Mark Scheme

Q1.

Question Number	Acceptable Answers	Additional guidance	Mark
	• The resolution would be the same but the distance measured is greater **Or** The uncertainty would be the same but is divided by a greater length (1)		1

Q2.

Question Number	Answer	Additional Guidance	Mark
	• calculates $\theta = 24°$ **and** $d = 3.3 \times 10^{-6}$ m • use of $n\lambda = dsin\theta$ • $6.7 - 6.8 \times 10^{-7}$ m	Example of calculation $\tan\theta = \frac{0.89\text{ m}}{2.0\text{ m}}$ $\theta = 24°$ $d = \frac{1\times10^{-3}}{300} = 3.3 \times 10^{-6}$ m $\lambda = \frac{3.3\times10^{-6}\text{ m} \times \sin 24}{2} = 678$ nm	3

Q3.

Question Number	Acceptable answers	Additional guidance	Mark
	• measure distance from grating to screen l and from centre to dot x (1) • use $\tan\theta = x / l$ to determine θ (1)		2

Q4.

Question Number	Acceptable answers		Additional guidance	Mark
	• Axes with labels • scales • plots • line of best fit	(1) (1) (1) (1)	**MP2**: scales only in 1,2,4,5 and must cover at least half of paper **MP3**: a 2 mm square tolerance, check all points	**4**

Q5.

Question Number	Acceptable Answers		Additional guidance	Mark
	• Use of $\tan\theta = \frac{x}{D}$ • Use of $d = 1/300$ • Use of $n\lambda = d\sin\theta$ • $\lambda = 530$ (nm) with conclusion green	(1) (1) (1) (1)	Example of Calculation $d = 1/(300 \times 10^{3}\text{m}^{-1}) = 3.33 \times 10^{-6}$ m $\theta = \tan^{-1}\frac{1.35}{4.0} = 18.65°$ $\lambda = \frac{3.33\times10^{-6}\text{ m}\times\sin 18.65°}{2} = 5.32 \times 10^{-7}$m = 532 nm Green	**4**

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• use of $n\lambda = d\sin\theta$ (1) • use of $1/d$ (1) • 520 000 lines per metre (1)	Example calculation $d = 650 \times 10^{-9}$ m / sin 19.9° $= 1.9 \times 10^{-6}$ m $1/ 1.9 \times 10^{-6}$ m = 520 000 lines per metre	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	• measure angle for first order on either side and divide by 2 (1) • if there is a zero error it will be eliminated (1) OR • measure a larger angle (1) • this will reduce the percentage uncertainty (1)		**(2)**

Q7.

Question Number	Acceptable Answers	Additional guidance	Mark
(i)	Any one • Monochromatic **or** small range of wavelength / frequencies • Coherent • Little divergence of wave over a distance • Produces plane wavefronts		1
(ii)	• d = 0.005 mm **or** use of $d = \frac{1}{200\ \text{mm}^{-1}}$ (1) (1) • Use of tan to find θ (1) • Use of $n\lambda = d\sin\theta$ with $n = 3$ (1) • $\lambda = 5.4 \times 10^{-7}$ (m) • Concludes that the laser light is green **Or** conclusion consistent with their value of λ (1)	Example of Calculation $d = \frac{1}{200\ \text{mm}^{-1}} = 0.005$ mm $\theta = \tan^{-1}\left(\frac{1.02\ \text{m}}{3.0\ \text{m}}\right) = 18.8°$ $\lambda = \frac{(5\times10^{-6}\text{m})\times\sin 18.8°}{3} = 5.37 \times 10^{-7}$m so light is green	5

Q8.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• set up diffraction grating at right angles to light from laser (1) **Or** set up grating parallel to screen • measure the distance between the diffraction grating and the screen (1) • measure the distance between 1st order images on the screen (1)	An annotated diagram could score these marks MP3 accept between other correct specified orders.	3

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• use of $d\sin\theta = n\lambda$ (1) • Calculation of one of the diffraction angles (for any n) (1) • Attempt to calculate a difference in the angles (1) **Or** statement that the two angles are very similar • So (accurate) measurement would be very difficult (1) **Or** the difference in wavelength could not be determined with this grating	MP4 dependent on MP3 Example of calculation: $\sin\theta_1 = \frac{656.2\times10^{-9}\,\text{m}}{2.2\times10^{-6}\,\text{m}}$ $\therefore \theta_1 = 17.354°$ $\sin\theta_2 = \frac{656.0\times10^{-9}\,\text{m}}{2.2\times10^{-6}\,\text{m}}$ $\therefore \theta_1 = 17.348°$ $\therefore \Delta\theta = 17.354° - 17.348° = 0.006°$	4

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	• measure distance from grating to screen l and from centre to dot x (1) • use $\tan\theta = x / l$ to determine θ (1)		2

Question Number	Acceptable answers	Additional guidance	Mark
	• Axes with labels (1) • scales (1) • plots (1) • line of best fit (1)	**MP2**: scales only in 1,2,4,5 and must cover at least half of paper **MP3**: a 2 mm square tolerance, check all points	4

Question Number	Acceptable answers	Additional guidance	Mark
	• calculation of a gradient (1) • use gradient = d/λ (1) • use d = 0.001 / 300 (1) • wavelength = 6.3×10^{-7} m (1)	Example of calculation $\text{gradient} = \frac{4.0}{0.76} = 5.26$ $\frac{0.001}{300} = 5.26 \times \lambda$ wavelength = 6.3×10^{-7} m	4

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• laser light should not be aimed directly into the eye (1) • as concentrated beam can cause damage to the retina (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	EITHER • all x values should be recorded to the same number of decimal places, so x_2 and x_4 are incorrectly recorded (1) OR • all processed data should be recorded to the same number of significant figures, so sin θ for x_1 is incorrectly recorded	Do not award repeat readings, not appropriate in this experiment	**(1)**
(b)(ii)	• use of $\tan\theta = \frac{x}{D}$ [θ = 22.9°] (1) • $\sin\theta$ = 0.390 (1)	Example of calculation: $\tan\theta = \frac{0.741}{1.75} = 0.423$ $\therefore \theta = 22.9°$ $\therefore \sin\theta = 0.3899$	**(2)**
(b)(iii)	point plotted correctly and best straight line drawn through points (1)		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iv)	• $\sin\theta = \frac{n\lambda}{d}$, so gradient = $\frac{\lambda}{d}$ (1) • gradient = 0.194 (1) • use of d = 1/number of lines per mm (1) • d = 3.33×10^{-6} (m) (1) • $\lambda = 6.5 \times 10^{-7}$ m (1)	Example of calculation: $d = \frac{1}{3\times10^{5}\,\text{m}^{-1}} = 3.33\times10^{-6}\,\text{m}$ $\lambda = 3.33\times10^{-6}\,\text{m}\times0.194$ $= 6.47\times10^{-7}\,\text{m}$	**(5)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	An answer that makes reference to two of the following pairs: • use a Vernier scale to record *x* (1) • so that data to the nearest 0.1 cm could be obtained to reduce the percentage uncertainty (1) • use a larger grating to screen distance (1) • so that all *x* values would be greater to reduce the percentage uncertainty (1) • measure from nth order on one side to nth order on the other side (1) • so that the distance measured is larger hence reducing the percentage uncertainty in x (1) • use a grating with more lines per mm (1) • so that values of *x* will be greater to reduce the percentage uncertainty (1)	Do not award repeat readings, not appropriate in this experiment	**(4)**