

Waves that add: fringes and grating spectra

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

Model answers use the sample results above. Your measurements will differ a little, but the value of the wavelength should lie near the stated value, and the graph of $\sin \theta$ against n should be a straight line.

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

Question 1 Slit spacing

$$d = 1 \div 300\,000 = \mathbf{0.0000\text{ m}} \text{ (3.33 } \mu\text{m)}.$$

Question 2 Angle of the first order

$$\tan \theta = x/L = 0.200 \div 1.000, \text{ so } \theta = \mathbf{11.31^\circ}, \text{ and } \sin \theta = 0.1961.$$

Question 3 Wavelength from each order

$$\lambda = d \sin \theta \div n: n = 1 \text{ gives } 653.7 \text{ nm}; n = 2 \text{ gives } 649.3 \text{ nm}; n = 3 \text{ gives } 651 \text{ nm. Mean} = \mathbf{651 \text{ nm}}.$$

Question 4 Graph of $\sin \theta$ against n

$$\text{Gradient} = (0.5859 - 0.1961) \div 2 = 0.1949. \text{ Gradient} = \lambda/d, \text{ so } \lambda = 0.1949 \times 0.0000 = \mathbf{650 \text{ nm}}.$$

Question 5 Uncertainty in x

$$\text{For } n = 1: 0.002 \div 0.200 \times 100 = 1 \%. \text{ For } n = 3: 0.002 \div 0.723 \times 100 = 0.28 \%. \text{ The third order has the smallest percentage uncertainty, since } x \text{ is larger.}$$

Question 6 Small-angle approximation

$$x/L = 0.723 \text{ instead of } \sin \theta = 0.5859, \text{ a difference of } 23 \%. \text{ For } \theta = 35.9^\circ \text{ the approximation is not acceptable; use } \sin(\tan^{-1}(x/L)).$$

Question 7 Comparison

$$\text{Difference} = |651 - 650| \div 650 \times 100 = \mathbf{0.21 \%}. \text{ This is within the measurement uncertainty; small errors in locating the spot centres and in the grating spacing contribute.}$$

Question 8 Improving the experiment

Measure from the $n = -3$ spot to the $n = +3$ spot and halve it to reduce the effect of the central spot being hard to place. Increase L to enlarge x and reduce the percentage uncertainty. **Check that the grating is exactly perpendicular to the beam.**