WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 2

PHYSICS



EXAM QUESTION PACK

2.5 SOLIDS UNDER STRESS

SCORE	PERCENTAGE
/160	%

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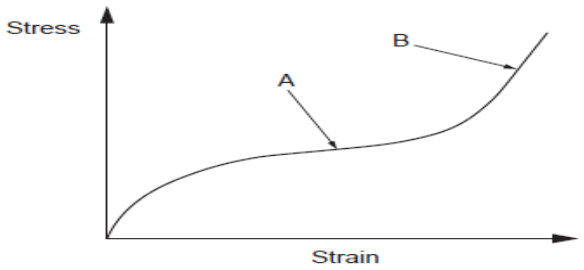
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#1

(a) Materials can be classified as being *crystalline*, *amorphous* or *polymeric*. Making reference to their microscopic structures explain what is meant by each of these terms. Give **one** example of each type of material. [3]

(b) Experiments are carried out on a specimen of rubber. The diagram shows a stress-strain curve for the specimen when it is gradually loaded.



(i) By referring to the molecular structure of rubber, explain why the gradient at A is less than the gradient at B. [3]

(ii) When the specimen is gradually unloaded, it is noted that the curve for unloading is different from the curve for loading.

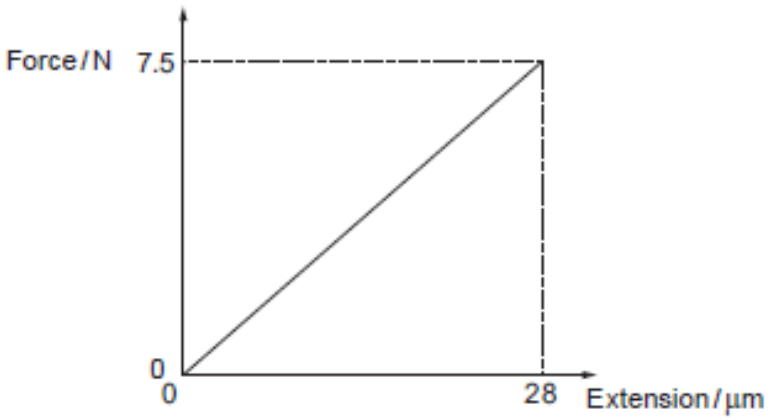
I. Name this phenomenon and account for it in terms of energy. [2]

II. **Sketch the curve** for unloading on the graph opposite. [1]

Question taken from Eduqas examination paper 842102, November 2020

#2

1. Emily carries out an experiment to obtain a force-extension graph for a thin glass fibre. She loads the thin glass fibre until it breaks. The force-extension graph obtained is shown below.



(a) (i) Emily measures the length and diameter of the glass fibre and finds them to be 19.8 cm and 1.01 mm respectively. Suggest what measuring instruments she uses. [1]

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(ii) Determine the Young modulus of glass. [3]

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(iii) Write a risk assessment for Emily's experiment. [2]

(iv) Determine the energy stored in the glass just before breaking point is reached. [2]

(b) Glass is a brittle material. Describe the process by which glass fractures. [3]

Question taken from Eduqas examination paper 842001, June 2018

#3

3. A child's jumping toy uses the compression of a spring to fire it up into the air. The spring used requires a force of 0.50 N to compress it by 1.0 cm.





(a) State Hooke's law. [1]

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(b) The toy has a mass of 20 g and the spring is compressed by 6.0 cm and then released.

(i) Calculate the velocity with which it leaves the ground. [3]

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(ii) Determine the initial acceleration of the toy as the spring extends. State any assumption you make. [2]

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(c) (i) Ignoring air resistance, determine the maximum height gained by the toy. [3]

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(ii) Determine the total time of flight. [2]

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Question taken from Eduqas examination paper 842001, June 2019

#4

1. *(a)* (i) Define the Young modulus of a material. [1]

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(ii) Express the unit of the Young modulus in terms of S.I. base units. [3]

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(b) (i) When a rubber band is gradually loaded and then unloaded it shows *hysteresis* and *permanent set*. Sketch, and **clearly label** a force-extension graph for rubber to illustrate these two effects. [3]



(ii) Considering the molecular structure of rubber explain why it has a much lower value of Young modulus than that of a metal. [2]

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(iii) What is the effect on the Young modulus of rubber when its temperature rises? Explain your answer. [2]

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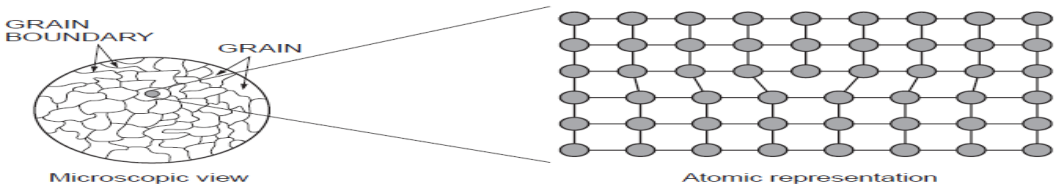
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Question taken from Eduqas examination paper 842001, June 2019

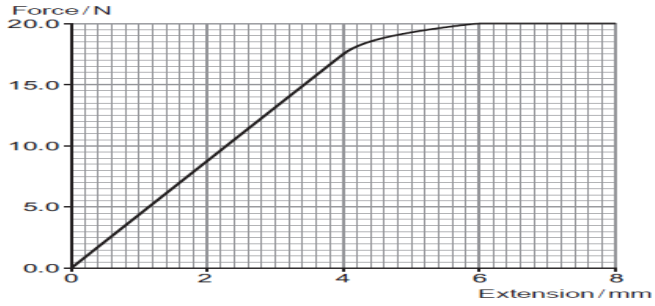
#5

(a) The diagrams show a microscopic view and an atomic representation of the crystalline structure of a typical metal.



Describe how plastic deformation takes place in ductile metals and explain methods for increasing the strength of ductile metals. [6 QER]

(b) A student investigates the force-extension properties of copper wire. He measures the diameter of the wire to be 0.32 mm and the original length to be 2.2 m. He measures the extension of the wire for various loads applied to it, up to a maximum load of 20.0 N. He draws a graph of force against extension from his results.



(i) Determine whether or not these measurements are consistent with copper having a Young Modulus of 120 GPa. [3]

(ii) Estimate the work needed to produce a strain of 0.2% in the wire. [2]

(iii) **Sketch a line on the graph** to show the possible behaviour of the wire when the 20 N force is removed. [Assume the wire has been stretched beyond its elastic limit.] [1]

Question taken from Eduqas examination paper 842102, June 2017

#6

6. *(a)* Define the *capacitance* of a capacitor. [1]

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(b) Two capacitors, initially uncharged, are arranged in series as shown. When a battery is connected across A and B, the charge on plate P is found to be +75 nC.



(i) Write down the charges on each of the plates Q, R and S. Give a reason for your answer to the charge on plate S. [3]

Charge on Q: .....

Charge on R: .....

Charge on S: .....

Reason:

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(ii) Calculate the pd across A and B. [2]

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(iii) A Physics student makes the following comment:

For capacitors in series, a capacitor of higher capacitance stores more energy than a capacitor of smaller capacitance.

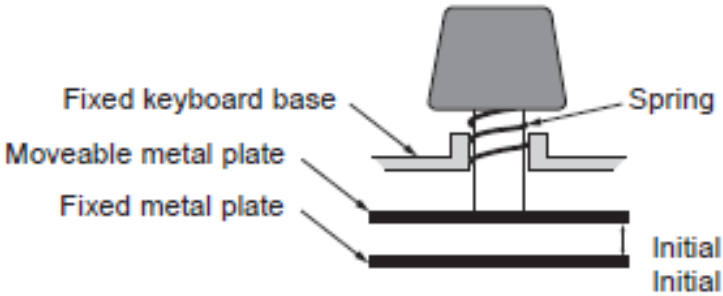
By considering this combination of capacitors, investigate whether or not the student is correct. [2]

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(c) Some computer keyboards work on the principle of varying capacitance. When a key is pressed, a spring is compressed and the separation of two parallel metal plates is decreased. The computer responds if the increase in capacitance of the plates is 0.20 pF or more.
The diagram shows how a single key is constructed.



Initial separation of plates = 5.2×10^{-3} m
Initial capacitance = 0.27 pF
Plate area = 1.6×10^{-4} m^2

The designers of a keyboard require that the increase in capacitance of 0.20 pF occurs when a force of 0.20 N is exerted on a key. Different springs are available, of spring constant 90 N m^{-1}, 120 N m^{-1} and 150 N m^{-1}. Determine which (if any) of these springs would be suitable in meeting the designer's requirements. The capacitor is filled with air. [4]

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Question taken from Eduqas examination paper 842102, June 2018

#7

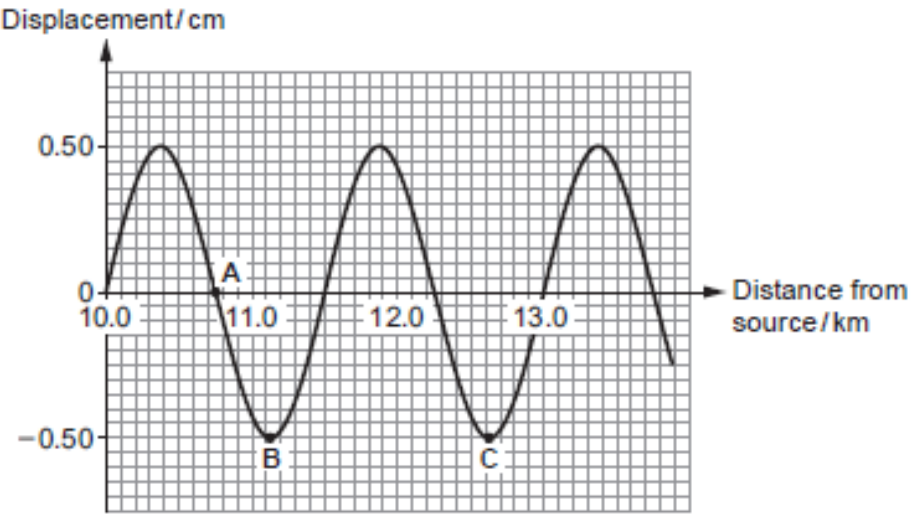
1. *(a)* Explain what is meant by a progressive wave. [2]

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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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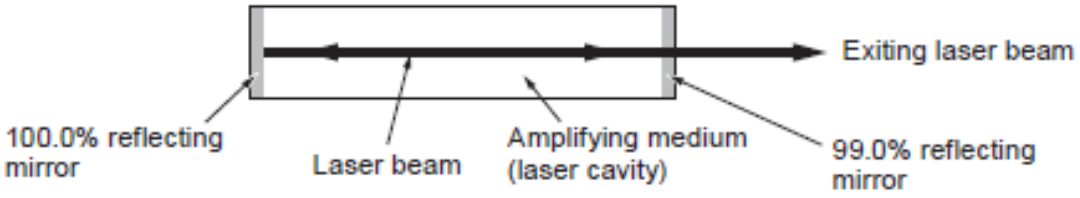
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Question taken from Eduqas examination paper 842002, June 2018

#8

4. A laser has two mirrors either side of the amplifying medium as shown.



(a) Explain the purpose of the 99.0% reflecting mirror and the 100.0% reflecting mirror. [2]

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(b) Explain the purpose of a population inversion in the laser cavity. [3]

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(c) (i) The light intensity inside a powerful laser is 2.0×10^{15} W and its wavelength is 1.05 μm. Show that this corresponds to approximately 1×10^{34} photons per second. [2]

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(ii) Show that the momentum of a 1.05 μm photon is approximately 6×10^{-28} kg m s^{-1}. [1]

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(iii) Show that the force exerted on a 100.0% reflecting mirror by a beam of power 2.0×10^{15} W is approximately 1×10^{7} N. [2]

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(iv) Calculate the strain produced in a laser structure if the power of the beam between the mirrors is 2.0×10^{15} W. You may assume that the structure of the laser cavity has a cross-sectional area of 43 cm^2 and is made of a material with Young modulus 2.8×10^{11} Pa. [3]

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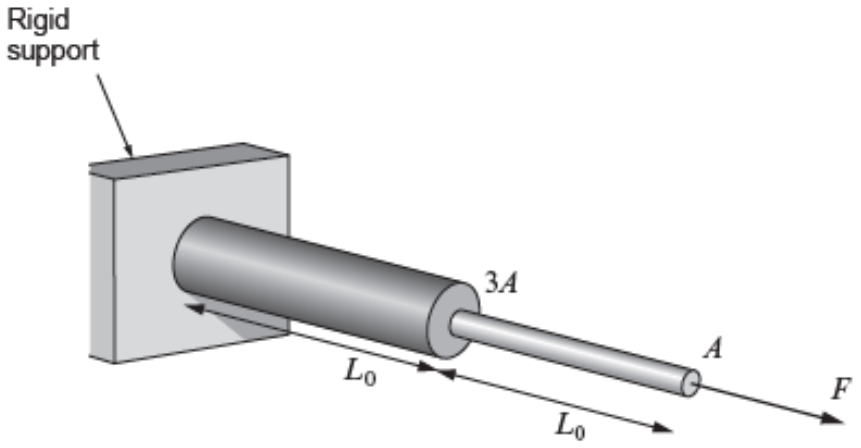
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Question taken from Eduqas examination paper 842103, June 2018

#9

5. *(a)* The bar in the figure below is made from a **single piece of metal**. It consists of two parts of equal length L_0 and cross-sectional area A and $3A$. The diagram is not drawn to scale.



(i) Show that the **total** extension, Δx_{total}, of the bar under the action of an applied force, F, as shown in the diagram, can be given by:

$$\Delta x_{\text{total}} = \frac{4FL_0}{3AE}$$

where E represents the Young modulus of the metal in the bar. [3]

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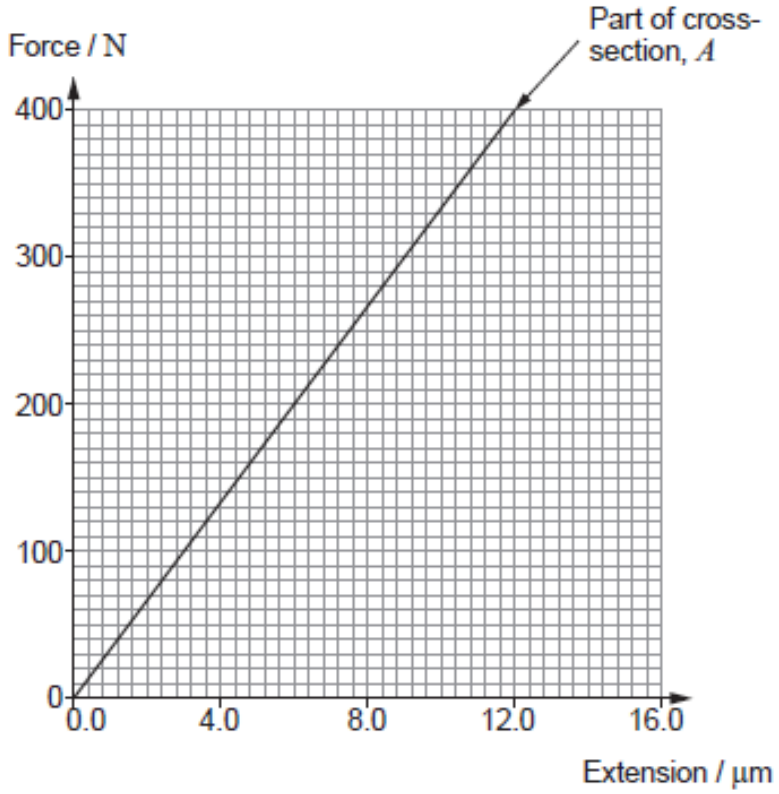
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(ii) The graph shows the variation of extension with applied force for the part of cross-section, A. **Draw** (on the same grid) the expected force-extension graph for the segment of cross-section $3A$. [1]



(iii) Determine the Young modulus of the metal in the bar given that $L_0 = 1.2\,\text{m}$ and $A = 2.0 \times 10^{-4}\,\text{m}^2$. [3]

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(iv) Calculate the elastic potential energy stored in the whole bar when $F = 400\,\text{N}$. [2]

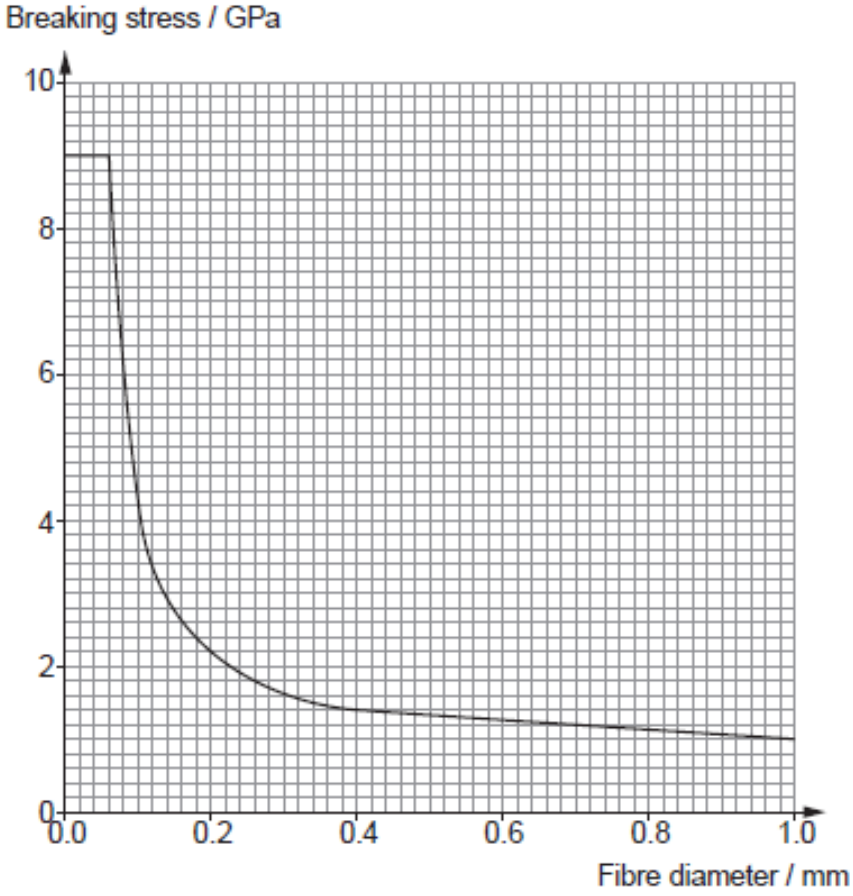
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(b) Glass is a brittle material. The graph shows how the breaking stress of glass, in the form of thin fibres and rods, varies with the diameter of the fibre.



(i) Use the graph to estimate the greatest mass which can be hung from a glass fibre of diameter 0.2 mm. [3]

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(ii) Explain the term *brittle fracture* as it applies to glass and give a reason why very thin fibres have a greater breaking stress than thicker ones. [2]

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Question taken from Eduqas examination paper 842102, June 2019

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#11

Two students, Simon and Natalie are investigating the mechanical properties of a steel wire of length 2.5 m and cross-sectional area 1.0 mm^2.

(a) They are given the following information.
[Young modulus, $E_{steel} = 2.0 \times 10^{11}$ N m^{-2}, Stress, σ_{steel} (at elastic limit) = 1.0×10^{8} N m^{-2}].

(i) Show that the maximum extension possible for the wire without the elastic limit being exceeded is 1.25 mm. [2]

(ii) Simon believes that this maximum extension (1.25 mm) of the steel wire depends on the radius of the wire. Natalie disagrees. Discuss who is correct, explaining carefully how you arrive at your answer. [3]

(b) Natalie suspends a mass, m, from the wire vertically. The wire can be considered to be weightless.

(i) Show that the force per unit extension, k, of the wire is 80 kN m^{-1}. [3]

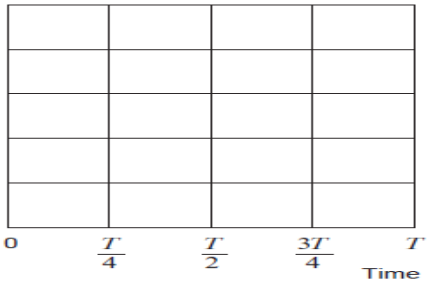
(ii) Determine the mass, m, that causes an equilibrium extension of 1.0 mm. [2]

(c) This mass is given a small downward displacement and released from rest. The mass oscillates with simple harmonic motion (SHM) **provided that the maximum extension of the wire never exceeds the elastic limit**.

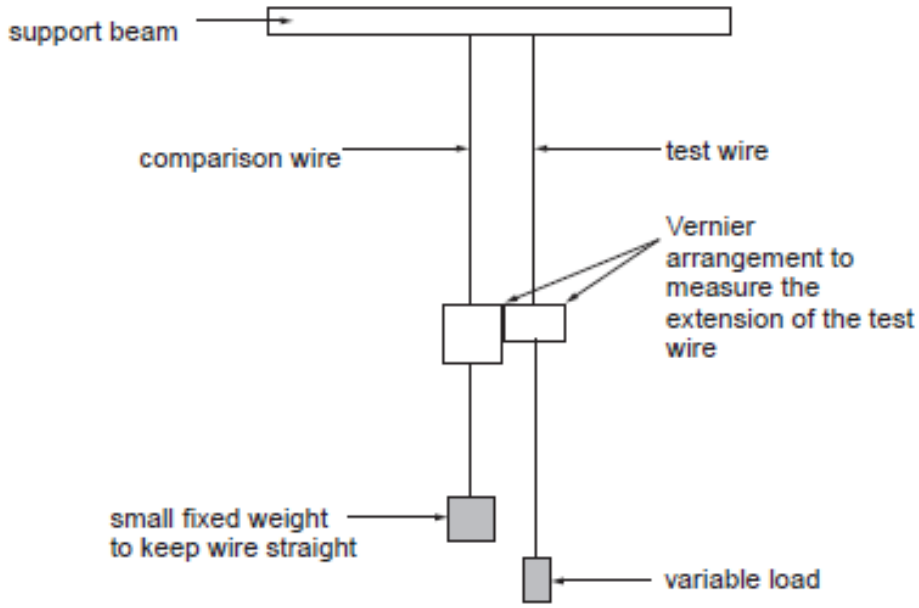
(i) Calculate the period of this oscillation. [2]

(ii) Calculate the maximum possible velocity of the mass, m. [3]

(iii) Assuming the mass is released when the wire is at maximum extension without exceeding the elastic limit, sketch a graph showing how the stress in the wire varies with time **for one complete oscillation** from the moment of release of the mass. Indicate appropriate numerical values on the stress axis of your graph.
Space for calculations. [4]



3. Kiera uses the following apparatus to find the Young modulus of a metal alloy in the form of a wire.



(a) Explain how the choice of a suitable comparison wire minimises the effect of a change in temperature. [2]

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(b) Kiera uses a micrometer of resolution 0.01 mm to measure the mean diameter of the wire. She determines the mean diameter to be 0.16 mm. Calculate the cross-sectional area of the wire **in m^2**, along with its **percentage uncertainty**. [3]

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(c) Kiera then uses a metre ruler with a resolution of 1 mm to measure the initial length of the wire. She determines the length to be 1.680 m. Show, with an appropriate calculation, that the percentage uncertainty in this reading can be considered negligible. [2]

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(d) Kiera adds various masses to the test wire and measures the extension. The table shows the extension of the wire for increasing load.

Load (negligible absolute uncertainty) / N	Mean extension / mm	Absolute uncertainty in extension / mm
1.96	1.4	± 0.2
3.92	2.7	± 0.2
5.89	4.1	± 0.2
7.85	5.5	± 0.2
9.81	6.8	± 0.2

Kiera plots a graph (shown opposite) of load against extension from her data, but does not include error bars.

(i) I. **Add error bars** for the extension on the plotted points. [1]

II. Draw lines of maximum gradient and minimum gradient and determine the gradients of both lines. [3]

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(ii) Hence, calculate the mean gradient and the **percentage** uncertainty in its value. [2]

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(e) Determine the Young modulus of the metal alloy, along with its **absolute** uncertainty. Give your answer to an appropriate number of significant figures. [5]

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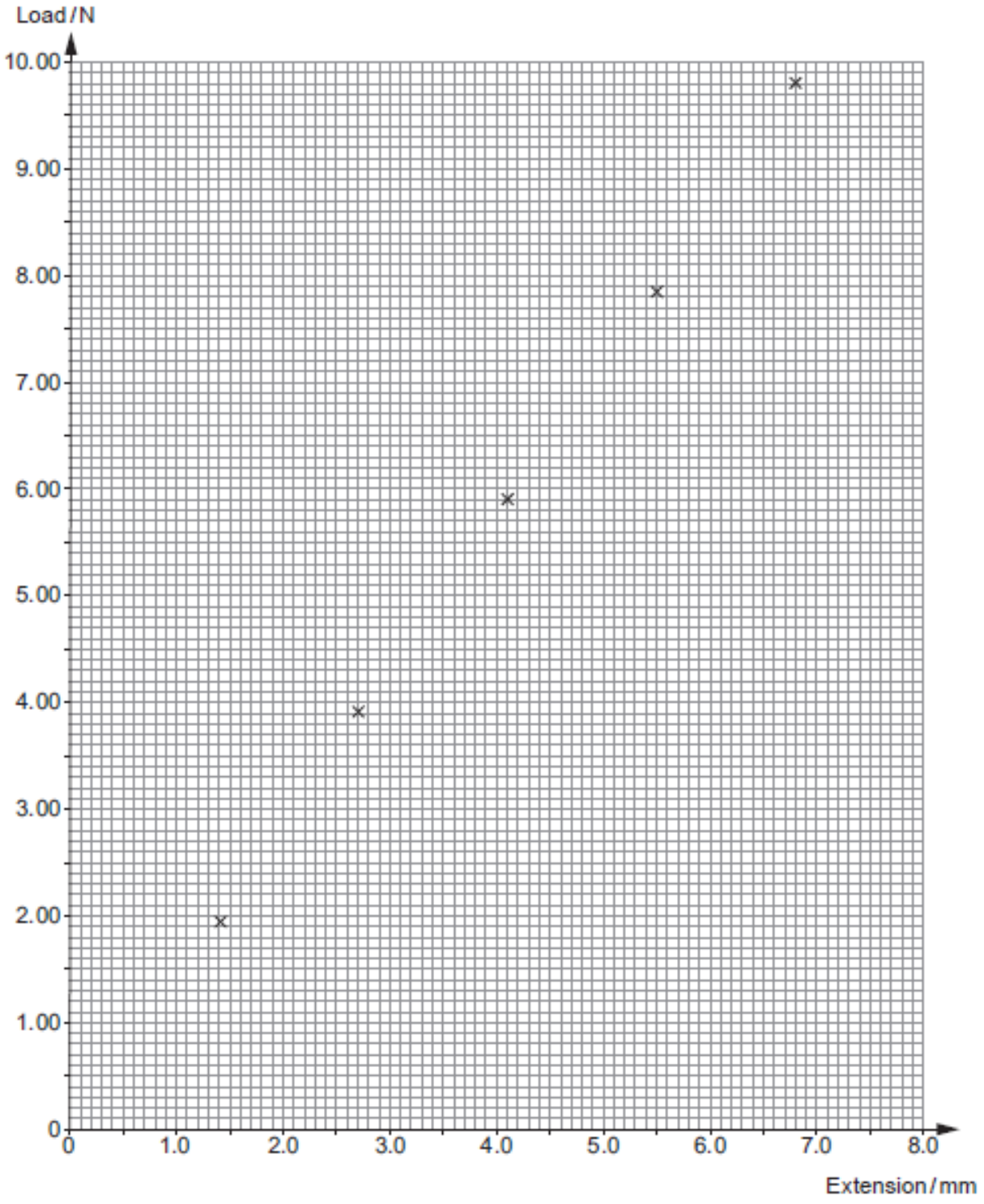
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(f) State which of the measurements contributes most to the overall uncertainty in your answer and suggest one change Kiera could make to her experiment which would reduce the size of this uncertainty. [2]

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Question taken from Eduqas examination paper 842102, June 2018

Marking Scheme

#1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)			**Description and appropriate example given for each [3 × 1]** **Crystalline**- long range, regular (unit cell repeated) Accept 'lattice'. **Amorphous** - no order (accept: short range, irregular) **Polymeric** - long chain molecules (no order between, only within molecules)	3			3		
	(b)	(i)		At (A) molecules unravel (accept untangle) under the action of a force. [Accept – C-C bond rotates] [1] At (B) molecules fully stretched/ strong forces between atoms within molecule / stretching bonds (covalent) [1] Either: Small force (or stress) produces large extension (or strain) at A [hence shallow gradient] Or: Large force (or stress) produces small extension (or strain) at B [hence steep gradient] [1]	1 1	1		3		3
		(ii)	I	Hysteresis [1] Explanation: e.g. area between curves represents energy 'lost' in the cycle or energy is transferred to internal energy in the rubber and then lost as heat [1]	2			2		
			II	Correctly drawn curve, of the same shape but 'below' the extension curve at all points. Can return to origin or shown as small 'permanent set'	1			1		
				Question total	**8**	**1**	**0**	**9**	**0**	**3**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*	(i)	Ruler and micrometer or Vernier callipers	1			1		1
		(ii)	Area = $\pi \times (0.505 \times 10^{-3})^2 = 8.01 \times 10^{-7}$ [m^2] (1) $E = \frac{Fl}{\Delta l A} = \frac{7.5 \times 0.2}{(28 \times 10^{-6} \times 8.01 \times 10^{-7})}$ (1) $E = 6.6 \times 10^{10}$ Pa / N m^{-2} with units (1) Accept in N mm^{-2}	1	1 1		3	3	3
		(iii)	Hazard and Risk – thin glass could shatter and cut the skin (1) Control measure – handle with care / wear gloves or protective clothing (1) **Alternative:** Hazard and Risk – [broken glass is sharp] thin glass could shatter and enter the eyes (1) Control measure – handle with care / wear goggles (1)			2	2		2
		(iv)	Work done = energy stored = ½$F\,\Delta l$ (1) $0.5 \times 7.5 \times 28 \times 10^{-6} = 1.05 \times 10^{-4}$ [J] (1)	1	1		2	2	2
	(b)		Surface cracks (1) All force concentrated on a single / few bonds below the crack (1) When under tension (1)	3			3		
			Question 1 total	**6**	**3**	**2**	**11**	**5**	**8**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)		Force (of a spring) is directly proportional to its extension	1			1		
	(b)	(i)	$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ (1) k = 50 [N m^{-1}] (1) v = 3.0 [m s^{-1}] (1)		3		3	2	
		(ii)	$a = \frac{kx}{m}$ (1) a = 150 [m s^{-2}] and assumption that g is ignored (1)		2		2	1	
	(c)	(i)	Use of $v^2 = u^2 + 2as$ and v = 0 (1) $h = \frac{v^2}{2g}$ (1) h = 0.46 [m] (1) **Accept alternatives** Equating energies (1) Rearranging (1) h = 0.46 m accept 0.46 + 0.06 = 0.52 m (1)	1	1 1		3	2	
		(ii)	Use of $v = u + at$ or $t = \frac{u}{a}$ (1) Total time = 2 × 0.306 = 0.61 [s] (1)	1	1		2	2	
			Question 3 total	**3**	**8**	**0**	**11**	**6**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)	$\frac{\text{stress}}{\text{strain}}$ (1)	1			1		
		(ii)	Strain: no units (1) Stress: $\frac{\text{kg m s}^{-2}}{\text{m}^2}$ (1) Young modulus: kg m^{-1} s^{-2} (1)	1	1 1		3	3	
	(b)	(i)	's' shape on graph (1) Loading and unloading labelled (1) Hysteresis shown (1)	3			3		3
		(ii)	Weak (van de Waals) bonds between molecules / unravelling of long chain molecules (1) Easily broken / strong (metallic) bonds in metals (1)		2		2		
		(iii)	Molecules become more entangled / vibrations increase (1) Increase (1)	2			2		
			Question 1 total	**7**	**4**	**0**	**11**	**3**	**3**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		**Plastic Deformation:** P1 - Reference to dislocations or incomplete planes of atoms P2 - Applied forces break bonds near to dislocations P3 - Dislocations slip P4 - Original bonds permanently broken and do not reform or crystal does not return to original form when force removed **Increasing Strength:** S1- Foreign atom S2- Reduce grain size or increase number of grain boundaries S3- Further dislocations S4- Reason - how they work - inhibit dislocation movement **5-6 marks** Comprehensive description including both plastic deformation and increasing strength typically 6 or more points covered. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of either plastic deformation or increasing strength or brief description of both plastic deformation and increasing strength typically 4 - 5 points covered. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Brief description of either plastic deformation or increasing strength 1 - 3 points covered. *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		
	(b)	(i)	CSA = $\pi \times (0.16 \times 10^{-3})^2$ = [8.0×10^{-8}] (1) Gradient from graph = 4 375 or use of a point from the straight portion (1) Young Modulus = grad $\times \frac{l}{A}$ shown to be 1.2×10^{11} Pa (1)			3	3	3	3
		(ii)	0.2% strain corresponds to an extension of 4.4 mm (1) Area under graph calculated = ½ × 4.4 × 10^{-3} × 18.5 (1) [W = 0.04 J]		2		2	2	2
		(iii)	Straight line from end of graph (between 6 – 8 mm) parallel to original line to x-axis. Tolerance: x-axis intercept between 0.4 - 4.0 mm.	1			1		1
			Question total	**7**	**2**	**3**	**12**	**5**	**6**

#6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*		capacitance = $\frac{\text{charge (on either plate)}}{\text{pd (between the plates)}}$ Accept charge per unit pd / voltage [between plates] (1) Accept $C = \frac{Q}{V}$ if Q and V defined	1			1		
	(b)	(i)	Q = - 75 nC, R = + 75 nC, S = - 75 nC All numerical values stated as 75 [nC] (1) Correct signs and unit, i.e. nC (1) One of: (1) • Capacitors in series carry equal charges when joined to common pd • Conservation of charge applies for series circuit [hence if +75 μC moves from A to plate P, the same moves from Q → R etc] • Opposite charge to P (accept R), since connected to negative potential [Accept: battery transfers electrons from P to Q]	3			3		
		(ii)	Total capacitance = 7.5 nF (1) $V = \frac{75 \times 10^{-9}}{7.5 \times 10^{-9}}$ **(ecf on total C)** V = 10 V (1) **Alternative:** Application and substitution into $\frac{Q}{C_1} + \frac{Q}{C_2}$ i.e. $\frac{75 \times 10^{-9}}{30 \times 10^{-9}} + \frac{75 \times 10^{-9}}{10 \times 10^{-9}}$ (1) V = 10 V (1)		2		2	2	
		(iii)	**Either:** Q same on both capacitors (1) $\frac{1}{2}\frac{Q^2}{C}$ is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis) **Or:** $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ CV^2 bigger across smaller capacitor (V^2 factor) (1) (Award 2 marks for correct numerical analysis) **Or** Q same on both capacitors and $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ QV is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis			2	2		
	(c)		New C = 0.47 pF (1) New $d = 3.0 \times 10^{-3}$ m (1) $\Delta d = 5.2 \times 10^{-3} - 3.0 \times 10^{-3} = 2.2 \times 10^{-3}$ m (1) (**ecf** from new d) Application of $F = k\Delta d$ ecf k = 91 N m^{-1} so spring of k = 90 N m^{-1} suitable [conclusion consistent with value of F](1) **Alternative 'Trial and Error' :** Application of $x = \frac{F}{k}$ for each spring constant, showing that for: k = 120 N m^{-1}, $x = 1.67 \times 10^{-3}$ m k = 150 N m^{-1}, $x = 1.33 \times 10^{-3}$ m k = 90 N m^{-1}, x = 2.22 x 10^{-3} m (All required for1) New C = 0.47 pF (1) Application of $C = \frac{\varepsilon_0 A}{d}$ for each value of x above to show that, for $x = 2.22 \times 10^{-3}$ m, $C = 0.475 \times 10^{-12}$ F, so k = 90 N m^{-1} suitable. (1)			4	4	3	
			Question 6 total	**4**	**2**	**6**	**12**	**5**	**0**

#7

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**

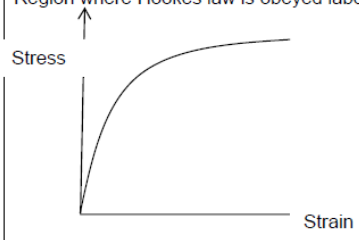
#8

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		{Multiple passes of beam / reflection / keeps most of the light} for more amplification / stimulated emission or increased collimation (1) Some light (1%) transmitted by 99% mirror (1)	2			2		
	(b)		Increase of stimulated emission (1) Compared with absorption (1) [Exponential] increase in intensity or amplification or more power] (1) NB Stimulated emission > absorption → 2 marks	3			3		
	(c)	(i)	Energy of photon = 1.89×10^{-19} [J] seen or implied (1) $\frac{2 \times 10^{15}}{1.89 \times 10^{-19}}$ seen or implied (1.056×10^{34}) (1) [no e.c.f.]		2		2	2	
		(ii)	$p = \frac{6.63 \times 10^{-34}}{1.05 \times 10^{-6}}$ [kg m s^{-1}] seen or implied [= 6.314×10^{-28} N s]		1		1	1	
		(iii)	$1.06 \times 10^{34} \times 6.31 \times 10^{-28}$ [N] seen or implied (1) 2 × due to reflection stated (1) [→ 1.33×10^7 N] [Using the 'show that' figures → 1.2×10^7 N]		2		2	1	
		(iv)	$E = \frac{\text{stress}}{\text{strain}}$ used (1) [or by implication] Stress = $\frac{F}{A}$ used (1) [or by implication] Answer = 0.0083 or 0.011 (or 0.0105) seen (depends on (iii) but check) (1) [0.83% ✓]	1 1	1		3	3	
			Question 4 total	**7**	**6**	**0**	**13**	**7**	**0**

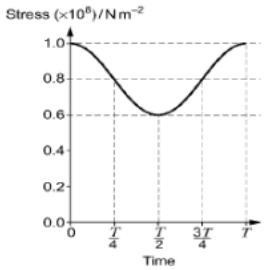
#9

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)	$\Delta x_{total} = \Delta x_A + \Delta x_{3A}$ (or by implication) [1] $\Delta x_{total} = \frac{FL_0}{AE} + \frac{FL_0}{3AE}$ [1] Convincing algebra e.g. $\frac{3FL_0}{3AE} + \frac{FL_0}{3AE}$ seen [1]		3		3	2	
		(ii)	Straight line from origin to (400 N, 4.0×10^{-6} m)		1		1		
		(iii)	**Using combination:** $Y = \frac{4FL_0}{3A\Delta x_{total}}$ and $\Delta x_{total} = 16 \times 10^{-6}$ [m] [1] Substitution - $E = \frac{4 \times 400 \times 1.2}{3 \times 2 \times 10^{-4} \times 16 \times 10^{-6}}$ [1] (gains first and second marks) $E = 2 \times 10^{11}$ Nm^{-2} or Pa **unit mark** [1] **Using bar of CSA A:** $E = \frac{FL_0}{A\Delta x_A}$ and $\Delta x_A = 12 \times 10^{-6}$ [m] [1] Substitution – $E = \frac{400 \times 1.2}{2 \times 10^{-4} \times 12 \times 10^{-6}}$ [1](gains first and second marks) $Y = 2 \times 10^{11}$ Nm^{-2} or Pa **unit mark** [1] **Using bar of CSA $3A$: - ecf** $E = \frac{FL_0}{3A\Delta x_{3A}}$ and $\Delta x_{3A} = 4 \times 10^{-6}$ [m] [1] Substitution – $E = \frac{400 \times 1.2}{3 \times 2 \times 10^{-4} \times 4 \times 10^{-6}}$ [1](gains first and second marks) $E = 2 \times 10^{11}$ Nm^{-2} or Pa **unit mark** [1]		3		3	3	
		(iv)	$E_{elastic} = \frac{1}{2} F x_{total}$ and substitution: $E = \frac{1}{2} \times 400 \times 16 \times 10^{-6}$ [1] $E = 3.2$ m[J] [1] **Alternative:** $E_{elastic} = \frac{2F^2 L_0}{3AE}$ used with substitution: $E_{elastic} = \frac{2 \times (400^2) \times 1.2}{3 \times 2 \times 10^{-4} \times 2 \times 10^{11}}$ [1] $E_{elastic} = 3.2$ m[J] [1] **Alternative: Area under graphs - ecf** ½ × $4 \times 10^{-6} \times 400$ + ½ × $12 \times 10^{-6} \times 400$ [1] $E_{elastic} = 3.2$ m[J] [1]	1	1		2	2	
	(b)	(i)	From graph, stress = 2.2×10^9 Pa [1] $F = 2.2 \times 10^9 \times \pi \times (0.1 \times 10^{-3})^2 = 69$ [N] [1] **ecf** for 2.1×10^9 Pa Mass = $\frac{69}{9.81} = 7.0$ k[g] [1]		3		3	2	
		(ii)	**Crack propagation** [around surface imperfection] - no details in terms of breaking bonds needed [1] **Thinner fibre contains fewer surface imperfections** [1] (mention of 'surface' required only once)	2			2		
			Question 5 total	**3**	**11**	**0**	**14**	**9**	**0**

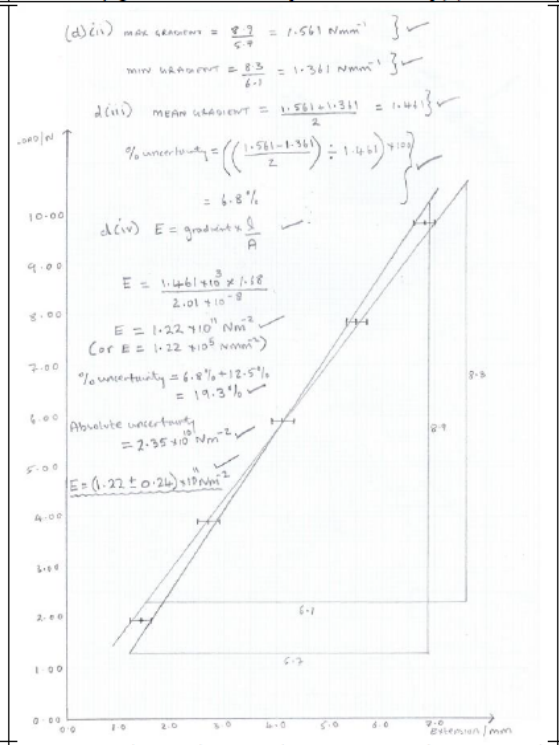
#10

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Amorphous (1) [Short range and] long range order / regular lattice / regular array of planes / ordered layers (1) Long chain molecules (1)	3			3		
	(b)		Shape i.e. linear followed by curve flattening out (1) Yield point labelled (1) Elastic limit labelled (1) Region where Hookes law is obeyed labelled (1)  	4			4		
	(c)	(i)	Load/weight = mg = 5 × 9.81 [N] Stress = $\frac{F}{A}$ / substitution correct **ecf** for load (1) Area = 8.175×10^{-7} [m^2] (1) Diameter = 1.0[2] × 10^{-3} m / 1.0[2] mm with units (1)	1 1	 1 1		 4	 4	
		(ii)	Strain = $\frac{\Delta l}{l}$ = 0.02 (1) E = 3.0 GPa with units **no ecf** (1)		2		2	2	
		(iii)	Diameter increases by $\sqrt{10}$ (1) Diameter = 3.2[2] mm with units (1)	1	1		2	2	
			Question total	**10**	**5**	**0**	**15**	**8**	**0**

#11

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		Substitution and re-arrange e.g. $\Delta x_{max} = \frac{(1.0 \times 10^{8} \times 2.5)}{2.0 \times 10^{11}}$ [1] $\Delta x_{max} = 1.25 \times 10^{-3}$ m or 1.25 mm [1] Accept use of 1.25 mm to show $E_{steel} = 2.0 \times 10^{11}$ [N m^{-2}]		2		2	2	
		(ii)		Stress required to reach elastic limit will remain constant irrespective of radius e.g. If radius is doubled the tension is increased by factor 4 [1] Δx_{max} (of this wire) will be the same (depends only on stress) [1] Δx_{max} does not depend on the radius, Natalie correct (or Simon incorrect) [1]			3	3		
	(b)	(i)		Re-arrangement and substitute: $F = \frac{EA\Delta x}{l}$ i.e. $F = \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-6} \Delta x}{2.5}$ [1] $F = k\Delta x$ seen or implied [1] Correct algebra to show $k = 8 \times 10^{4}$ [N m^{-1}] [1] **Alternative:** At elastic limit $k = \frac{100}{1.25 \times 10^{-3}}$ (= 80 kN m^{-2}) - award 3 marks		3		3	3	
		(ii)		$mg = k\Delta x$ seen or implied [1] $m = \frac{8.0 \times 10^{4} \times 1 \times 10^{-3}}{9.81}$ m = 8.2 k[g] [1]		2		2	1	
	(c)	(i)		Substitution into $T = 2\pi\sqrt{\frac{m}{k}}$ [1] (**ecf** on m) T = 0.06[3 s] [1]	1	1		2	2	
		(ii)		Elastic limit must not be exceeded, so max possible displacement = 1.25 mm – 1.0 mm = 0.25 [mm] [1] Substitution into $v_{max} = A\omega$ or equivalent: e.g. $v_{max} = 0.25 \times 10^{-3} \times \frac{2\pi}{0.06}$ [1] (**ecf** on T and Δx_{max}) v_{max} = 0.026 [m s^{-1}] [1]	1	1 1		3	2	
		(iii)		Stress in equilibrium position calculated or seen on graph i.e. $= \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-3}}{2.5}$ (= 0.8×10^{8} N m^{-2}) [1] Appropriate stress scale e.g. as shown or in steps of 0.2×10^{8} N m^{-2} [1] Correct general shape with no reference to time/ stress scales [1] Correct shape and stress and timings [1]  		4		4	2	
				Question total	**2**	**14**	**3**	**19**	**12**	**0**

#12

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*			Test wire and reference wire made from the same material (or identical) (1) Do not accept reference to common support. [Change in] temperature will affect both **equally** (1)			2	2		2
	(b)			$A = \pi (0.08 \times 10^{-3})^2$ and conversion to m^2 $A = 2.01 \times 10^{-8}$ [m^2] (1) % Uncertainty = $\frac{(0.01)\times 100}{0.16}$ (1) (= 6.25%) × 2 [doubling ecf] (= **12.5% / 13%**) (1) [accept 3 s.f.] (award 2 marks if 12.5% or 13% seen)		3		3	3	3
	(c)			Correct reference to uncertainty taken as ruler resolution i.e. 1 mm (or 1×10^{-3} m) (1) ecf on same mistake in resolution as *(b)* Calculation of % uncertainty: 0.059% (or 0.06%) (1) Answer gains both marks	1	1		2	1	2
	(d)	i	I	Error bars correctly included for all points ± 2 small divisions on extension axis		1		1	1	1
			II	Lines for steepest and least steep gradients drawn appropriately (1) [do not accept lines through the origin] Steepest gradient calculated: [1.5 to 1.6 N mm^{-1}] (1) Least steep gradient calculated: [1.3 to 1.4 N mm^{-1}] (1)		3		3	3	3
										
			(ii)	Mean gradient calculated correctly using answers to d(i): expect 1.4 to 1.5 N mm^{-1} (1) ecf % uncertainty in mean calculated: expect 6%-10% (1) ecf		2		2	2	2
	(e)			Understanding shown that E = gradient × $\frac{l}{A}$ (1) [or by implication] [not awarded for use of data point rather than line] Substitution and value of E found to any sig fig and using any unit (does not need to be given).e.g. $E = 1.22 \times 10^{11}$ N m^{-2} (1) ecf on A. Total % uncertainty calculated from (b) [+ (c)] + (d)(ii) e.g. 7% + 12.5% = 19.5% (1) ecf Absolute uncertainty calculated: e.g. 2.38×10^{10} N m^{-2} (1) Answer and uncertainty to appropriate sig figs with correct unit: e.g. $E = (1.22 \pm 0.24) \times 10^{11}$ N m^{-2} or $(1.2 \pm 0.2) \times 10^{11}$ N m^{-2} (1)			5	5	4	5
	(f)			Diameter (1) Use 'thicker' wire or more accurate measuring instrument (or instrument with higher/greater resolution) (1) Apply ecf if candidate's gradient uncertainty greater than candidate's calculation of uncertainty in area: Extension (1); use a micrometer for extension			2	2		2
				Question 3 total	**1**	**10**	**9**	**20**	**13**	**20**