

Waves and optics

GRE undergraduate preparation · local supported objectives

Choose the physical question

Reasoning

Two individually bright waves can cancel at a point if their phases oppose. Analyse wave superposition and interference Use diffraction, polarisation and optical imaging Relate phase, frequency and dispersion

Choose the system and model

Reasoning

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

Use the governing relation

Reasoning

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

Apply the conditions

Reasoning

For a single slit, minima satisfy $a \sin \theta = m\lambda$ for nonzero integers m . A double slit has a different interference condition.

Check the conclusion

Reasoning

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

Worked reasoning 1

Reasoning

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

Worked relation 2

Reasoning

Apply this relation only under the conditions just stated.

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

Worked reasoning 3

Reasoning

For equal individual intensities I_0 and a path difference of one quarter wavelength,

Worked relation 4

Reasoning

Apply this relation only under the conditions just stated.

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

Worked relation 6

Reasoning

Apply this relation only under the conditions just stated.

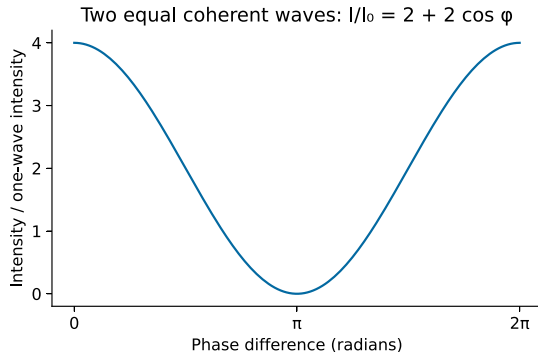
$$I = 2I_0(1 + \cos \delta) = 2I_0(1 + \cos(\pi/2)) = 2I_0.$$

Worked reasoning 7

Reasoning

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.

Read the original diagram



- Original GRE teaching diagram: Waves and optics
- Identify the axes, units, directions and the stated model.

Independent transfer · attempt

Reasoning

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]**

Independent transfer · reasoning

Reasoning

Amplitudes scale as $\sqrt{I}$ and $2\sqrt{I}$. $I_{\max} = (\sqrt{I} + 2\sqrt{I})^2 = 9I$ and $I_{\min} = (2\sqrt{I} - \sqrt{I})^2 = I$.
Visibility is $(9I - I)/(9I + I) = 0.8$. Unequal amplitudes cannot cancel completely.
Award maximum, minimum, visibility and explanation: one mark each.

Check assumptions and limits

Reasoning

The central single-slit maximum is not obtained by setting $m=0$ in the minima condition.

Keep the technical distinctions

Reasoning

coherence : A stable phase relationship between waves. diffraction : Wave spreading and interference caused by an aperture or obstacle.

Check yourself

- Define coherence and give its condition of use.
- Define diffraction and give its condition of use.
- Redo the original transfer with a changed parameter; check a limiting case.