

Waves that add: fringes and grating spectra

Physics grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These problems move from adding wave displacements and finding path differences to double-slit fringes, diffraction gratings and single-slit spreading. They suit A Level, IB physics and Class 11-12 students. Pay attention to unit conversions between nm, mm and m.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB C.3

Problem 1 Conditions for interference (easy)

Wanjiru in Nairobi writes notes on interference of two coherent sources of wavelength λ .

1. State the path difference for constructive interference and for destructive interference.
2. Define coherent sources.
3. Explain why two ordinary light bulbs do not show an interference pattern.

Problem 2 Two loudspeakers (easy)

Two loudspeakers connected to the same signal generator play a 680 Hz tone in a hall in Johannesburg. The speed of sound is 340 m/s. A listener is 5.40 m from one speaker and 6.15 m from the other.

1. Calculate the wavelength.
2. Calculate the path difference.
3. State whether the sound is loud or quiet at the listener and explain.

Problem 3 Adding two pulses (easy)

Two pulses on a rope meet. Pulse A has displacement +3.0 cm at the meeting point and pulse B has +2.0 cm in one case and -2.0 cm in another.

1. Calculate the resultant displacement when B is +2.0 cm.
2. Calculate the resultant displacement when B is -2.0 cm.
3. Name the principle you used.

Problem 4 Fringe spacing (easy)

A helium-neon laser of wavelength 633 nm illuminates two slits 0.25 mm apart. The screen is 1.50 m away.

1. Write down the formula for the fringe spacing.
2. Calculate the fringe spacing in mm.
3. Calculate the distance between the central fringe and the third bright fringe.

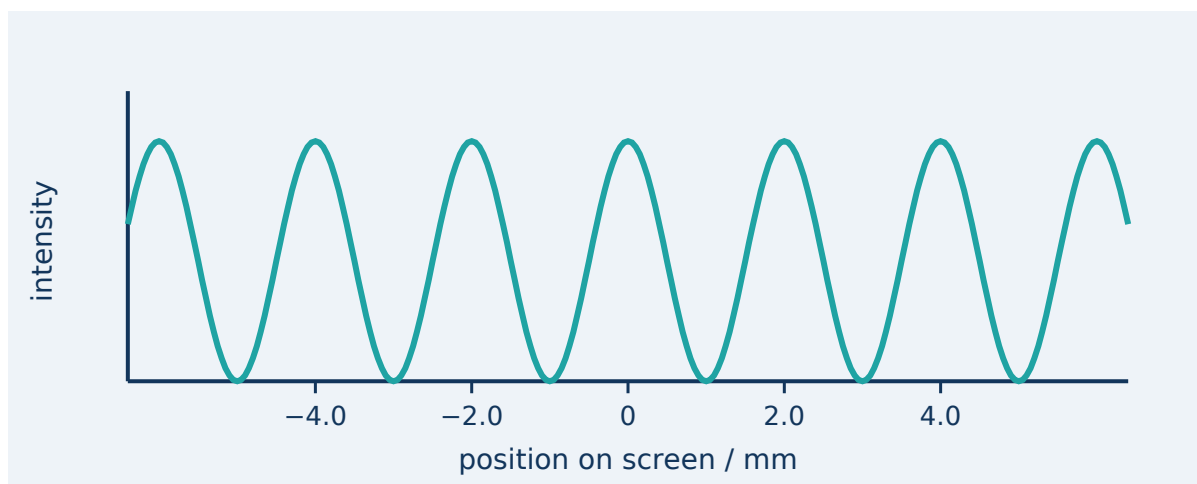
Problem 5 Lines per millimetre (easy)

A school has two gratings, one marked 300 lines/mm and one marked 800 lines/mm.

1. Calculate the slit spacing d of each in micrometres.
2. State which grating will spread the light through the larger angles.
3. Calculate how many lines there are in a 5.0 mm wide beam on the 800 lines/mm grating.

Problem 6 Reading a fringe pattern (easy)

Diego in Texas records the intensity pattern of a double-slit experiment.



Intensity against position on the screen.

1. Read the fringe spacing from the graph.
2. State the position of the second bright fringe from the centre.
3. The light has wavelength 600 nm and the screen is 1.50 m away. Calculate the slit separation.

Problem 7 Waves through gaps (easy)

A ripple tank has waves of wavelength 2.0 cm. They pass through gaps of width 20 cm, 2.0 cm and 0.5 cm in turn.

1. Describe what happens at each gap.
2. State which gap gives the most diffraction.
3. Explain why you can hear a person speaking round a corner but cannot see them.

Problem 8 Wavelength from fringes (medium)

Mei in Singapore uses slits 0.50 mm apart and a screen 1.20 m away. Ten fringe spacings together measure 12.0 mm.

1. Calculate the fringe spacing.
2. Rearrange the double-slit formula for λ .
3. Calculate the wavelength in nm.

Problem 9 Red light to blue light (medium)

Red light of 650 nm gives a fringe spacing of 2.4 mm in a double-slit set-up. Nothing else changes except that blue light of wavelength 450 nm is used.

1. Explain how w depends on λ .
2. Calculate the new fringe spacing.
3. Predict the fringe spacing if the slit separation is also doubled.

Problem 10 Angles from a grating (medium)

A grating has 400 lines per mm and is illuminated at right angles by light of wavelength 520 nm.

1. Calculate the slit spacing.
2. Calculate the angle of the first order.
3. Calculate the angle of the second order.

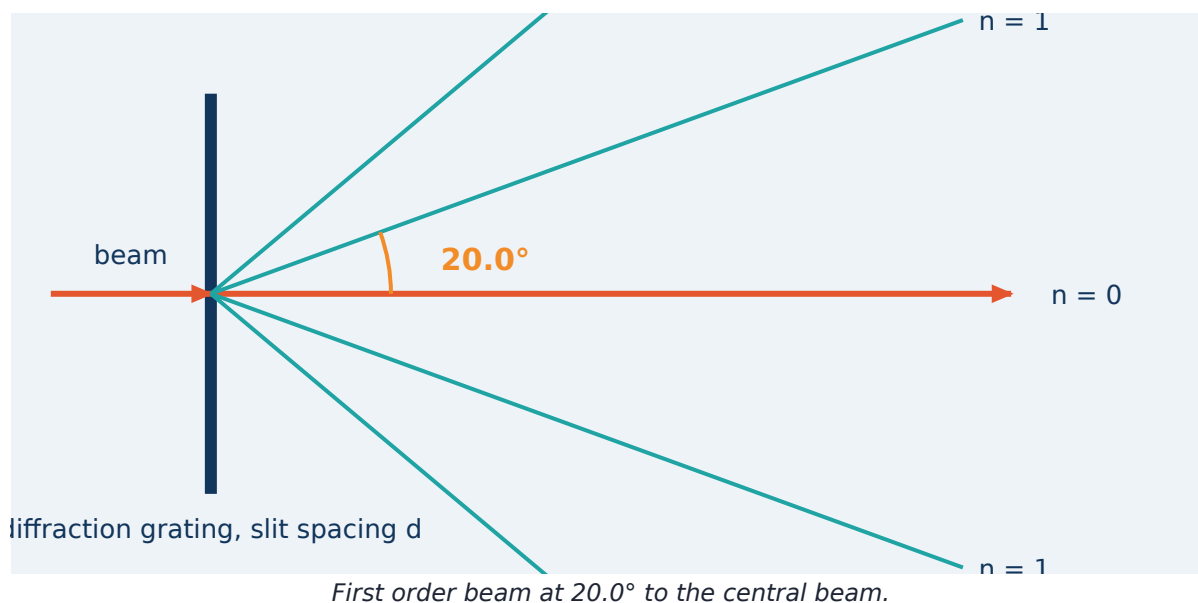
Problem 11 How many spots? (medium)

Red light of wavelength 650 nm meets a grating with 600 lines per mm.

1. Calculate d .
2. Calculate the highest order.
3. Calculate the angle of the highest order and the total number of bright spots on the screen.

Problem 12 Wavelength from a measured angle (medium)

Aarav in Pune measures the angle of the first order using a grating of 500 lines per mm.



1. Calculate d in metres.
2. Calculate the wavelength of the light.
3. State the colour you would expect.

Problem 13 A white light spectrum (medium)

White light (400 nm to 700 nm) falls on a grating with 500 lines per mm.

1. Calculate the angles for violet (400 nm) and red (700 nm) in the first order.
2. State which colour is deviated more and explain.
3. Show that the spectra of the second and third orders overlap.

Problem 14 Single-slit spreading (medium)

Light of wavelength 600 nm passes through a single slit of width 0.10 mm. The screen is 2.0 m away.

1. Calculate $\sin \theta$ for the first minimum.
2. Calculate the angle.
3. Calculate the full width of the central bright maximum on the screen in mm.

Problem 15 Phase difference (medium)

Light of wavelength 500 nm from two slits arrives at a point with a path difference of 1.25 μm .

1. Calculate the path difference in wavelengths.
2. Calculate the phase difference in radians.
3. State whether the point is bright or dark.

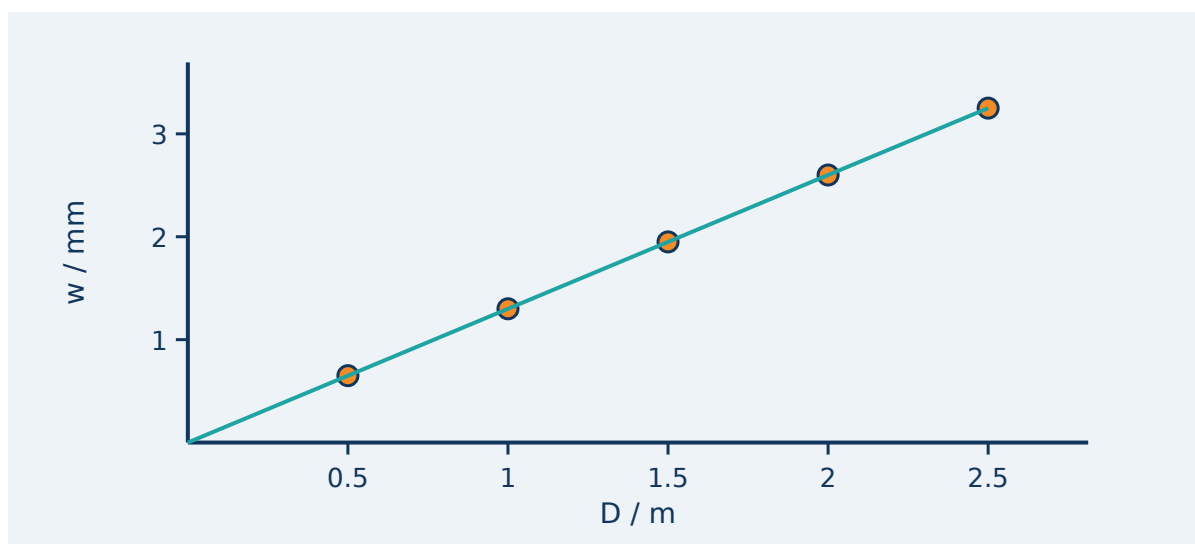
Problem 16 A film over one slit (hard)

A thin transparent film of refractive index 1.50 is placed over one slit of a double-slit apparatus using light of wavelength 600 nm. The extra optical path introduced is $(n - 1)t$, where t is the thickness. The whole pattern shifts sideways by 8 fringes.

1. Explain why the pattern shifts.
2. Write an equation linking the shift to the extra optical path.
3. Calculate the film thickness in μm .

Problem 17 Fringe spacing against distance (hard)

Kofi in Accra records the fringe spacing w for different screen distances D . The slit separation is 0.40 mm.



Fringe spacing against screen distance.

1. Describe the shape of the graph and what it shows.
2. Calculate the gradient using the first and last points.
3. Calculate the wavelength of the light in nm.

Problem 18 Two colours together (hard)

A double-slit apparatus ($s = 0.50$ mm, $D = 2.0$ m) is lit by two wavelengths together, 450 nm and 600 nm.

1. Calculate the fringe spacing for each wavelength.
2. Show that the fourth bright fringe of the 450 nm light coincides with the third of the 600 nm light.
3. Calculate the distance of this first coincidence from the central fringe.

Problem 19 Spot the error (hard)

A student uses a grating labelled 500 lines per mm and measures the second order at 30.0° . The student writes: $d = 1/500 = 0.0020$ mm $= 2.0 \times 10^{-3}$ m, then $\lambda = (2.0 \times 10^{-3} \times \sin 30.0^\circ) \div 2 = 5.0 \times 10^{-4}$ m.

1. Identify the error.
2. Calculate the correct wavelength in nm.
3. Explain why the student's answer should have been rejected immediately.

Problem 20 Close wavelengths (hard)

A mercury lamp emits two yellow lines at 577 nm and 579 nm. Chiamaka in Lagos views them in the second order of a grating with 600 lines per mm.

1. Calculate the second order angle for each wavelength.
2. Calculate the angular separation in degrees.
3. Explain why a grating with more lines illuminated would separate them better.