

Exercise walk-through

2.2

Superposition and standing waves (statements 38–43, core practicals 4–5)

Intensity needs an area conversion

- 1 **Convert** $A = 25 \times 10^{-4} = 0.0025 \text{ m}^2$
- 2 **Incident** $P = IA = 800 \times 0.0025 = 2.0 \text{ W}$
- 3 **Useful** $P_{out} = \eta P = 0.20 \times 2.0 = 0.40 \text{ W}$

Decision

A 0.50 W device cannot run from this useful output.

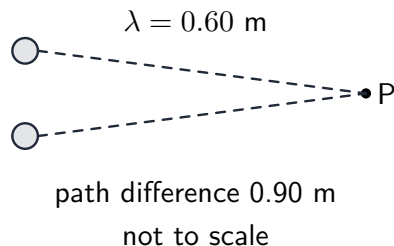
Frequency and intensity change different things

Change	Photon energy	Maximum electron energy
Intensity rises; frequency fixed	Unchanged	Unchanged
Frequency rises	Increases	Increases above threshold

Exercises 2.1·2.2

2.1 Define coherent sources. Must coherent sources always vibrate in phase? [2]

2.2 Two in-phase sources have wavelength 0.60 m. Their path difference at a point is 0.90 m. Calculate phase difference and describe the interference. State a further condition for complete cancellation. [3]

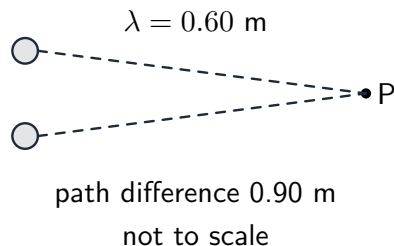


Exercises 2.1·2.2

2.1 Define coherent sources. Must coherent sources always vibrate in phase? [2]

2.1 They have the same frequency and a constant phase difference. No: that constant phase difference can be non-zero.

2.2 Two in-phase sources have wavelength 0.60 m. Their path difference at a point is 0.90 m. Calculate phase difference and describe the interference. State a further condition for complete cancellation. [3]

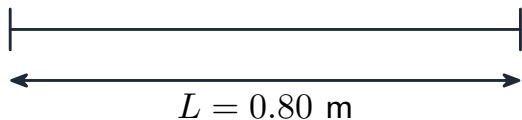


2.2 $\Delta\phi = (\Delta x/\lambda)360^\circ = (0.90/0.60)360^\circ = 540^\circ$, equivalent to 180° . Destructive interference. Equal arriving amplitudes are also needed for complete cancellation.

Exercise 2.3

2.3 A 0.80 m string fixed at both ends vibrates in its second harmonic at 150 Hz. Find wavelength and speed. State the separation of adjacent nodes and the phase relation between neighbouring loops. [4]

second harmonic, 150 Hz

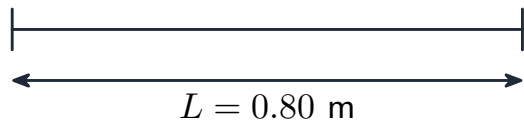


3 Exam-style questions

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second harmonic, 150 Hz



3 Exam-style questions

2.3 The second harmonic has two half-wavelengths in L : $\lambda = L = 0.80 \text{ m}$. $v = f\lambda = 150 \times 0.80 = 120 \text{ m s}^{-1}$. Node separation $= \lambda/2 = 0.40 \text{ m}$. Neighbouring loops vibrate in opposite phase.

Exercises 3.1·3.2

3.1 A string has $L = 0.50$ m, $\mu = 2.0 \times 10^{-3}$ kg m⁻¹ and tension 18 N. Calculate its fundamental frequency. Predict the frequency if tension becomes 72 N. Explain how to investigate tension without confusing its effect with another variable. [5]

$T = 18$ N

|-----|

$L = 0.50$ m, $\mu = 2.0 \times 10^{-3}$ kg/m

3.2 Plan the specified two-beam oscilloscope measurement of sound speed. Include the two signals, wavelength measurement, frequency measurement, calculation and one way to reduce percentage distance uncertainty. [6]

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$$T = 18 \text{ N}$$



$$L = 0.50 \text{ m}, \mu = 2.0 \times 10^{-3} \text{ kg/m}$$

3.1 For the fundamental, $\lambda = 2L$. $v = \sqrt{T/\mu} = \sqrt{18/0.002} = 94.9 \text{ m s}^{-1}$. $f = v/(2L) = 94.9 \text{ Hz}$. Quadrupling tension doubles f to 190 Hz. Keep string linear density, vibrating length and harmonic number fixed while varying tension.

3.2 Plan the specified two-beam oscilloscope measurement of sound speed. Include the two signals, wavelength measurement, frequency measurement, calculation and one way to reduce percentage distance uncertainty. [6]

3.2 Connect a generator reference and microphone output to separate channels; the generator drives a speaker. Move the microphone along a measured line and identify repeated in-phase positions. Separation of consecutive in-phase positions gives λ . Read period from divisions and time base, then $f = 1/T$. Calculate $v = f\lambda$. Measure across several wavelengths and divide by their count, reducing percentage distance uncertainty.

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3.3 For a fixed-end string, explain how to investigate separately the effects of length and mass per unit length on fundamental frequency. Give a suitable graph for each investigation and two controls for each.

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3.3 Length investigation: vary vibrating length and tune to the fundamental each time, keeping tension and string linear density fixed. Plot f against $1/L$ for a straight line through the origin. Density investigation: use strings with different measured $\mu = m/l$ and tune each to the fundamental, keeping tension and vibrating length fixed. Plot f^2 against $1/\mu$ for a straight line through the origin.