WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 3

PHYSICS



EXAM QUESTION PACK

3.3 REFRACTION OF LIGHT

SCORE	PERCENTAGE
/50	%

STEMUP

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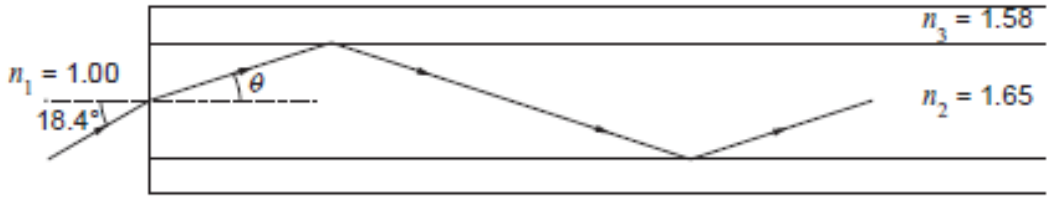
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#1

2. A light ray enters an optical fibre as shown.



(a) Show that the angle θ is approximately 10°. [2]

(b) Deduce whether or not this light will propagate along the length of the optical fibre with total internal reflection as shown. [4]

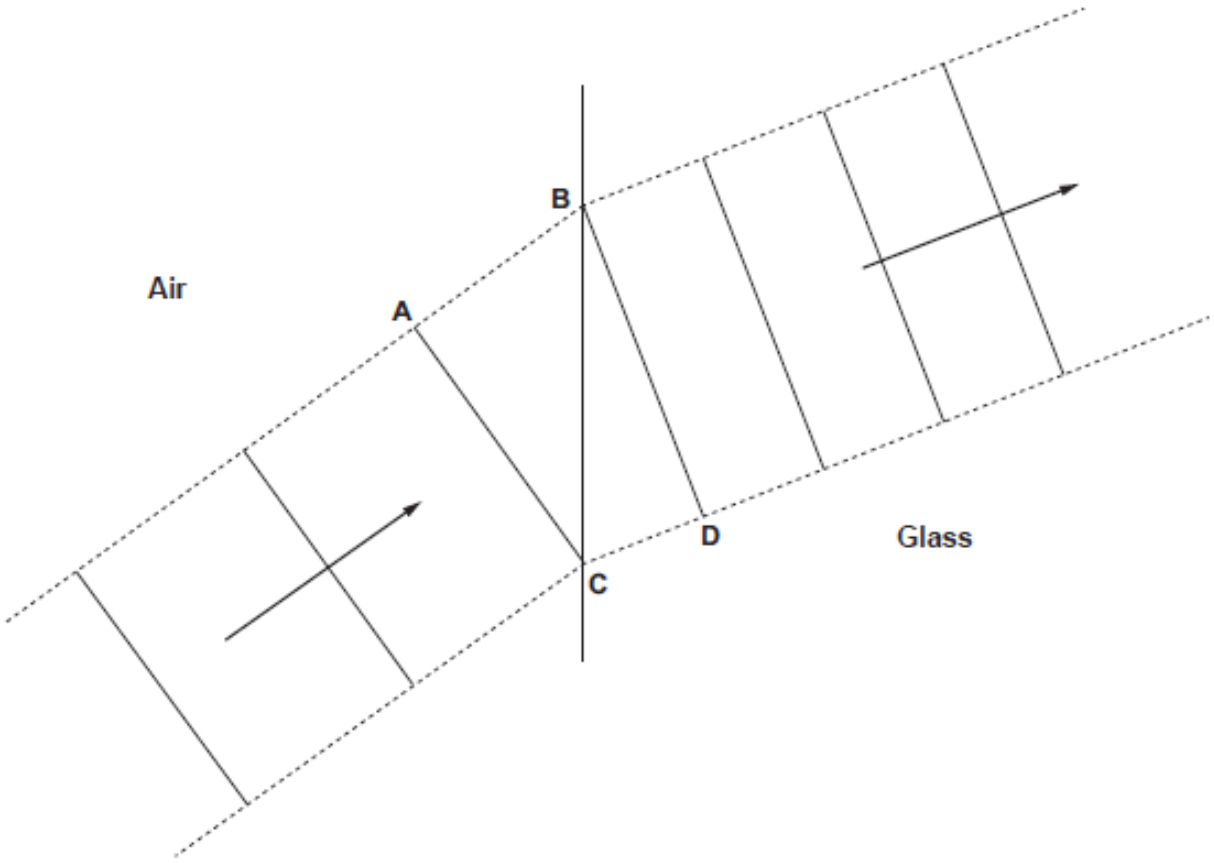
Question taken from Eduqas examination paper 842103, June 2018

#2

Explain the advantages of monomode optical fibres over multimode optical fibres when transmitting a rapid sequence of pulses. [6 QER]

Question taken from Eduqas examination paper 842103, June 2017

3. A light beam travelling in air hits a boundary with glass. The diagram shows wavefronts on the light beams in the air and in the glass.



(a) State what is meant by refraction and use the diagram to explain why refraction occurs. [3]

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(b) By measuring appropriate lengths from the diagram calculate the speed of light in the glass. [3]

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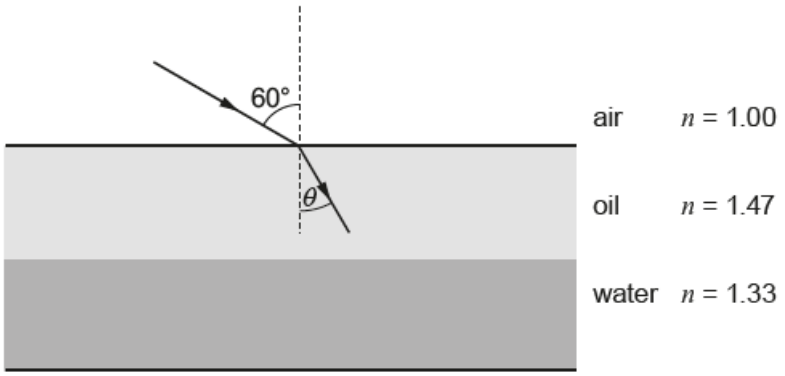
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Question taken from Eduqas examination paper 842002, June 2019

#4

The diagram shows a ray of light incident at an angle of 60° to the surface of a layer of oil that is floating on water.



(a) Calculate the angle of refraction, θ. [2]

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(b) (i) Calculate the critical angle for a ray of light travelling from oil to water. [2]

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(ii) State and explain what happens to the ray of light in the diagram above when it reaches the boundary with the water. [2]

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(c) Determine the speed of the light in the oil. [2]

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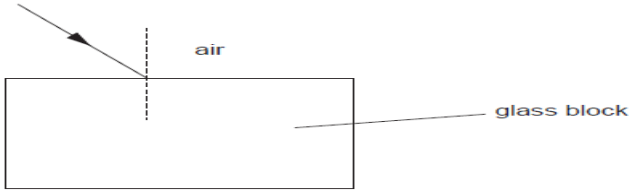
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Question taken from Eduqas examination paper 842002, June 2017

#5

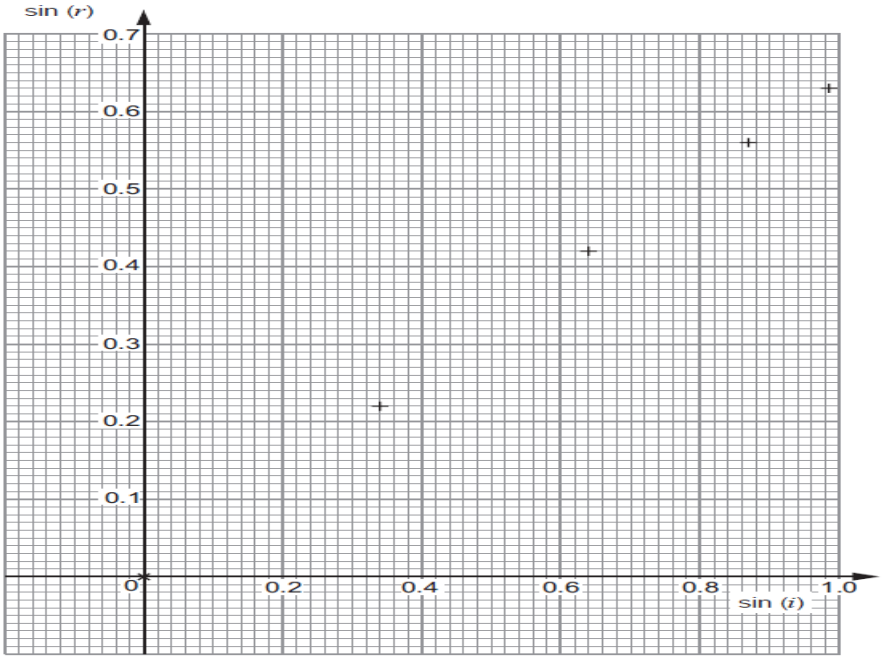
An experiment is carried out to investigate Snell's law. Laser light is passed through a glass block and the angles of incidence and refraction are measured using a protractor.



(a) **Draw** the refracted ray and the ray emerging from the glass block on the above diagram. [2]

(b) The results obtained are collated in the following table and plotted on the grid.

Incident angle (i) / degrees ±1°	Refracted angle (r) / degrees ±1°	sin (i)	sin (r)
0	0	0.00 ± 0.02	0.00 ± 0.02
20	13	0.34 ± 0.02	0.22 ± 0.02
40	25	0.64 ± 0.01	0.42 ± 0.02
60	34	0.87 ± 0.01	0.56 ± 0.01
80	39	0.985 ± 0.005	0.63 ± 0.01



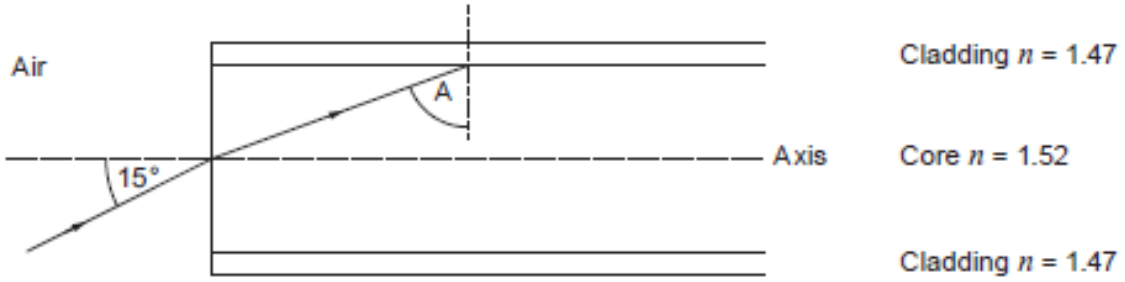
(i) **Add error bars** to the data points and also draw the lines of maximum gradient and minimum gradient. [4]

(ii) Determine the refractive index of the block along with a value for its **absolute uncertainty**, quoting your results to an appropriate number of significant figures. [4]

Question taken from Eduqas examination paper 842103, June 2017

#6

6. *(a)* A multimode optical fibre has a core made of glass of refractive index 1.52. The cladding is made of a material with refractive index 1.47.



(i) Calculate the critical angle for the core-cladding boundary. [2]

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(ii) A beam of light enters the optical fibre from air at an angle of 15° as shown. Calculate angle A. [3]

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(iii) A technician states that the beam of light entering the fibre from air at an angle of 15° will not travel down the optical fibre. Evaluate whether the technician is correct. [2]

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(b) Calculate the time taken for the light to travel along **the axis** of a straight optical fibre of length 15 km. [3]

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(c) (i) State how the paths of light in monomode and multimode optical fibres differ. [1]

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(ii) Explain the advantage of monomode optical fibres over multimode optical fibres for communicating a rapid sequence of data encoded as light pulses. [3]

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Question taken from Eduqas examination paper 842002, June 2018

Marking Scheme

#1

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
2	(a)		Use of Snell's law (1), e.g. $\sin 18.4^\circ = 1.65 \sin\theta_2$ Manipulation or Answer = 11.0° (1) accept $\sin^{-1}\left(\frac{\sin 18.4^\circ}{1.65}\right)$ but not just 10°	1	1		2	1	
	(b)		$\phi = 90 - \theta$ (79 or 80) (1) $n_2 \sin\theta_2 = n_3 \sin 90$ applied (1) or $n_2 \sin 79 = n_3 \sin\theta$ Answer = 73.2° (1) or no solution for θ Conclusion = Yes since ϕ greater than critical (1) [allow ecf on a calculated value of critical angle] or Yes refraction is impossible			4	4	3	
			Question 2 total	**1**	**1**	**4**	**6**	**4**	**0**

#2

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
				Multimode points 1 – Multiple paths/angles (of propagation) or in diagram 2 – Paths of varying lengths take different times / longer zigzag or in diagram 3 – (Individual) pulses spread out / blurring / smearing / dispersion 4 – Pulses can overlap / not in the same sequence 5 – (Leads to) data loss / pulses unreadable **Monomode points** 1 – Only one path or in diagram 2 – No or minimal dispersion 3 – Cores are very thin or a few wavelengths thick or multimode thicker i.e. by implication 4 – Advantage is greater bandwidth/pulse frequency/greater distance [without data loss] **5-6 marks** 7-9 points made *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** 4-6 points made *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** 1-3 points made *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** *No attempt made or no response worthy of credit.*	6			6		
				Question total	**6**	**0**	**0**	**6**	**0**	**0**

#3

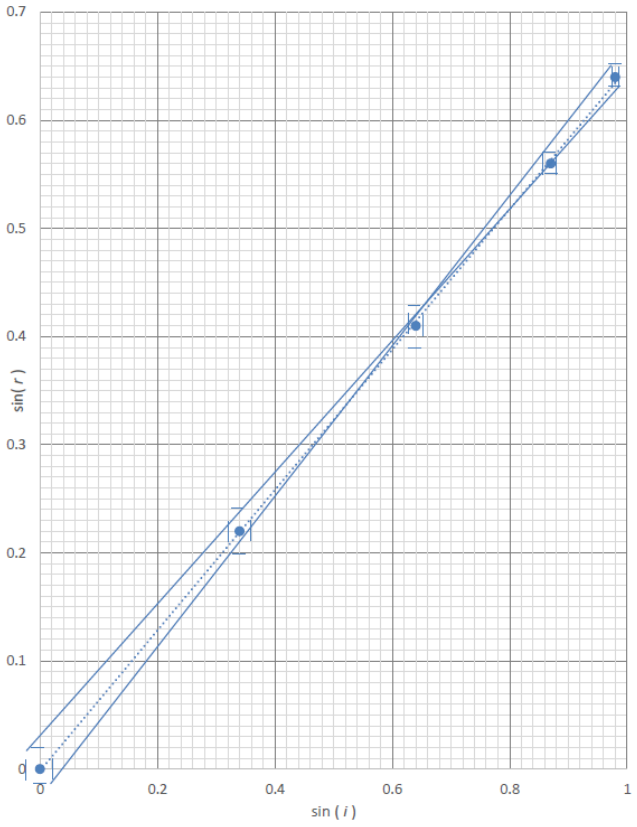
Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
3	(a)		Refraction is a change in direction of the travel of waves (1) Waves travel more slowly in glass than in air (1) Therefore AB is greater than CD (1)	1 1	1		3		
	(b)		Measuring lengths AB = 2.9 cm and CD = 1.8 cm within 0.1 cm (1) Speed = $\frac{BD}{t}$ and $\frac{AC}{t}$ (can be implied) (ecf) (1) Speed = 1.9 [or 1.86] × 10^8 [m s^{-1}] (1)	1	1 1		3	2	
			Question 3 total	**3**	**3**	**0**	**6**	**2**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Use and rearrangement of: $n_1 \sin\vartheta_1 = n_2 \sin\vartheta_2$ (1) Angle θ = 36[°] (1)		2		2	2	
	(b)	(i)	Use and rearrangement of: 1.47 sin θ = 1.33 sin 90 (1) Critical angle = 65[°] (1)		2		2	2	
		(ii)	Angle of incidence [at boundary] less than critical angle (1) Refraction [occurs] (1)		2		2		
	(c)		Use and rearrangement of: $n = \frac{c}{v}$ (1) Speed of light in oil = 2.0×10^8 [m s^{-1}] (1)		2		2	2	
			Question total	**0**	**8**	**0**	**8**	**6**	**0**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Bending toward the normal in the glass (not along normal) (1) Light comes out approximately parallel to original (by eye) (1)	2			2		2
	(b)	(i)	See graph on next page Most y error bars correct (1) Most x error bars correct (1) All error bars correct (1) Drawing maximum and minimum lines (1)		4		4	4	4
		(ii)	Method for calculating gradient (accept inverse if used correctly) (1) At least 2 gradients correct (0.695, 0.648, 0.606) (1) Refractive index = $\frac{1}{\text{gradient}}$ used or implied (1) n = 1.6 ± 0.1 or 1.56 ± 0.12 needs to be with consistent sig figs allow a max of 2 sig figs for the uncertainty (1) **accept** 0.08 - 0.12 for the uncertainty			4	4	4	4
			Question total	**2**	**4**	**4**	**10**	**8**	**10**



#6

Question			Marking details		Marks available				
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)	Rearranging $\sin c = \frac{1.47 \sin 90}{1.52}$ (1) Critical angle = 75.3° (1)		2		2	2	
		(ii)	Substitution into Snell's law i.e. $\sin 15° = 1.52 \sin \theta_r$ (1) Refracted angle = 9.8° (1) A = 80.2° (90 - θ_r) (ecf on θ_r) (1)	1	1 1		3	2	
		(iii)	Angle A is greater than critical angle (ecf on A and critical angle) (1) So total internal reflection and light will travel down the fibre OR technician not correct (1)			2	2		
	(b)		Substituting values in speed = $\frac{\text{distance}}{\text{time}}$ (1) Speed of light in fibre = $\frac{c}{1.52}$ (1) Time = 7.6×10^{-5} s (1)	1	1 1		3	3	
	(c)	(i)	Monomode – parallel to axis/straight – Multimode zig zag paths	1			1		
		(ii)	No spreading of pulses OR only one path for data (1) Each pulse arrives at same time OR No overlapping of pulses (1) Allows faster rate of data transfer (1)	3			3		
			Question 6 total	**6**	**6**	**2**	**14**	**7**	**0**