

Measuring wavelength • Required Practical 2

35–40 minutes independent practice + 15–20 minutes review | 36 marks

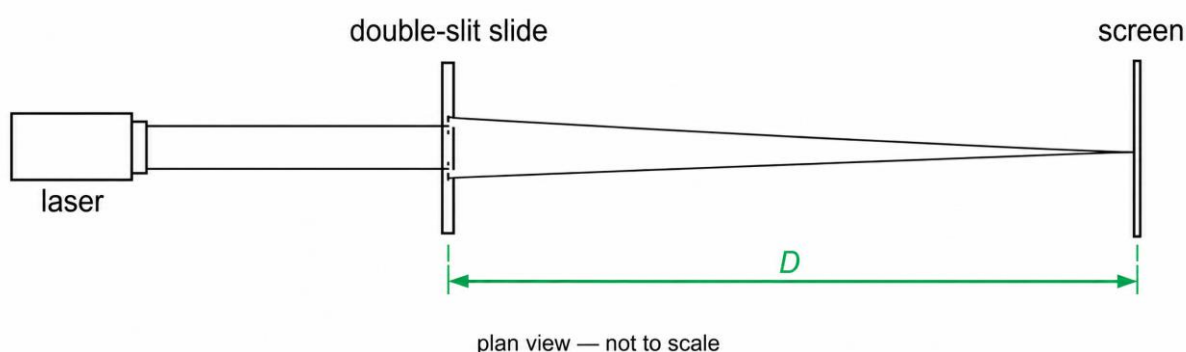
AQA AS Physics 7407 • First-year A Level 7408

Specification points covered

AQA AS 7407 / first-year A Level 7408: 3.3.2.1 — coherence, path difference, Young's slits and fringe spacing; Required Practical 2: interference with double slits and a diffraction grating. 3.3.2.2 — plane transmission grating at normal incidence; $d \sin \theta = n\lambda$ and its application. Supporting: 3.3.1.1 — $c = f\lambda$; 3.1.2 — absolute, percentage and combined uncertainties.

A wavelength check for a laser module

An optics team checks a replacement green laser module for a scanning instrument. It measures wavelength using double slits and a diffraction grating. The double-slit camera can record only a limited width. The module may be approved only if its whole wavelength uncertainty interval lies within 525–540 nm, inclusive.



Use $w = \lambda D/s$ for the small-angle double-slit arrangement and $d \sin \theta = n\lambda$ for a grating at normal incidence. D is the perpendicular slit/grating-to-screen distance. Use exact trigonometry for grating angles. $1 \text{ nm} = 10^{-9} \text{ m}$. Use worst-case uncertainties throughout. All diagrams are schematic; do not measure them.

1. Prepare the wavelength test [2 marks]

The same laser illuminates both narrow, parallel slits. Later the slide is replaced by a transmission grating with 400 lines per mm.

(a) State the two conditions that define coherent waves. [1 mark]

(b) Calculate the separation d of adjacent grating lines in metres. [1 mark]



2. Measure the double-slit fringes [7 marks]

The marks show the centres of nine consecutive bright fringes. The measured span X between the first and last centres is 27.2 mm. The slit separation s is 0.250 mm and the screen distance D is 1.60 m.



bright-fringe centres — not to scale

(a) Use the diagram to determine the number of fringe spacings in X , then calculate the fringe spacing w . [1 mark]

(b) Determine the wavelength of the laser light in nm. [2 marks]

(c) Light leaves the two slits in phase. Explain, using path difference, why bright fringes and dark fringes occur. Assume the arriving waves have equal amplitudes. [2 marks]

(d) A second test beam has 1.25 times the original frequency. With the same s and D , calculate its fringe spacing and explain the change. Light speed in air is unchanged. [2 marks]



3. Work within the camera window [7 marks]

The camera gives the first and last centre positions as (11.0 ± 0.2) mm and (38.2 ± 0.2) mm. Treat these endpoint uncertainties as separate worst-case contributions. The percentage uncertainty in s is 1.0%, and $D = (1.60 \pm 0.01)$ m.

(a) Calculate the absolute and percentage uncertainty in $X = 27.2$ mm. [2 marks]

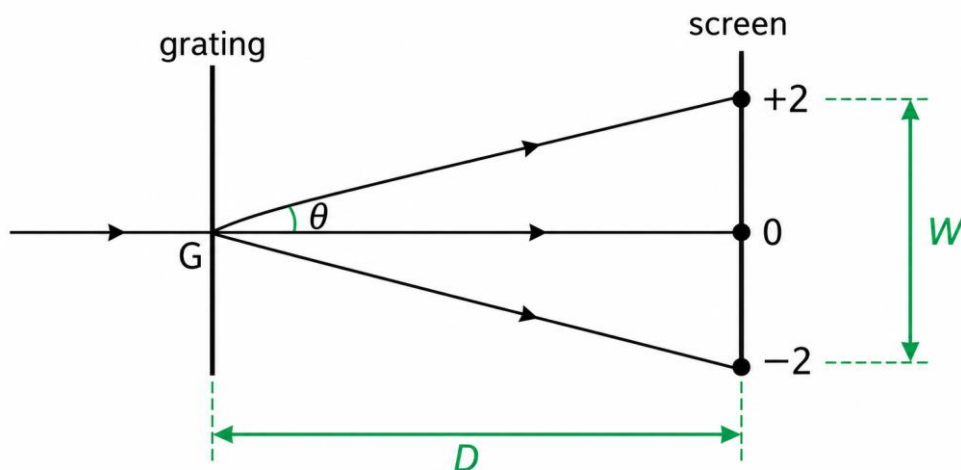
(b) Use $\lambda = ws/D$ to calculate the percentage uncertainty in the wavelength from Question 2. The interval count is exact. [2 marks]

(c) The usable camera window is 30.0 mm wide and may be shifted sideways to frame the chosen fringes. The team proposes increasing D to 2.40 m, with the same light and slits. Calculate the new w and the greatest whole number of consecutive fringe spacings that fits. If ΔX stays at 0.4 mm, does measuring that maximum span reduce the percentage uncertainty in X compared with the original test? Support your conclusion numerically. [3 marks]



4. Cross-check with the diffraction grating [6 marks]

The 400 lines per mm grating is illuminated at normal incidence. A separate, larger screen is parallel to it at $D = 0.800$ m. The separation W of the two second-order spots is 0.752 m. Only orders 0 and ± 2 are drawn.



only orders 0 and ± 2 shown — not to scale

(a) Calculate the diffraction angle θ of either second-order beam relative to the central beam. [2 marks]

(b) Use the grating equation to determine the wavelength in nm. [2 marks]

(c) A spreadsheet replaces $\sin \theta$ by $\tan \theta$ in the grating equation. Calculate the wavelength it would report and explain why this is unsuitable for the test. [2 marks]



5. Write the practical methods [7 marks]

Parts (a) and (b) scaffold a six-mark-style response. Describe repeatable methods for measuring this laser's wavelength. The camera reads calibrated screen positions; no spectrometer is used.

(a) Describe a double-slit method. Include the arrangement, the measurements used to find w and the calculation, and a way to improve the reliability of the result. [3 marks]

(b) Describe a diffraction-grating method using a flat screen. Include alignment, the measurements and equations, and a check that improves confidence in the result. [3 marks]

(c) State one specific laser precaution for this arrangement. Do not give a general laboratory clothing rule. [1 mark]



6. Check screen limits and approve the module [7 marks]

For this final section use $\lambda = 532 \text{ nm}$ and $d = 2.50 \times 10^{-6} \text{ m}$, regardless of your earlier answers. Assume a grating order exists when $n\lambda/d \leq 1$, and ignore brightness limits. The grating measurement has a stated worst-case wavelength uncertainty of 1.5%; you do not need to propagate angular uncertainties.

(a) Calculate the highest possible diffraction order. State the total number of maxima, including both sides and the central maximum, if the screen size is unlimited. [2 marks]

(b) The actual screen extends 0.500 m on each side of its central maximum and is 0.800 m from the grating. Determine how many maxima fall on this screen. Justify your count with a calculation. [2 marks]

(c) Calculate the uncertainty interval for the 532 nm grating result. Apply the rule that the whole interval must lie within 525–540 nm, inclusive, to decide whether the team can approve the module from this result. [2 marks]

(d) The double-slit result has an uncertainty interval of about 515–548 nm. Does it agree with the grating result within the stated uncertainties? Explain why this is a different judgement from approving the module. [1 mark]

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk

