

Interference, resonance and the Doppler shift

AP Physics 2 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to link path difference and phase to bright and dark fringes, resonant frequencies and the Doppler shift. They climb from one-step recall to AP-style multi-part reasoning and design. They suit AP Physics 2 unit 14 and the wave sections of A level and first-year physics courses.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 14

Problem 1 Path difference and interference (easy)

Two loudspeakers vibrate in phase and produce sound of wavelength 0.50 m. A microphone is 3.0 m from one speaker and 4.5 m from the other.

1. Calculate the path difference.
2. Express the path difference in wavelengths.
3. State whether the signals add or cancel at the microphone.

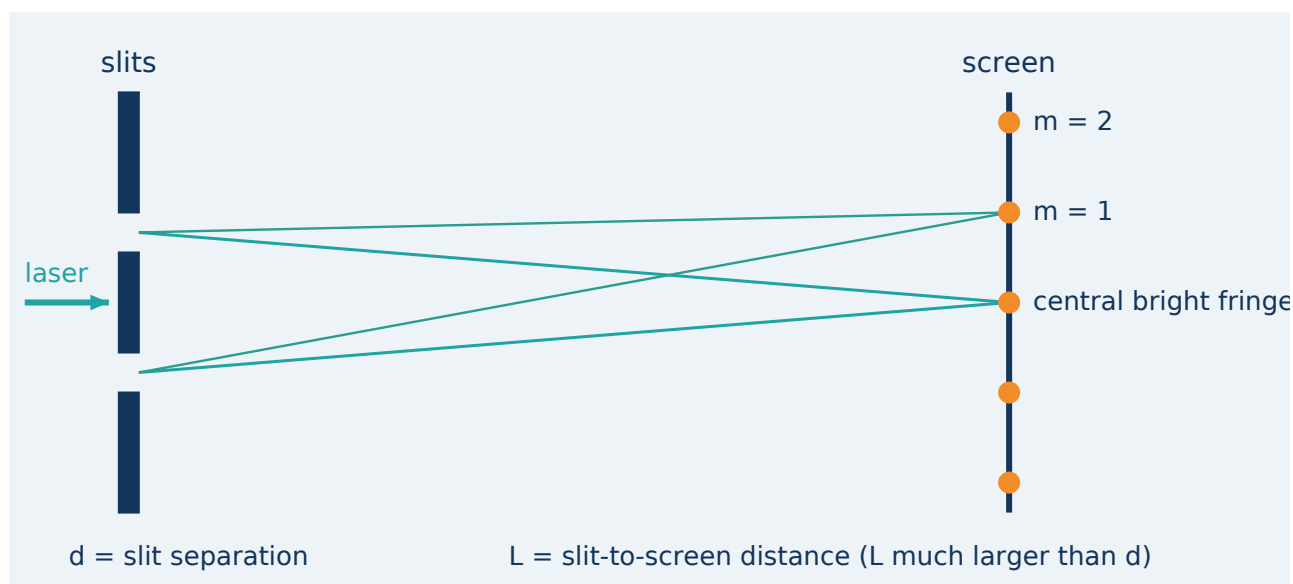
Problem 2 Wavelength of a sound note (easy)

Chiamaka in Lagos plays a note of frequency 440 Hz. Sound travels at 343 m/s.

1. Calculate the wavelength.
2. Calculate the period of the vibration.

Problem 3 Fringe spacing from a double slit (easy)

A laser of wavelength 500 nm illuminates two slits separated by 0.10 mm. The screen is 1.5 m away. The figure shows the set-up.



Double-slit set-up: bright fringes appear where the path difference is a whole number of wavelengths.

1. Convert the wavelength and the slit separation to metres.
2. Calculate the spacing between neighbouring bright fringes.

Problem 4 Converting wave quantities (easy)

A slide has slits 0.25 mm apart. A laser has a frequency of 4.6×10^{14} Hz.

1. Write 0.25 mm in metres.
2. Calculate the wavelength of the laser light in nanometres. Use $c = 3.0 \times 10^8$ m/s.

Problem 5 Fundamental of a string (easy)

A guitar string of length 0.65 m is fixed at both ends. Waves travel along it at 260 m/s.

1. State the wavelength of the fundamental mode.
2. Calculate the fundamental frequency.
3. Calculate the frequency of the third harmonic.

Problem 6 Phase flips in an oil film (easy)

Light in air strikes a thin layer of oil ($n = 1.45$) floating on water ($n = 1.33$).

1. State whether the reflection at the air-oil surface flips the phase.
2. State whether the reflection at the oil-water surface flips the phase.
3. State the net phase difference between the two reflected rays that comes from reflection alone.

Problem 7 Pipes open and closed (medium)

A pipe of length 0.50 m is filled with air. Take the speed of sound as 340 m/s.

1. Calculate the first three resonant frequencies if the pipe is open at both ends.
2. Calculate the first two resonant frequencies if one end is closed.

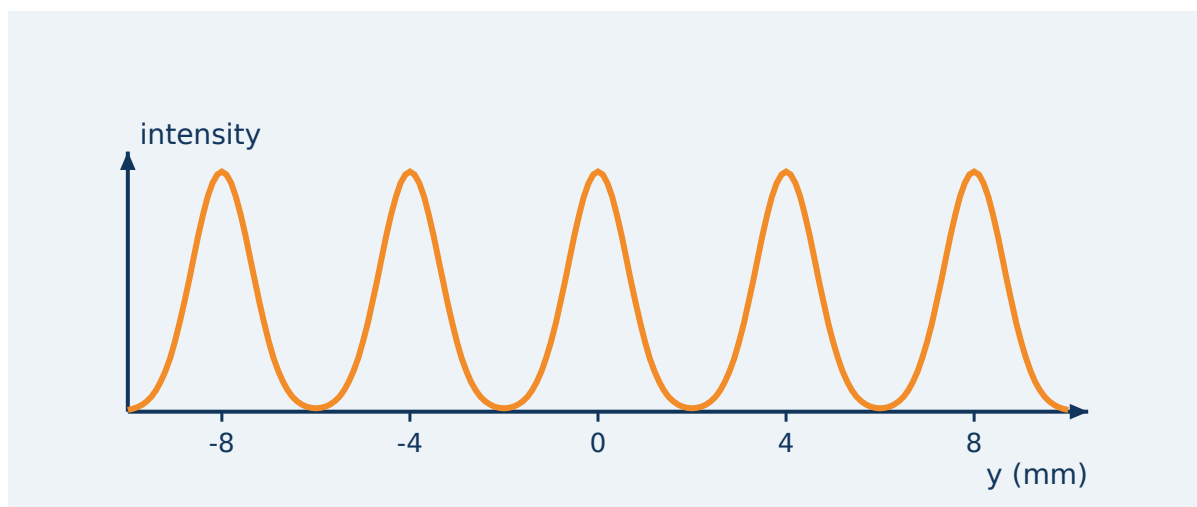
Problem 8 Doppler shift of a horn (medium)

A car horn emits 500 Hz. The car moves toward a stationary listener at 20 m/s. Sound travels at 340 m/s.

1. Calculate the frequency heard as the car approaches.
2. Calculate the frequency heard after the car has passed.

Problem 9 Reading a fringe graph (medium)

The graph shows the intensity of light along a screen 2.0 m from slits that are 0.30 mm apart.



Intensity along the screen: neighbouring bright fringes are 4.0 mm apart.

1. Read the spacing between neighbouring bright fringes.
2. Calculate the wavelength of the light.
3. State the path difference at the fringe at +8 mm.

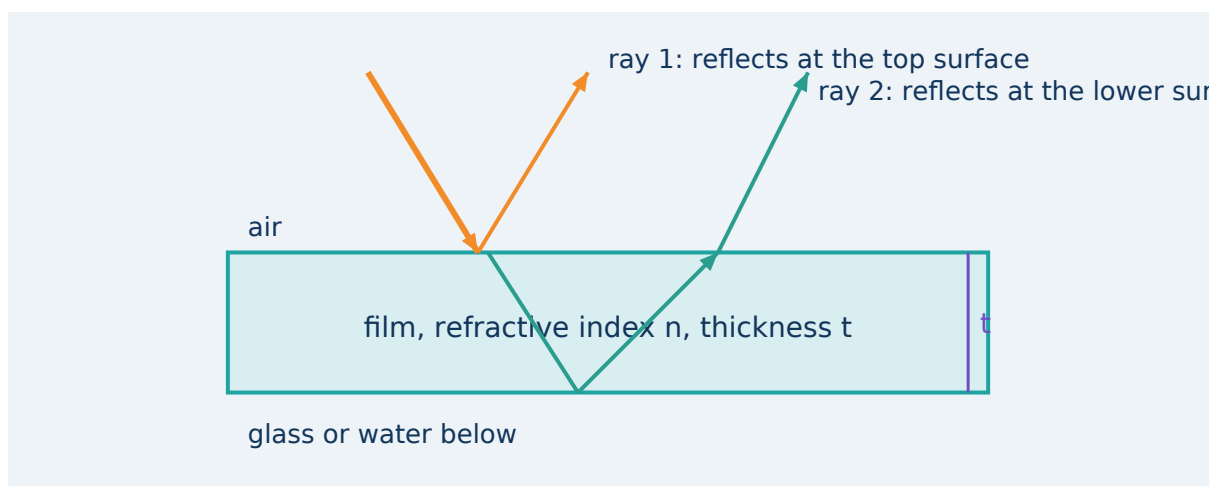
Problem 10 Angles in a double slit (medium)

Light of wavelength 600 nm falls on two slits 4.0 μm apart.

1. Calculate the angle of the second-order bright fringe.
2. Calculate the highest order that can be seen.

Problem 11 Soap film thickness (medium)

A soap bubble ($n = 1.33$) in air reflects light of wavelength 560 nm strongly. The figure shows the two reflected rays.



Two reflected rays: ray 2 travels an extra distance of about $2t$ inside the film.

1. Explain why $2nt = \lambda/2$ gives the thinnest film that reflects strongly.
2. Calculate that thickness.

Problem 12 Anti-reflection coating (medium)

Mei in Singapore designs a lens coating of magnesium fluoride ($n = 1.38$) on glass ($n = 1.50$). The target wavelength is 550 nm, in air.

1. State how many reflections flip the phase.
2. Explain why the coating thickness should satisfy $2nt = \lambda/2$.
3. Calculate the minimum coating thickness.

Problem 13 Beats from two sources (medium)

A tuning fork of 440 Hz and a guitar string sound together. The musician hears 6 beats in 2.0 s. Tightening the string increases the beat rate.

1. Calculate the beat frequency.
2. State the two possible frequencies of the string before tightening.
3. Decide which one is correct and explain.

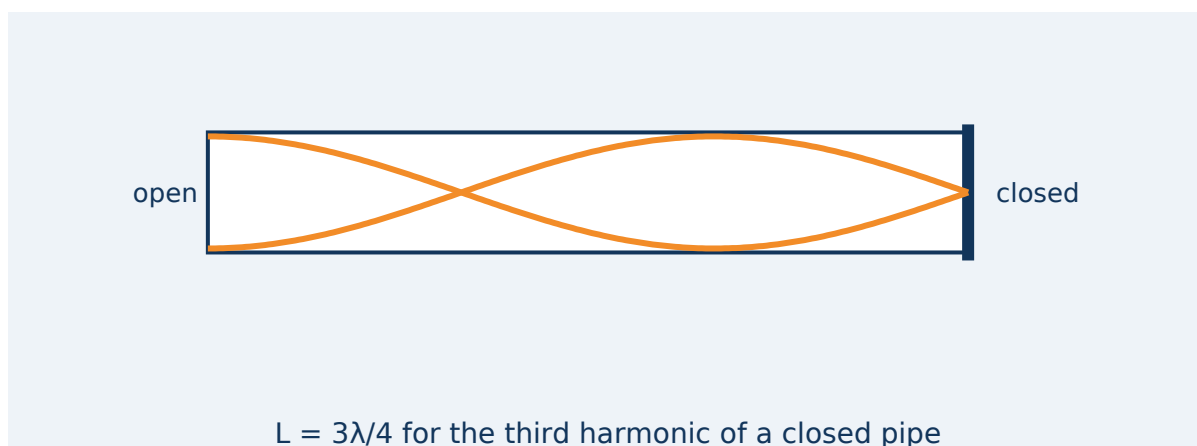
Problem 14 Red against violet fringes (medium)

White light passes through slits 0.20 mm apart onto a screen 1.0 m away. Take $\lambda(\text{red}) = 700$ nm and $\lambda(\text{violet}) = 400$ nm.

1. Calculate the first-order fringe distance from the centre for each colour.
2. Describe the colours seen on either side of the central white fringe.

Problem 15 Resonance tube lengths (medium)

A tuning fork of frequency 512 Hz is held over a tube closed at the bottom by water. The water level is lowered. Sound speed is 343 m/s.



Third harmonic of a pipe closed at one end: three quarters of a wavelength fit in the length L .

1. Calculate the wavelength.
2. Calculate the two shortest air-column lengths that give resonance.

Problem 16 Slit separation from a pattern (hard)

Wanjiru in Nairobi uses a laser of wavelength 633 nm and a screen 3.20 m away. The distance between the third-order bright fringes on opposite sides of the centre is 60.8 mm.

1. Write an expression for the distance between the two third-order fringes.
2. Calculate the slit separation.

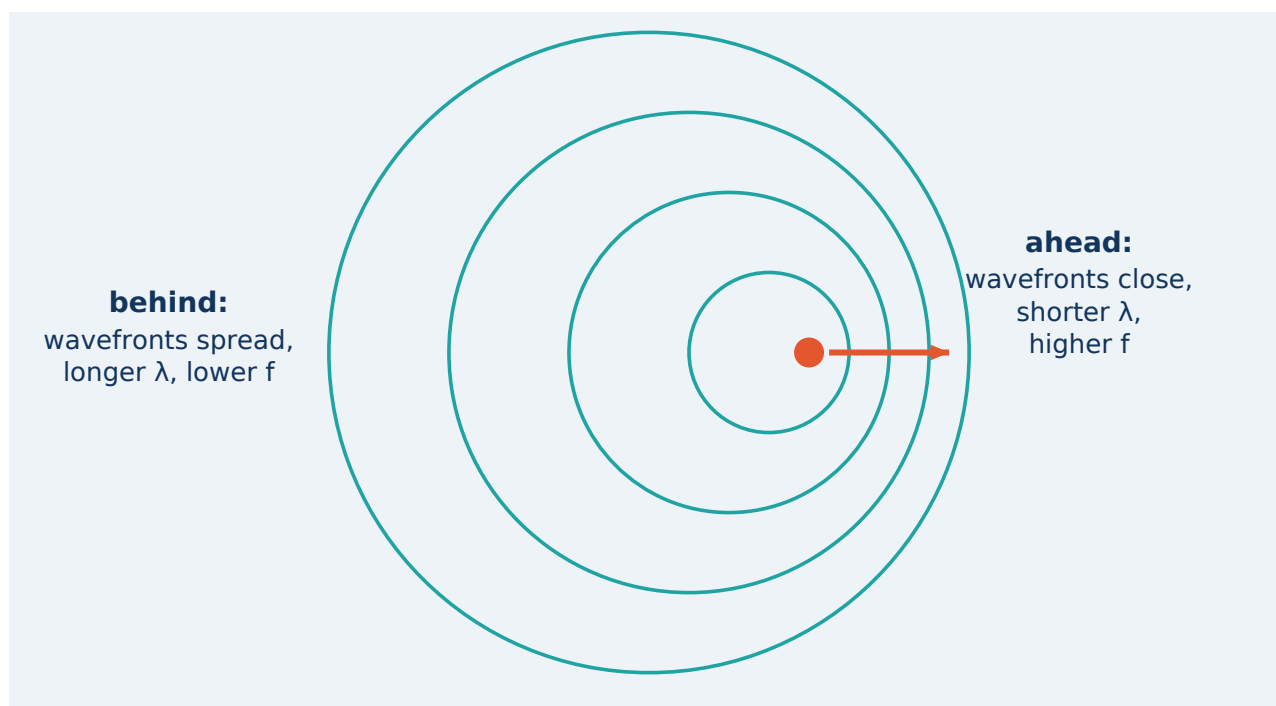
Problem 17 Colours reflected by a bubble (hard)

A soap film ($n = 1.33$) is 380 nm thick and lit by white light. Only the top reflection flips the phase.

1. Write the condition for constructive reflection.
2. Calculate the wavelengths in the visible range (400–700 nm) that are reflected strongly.
3. Predict the colour of the reflected light.

Problem 18 Wavelength squeezed by motion (hard)

An ambulance siren has a frequency of 650 Hz. The ambulance moves at 30 m/s toward a listener. Sound speed is 343 m/s.



Wavefronts from a moving source: compressed in front, stretched behind.

1. Calculate the wavelength of the sound when the ambulance is at rest.
2. Calculate the wavelength in front of the moving ambulance.
3. Calculate the frequency heard by the listener.

Problem 19 Closed pipe claim, spot the error (hard)

A student argues: "A closed pipe of length 0.85 m rings with a lowest frequency of 100 Hz in air at 340 m/s, so it must also ring at 200 Hz." Evaluate the claim.

1. Calculate the fundamental frequency of the pipe.
2. List the next two frequencies it can sustain.
3. Identify the error in the student argument.

Problem 20 Design a wavelength measurement (hard)

Design an experiment to find the wavelength of a laser pointer using a double slit of known separation d .

1. List the quantities to measure and the apparatus.
2. State how to reduce the uncertainty in the fringe spacing.
3. Describe a graph that gives λ from its gradient and state what the gradient is.