A-Level Physics

Young's Double Slits Experiment

Mark Scheme

Time available: 63 minutes
Marks available: 42 marks

1. (a) w from $\frac{R2-R1}{6} = 0.408\text{mm} = 4.08\times10^{-4}\text{m}$ ✓

3 sf answer ✓

2

(b) double slit formula rearranged to give $d = \frac{\lambda \times D}{w}$ $_1$✓

$d = \frac{589.3\times10^{-9}\times0.395}{0.408\times10^{-3}} = 5.7(1)\times10^{-4}\text{m}$ $_2$✓

allow ecf in $_2$✓ for wrong w but not for POT error

2

(c) use of $PQ = \frac{d\times(D+L)}{L} = 5.46\times10^{-3}\text{m}_1$ ✓

allow ecf for wrong d in $_1$ ✓

number of fringes seen $= \frac{PQ}{w} = \frac{5.46}{0.41}^2$ ✓

number of fringes seen = 13 (integer only)$_3$ ✓

allow 12 or 14 fringes

3

(d) close jaws using ratchet ✓

confirm that instrument reads zero ✓

2

(e) mean = 0.57(0) mm; uncertainty = 0.5 × range ✓

$\text{percentage uncertainty} = 100\times\frac{0.5\times(0.574-0.566)}{0.570} = 0.70(2)\%$ ✓

2

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2. (a) 1.43, 1.29

1

(b) Both plotted points to nearest mm ✓

Best line of fit to points ✓

The line should be a straight line with approximately an equal number of points on either side of the line.

2

(c) (i) Large triangle drawn (at least 8 cm × 8 cm) ✓

Correct values read from graph ✓

Gradient value in range (0.618 to 0.652) × 10^{-6} to 2 or 3 sf ✓

Allow the 2nd mark for incorrect numerical values read ignoring incorrect power of 10.

Incorrect power of 10 is penalised in gradient value.

3

(ii) Same figure quoted for gradient but with correct unit

1

(d) (i) Straight line (through origin) ✓

(directly) proportional ✓

2

(ii) Evidence of substituting data from the table / graph into $w = mD/s + c$ (from $y = mx + c$) ✓

Computation of correct value for c (i.e. value of w when $D/s = 0$) with correct unit.

Should be approximately 0.1 × 10^{-3} m, depending on the exact lobf drawn.

2

(iii) *w*

1

(e) Any reference to **either** width of slits **OR** single slit diffraction ✓

1

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3.

(a) Measurement of at least 30 fringe widths
(check that candidate has not miscounted) e.g. 30 fringe widths = 40 mm or 41 mm.

Correct answer of 1.3 or 1.4 mm quoted to 2sf with unit ✓(one mark)
OR
Correct answer 1.33 – 1.37 mm to 3sf with correct unit ✓✓ (two marks).

If candidate quotes value in range 1.33 – 1.37 mm to 3sf they achieve both the 2nd and 3rd marks (A quote to 3sf is justified in terms of uncertainty if a large number of fringe widths have been measured).

For 2nd & 3rd marks allow ecf from incorrect measurement in 1st mark.

If the printing process in your centre alters the scale of this diagram, measure the values on your printed question papers and mark the scripts accordingly. Send details to the moderator.

If a candidate is visually impaired and using a modified paper that alters the scale of this diagram, measure the values on the printed question paper and mark the script accordingly.

3

(b) 1 mark for intermediate step where candidate doesn't get correct final answer. i.e. calculating % uncertainty of total measurement (i.e. % uncertainty in *w*) ✓

OR for both marks:

Uncertainty in *w* = ± 0.03 mm ✓✓

(Full 2 marks for correct answer with unit – No unit no mark unless a correct intermediate step has been completed which will have been credited for 1 mark as explained above)

Uncertainty in measurement of multiple fringes is ± 1 mm (precision of ruler used).

E.g. for length 41 mm ± 1 mm % uncertainty = 1/41 x 100 = 2.4 %

Uncertainty in w (single fringe)

= 2.4 x 1.4/100 = ±0.03 mm

Simply quoting 0.03 - ***NO marks***

No penalty for omission of ±

2

(c) (i) (Using w = 1.40 mm)

Wavelength = 5.60×10^{-7} m ✓

*Allow ecf for value of w from **(b)***

Consistent unit required for the mark. No sf penalty.

1

(ii) (Intermediate step) % uncertainty = 5.8% ✓

(From %uncty s = 3.3%, w = 2.4%, D = 0.1% % uncertainty in wavelength = 3.3 +2.4+0.1 = 5.8%).

*Allow ecf from **(b)***

1

(iii) (Using wavelength = 5.60×10^{-7} m)

Uncertainty in wavelength = $\pm 3.2 \times 10^{-8}$ (m) ✓ or ± 32 (nm) or $\pm 3.2 \times 10^{-5}$ (mm)

*Allow ecf from **(c)(i)** & **(ii)***

No sf penalty

*If the value is consistent with the wavelength quoted in **(c)(i)**, **allow the numerical answer without the unit**, otherwise a unit is required.*

1

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4.

(a) (i) wavelength = $\frac{h}{mv}$ **(1)**

$= \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 1.2 \times 10^{3}}$ **(1)** $(= 6.1 \times 10^{-7}\ \text{m})$

(ii) charge (= current × time = $4.8 \times 10^{-13} \times 1.0 \times 10^{-3}$) = 4.8×10^{-16} C **(1)**

number of electrons per fringe = $\frac{4.8 \times 10^{-16}}{(1.6 \times 10^{-19} \times 6)}$ = 500 **(1)**

(4)

(b) (i) same **(1)**

(ii) interference fringes would be further apart **(1)**

at twice the spacing **(1)**

as the wavelength would be doubled **(1)**

because $\lambda \propto \frac{1}{\text{speed}}$ $\left[\text{or} \propto \frac{1}{\text{momentum}}\right]$ **(1)**

(max 4)

(c) $f\left(=\frac{c}{\lambda}\right)=\frac{300\times10^{8}}{6.1\times10^{-7}}$ **(1)**

$= 4.9 \times 10^{14}$ Hz **(1)**

(2)

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