Question Number	Answer	Mark
2(a)	• Uncertainty is half resolution (0.5˚) (1) • Use of percentage uncertainty = (uncertainty / angle value) × 100% for either angle (1) • % uncertainty in θ_1 = 1.4% (accept 1%) **and** % uncertainty in θ_2 = 0.8% (1) If the full resolution of protractor is used (1˚) – award MP2 for use of equation and MP3 for correctly values 2.9% (3%) and 1.6% (2%) Example Calculation % uncertainty in θ_1 = (0.5˚ / 35˚) × 100% = 1.4% % uncertainty in θ_2 = (0.5˚ / 62˚) × 100% = 0.81%	**3**
2(b)(i)	• See $n_1 \sin\theta_1 = n_2 \sin\theta_2$ with refractive index of air $n_2 = 1$ (1) • Rearranges **and** compares with $y = mx$ (+ c) **Or** rearranges **and** compares $n_1 = \frac{\sin\theta_2}{\sin\theta_1}$ with gradient $= \frac{\Delta\sin\theta_2}{\Delta\sin\theta_1}$ (1) • Identifies n_1 = gradient (1) For MP1 accept $n \sin\theta_1 = \sin\theta_2$ For MP2 accept comparing $\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$ with gradient $= \frac{\Delta\sin\theta_2}{\Delta\sin\theta_1}$	**3**
2(b)(ii)	• Uses two points on the line to determine the gradient (1) • n_1 between 1.46 and 1.54 (1) MP2 dependent on MP1 MP2 allow correct use of gradient = 1/n from 2(b)(i) Example Calculation n_1 = (0.77 – 0.17) / (0.50 – 0.10) n_1 = 1.5	**2**

Question Number	Answer	Mark
2(c)	• Realistic cause of a systematic error in measured data suggested (1) • Suitable method to reduce effect of the cause suggested (1) MP2 dependent on MP1 <u>Examples</u> • Normal line not correctly drawn at 90˚ to the flat surface • Use a protractor/set square to check the normal line • Zero error because protractor not aligned correctly • Ensure the protractor is aligned to the normal • Ray of light not directed to centre of the flat surface **Or** incident ray not perpendicular to curved surface • Mark the position of the centre of the flat surface on paper • Block moved • Mark the position of the block on paper **Or** tape the block in position • Did not repeat measurements with angles of incidence either side of the normal • Repeat measurements (for angles of incidence on both sides of the normal) and calculate mean value	**2**
	Total for question 2	**10**