Session 4 14/4/2025

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Waves.

📓 A-Level Physics: Waves – Question Set

✳️ Section 1: Conceptual Questions (~10 mins)

1. Define the following terms:
   a. Displacement

   b. Amplitude

   c. Frequency

   d. Wavelength

   e. Phase difference

   f. Polarisation

1. What is the difference between transverse and longitudinal waves? Give an example of each.

1. Explain what is meant by *superposition* and state the principle behind it.

1. What conditions are required for two waves to be *coherent*?

1. What is *diffraction* and when is it most noticeable?

🧮 Section 2: Short Calculations (~15 mins)

1. A wave on a string has a frequency of 50 Hz and a wavelength of 0.8 m.
   a. Calculate its speed.

   b. If the frequency is doubled, what happens to the wavelength (assuming wave speed stays constant)?

1. A sound wave travels through air at 343 m/s. If its frequency is 256 Hz, what is its wavelength?

1. A radio wave has a wavelength of 1500 m. What is its frequency? (Speed of light = 3×1083 \times 10^83×108 m/s)

1. A diffraction grating has 600 lines/mm. Light of wavelength 550 nm is incident normally. Calculate the angle of the first-order maximum.

🔍 Section 3: Application & Explanation (~20 mins)

1. Describe and explain what is seen when monochromatic light passes through a double slit. Include a labelled diagram.

1. Two loudspeakers emit sound waves in phase at the same frequency. A student walks from one speaker directly towards the other and hears alternating loud and quiet sounds. Explain why this happens.

1. Draw and label the first two harmonic modes of vibration on a stretched string fixed at both ends. Indicate the wavelength for each.
   ✏️ *(Use space below to sketch)*

1. A string fixed at both ends vibrates at its third harmonic. The length of the string is 1.2 m and the wave speed is 240 m/s.

a. What is the wavelength of the third harmonic?

b. What is the frequency of this mode?

🧪 Section 4: Exam-Style Problem Solving (~15 mins)

1. In a Young's double-slit experiment:
- Slit separation = 0.25 mm
- Screen distance = 2.0 m
- Fringe separation = 5.0 mm

Calculate the wavelength of the light used.

1. A microwave generator is used with a pair of slits to demonstrate interference. The wavelength is 3 cm.
   a. Describe an experiment to show interference using the microwaves.

b. Explain why interference is observed.

☑ Answers: A-Level Physics – Waves

Section 1: Conceptual Questions

a. Displacement – distance from the equilibrium position.
b. Amplitude – maximum displacement from equilibrium.
c. Frequency – oscillations per second (Hz).
d. Wavelength – distance between points in phase.
e. Phase difference – difference in phase angle (usually in radians or degrees).
f. Polarisation – restriction of wave oscillations to one plane (only for transverse waves).

- Transverse: oscillations perpendicular to wave direction (e.g., light).
- Longitudinal: oscillations parallel to wave direction (e.g., sound).

Superposition: when waves meet, their displacements add algebraically, forming constructive or destructive interference.
Same frequency and a constant phase difference.
Diffraction is wave spreading when passing through a gap or around an obstacle. It’s most noticeable when the gap ≈ wavelength.

Section 2: Short Calculations

a. v=fλ=50×0.8=40 m/sv = f\lambda = 50 \times 0.8 = 40\, \text{m/s}v=fλ=50×0.8=40m/s
b. If fff doubles, λ\lambdaλ halves (speed constant): λ=0.4 m\lambda = 0.4\, \text{m}λ=0.4m
λ=v/f=343/256≈1.34 m\lambda = v/f = 343 / 256 \approx 1.34\, \text{m}λ=v/f=343/256≈1.34m
f=v/λ=3×108/1500=2×105 Hzf = v/\lambda = 3 \times 10^8 / 1500 = 2 \times 10^5\, \text{Hz}f=v/λ=3×108/1500=2×105Hz
Grating spacing d=1/600000=1.67×10−6 md = 1/600000 = 1.67 \times 10^{-6}\, \text{m}d=1/600000=1.67×10−6m
θ=sin −1(nλ/d)=sin −1(550×10−9/1.67×10−6)≈18.97∘\theta = \sin^{-1}(n\lambda/d) = \sin^{-1}(550 \times 10^{-9} / 1.67 \times 10^{-6}) \approx 18.97^\circθ=sin−1(nλ/d)=sin−1(550×10−9/1.67×10−6)≈18.97∘

Section 3: Application & Explanation

Double-slit interference: bright/dark fringes from constructive/destructive interference. Diagram: central bright fringe, symmetrical pattern.
Path difference between speakers causes phase differences → alternating constructive (loud) and destructive (quiet) interference.
1st harmonic: half a wavelength (λ = 2L).
2nd harmonic: one full wavelength (λ = L).
Draw: nodes at fixed ends, antinodes in between.
a. λ=2L/3=2.4/3=0.8 m\lambda = 2L/3 = 2.4/3 = 0.8\, \text{m}λ=2L/3=2.4/3=0.8m
b. f=v/λ=240/0.8=300 Hzf = v/\lambda = 240 / 0.8 = 300\, \text{Hz}f=v/λ=240/0.8=300Hz

Section 4: Exam-Style Problem Solving

λ=(fringe spacing×slit separation)/screen distance\lambda = (fringe\, spacing \times slit\, separation) / screen\, distanceλ=(fringespacing×slitseparation)/screendistance
=(5.0×10−3×2.5×10−4)/2.0=625×10−9=625 nm= (5.0 \times 10^{-3} \times 2.5 \times 10^{-4}) / 2.0 = 625 \times 10^{-9} = 625\, \text{nm}=(5.0×10−3×2.5×10−4)/2.0=625×10−9=625nm
a. Set up two microwave sources or reflectors; use a receiver to detect signal strength as it moves.
b. Interference occurs due to constant phase difference and equal frequency.