WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 3

PHYSICS



EXAM QUESTION PACK

3.1 THE NATURE OF WAVES

SCORE	PERCENTAGE
/74	%

STEMUP

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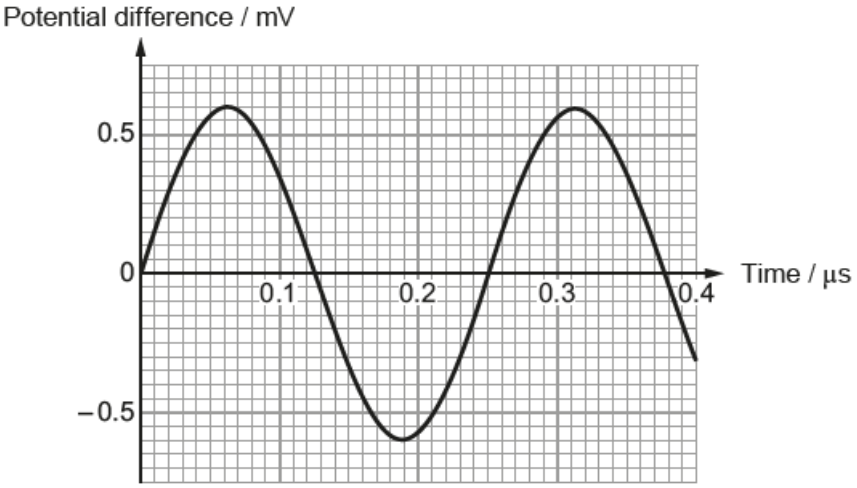
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#1

The diagram shows a potential difference against time graph detected with a microphone in response to a sound wave.



(a) Sound is a longitudinal wave. State what is meant by a longitudinal wave. [2]

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(b) Determine the amplitude of the signal shown. [1]

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(c) (i) In order to probe muscle tissue in the human body, ultrasound is used with a wavelength of 0.40 mm and a speed in muscle of 1 580 m s^{-1}. Calculate the frequency of this ultrasound. [1]

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(ii) Evaluate whether the sound wave detected by the microphone as shown above can be used to probe muscle tissue. [3]

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Question taken from Eduqas examination paper 842002, June 2017

#2

1. *(a)* State the difference between transverse and longitudinal waves. [2]

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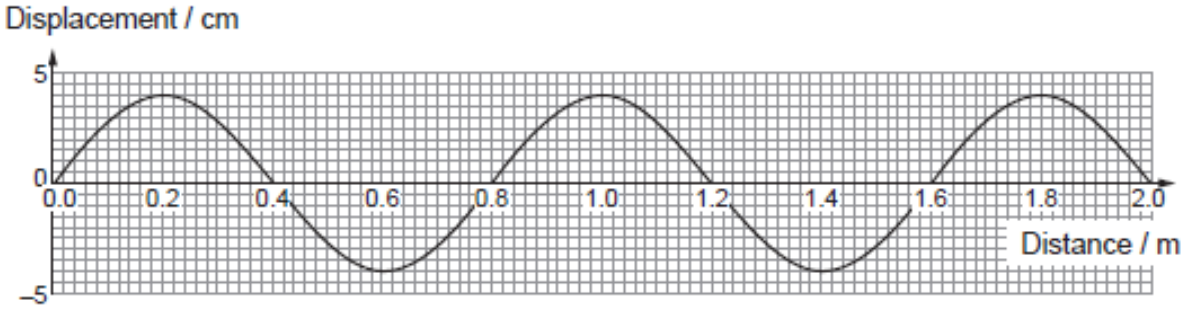
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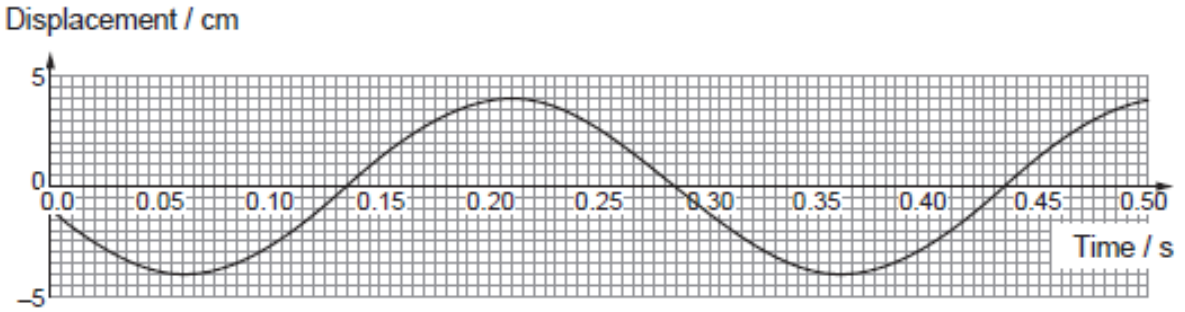
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(b) The variation of displacement with respect to position and time is shown in the following two graphs for the same surface wave on water.

Graph of displacement against distance (at a given time)



Graph of displacement against time (at a given distance)



(i) State the amplitude of the wave. ..... [1]

(ii) State the wavelength of the wave. ..... [1]

(iii) Calculate the speed of the wave. [3]

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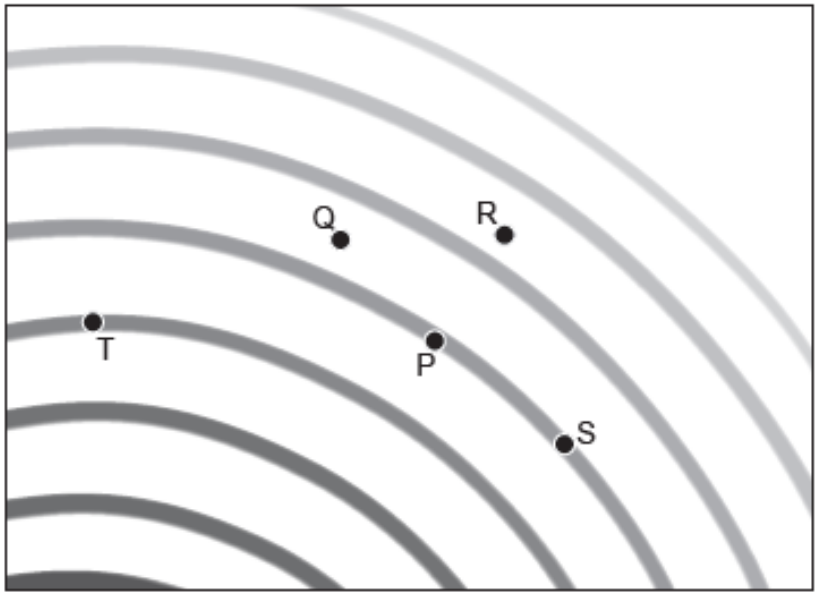
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(c) A wavefront diagram for waves on the surface of water is shown.



(i) **Draw an arrow** to indicate the direction of motion of the wavefront at point **S**. [1]

(ii) State the point(s) oscillating in phase with point P. ..... [1]

Question taken from Eduqas examination paper 842103, June 2019

#3

2. *(a)* Explain what properties of light from a laser can be determined using polarisation and interference. Give practical details. [6 QER]

(b) The polarisation of light is used in Liquid Crystal Display TVs. These have been developed from research into new organic materials. Discuss the importance of research and development into new materials, in general, by giving a benefit and an issue that may arise from using new materials. [3]

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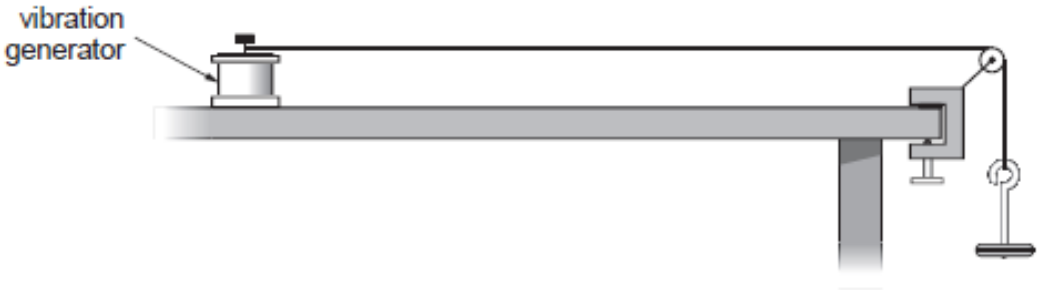
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Question taken from Eduqas examination paper 842002, June 2019

#4

1. The apparatus below is used to demonstrate stationary waves on a string. Both the weight, and the distance between the pin and the pulley are kept constant.



The following stationary wave pattern is observed on the string.



(a) Explain why stationary waves are formed at particular frequencies only. [3]

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(b) Another stationary wave is formed when the frequency is 450 Hz and the length of each loop is 12.0 cm long.

(i) Calculate the speed of the waves on the string. [3]

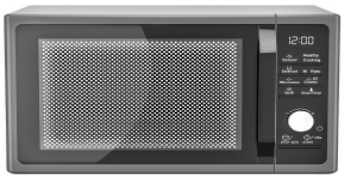
(ii) At a higher frequency there are two more loops formed than at 450 Hz and each is of length 10.0 cm. Determine the number of loops observed at 450 Hz. [4]

Question taken from Eduqas examination paper 842002, June 2019

#5

(a) Bruce throws a lump of coal towards Dani which she catches. Bruce claims that, because chemical energy is being transferred from himself to Dani, the lump of coal is a **wave**. Explain whether or not Bruce is correct. [2]

(b) The door of a microwave oven has a metal grille and this grille has holes in it of diameter 2 mm so that the food can be seen within the oven.

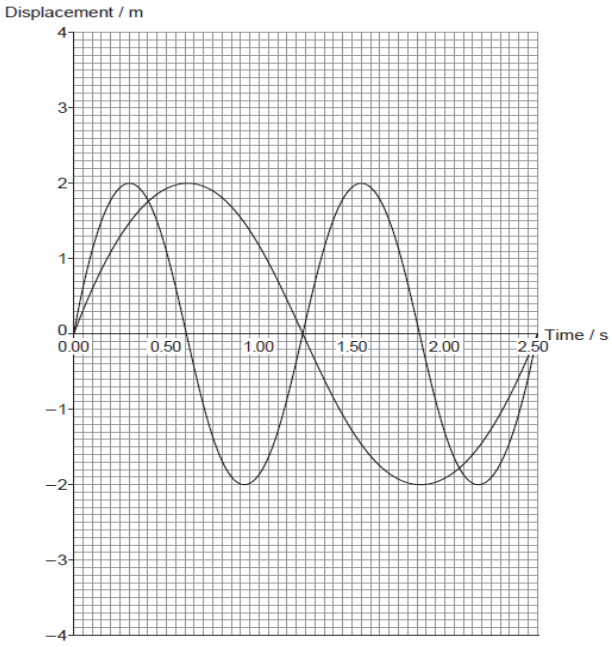


(i) Explain why the food can be seen through the door while the user is safe from dangerous microwaves of wavelength 12 cm. [3]

(ii) State or calculate a typical photon energy of visible light. [1]

(iii) Explain whether or not a microwave photon has a greater or smaller energy than a visible photon. [1]

(c) Two water waves of equal amplitude but different frequencies meet. The variation of the displacements of each wave is shown in the graph at the meeting point of the two waves.



Use the principle of superposition to plot the resultant displacement of the two waves at times 0.00 s, 0.40 s, 1.00 s, 1.25 s, 1.50 s, 2.10 s, 2.50 s **on the same grid** and draw a suitable curve. [4]

Question taken from Eduqas examination paper 842103, November 2020

#6

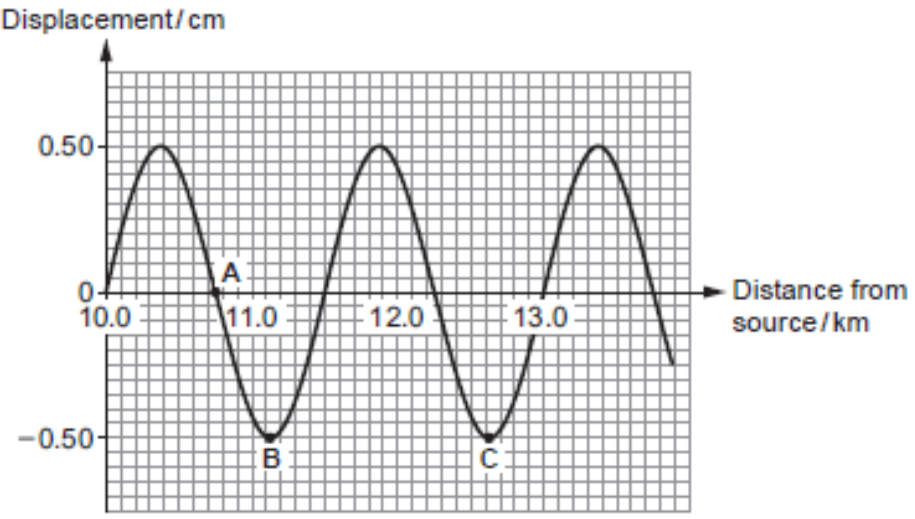
1. *(a)* Explain what is meant by a progressive wave. [2]

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(b) Earthquakes produce seismic waves that travel through rock. The following graph shows the displacement at a given instant for a seismic wave.



(i) Determine the phase difference between: [2]

A and B .....

B and C .....

(ii) A geologist at a monitoring station notes that there are 50 complete cycles of the wave in a time interval of 20 s. Calculate the speed of the wave. [4]

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(c) A section of rock undergoes a tensile stress of 900 MPa during an earthquake. Calculate the tensile strain if the Young modulus is 70 GPa for rock. [3]

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(d) Explain how data obtained by geologists about earthquakes from various monitoring stations can benefit society. [2]

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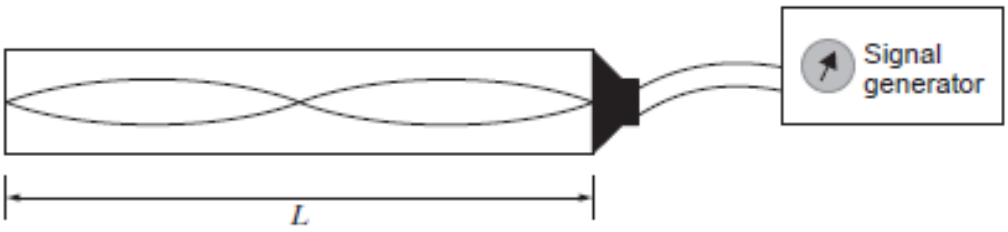
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Question taken from Eduqas examination paper 842002, June 2018

#7

5. An experiment is carried out using stationary waves to measure the speed of sound in air. A loudspeaker is placed at one end of a hollow tube so that both ends are closed. The frequency, f, of the signal generator connected to the loudspeaker is varied and those frequencies corresponding to loud noises recorded.



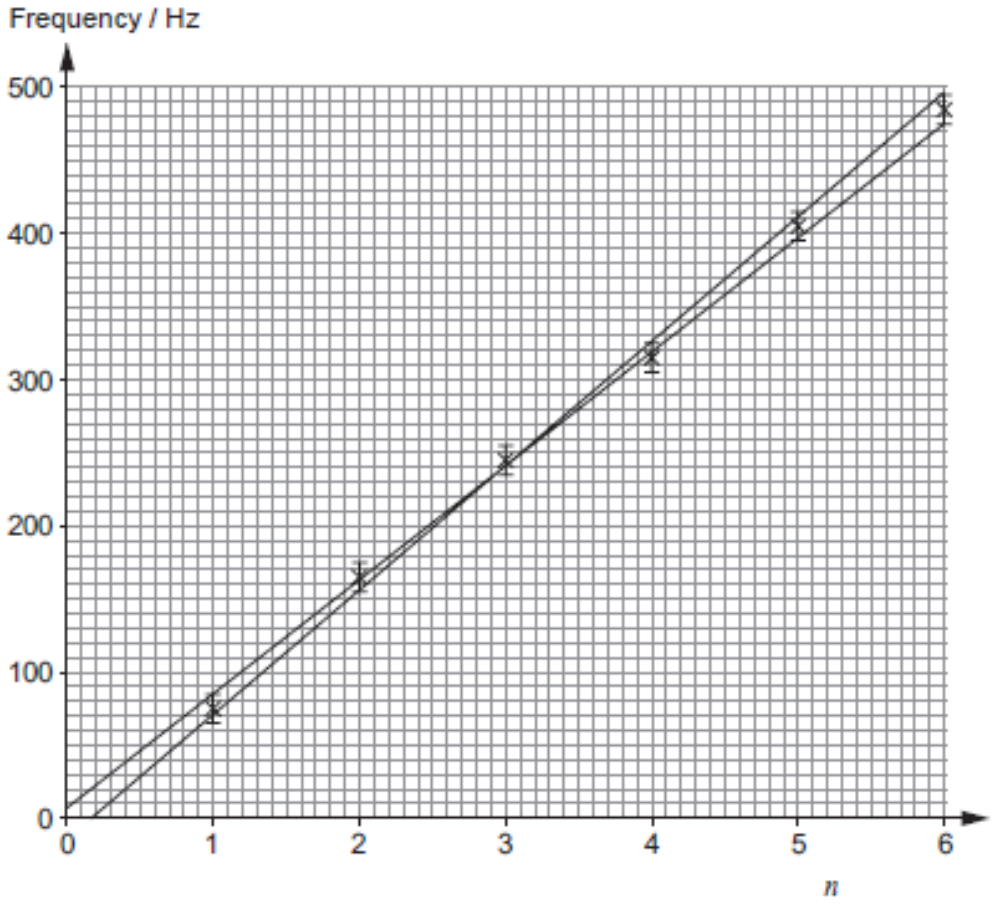
(a) Describe the differences between a stationary wave and a progressive wave in terms of energy, phase and amplitude. [3]

(b) Show that the frequencies corresponding to stationary waves are given by:

$$f = \frac{v}{2L} n$$

where n is any whole number (n = 2 in the above diagram). [3]

(c) The data obtained are plotted on the grid below.



Explain to what extent the graph agrees with the equation: [3]

$$f = \frac{v}{2L} n$$

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(d) The experiment is repeated with the tube filled with nitrogen dioxide (NO_2), a gas that is 1.5 times denser than air. The speed of sound in a gas is inversely proportional to the square root of the density, ρ:

$$v \propto \frac{1}{\sqrt{\rho}}$$

Explain what effect this will have on the gradient of the graph. [3]

(e) A car company is fined £15 billion for excessive NO_2 emissions of its diesel engines. However, there is little or no reliable evidence that NO_2 produces any detrimental health effects at the concentration levels present in the atmosphere. Discuss whether or not the car company or pedestrians have been treated unfairly. [3]

Question taken from Eduqas examination paper 842103, June 2018

Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		[Particle] oscillations accept displacement (1) Along/parallel to direction of wave travel (1)	2			2		
	(b)		0.6 [mV]	1			1		
	(c)	(i)	Rearrangement of $c = f\lambda$ to give = 3.95×10^8 [Hz]		1		1	1	
		(ii)	Using $T = \frac{1}{f}$ (1) Frequency = 4×10^6 [Hz] (1) Yes must be clarified – close to 3.95×10^6 Hz or values similar (1) **ecf** **Alternative:** Calculation of period 0.25×10^{-6} [s] (1) Period = $\frac{1}{3.95 \times 10^6}$ (1) Yes must be clarified – values similar (1) **ecf**			3	3	2	
			Question total	**3**	**1**	**3**	**7**	**3**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)		Transverse – oscillations / vibrations 90° or perpendicular to energy transfer/wave direction [1] Longitudinal – oscillations / vibrations parallel/same direction to energy transfer / wave direction [1] Penalise missing oscillations / wave direction only once	2			2		
	(b)	(i)	4 [cm]	1			1	1	
		(ii)	0.8 [m]	1			1	1	
		(iii)	Period = 0.3 [s] [1] $f = \frac{1}{T}$ and $v = f\lambda$ used or $v = \frac{\lambda}{T}$ [1] ecf on T Answer = 2.67 [m/s] [1] don't accept 2.6 [m/s]	1	1 1		3	1	
	(c)	(i)	Arrow radially outward (accept inward) based on point S	1			1		
		(ii)	S and T only	1			1		
			Question 1 total	**7**	**2**	**0**	**9**	**3**	**0**

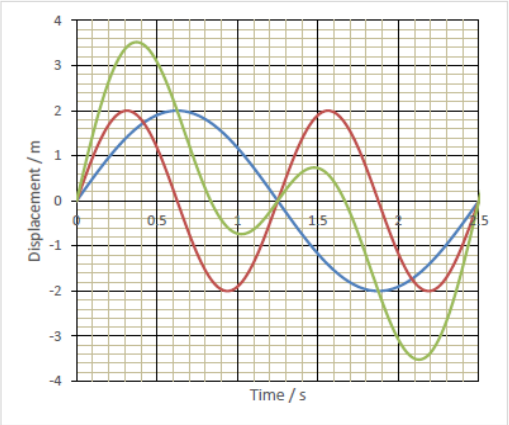
#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*		**Polarisation** Polarised – vibrations in one plane only Use polarising filters Rotate filter If polarised; intensity will change Intensity will change at intervals of 90° Wave is transverse only. **Interference** Laser light is a coherent source Use of double slits to observe pattern Description of interference pattern Constructive interference occurs when path difference = $n\lambda$ Destructive interference when path difference = (n + ½) λ Young's double slit formula quoted $y = \frac{\lambda D}{a}$ Symbols explained Wavelength can be determined AO1 – show understanding of what polarisation and interference are AO3 – evaluate what properties can be determined using polarisation and interference **5-6 marks** Comprehensive description including both polarisation and interference. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of either polarisation or interference OR limited description including both polarisation and interference. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited description of either polarisation or interference. *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.	2		4	6		6
	(b)		Advantage – Efficiency; improvements to society (1) Issue – Disposal of materials (1) Benefit of research and development given - impact on environment should always be considered before developing new materials (1)			3	3		
			Question 2 total	**2**	**0**	**7**	**9**	**0**	**6**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*		Each end has zero displacement (1) Only integers of half wavelengths can fit on string (1) As $c = f\lambda$ and speed is constant - this only occurs at particular frequencies (1) OR Waves are reflected from the fixed end (1) At particular frequencies only - arrive in phase with the next wave leaving / complete half wavelengths / nodes created (1) By principle of superposition *or* interference occurs to create nodes / antinodes (1)	3			3		
	(b)	(i)	Node to node distance = $\frac{\lambda}{2}$ (1) Wavelength = 0.24 [m] (1) Speed ($v = f\lambda$) = 108 [m s^{-1}](1)	1	1 1		3	2	
		(ii)	At 450 Hz: Length of string = $n \times 0.12$ (n = no. of loops) (1) At higher f: $(n + 2) \times 0.1$ = length of sting (1) Therefore $0.12n = 0.1\ (n + 2)$ (1) n = 10 (1)		4		4	4	
			Question 1 total	**4**	**6**	**0**	**10**	**6**	**0**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Matter also transferred / no vibrations involved (1) So wrong (1) Accept de Broglie wavelength argument for 1 mark			2	2		
	(b)	(i)	Holes far smaller than wavelength of micro (1) So nothing passes (1) Light wavelength far smaller than 2 mm (so little or no diffraction) (1)	1 1	1		3		
		(ii)	1.6-3.3 eV or 2.56-5.28 × 10^{-19}J (or calculation leading to said numbers)	1			1		
		(iii)	Smaller because f smaller or lambda longer		1		1		
	(c)		Evidence of application of superposition e.g. 0 s (1) 0.4 and 2.1 s correct i.e. 3.4/3.6 and -3.4/-3.6 (1) 1 s and 1.5 s i.e. -0.7 and +0.7 (1) Smoothish curve through points (1) 		4		4	2	
			Question total	**3**	**6**	**2**	**11**	**2**	**0**

#6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*		A pattern of disturbances travelling through a medium and carrying energy with it (1) involving the particles of the medium oscillating about their equilibrium positions (1) [Accept answers appropriate to e-m waves: A travelling pattern of oscillating electric and magnetic fields (1) carrying energy with it (1)]	2			2		
	(b)	(i)	Phase difference between A and B = 90° or $\frac{\pi}{2}$ accept fractions of cycle i.e. ¼ (1) Phase difference between B and C = 0 or n 2π or n 360°(1)		2		2	1	
		(ii)	Determining $f = \frac{1}{T} = \frac{1}{0.4}$ = 2.5 Hz (1) Wavelength = 1.5 km (1) Using $v = f\lambda$ (1) 3.75 × 10^3 m s^{-1} accept 3.75 km s^{-1} (1)	1	1 1 1		4	4	
	(c)		Substituting values in Young modulus = $= \frac{\text{stress}}{\text{strain}}$ (1) Rearranging strain = $\frac{900\text{ MPa}}{70\text{ GPa}}$ (1) Strain = 0.013 (1) (ecf power of 10)	1	1 1		3	3	
	(d)		Data can be used to determine locations/frequency of Earthquakes (hotspots) (1) Informs planning and sites for new builds or increases knowledge of structure of the Earth (1)			2	2		
			Question 1 total	**4**	**7**	**2**	**13**	**8**	**0**

#7

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*		Energy - progressive carries [stationary not] or converse (1) Phase – stationary: constant in loop or successive loops in antiphase; progressive: varies with distance [or can have any value] along (1) Amplitude - antinodes & nodes or varies in stationary, constant amplitude in progressive(1)	3			3		
	(b)		$n \times \frac{\lambda}{2} = L$ (1) Multiply by the frequency or substitution: $\lambda = \frac{v}{f}$ (1) Neatly laid out algebra (1) NB.Stating $\lambda = \frac{2L}{n} \rightarrow$ no credit for 2nd mark.		3		3	2	3
	(c)		'Good agreement' on its own → 0 Straight line [with positive gradient] & good agreement (1) Lines / line of best fit [allow: mean line] pass(es) through all error bars (1) Lines straddle the origin [accept: line of best fit passes through the origin] (1)			3	3		3
	(d)		Velocity decreases (1) Gradient decreases [implied if factor < 1] (1) By factor $\sqrt{1.5}$ (1) [changes by factor $\frac{1}{\sqrt{1.5}}$ or ×0.82 - not: 25%]		3		3	1	3
	(e)		**Any sensible 2 ×(1) from:** e.g. higher concentrations (might) cause bad effects (precautionary principle) Some pedestrians suffer health effects die - respiratory problems Respiratory problems caused by other chemicals Acid rain produced by NO_2 Some pedestrians claim NO_2 bad - psychosomatic Reliable data difficult to obtain - Worse for asthma sufferers Data may be more conclusive in future Accept cheating NO_2 figures is fraud Sensible conclusion (1)			3	3		
			Question 5 total	**3**	**6**	**6**	**15**	**3**	**9**