in the opposite direction.

Problem 19 Rope data

1. $2.0 \times 1.50 = 3.0$; $3.0 \times 1.00 = 3.0$; $4.0 \times 0.75 = 3.0$; $5.0 \times 0.60 = 3.0$; $6.0 \times 0.50 = 3.0$. The speed is $\mathbf{3.0 \text{ m/s}}$ every time.
2. λ is inversely proportional to f . The rope sets the speed, so $v = f \lambda$ gives a smaller λ when f increases.
3. $\lambda = 3.0 / 7.5 = \mathbf{0.40 \text{ m}}$

Problem 20 Radio and hills

Diffraction is greatest when the obstacle is about the same size as the wavelength or smaller. The 1500 m waves are much longer than the hill (7.5 times), so they bend round it and fill the shadow. The 0.15 m waves are tiny compared with the hill (more than a thousand times smaller), so there is almost no diffraction and a shadow forms. **The long-wavelength signal reaches the town more easily.**