3.1 Waves and optics

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS coherence • diffraction

Objective

Analyse wave superposition and interference; Use diffraction , polarisation and optical imaging; Relate phase, frequency and dispersion. Original public practice; not an ETS paper.

1 Key knowledge and worked examples

Add wave amplitudes, then calculate intensity. Intensity is proportional to squared amplitude for the same medium.

A path difference gives phase difference $2\pi\Delta/\lambda$. Coherent sources need stable relative phase.

For a single slit, minima satisfy a sin θ=mλ for nonzero integers m. A double slit has a different interference condition.

Geometric optics needs a stated sign convention. Wave effects matter when apertures are comparable to wavelength.

■ Worked method

Coherent waves have a stable phase difference. Add amplitudes before squaring.

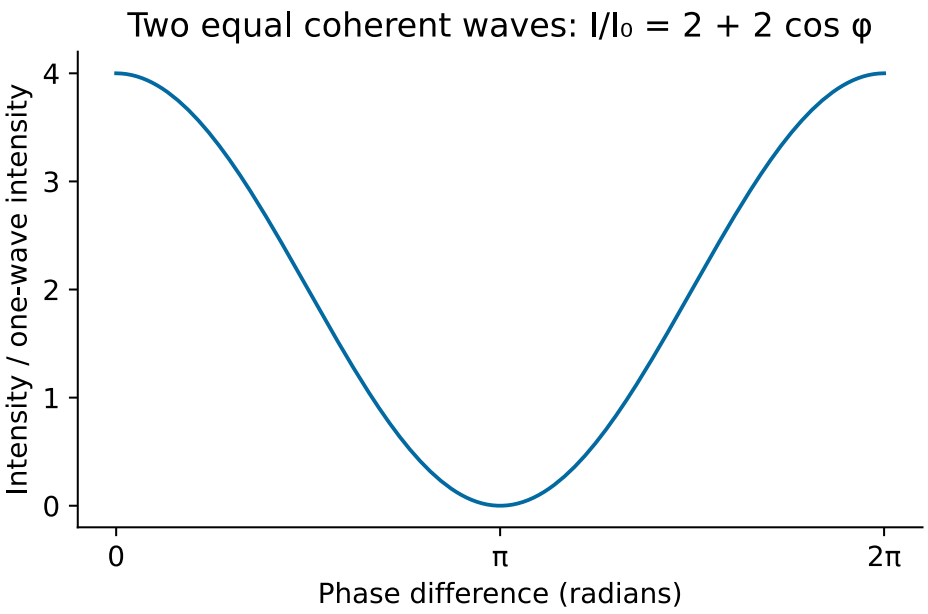
$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta.$$

For equal individual intensities I0 and a path difference of one quarter wavelength,

$$\delta = 2\pi\Delta/\lambda = 2\pi(\lambda/4)/\lambda = \pi/2.$$

$$I = 2I_0(1+\cos\delta) = 2I_0(1+\cos(\pi/2)) = 2I_0.$$

This is neither a maximum nor a minimum. Random relative phase removes the cross term in a long time average; stable coherence is a physical condition, not a drawing convention.



2 Practice

2.1 Choose one answer. Doubling wavelength at fixed slit width makes the first minimum angle: [1]

- **A** larger
- **B** smaller
- **C** unchanged

2.2 Choose one answer. An ideal polariser transmits unpolarised intensity I as: [1]

- **A** I
- **B** I/2
- **C** zero

2.3 For frequency 5 Hz and wavelength 2 m, wave speed is _____ m/s. Show your relation and units. [2]

2.4 Decide whether this claim is true. Justify it: Wave intensities can always be added without considering phase. [2]

3 Exam-style questions

3.1 Two coherent beams have individual intensities I and 4I in the same polarisation. Find the largest and smallest combined intensity, and the fringe visibility $(I_{max}-I_{min})/(I_{max}+I_{min})$. Explain why a dark fringe is not perfectly dark. [4]