A Level AQA Physics

5 Refraction, defraction, and interference – answers

Question	Answers	Extra information	Mark	AO	Spec reference
01.1	One with a constant/fixed phase relationship/difference		1	1	3.3.2.1
01.2	One with a single wavelength/frequency		1	1	3.3.2.1
01.3	Do not look directly at laser/do not point laser at anyone/do not look at reflection of laser light/wear safety goggles	Allow any sensible suggestion	1	1	3.3.2.1
01.4	$w = \frac{8\times10^{-3}}{4}\text{ m} = 2\times10^{-3}\text{ m}$ $w = \frac{\lambda D}{s}$ $\lambda = \frac{ws}{D} = \frac{2\times10^{-3}\times0.4\times10^{-3}}{1.5}$ $\lambda = 5.3\times10^{-7}\text{ m}$		1 1 1	2	3.3.2.1
01.5	% uncertainty in $D = \frac{0.001}{1.5}\times100\% = 0.07\%$ % uncertainty in $s = \frac{0.01}{0.40}\times100\% = 2.5\%$ % uncertainty in $w = \frac{0.1}{8.0}\times100\% = 1.3\%$ % uncertainty in $\lambda = 0.07 + 2.5 + 1.3 = 3.9\%$		1 1 1	2	3.3.2.1 3.1.2
01.6	s and D remain constant so $\lambda \propto w$ Longer λ means the maxima would be further apart	Can be expressed in words but must state s and D constant for this mark ignore 'different colour'	1 1	3	3.3.2.1
02.1	$n_1\sin\theta_1 = n_2\sin\theta_2$ $n_1 = 1$ $\sin\theta_2 = \frac{\sin\theta_1}{n_1} = \frac{\sin 60}{1.5}$ $\theta_2 = 35°$		1 1	2	3.3.2.3

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02.2	$\sin\theta_c = \frac{n_1}{n_2} = \frac{1}{1.5}$ $\theta_c = 42$ (41.8°)		1	2	3.3.2.3
02.3	Angle of incidence side **KL** = 55° Since this is > critical angle, ray is totally internally reflected	Could be shown on sketch On the diagram – possible e.c.f. here from **02.1**	1 1	3	3.3.2.3
02.4	$\sin\theta_c = \frac{1.4}{1.5}$ $\theta_c = 59°$		1	2	3.3.2.3
03.1	• Superposition of waves from two slits • Diffraction (patterns) from both slits overlap • Constructive interference/reinforcement/waves arrive in phases at maxima and destructive interference/waves arrive in antiphase at minima • Path difference = $n\lambda$ at maxima and path difference = $\frac{n\lambda}{2}$ at minima	Any mention of nodes/antinodes loses marks	max 3	2	3.3.2.1
03.2	$f = 1500$ Hz $c = 340$ m s^{-1} $c = f\lambda$ $\lambda = \frac{c}{f} = \frac{340}{1500} = 0.23$ m		 1 1	2	3.3.1.1
03.3	$w = \frac{\lambda D}{s}$ $w = 0.23 \times \frac{20}{10} = 0.46$ m		1	2	3.3.2.1
03.4	$f \propto \frac{1}{\lambda}$ so λ halves s and D remain constant so $\lambda \propto w$ Minima will be closer together	ignore 'higher pitched'	1 1	3	3.3.2.1

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04.1	Place the diffraction grating at a distance of 4 m (must be >1 m) from a screen Measure distance with a metre ruler or tape measure Shine laser directly onto grating (Identify the central maxima) and measure the distance of the first order maxima either side with a ruler Find the mean (or measure distance between 1st order and divide by 2)	Correct names for measuring instruments should be given One point describing how to make results more accurate required for full marks	max 4	2	3.3.2.2
04.2	$\frac{1 \times 10^{-3}\text{ m}}{330} = 3.0 \times 10^{-6}\text{ m}$		1	2	3.3.2.2
04.3	$n\lambda = d\sin\theta$ $\lambda = 3.0 \times 10^{-6} \sin 12.5 = 6.5 \times 10^{-7}\text{ m}$ $\lambda = 650\text{ nm}$ (649 nm)		1 1	2	3.3.2.2
04.4	Central white maxima Each of the orders is now a spectrum Violet closest to the centre/red furthest from centre $\lambda \propto \theta$ so, as λ increases, so does θ		max 3	3	3.3.2.2
05.1	$n_2 = \text{air} = 1$ $\sin\theta_c = \frac{n_2}{n_1} = \frac{1}{1.6}$ $\theta_c = 39°$ (38.7°) The angle of incidence = 50° (90 – 40) so angle of incidence > critical angle, so light will be totally internally reflected		1 1 1	2	3.3.2.3
05.2	$n = \frac{c}{c_s}$ $c_s = \frac{3 \times 10^8}{1.5}$ $c_s = 2 \times 10^8\text{ m s}^{-1}$		1	2	3.3.2.3

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05.3	$\sin 40 = \frac{0.012}{x}$ Distance $= 2x = \frac{2 \times 0.012}{\sin 40}$ $T = \frac{d}{c_s} = \frac{2 \times 0.012}{\sin 40 \times 2 \times 10^8} = 1.9\ (1.87) \times 10^{-10}$ s		1 1	2	3.3.2.3 3.4.1.3
05.4	$\sin \theta_c = \frac{n_2}{n_1} = \frac{1.4}{1.6}$ $\theta_c = 61°$		1	2	3.3.2.3
05.5	• Keeps signals secure • Maintains quality/reduces pulse broadening/smearing • It keeps (most) light rays in the core (due to total internal reflection at the cladding–core boundary) • It prevents scratching **of the core** • Prevents crossover of **information/signal/data** to **other** fibres		max 2	1	3.3.2.3
05.6	The reduced amplitude is due to absorption/scattering/attenuation of the signal in the fibre The broadening is due to modal dispersion/multipath dispersion/due to different distances travelled on different paths		1 1	3	3.3.2.3
06.1	Intensity decreasing with distance from central max (at least 3) Have correct width (half width of central max)/are in correct positions	Judge by eye – does not matter which side drawn on	1 1	2	3.3.2.2
06.2	The central fringe would become narrower		1	1	3.3.2.2
06.3	The central fringe would become wider		1	1	3.3.2.2
06.4	Central fringe is white Other fringes show spectrum Red further from centre/ violet closer to centre		1 1 1	2	
07.1	Single wavelength (or frequency)		1	1	3.3.2.1

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OXFORD Revise

Question	Answers	Extra information	Mark	AO	Spec reference
07.2	$\sin\theta_c = \frac{1.30}{1.45}$ $\theta_c = 63.7°$ (64°)		1 1	2	3.3.2.3
07.3	• Ray is reflected at **A** or travels from **A** to **B** to **C** (owtte) • Interference or superposition of the two rays • Bright fringes – constructive interference, dark fringes – destructive interference • If the path difference = $n\lambda$, constructive interference occurs (bright fringe) • If the path difference = $\frac{n+\frac{1}{2}}{\lambda}$, (owtte) destructive interference occurs (dark fringe)		max 3	3	3.3.2.1
07.4	Different colours of white light have different wavelengths Constructive/destructive interference will happen for different thicknesses of oil Different wavelengths refract differently		max 2	3	3.3.2.1
08.1	Shows the wave-like nature of electrons		1	1	3.2.2.4
08.2	Diffraction patterns of electrons as they pass through lattice overlap Interference/superposition Constructive interference/reinforcement causes bright circles Path difference = $n\lambda$ at maximum intensity		max 3	2	3.2.2.4
08.3	$V = \frac{W}{Q}$ $W = 1000\,\text{V} \times 1.6\times10^{-19}\,\text{C} = 1.6\times10^{-16}\,\text{J}$		1	2	3.5.1.1
08.4	$E_k = \frac{1}{2}mv^2$ $v^2 = \frac{2 \times 1.6\times10^{-16}}{9.11\times10^{-31}}$ $v = 1.87\times10^7\,\text{m s}^{-1}$		1 1	2	3.4.1.8

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08.5	$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times1.9\times10^{7}}$ $\lambda = 3.8\times10^{-11}$ m		1	2	3.2.2.4
08.6	• The pattern would be brighter • Circles get closer together • Increasing V increases velocity/ increases momentum • Since $\lambda \propto \frac{1}{mv}$ or as velocity/momentum increases, wavelength decreases • $\lambda \propto \sin\theta$ or reference to $n\lambda = d\sin\theta$		max 4	2	3.2.2.4

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OXFORD Revise

Skills box answers

Question	Answer
1	$d = \frac{1}{500 \times 10^{-3}}$ $\tan\theta = \frac{0.38}{1.25}$, so $\theta = 16.9°$ $n = 1$ $\lambda = ?$ $\lambda = \frac{d \sin\theta}{n} = \frac{\left(\frac{10^{-5}}{5}\right) \times \sin 16.9}{1}$ $\lambda = 5.8 \times 10^{-7}$ m (580 nm)
2(a)	$d \sin\theta = n\lambda$ so $\sin\theta = \frac{n\lambda}{d} = 1 \times 520 \times 10^{-9} \times 600 \times 10^{3}$ $\sin\theta = 0.312$ $\theta = 18.2°$
2(b)	$\sin\theta = \frac{n\lambda}{d} = 2 \times 520 \times 10^{-9} \times 600 \times 10^{3}$ $\sin\theta = 0.312$ $\theta = 38.6°$
2(c)	$\frac{d}{\lambda} = \frac{10^{-3}}{(600 \times 520 \times 10^{-9})} = 3.21$ rounds down to 3
3	$d \sin\theta = n\lambda$ $d = \frac{n\lambda}{\sin\theta} = \frac{1 \times 650 \times 10^{-9}}{\sin 40.5°} = 1.00 \times 10^{-6}$ m number per mm $N = \frac{10^{-3}}{d} = \frac{10^{-3}}{10^{-6}} = 1000$