PRESTON MANOR

Physics Exam Pack

Materials

Name:

Date:

Question / Paper	Mark

5 In this question, two marks are available for the quality of written communication.

This question is about an experiment to determine the Young modulus of a metal in the form of a wire.

(a) Describe, with the aid of a diagram, the **apparatus** you would use.

[2]

(b) Describe how you would make the necessary **measurements**.

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....[4]

(c) Describe how you would determine the Young modulus from your measurements.

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....[4]

Quality of Written Communication [2]

[Total: 12]

Mark Scheme Page 5 of 6	Unit Code 2821	Session JANUARY	Year 2008	Version FINAL
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward			

Question 5	Expected Answers	Marks
Apparatus	Clearly labelled diagram could score both marks (Long) wire fixed at one end, pulley, masses required to produce extension shown at other end / Searles apparatus (workable arrangement) Micrometer; metre rule (for length and extension); or other instrument for measuring the extension described or shown	M1 A1
Readings	(Original) length with a ruler Extension with relevant instrument Extension related to the correct original length <u>Diameter</u> with micrometer screw gauge /<u>digital</u> vernier callipers mg for the load / balance for mass / newton meter for weight long wire e.g. > 2m / measure length to marker in correct region / measure diameter in several places /second wire to allow for temperature changes	B4 max
Analysis	graph of F / e or graph of stress / strain determine gradient stress and strain defined E = (grad x original length) / area gradient is E E = stress / strain E = Fl / eA; symbols defined Area = π d^2 / 4 Good physics determine E in the elastic region	B4 max
QWC	SPAG B1 (< 4 errors) Organisation B1	B2 Total: 12

6 Fig. 6.1 shows the force F against extension x graph for a copper wire.

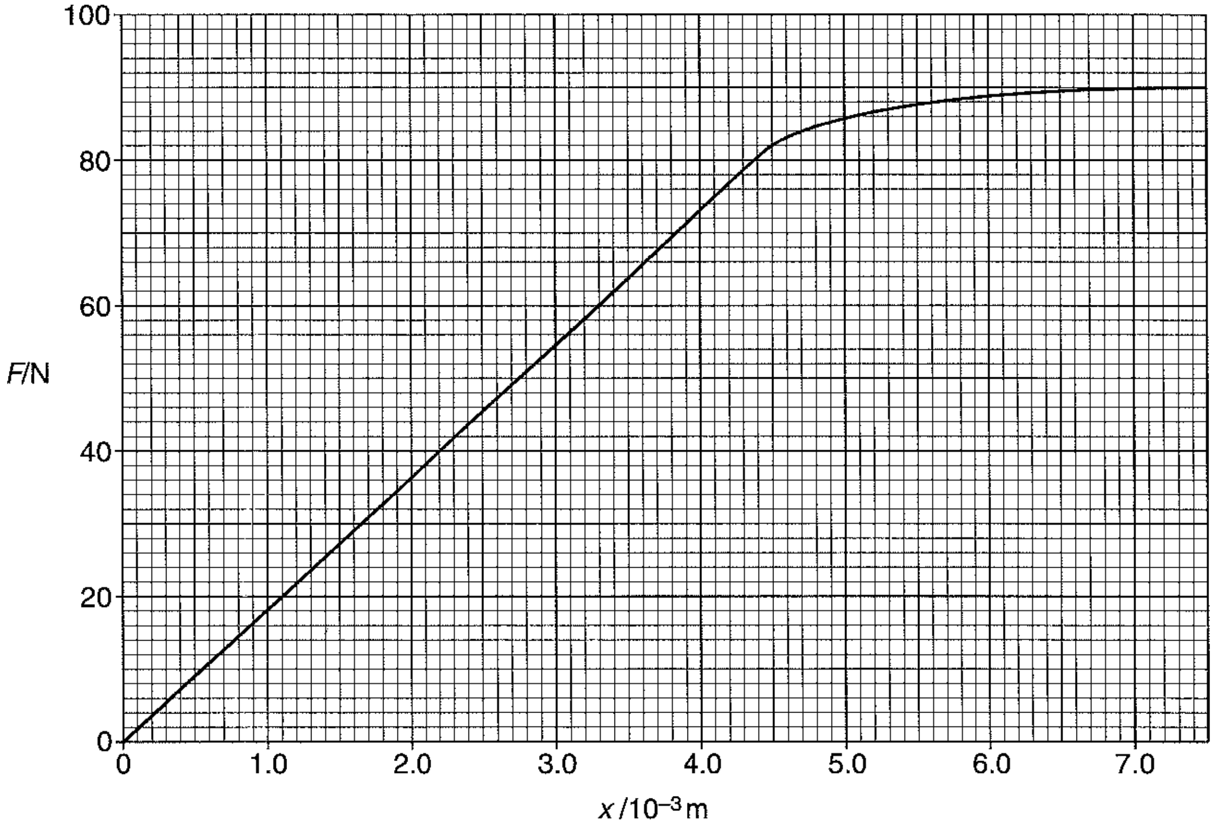

Fig. 6.1

(a) The original length of the wire was 4.0 m and its cross-sectional area $6.3 \times 10^{-7}\,m^2$. Use Fig. 6.1 to calculate

(i) the Young modulus of copper

Young modulus = ... Pa [4]

(ii) the strain energy stored in the wire when it is extended by a force of 80 N.

strain energy = ... J [2]

(b) The wire is now extended by a force of 90 N. Describe what happens to the extension of the wire when this force is removed.

....

....

....[1]

(c) In this part of the question, one mark is available for the quality of written communication.

Describe the behaviour and properties of the copper wire shown by Fig. 6.1 and compare with the behaviour and properties of a stretched glass fibre.

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....[6]

Quality of Written Communication [1]

[Total: 14]

END OF QUESTION PAPER

Question			Expected Answers	Marks	Additional Guidance
6	a	i	E = stress / strain	C1	
			= (F x l) / (A x e)	C1	
			= (60 x 4) / (0.63 x 10^{-6} x 3.3 x 10^{-3})	C1	Any correct points from the graph up 82 (N) Max 2/4 if force value is greater than 82 N
			= 1.15 x 10^{11} (Pa)	A1	Allow 1.2 and 1.1 if consistent with correct values from graph e.g 36 N and 2.0 mm.
		ii	Strain energy = ½ x F x e or area under graph	C1	
			= 0.5 x 80 x (4.4 x 10^{-3})		Allow 4.35 x 10^{-3} to give 0.174 (J)
			= 0.176 (J)	A1	Do not penalise the omission of 10^{-3} in this part if already penalised in section (a)(i)
	b		graph does not return to zero extension (may be on the graph) / there is permanent extension	B1	Do not allow answers that suggest it will return if it has not passed its elastic limit or any statement that explicitly states that the extension is the same as when the force was applied
	c		wire: ductile / malleable Hooke's law obeyed / force proportional to extension at start / over straight line section Elastic in first section Plastic when larger forces applied		Ignore comparative values of Young modulus, breaking force etc (but do not take these statements as part of the six assessed statements).

Question			Expected Answers	Marks	Additional Guidance
			Glass is brittle **Glass has <u>no</u> plastic region** **Glass has straight line section <u>only</u>**	**MAX B6**	Allow from a sketch graph. Stop marking after ticks and crosses add up to 6 but check for contradictions in any remaining text.
		QWC	**Use of technical language**	**B1**	Candidates are using correctly 2 of Hooke's law, extension proportional to force, elastic, plastic, ductile, malleable and brittle. We are not assessing spelling etc. in this section.
			Total	**14**	

7 **(a)** On the axes of Fig. 7.1, sketch a stress against strain graph for a typical ductile material.

Fig. 7.1

[2]

(b) Circle from the list below a material that is ductile.

jelly copper ceramic glass **[1]**

(c) Define *ultimate tensile strength* of a material.

....

.... **[1]**

(d) State *Hooke's law*.

....

.... **[1]**

(e) Fig. 7.2 shows a mechanism for firing a table tennis ball vertically into the air.

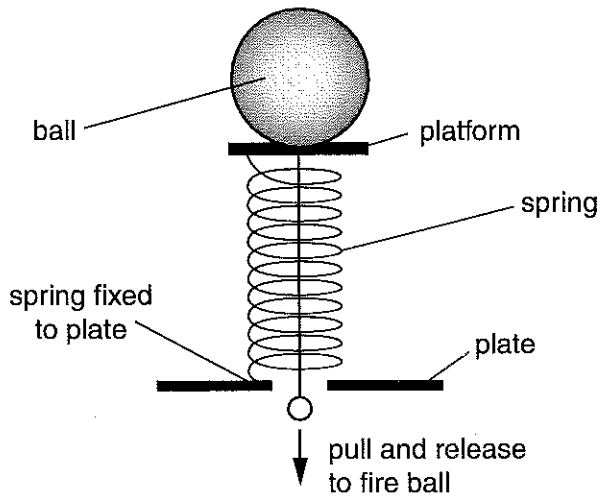

Fig. 7.2

The spring has a force constant of $75\,N\,m^{-1}$. The ball is placed on the platform at the top of the spring.

(i) The spring is compressed by 0.085 m by pulling the platform. Calculate the force exerted by the compressed spring on the ball **immediately** after the spring is released. Assume both the spring and the platform have negligible mass.

force = ...N **[2]**

(ii) The mass of the ball is 2.5×10^{-3} kg. Calculate the initial acceleration of the ball.

acceleration = ... $m\,s^{-2}$ **[1]**

(iii) Calculate the maximum height that could be gained by the ball. Assume all the elastic potential energy of the spring is converted into gravitational potential energy of the ball.

height = ... m **[3]**

[Total: 11]

END OF QUESTION PAPER

Question			Expected Answers	Marks	Additional Guidance
7	(a)		Straight line through origin (judge by eye) Correct shape of curve in the plastic region	B1 B1	
	(b)		Copper	B1	
	(c)		Maximum stress material can withstand (before fracture)	B1	**Allow**: UTS = breaking stress **Allow**: UTS = breaking force /(cross-sectional) area
	(d)		extension (or compression) $\propto$ force (as long as elastic limit is not exceeded)	B1	**Allow**: 'load' instead of force **Not**: $x \propto F$, unless the labels are defined
	(e)	(i)	force = 75 × 0.085 F = 6.38 (N) ≈ 6.4 (N)	C1 A1	
		(ii)	acceleration = $\dfrac{6.38}{2.5\times10^{-3}}$ acceleration = 2550 (m s^{-2})	B1	**Note**: $a=\dfrac{kx-mg}{m}$ gives 2540 (m s^{-2}) Possible ecf
		(iii)	Correct selection of equation: mgh / $\frac{1}{2}kx^2$ / $\frac{1}{2}Fx$ $0.0025\times9.81\times h=\dfrac{1}{2}\times75\times0.085^2$ height = 11 (m)	C1 C1 A1	 **Note**: Bald answer of 11 (m) scores 3/3 marks
			Total	**11**	

6 (a) Define

(i) *stress* ....

....

(ii) *strain* ....

.... [2]

(b) A wire of length 1.75 m and cross-sectional area $1.96 \times 10^{-7}\,m^2$ is extended by a force of 15.0 N. The material of the wire has a Young modulus of 2.00×10^{11} Pa.

(i) Calculate the extension of the wire.

extension = ... m [3]

(ii) A second wire made from the same material has the same volume. This wire has twice the original length and is extended by the same force. State and **explain** whether the extension of the second wire is greater, the same or less than the first wire.

....

....

.... [2]

[Total: 7]

Question 6			Expected Answers	Marks	Additional Guidance
(a)	(i)		Stress = force / (cross-sectional) area	B1	Allow 'over' If symbols are used then they need to be defined
	(ii)		Strain = extension / <u>original length</u>	B1	
(b)	(i)		$E = (F / A) / (e / l)$ $e = (15 \times 1.75) / (2 \times 10^{11} \times 1.96 \times 10^{-7})$ $= 6.70 \times 10^{-4}$ (m) (6.696×10^{-4})	C1 C1 A1	Allow E = stress / strain for the first mark Allow any subject for the first two marks
	(ii)		twice the length gives twice the extension half the area gives twice the extension 4e / greater than	B1 B1 A0	Allow: increase in 'e' due to increase in length B1 increase in 'e' due to decrease in area B1 hence overall increase A0
			Total	7	

Question 7			Expected Answers	Marks	Additional Guidance
(a)			Gradient values from graph to give $k = 25$ (N m^{-1})	B1	The conversion from mm to m must be clear
(b)	(i)		Work done = area under graph / $W = ½ Fx$ / $W = ½ kx^2$ $= ½ \times 0.3 \times 0.012$ / $= ½ \times 25 \times (0.012)^2$ $= 0.0018$ (J)	B1 B1 A0	
	(ii)		k.e. = $½ m v^2$ $v^2 = (0.0018 \times 2) / 0.45$ $v = 0.089(4)$ m s^{-1}	C1 C1 A1	 Allow any subject 2 sf needed

7 Fig. 7.1 shows how the force F for a spring varies with the compression x.

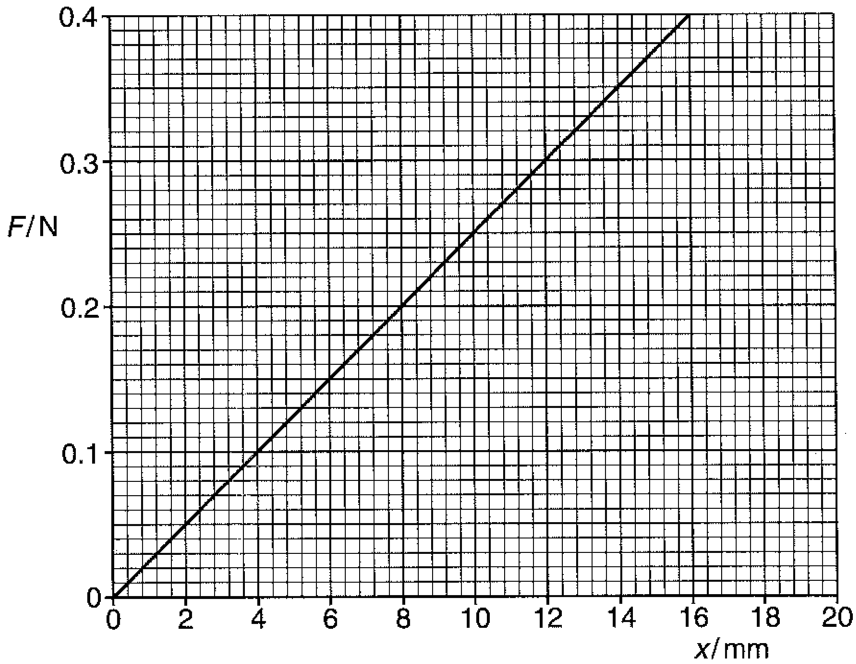

Fig. 7.1

(a) Show that the spring constant for the spring is 25 N m^{-1}.

[1]

(b) Fig. 7.2 shows the spring being used in a buffer to stop a moving toy train.

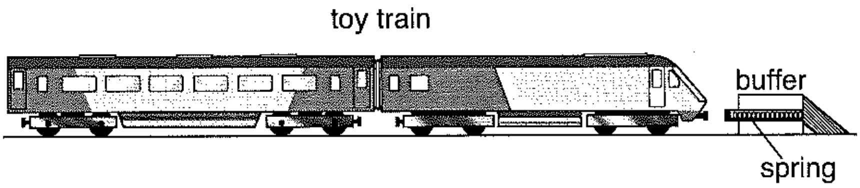

Fig. 7.2

The train of mass 0.45 kg was moving at a speed v when it hit the buffer. The train was brought to rest by the spring as it compresses 12 mm.

(i) Show that the work done compressing the spring is 1.8×10^{-3} J.

[2]

(ii) Calculate the speed of the train just before it hits the buffer. Assume that the work done compressing the spring is equal to the initial kinetic energy of the train.

speed = ... $m s^{-1}$ **[3]**

(c) State and explain the effect on the compression of the spring if the speed of the train is doubled.

....

....

.... **[2]**

[Total: 8]

Question 6			Expected Answers	Marks	Additional Guidance
(a)	(i)		Stress = force / (cross-sectional) area	B1	Allow 'over' If symbols are used then they need to be defined
	(ii)		Strain = extension / <u>original length</u>	B1	
(b)	(i)		E = (F / A) / (e / l) e = (15 x 1.75) / (2 x 10^{11} x 1.96 x 10^{-7}) = 6.70 x 10^{-4} (m) (6.696 x 10^{-4})	C1 C1 A1	Allow E = stress / strain for the first mark Allow any subject for the first two marks
	(ii)		twice the length gives twice the extension half the area gives twice the extension 4e / greater than	B1 B1 A0	Allow: increase in 'e' due to increase in length B1 increase in 'e' due to decrease in area B1 hence overall increase A0
			Total	7	

Question 7			Expected Answers	Marks	Additional Guidance
(a)			Gradient values from graph to give k = 25 (N m^{-1})	B1	The conversion from mm to m must be clear
(b)	(i)		Work done = area under graph / W = ½ Fx / W = ½ kx^2 = ½ x 0.3 x 0.012 / = ½ x 25 x $(0.012)^2$ = 0.0018 (J)	B1 B1 A0	
	(ii)		k.e. = ½ m v^2 v^2 = (0.0018 x 2) / 0.45 v = 0.089(4) m s^{-1}	C1 C1 A1	 Allow any subject 2 sf needed

Question 7			Expected Answers	Marks	Additional Guidance
(c)	(i)		4x k.e. or 4 x work to be done (w.d. = ½ k x^2) hence double the compression	M1 A1	Do not allow the force doubles hence compression doubles
			Total	8	

Question 8			Expected Answers	Marks	Additional Guidance
(a)	(i)		$v^2 = u^2 + 2as$ a = 16^2 / 2 x 28 = 4.57 (m s^{-2})	 C1 A1	 Allow any subject Using 40, 16 or 12 (m) can score one mark providing some working shown. (Ans. 3.2, 8.0 or 10.7)
	(ii)		F = ma / F = 850 x 4.57 F = 3900 (3886) (N)	C1 A1	 Allow ecf from (a)(i) (eg. ans 2720, 6800 or 9100)
(b)	(i)		road supplies frictional force on tyre / wheel Friction provides a force backwards or opposite direction to motion (on tyre / wheel / car).	B1 B1	Do not allow on the car
	(ii)		Reduced friction	B1	
			Total	7	

(iv) Calculate the tension T_2.

T_2 = ... N **[1]**

(v) Calculate the minimum power required by the motor to lift the boat at a constant speed of $0.015\,m\,s^{-1}$.

power = ...W **[2]**

(c) Describe and explain one situation during the lifting of the boat when it will not be in equilibrium.

....

.... **[1]**

[Total: 10]

6 In this question, two marks are available for the quality of written communication.

(a) Use the following terms to explain the behaviour of a spring when a tensile force is applied:

extension **Hooke's law** **elastic limit** **spring constant**

....

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....

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.... **[3]**

THIS QUESTION CONTINUES ON PAGE 16

(b) Describe how the following terms may be used to compare materials:

stiff **strong** **brittle** **ductile**

In your answer you should include the quantities stress, strain and Young modulus and the terms elastic and plastic.

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.... **[5]**

Quality of Written Communication **[2]**

[Total: 10]

END OF QUESTION PAPER

Question 6			Expected Answers	Marks	Additional Guidance
QWC			The answer must involve physics, which attempts to answer the question. Structure and organisation: Award this mark if the whole answer is well structured / description easy to follow in reasonable order of terms SPAG do not award this mark if there are more than three spelling mistakes and grammatical errors.	B1 B1	need at least two sentences before these marks can be given
			Total	10	

Question 6	Expected Answers	Marks	Additional Guidance
(a)	**Extension: extended length – original length / the increase in length (when force is applied to spring)** **Hooke's Law: force is proportional to the extension or stress is proportional to strain (provided not past limit of proportionality)** **Elastic limit: spring returns to original length when <u>the force is removed</u> / or suffers <u>permanent</u> deformation** **Force constant: force / extension / F = ke / F = kx**	**MAX B3**	Not how much a wire stretches. Gradient of a force / extension graph or inverse gradient of an extension / force graph Allow symbols not defined
(b)	**Y M = stress / strain (up to the limit of proportionality)** **strain = extension / (original) length and stress = force / area** **A stiff material has high / large Y M** **stiffness related to how difficult it is to deform a material** **a strong material can take a high (maximum) <u>stress</u> (before breaking)** **brittle <u>no</u> plastic region / breaks in elastic region or at elastic limit** **ductile can be drawn into a wire / <u>large</u> plastic region / retains new or deformed shape**	**MAX B5**	both required but allow symbols only – do not accept a single combined expression for Young modulus e.g. bending, stretching, not large force

3 A lift has a mass of 500 kg. It is designed to carry a maximum of 8 people of total mass 560 kg. The lift is supported by a steel cable of cross-sectional area $3.8 \times 10^{-4}\,m^2$. When the lift is at ground floor level the cable is at its maximum length of 140 m, as shown in Fig. 3.1. The mass per unit length of the cable is $3.0\,kg\,m^{-1}$.

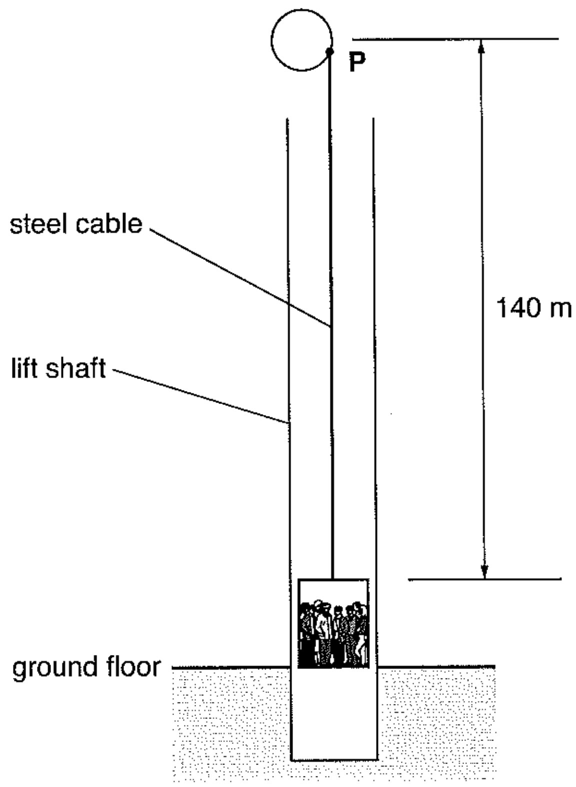


Fig. 3.1

(a) Show that the mass of the 140 m long steel cable is 420 kg.

[1]

(b) (i) The lift with its 8 passengers is stationary at the ground floor level. The initial upward acceleration of the lift and the cable is $1.8\,\text{m}\,\text{s}^{-2}$. Show that the **maximum** tension in the cable at point **P** is $1.7 \times 10^4\,\text{N}$.

[4]

(ii) Calculate the maximum stress in the cable.

stress = ... Pa **[2]**

[Total: 7]

Question			Expected Answers	Marks	Additional Guidance
3	(a)		mass = 140 × 3.0 (= 420 kg)	B1	**Allow:** $\frac{420}{3.0} = 140$ (reverse argument)
	(b)	(i)	total mass = 500 + 560 + 420 (= 1480 kg) total weight = 1480 × 9.8(1) / total weight = 14520 (N) net force = 1480 × 1.8 / net force = 2664 (N) tension = 14520 + 2664 tension = 1.7(2) × 10^4 (N)	C1 C1 C1 C1 A0	**Note:** Omitting one of the masses – can score maximum of 3 Omitting two masses – can score maximum of 2 **Examples:** 3 marks if mass of cable is omitted tension = 1908 +10400 = 1.23 × 10^4 (N) 2 marks if mass of cable and people are omitted tension = 900 + 4905 = 5.8 × 10^3 (N) **Note:** 4 marks for 'tension = $(m(g+a)=)$ 1480 × (9.81 + 1.8)'
		(ii)	stress = $\frac{1.72\times10^4}{3.8\times10^{-4}}$ / stress = $\frac{(b)(i)}{3.8\times10^{-4}}$ stress = 4.5(3) × 10^7 (Pa)	C1 A1	Possible ecf from **(i)** **Note:** A tension of 1.7 × 10^4 (N) gives an answer of 4.4(7) × 10^7 (Pa)
			Total	**7**	

6 The force against length graph for a spring is shown in Fig. 6.1.

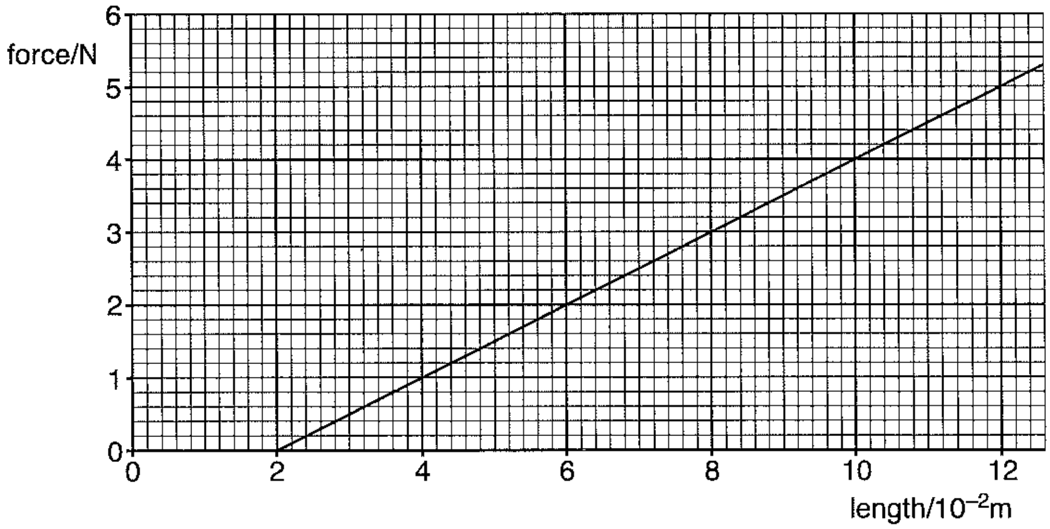


Fig. 6.1

(a) Explain why the graph does not pass through the origin.

....

.... **[1]**

(b) State what feature of the graph shows that the spring obeys Hooke's law.

....

.... **[1]**

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ... $N\,m^{-1}$ **[2]**

(d) Calculate the work done on the spring when its length is increased from 2.0×10^{-2} m to 8.0×10^{-2} m.

work done = ... J **[2]**

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 6.2 shows the displacement *s* against time *t* graph for the mass.

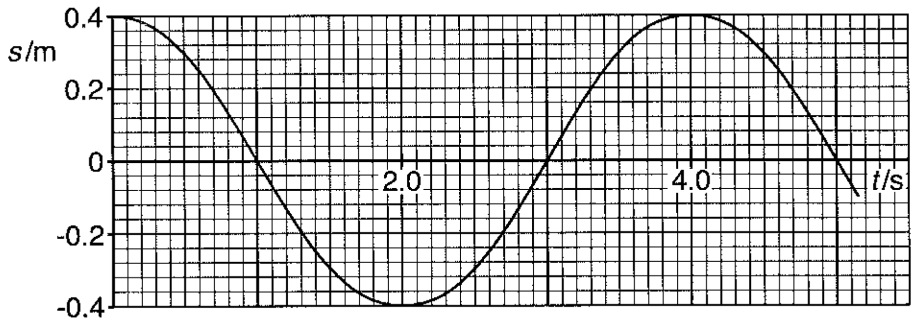


Fig. 6.2

Explain how you can use Fig. 6.2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

....

....

....

.... **[2]**

[Total: 8]

Question			Expected Answers	Marks	Additional Guidance
6	(a)		The graph shows length and not extension of the spring / spring has original length (of 2.0 cm) (AW)	B1	**Allow**: 'length cannot be zero'
	(b)		Straight line (graph) / linear graph / force $\propto$ <u>extension</u> / constant gradient (graph)	B1	**Not** 'force $\propto$ <u>length</u>'
	(c)		force constant = $\frac{2.0}{0.04}$ force constant = 50 (N m^{-1})	C1 A1	**Note**: The mark is for any correct substitution **Allow**: 1 mark for 0.5 (N m^{-1}) – 10^n error **Allow** 1 mark for 5/12 × 10^{-2} = 41.7 or 4/10 × 10^{-2} = 40 or 3/8 × 10^{-2} = 37.5 or 2/6 × 10^{-2} = 33.3 or 1/4 × 10^{-2} = 25
	(d)		work done = $\frac{1}{2}Fx$ or $\frac{1}{2}kx^2$ or 'area under graph' work done = $\frac{1}{2}\times 3.0\times 0.06$ or $\frac{1}{2}\times 50\times 0.06^2$ work done = 0.09 (J)	C1 A1	Possible ecf **Note**: 1 sf answer is allowed
	(e)		Find the gradient / slope (of the tangent / graph) Maximum speed at 1.0s / 3.0s / 5.0s / steepest 'part' of graph / displacement = 0	B1 B1	**Allow**:2 marks for 'steepest / maximum gradient'
			Total	**8**	

7 **(a)** Fig. 7.1 shows a length of tape under tension.

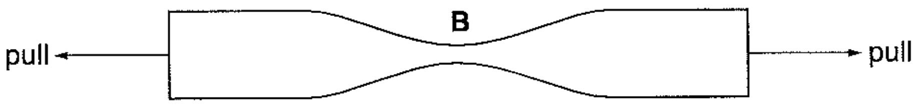


Fig. 7.1

(i) Explain why the tape is most likely to break at point **B**.

....

.... [1]

(ii) Explain what is meant by the statement:

'the tape has gone beyond its elastic limit'.

....

....

.... [1]

(b) Fig. 7.2 shows one possible method for determining the Young modulus of a metal in the form of a wire.

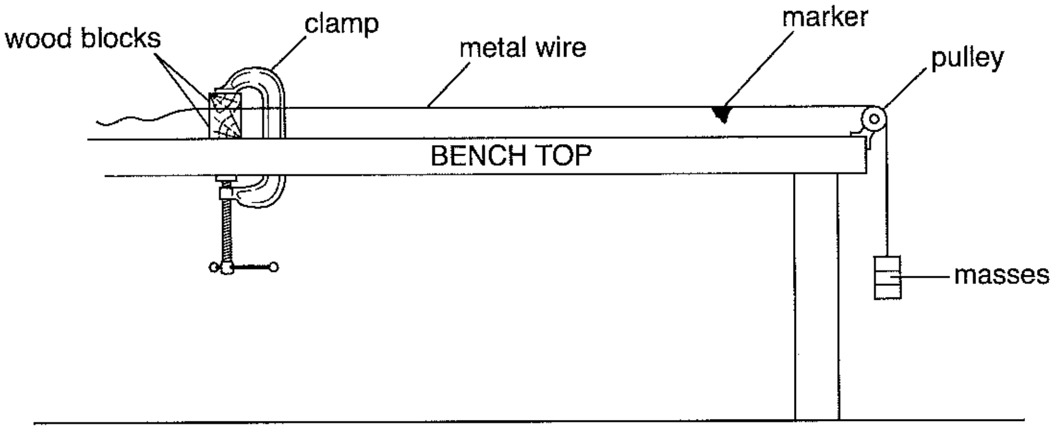


Fig. 7.2

Describe how you can use this apparatus to determine the Young modulus of the metal. The sections below should be helpful when writing your answers.

The **measurements** to be taken:

In your answer, you should use appropriate technical terms, spelled correctly.

The **equipment** used to take the measurements:

In your answer, you should use appropriate technical terms, spelled correctly.

How you would **determine** Young modulus from your measurements:

[8]

[Total: 10]

END OF QUESTION PAPER

Question			Expected Answers	Marks	Additional Guidance
7	(a)	(i)	It has maximum / large / increased stress at this point	B1	**Allow**: it has 'same force but thinner/smaller area' **Not**: Thin / small area
		(ii)	The tape has (permanent) extension / deformation when the force / stress is removed (AW)	B1	**Note**: Need reference to force or stress removed **Allow**: '.. does not return to original size / shape / length when force / stress is removed'
	(b)		**Measurement:** ✎ Diameter Any two from: • original / initial length (**Not**: final length) • extension / initial and final lengths • weight / mass	B1 B1 X 2	**The term *diameter* to be included and spelled correctly to gain the mark**
			Equipment: ✎ Micrometer / vernier (calliper) (for the diameter of the wire) Any two from: • Ruler / (metre) rule / tape measure (for measuring the original length / extension) • Travelling microscope (for measuring extension) • Scales / balance (for measuring the mass & *mg* equation is used or for measuring weight) / Newtonmeter (for the weight of hanging masses) / 'known' weights used	B1 B1 × 2	**The term *micrometer / vernier* (*calliper*) to be included and spelled correctly to the gain mark. (ALLOW: Micrometer is used to measure area / radius / thickness – as BOD)** **Allow**: 'known masses & *mg* equation' but **not** 'known masses'
			Determining Young modulus: • stress = force/(cross-sectional) area and strain = extension/original length • Young modulus = stress/strain / Young modulus is equal to the gradient from stress-strain graph (in the linear region)	B1 B1	**Allow**: stress = F/A and strain = x/L **Special case for determining Young modulus:** Gradient from force-extension graph is $\frac{EA}{L}$ B1 Young modulus = gradient × L/A B1
			Total	10	

7 **(a)** Fig. 7.1 shows stress against strain graphs for two materials **X** and **Y** up to their breaking points.

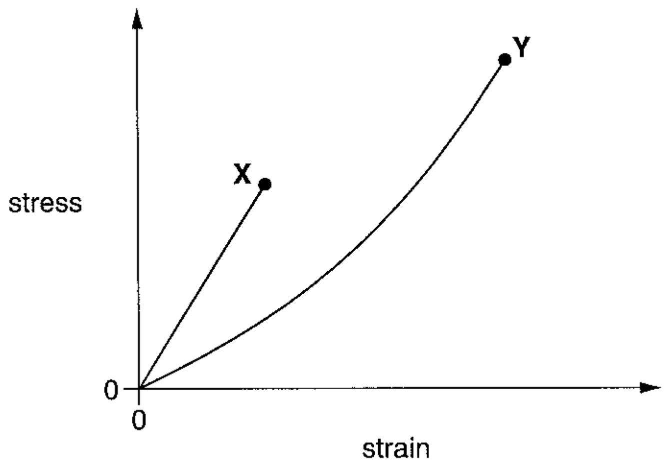


Fig. 7.1

Put a tick (✓) in the appropriate column if the statement applies to the material.

Statement	X	Y
This material is brittle.		
This material has greater breaking stress.		
This material obeys Hooke's Law.		

[1]

(b) Kevlar is one of the strongest man-made materials. It is used in reinforcing boat hulls, aircraft, tyres and bullet-proof vests. Sudden impacts cause this material to undergo plastic deformation.

(i) Explain what is meant by *plastic deformation.*

....

....

.... **[1]**

(ii) One particular type of Kevlar has breaking stress 3.00×10^9 Pa and Young modulus 1.30×10^{11} Pa. For a Kevlar thread of cross-sectional area 1.02×10^{-7} m^2 and length 0.500 m, calculate

1 the maximum breaking force

force = ... N

2 the extension of the thread when the stress is 1.20×10^9 Pa.

extension = ... m

[4]

[Total: 6]

END OF QUESTION PAPER

<table>
<tr><th>Q 7</th><th>Expected Answers</th><th>Marks</th><th>Additional Guidance</th></tr>
<tr><td>a</td><td><table><tr><th>X</th><th>Y</th></tr><tr><td>✓</td><td></td></tr><tr><td></td><td>✓</td></tr><tr><td>✓</td><td></td></tr></table></td><td>B1</td><td>All 3 ticks correctly placed for 1 mark</td></tr>
<tr><td>b(i)</td><td>Material is permanently deformed / longer when stress / force is removed (wtte)</td><td>B1</td><td>Note: The answer must make reference to stress or forces <u>removed</u></td></tr>
<tr><td>b(ii)1</td><td>(stress = force/area)
force = $3.00 \times 10^9 \times 1.02 \times 10^{-7}$

force = 306 (N) or 310 (N)</td><td>C1

A1</td><td>Allow: Any subject

Allow: 2 marks for a bald 306 (N) or 310 (N)</td></tr>
<tr><td>b(ii)2</td><td>(E = stress/strain)
strain = $\frac{1.20\times10^9}{1.30\times10^{11}}$ / strain = 9.23×10^{-3}
extension = $9.23 \times 10^{-3} \times 0.500$

extension = $4.6(15) \times 10^{-3}$ (m)</td><td>C1

A1</td><td>Allow: 4.6×10^{-3}, 4.61×10^{-3}, 4.62×10^{-3}
Allow: 2 marks for a bald $4.6(15) \times 10^{-3}$ (m)
Allow: 1 mark for using breaking stress of 3.0×10^9 Pa; this gives an extension of 0.0115 (m)

Alternative answer:
$x = (1.20 \times 10^9 \times 0.500)/1.30 \times 10^{11}$ C1 (Any subject)
extension = $4.6(15) \times 10^{-3}$ (m) A1</td></tr>
<tr><td></td><td>Total</td><td>6</td><td></td></tr>
</table>

7 **(a)** Fig. 7.1 shows stress against strain graphs for materials **X**, **Y** and **Z** up to their breaking points.

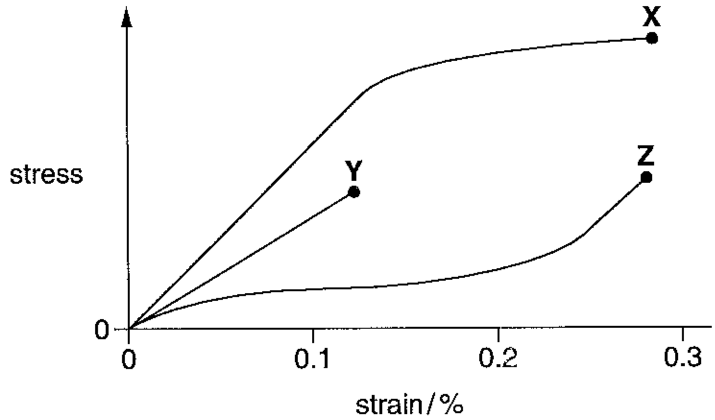


Fig. 7.1

(i) State which of these three materials is brittle.

.... **[1]**

(ii) State one similarity between the properties of materials **X** and **Y** for strains less than 0.05%.

....

.... **[1]**

(iii) State and explain which material has the greatest value for the Young modulus.

....

....

.... **[2]**

(b) Engineers are testing a new material to be used as support cables for a bridge. In a laboratory test, the breaking force for a sample of the material of diameter 0.50 mm is 240 N. Estimate the breaking force for a cable of diameter 15 mm made from the same material.

breaking force = ... N **[2]**

[Total: 6]

Please turnover for Question 8.

Q7	Expected Answers	Marks	Additional Guidance
a(i)	**Y** (is brittle)	B1	
a(ii)	(Both) obey Hooke's law	B1	**Allow** (For both) stress ∝ strain / elastic (behaviour) / 'not plastic (behaviour)' / force ∝ extension **Not**: 'straight line(s)'
a(iii)	Gradient (of the linear section) is equal to Young Modulus / gradient is largest **X** (has largest Young modulus)	B1 B1	**Allow**: 'slope' for 'gradient'
b	(force increases by a factor of) 30^2 force = 240×30^2 force = 2.16×10^5 (N)	C1 A1	 **Allow**: 1 mark for value of breaking stress of $1.2(2) \times 10^9$ (Pa)
	Total	6	

Answer **all** the questions.

1 **(a)** The areas under the graphs below are physical quantities.

(i) Fig. 1.1 shows a force against extension graph for a rubber band.

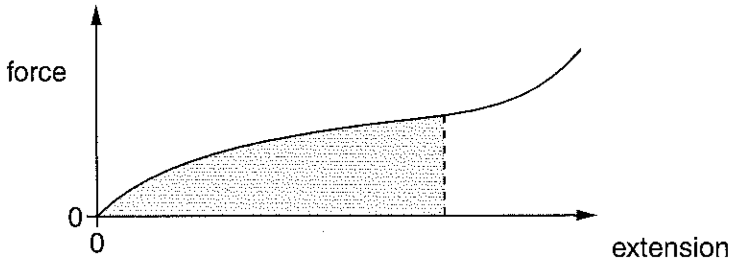


Fig. 1.1

State the quantity represented by the area under the force against extension graph.

.... [1]

(ii) Fig. 1.2 shows the velocity against time graph for an accelerating car.

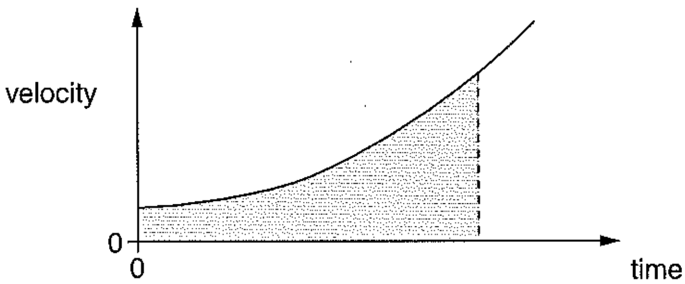


Fig. 1.2

State the quantity represented by the area under the velocity against time graph.

.... [1]

(b) State two quantities in physics that have the **same** unit of newton metre (N m).

quantity 1 .... [1]

quantity 2 .... [1]

[Total: 4]

Note about significant figures:

Significant figures are rigorously assessed in the practical skills.
If the data given in a question is to 2 sf, then allow answers to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Additional Guidance.

Question			Expected Answers	Marks	Additional Guidance
1	a	i	work (done) / (elastic potential) energy	B1	**Not:** heat / gravitational potential energy / kinetic energy
		ii	displacement / distance	B1	
	b		Any two from: • Torque (of a couple) • Moment (of a force) • Work (done) / energy	B1×2	**Not:** 'Couple' for 'torque' **Allow**: PE / KE
			Total	**4**	

7 **(a)** Atoms in a solid are held in position by electrical forces. These electrical forces can be represented by an imaginary 'interatomic spring' between neighbouring atoms, see Fig. 7.1.

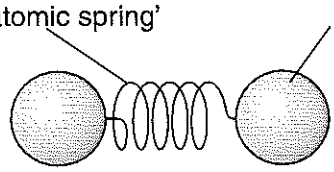


Fig. 7.1

The interatomic spring obeys *Hooke's law* and has a *force constant* just as a normal spring in the laboratory. Researchers in America have recently managed to determine the force experienced by an individual atom of cobalt when the atoms are squeezed together. The researchers found that a force of 210 pN changed the separation between a pair of atoms by a distance of 0.16 nm.

(i) State *Hooke's law.*

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

.... **[1]**

(ii) Calculate the force constant of the interatomic spring for a pair of cobalt atoms.

force constant = ... $N\,m^{-1}$ **[3]**

(b) Fig. 7.2 shows a stress against strain graph for a metal wire up to its breaking point.

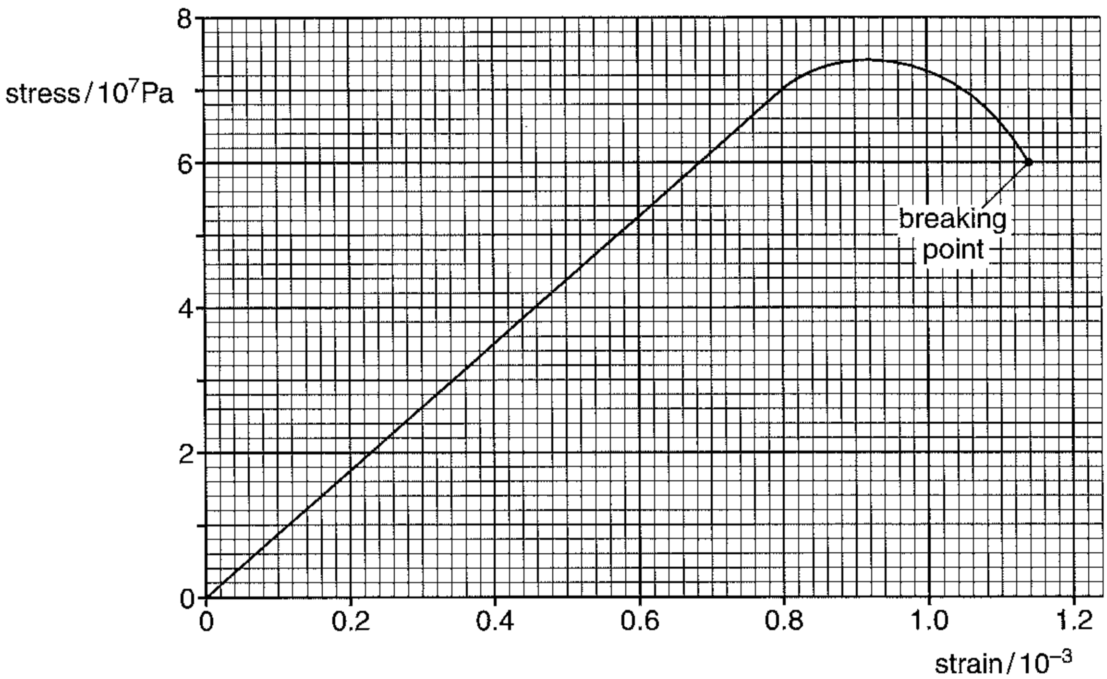


Fig. 7.2

(i) Use the graph to determine the Young modulus of the metal.

Young modulus = ... unit ....**[3]**

(ii) The wire breaks when a force of 19 N is applied. Use the graph to determine the cross-sectional area of the wire at the breaking point.

area = ... m^2 **[2]**

[Total: 9]

END OF QUESTION PAPER

Question			Expected Answers	Marks	Additional Guidance
7	a	i	Extension is proportional to force (applied as long as the elastic limit is not exceeded)	B1	**Must use tick or cross on Scoris to show if the mark is awarded** ✐ This B1 can only be scored when '***extension***' is spelled correctly **Note:** If '*change in length*' or '*Δ length*' used instead of '*extension*', then ***length*** must be spelled correctly **Allow:** stress ∝ strain as BOD (stress or stain must be spelled correctly)
		ii	$p \rightarrow 10^{-12}$ $n \rightarrow 10^{-9}$ $k = \frac{F}{x}$ / $k = \frac{210 \times 10^{-12}}{0.16 \times 10^{-9}}$ force constant = 1.3 ($N\ m^{-1}$) or 1.31 ($N\ m^{-1}$)	C1 C1 A1	Possible ecf **Allow:** 1 mark for '210/0.16 =1312.5'
	b	i	E = gradient / E = stress/strain (linear section) $E = \frac{70 \times 10^{6}}{0.8 \times 10^{-3}}$ $E = 8.8 \times 10^{10}$ (Pa) or 8.75×10^{10} (Pa) unit: $N\ m^{-2}$ or Pa	C1 A1 B1	**Allow:** An answer in the range (8.3 to 9.1) × 10^{10} (Pa) **Allow:** 1 mark for an answer 8.75×10^{n}, $n \neq 10$ **Note:** This is an independent mark
		ii	breaking stress = 6.0×10^{7} (Pa) $A = \frac{19}{6.0 \times 10^{7}}$ (Any subject) $A = 3.2 \times 10^{-7}$ (m^2) or 3.17×10^{-7} (m^2)	C1 A1	**Allow:** 1 mark 3.17×10^{n} (m^2), $n \neq -7$ **Note:** No marks if breaking stress of <u>6.0</u> × 10^{n} is not used
			Total	**9**	

6 **(a)** State *Hooke's law*.

....

.... **[1]**

(b) Fig. 6.1 shows a force against extension graph for a spring.

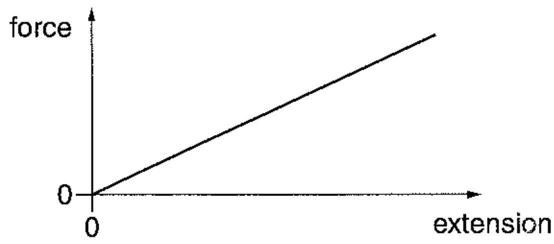


Fig. 6.1

Describe how such a force against extension graph can be used to determine

(i) the *force constant* of the spring

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(ii) the *work done* on the spring.

....

.... **[1]**

(c) Two identical springs are connected end-to-end (series). The force constant of each spring is k. The free ends of the springs are pulled apart as shown in Fig. 6.2.

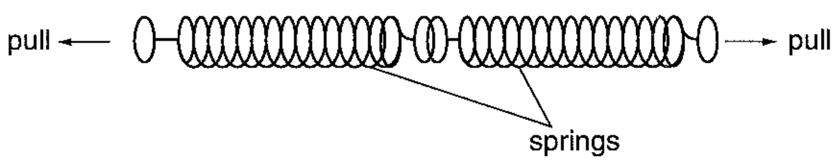


Fig. 6.2

Explain why the force constant of this combination of two springs in series is $\frac{k}{2}$.

....

....

.... **[2]**

(d) **(i)** Define the *Young modulus* of a material and state the condition when it applies.

....

....

.... **[2]**

(ii) A guitar string has length 0.70 m and cross-sectional area 0.20 mm^2. A constant tension of 4.2 N is applied to the string causing a strain of 0.015. Calculate

1 the stress in the string

stress = ... Pa **[2]**

2 the Young modulus of the material of the string

Young modulus = ... Pa **[2]**

3 the elastic potential energy (stored energy) in the string.

energy = ... J **[3]**

[Total: 14]

END OF QUESTION PAPER

Question			Answers	Marks	Guidance
6	(a)		The extension ∝ (applied) force (on spring) (as long as the elastic limit is not exceeded)	B1	
	(b)	(i)	Gradient / slope (of line / graph) / force divided by extension ✐ **The term *gradient /slope / divided* to be included and spelled correctly to gain the B1 mark**	B1	**Must use tick or cross on Scoris to show if the mark is awarded**
		(ii)	Area (under the graph / line)	B1	**Allow:** ½ × force × extension **Allow:** ½ × force constant × extension^2 if **(b)(i)** is correct
	(c)		The extension (for the combination) is doubled Force (for each spring) is the same / constant (force constant = force/extension, hence it is halved)	B1 B1	**Allow:** 1 mark for '*F* is the same, *x* is doubled' **Allow:** 2 marks for 'the springs need half the force to give the same (total) extension'
	(d)	(i)	Young modulus = stress/strain As long as the elastic limit is not exceeded / in the linear region of stress against strain graph / Hooke's law is obeyed	M1 A1	
		(ii) 1	stress = $\frac{4.2}{0.20 \times 10^{-6}}$ stress = 2.1×10^7 (Pa)	C1 A1	**Allow:** 1 mark for 2.1×10^n, $n \neq 7$
		(ii) 2	Young modulus = $\frac{2.1 \times 10^7}{0.015}$ Young modulus = 1.4×10^9 (Pa)	C1 A1	Possible ecf from **(ii)1**
		(ii) 3	energy = $\frac{1}{2}Fx$ $x = 0.70 \times 0.015$ / $x = 0.0105$ (m) energy = $\frac{1}{2} \times 4.2 \times (0.70 \times 0.015)$ energy = 2.2×10^{-2} (J)	 C1 C1 A1	
			Total	**14**	

6 **(a)** Fig. 6.1 shows the stress against strain graphs of two materials **X** and **Y**.

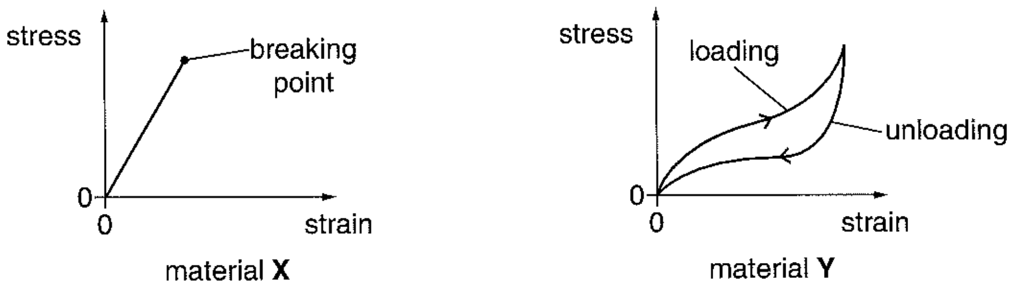


Fig. 6.1

Describe the properties of materials **X** and **Y**.

In your answer, you should use appropriate technical terms, spelled correctly.

material **X** ....

....

....

....

....

material **Y** ....

....

....

....

.... **[5]**

(b) You are given a spring, a metre rule and a 100 g mass. Describe how you would determine the force constant k of the spring.

....

....

....

....

.... **[3]**

(c) A glider of mass 0.180 kg is placed on a horizontal frictionless air track. One end of the glider is attached to a compressible spring of force constant $50\,N\,m^{-1}$. The glider is pushed against a fixed support so that the spring compresses by 0.070 m, see Fig. 6.2. The glider is then released.

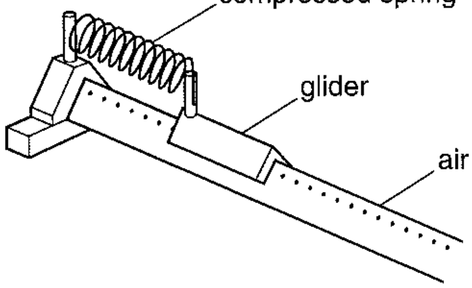


Fig. 6.2

(i) Calculate the horizontal acceleration of the glider **immediately** after release.

acceleration = ... $m\,s^{-2}$ **[3]**

(ii) After release, the spring exerts a force on the glider for a time of 0.094 s. Calculate the average rate of work done by the spring on the glider.

average rate of work done = ... $J\,s^{-1}$ **[2]**

[Total: 13]

Question			Answer	Marks	Guidance
6	(a)		Material **X** It is a ***brittle*** material No plastic deformation / It is elastic / It returns to same length when stress / force is removed Material **Y** It is a polymeric / polymer (material) It is elastic / It returns to same length when stress / force is removed **X** obeys Hooke's law / **Y** does not obey Hooke's law	 B1 B1 B1 B1 B1	**Use ticks on Scoris to show where the marks are awarded** ✐ ***Brittle*** must be spelled correctly to gain the mark. **Allow**: rubber / 'elastic band' **Allow**: energy 'lost' (when unloaded)
	(b)		Place the 100 g mass on the spring / hang the 100 g mass from the spring Determine the extension / compression of the spring (using a ruler) force constant = 0.98(1)/extension	B1 B1 B1	**Allow**: k = (0.1 × 9.8)/extension **Allow**: k = 1.0 (N)/extension
	(c)	(i)	$F = kx$ $F = 50 \times 0.070$ / F = 3.5 (N) a = 3.5/0.180 acceleration = 19 (m s^{-2})	 C1 C1 A1	Answer to 3 sf is 19.4 (m s^{-2})
		(ii)	average work done = <u>average</u> force × displacement = 1.75 × 0.070 (= 0.1225) av rate of work done = 0.1225/0.094 av rate of work done = 1.3 (J s^{-1})	 C1 A1	**Aternative** (allow full credit for other correct methods) $E = \frac{1}{2} \times 50 \times 0.070^2 (= 0.1225)$ C1 power = 0.1225/ 0.094 power = 1.3 (J s^{-1}) A1
			Total	**13**	

8 A sample of wire is tested in the laboratory. Fig. 8.1 shows the force, F against extension, x graph for this wire.

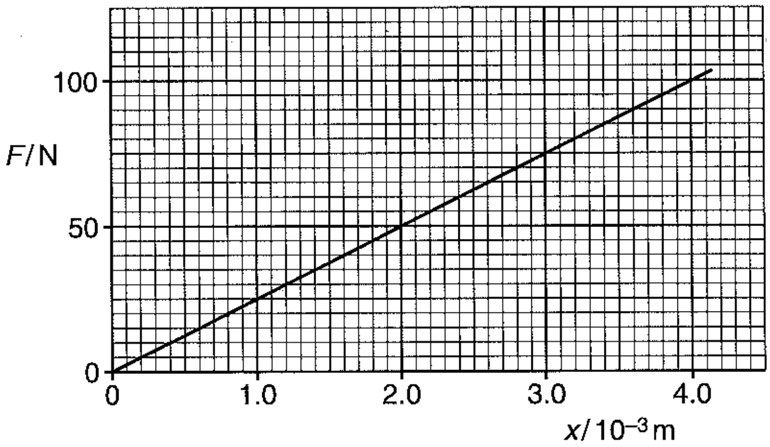


Fig. 8.1

(a) Explain how the graph shows that the wire obeys Hooke's law.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(b) State what the gradient of the graph represents.

.... **[1]**

(c) The initial length of the wire is 1.60 m. The radius of the wire is 2.8×10^{-4} m. Use the graph and this information to determine the Young modulus of the material of the wire.

Young modulus = ... Pa **[3]**

(d) The test is repeated for another wire made from the same material, having the same length but **half** the diameter. Explain how the force against extension graph for this wire will differ from the graph of Fig. 8.1.

....

....

....

....

.... [2]

(e) It is very dangerous if the wire under stress suddenly breaks. The elastic potential energy of the strained wire is converted into kinetic energy. Show that the 'whiplash' speed v of the wire is directly proportional to the extension x of the wire.

....

....

.... [2]

[Total: 9]

END OF QUESTION PAPER

Question			Answer	Marks	Guidance
8	(a)		The graph is a straight line through the origin / F proportional to x / force is proportional to extension	B1	**Use ticks on Scoris to show where the marks are awarded** ✎ ***origin / proportional*** must be spelled correctly to gain the mark **Not**: $F \propto x$
	(b)		force constant	B1	**Allow**: spring constant
	(c)		stress = $\frac{100}{\pi \times (2.8 \times 10^{-4})^2}$ (= 4.06×10^8 Pa) strain = $\frac{4.0 \times 10^{-3}}{1.60}$ (= 2.5×10^{-3}) $E = \frac{4.06 \times 10^8}{2.5 \times 10^{-3}}$ Young modulus = 1.6×10^{11} (Pa)	C1 C1 A1	**Allow** use of any other point on the graph. **Alternative method:** $E = \frac{FL}{Ax}$ C1 (Any subject) $E = \frac{100 \times 1.60}{\pi \times (2.8 \times 10^{-4})^2 \times 4.0 \times 10^{-3}}$ C1 $E = 1.6 \times 10^{11}$ (Pa) A1 **Allow** 2 marks for 1.6×10^n, $n \neq 11$ (POT error)
	(d)		(Straight line) with quarter gradient Correct reasoning, for example: • gradient = EA/L and A decreases by a factor of 4 • A decreases by a factor of 4 and the same force gives 4 times the extension	B1 B1	**Note**: No need to define the labels
	(e)		$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ Manipulation leading to $v \propto x$, for example: • taking square root of both sides (gives $v \propto x$) • $v^2 \propto x^2$ (hence $v \propto x$) • $v = (\sqrt{k/m})x$ (and therefore $v \propto x$)	M1 A1	**Note**: No need to define the labels
			Total	**9**	

3 **(a)** Define the *force constant* of a spring.

....

.... **[1]**

(b) Fig. 3.1 shows a trolley attached by two **stretched** springs **A** and **B** to fixed supports.

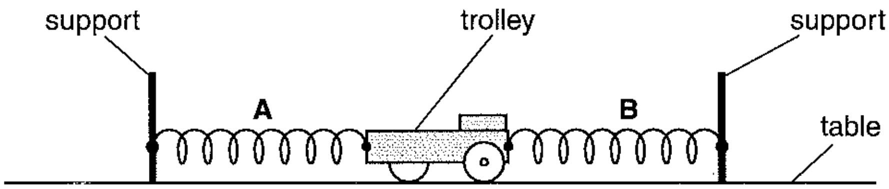


Fig. 3.1

The trolley is on a horizontal table and at rest. The springs **A** and **B** are identical.

(i) On Fig. 3.1, draw an arrow to show the direction of the force exerted by spring **A** on the trolley. Label this arrow **F**. **[1]**

(ii) The mass of the trolley is 0.80 kg. The force constant of each spring is $14\,N\,m^{-1}$. A student pulls the trolley to the left as shown in Fig. 3.2.

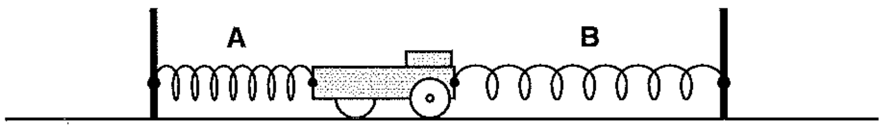


Fig. 3.2

The extension of spring **A** is 0.30 m and the extension of spring **B** is 0.50 m. The student releases the trolley. Calculate the **initial** values of

1 the acceleration of the trolley

acceleration = ... m s^{-2} **[3]**

2 the ratio

$$\frac{\text{elastic potential energy for spring } \mathbf{B}}{\text{elastic potential energy for spring } \mathbf{A}}.$$

ratio = ... **[2]**

(iii) Explain why the acceleration of the trolley decreases as it travels a small distance to the right.

....

.... **[1]**

(iv) State and explain how the acceleration in your answer to **(ii)1** would be different when a heavy object is fixed to the trolley.

....

....

....

.... **[2]**

[Total: 10]

Question			Answer	Marks	Guidance
3	(a)		force/extension or force per (unit) extension	B1	**Allow**: force/compression **Not**: $F = kx$ and the labels are defined, because k is not the subject
	(b)	(i)	Arrow showing the force exerted by **A** is to the <u>left</u> on Fig.3.1	B1	**Allow** an unlabelled arrow
		(ii)	**1** (F_A =) 14 × 0.30 (= 4.2 N) or (F_B =) 14 × 0.50 (= 7.0 N) or (net force =) 2.8 (N)	C1	**Allow**: (net force =) 14 × [0.50 – 0.30] = 2.8 (N) **Allow**: acceleration of either 5.25 (m s^{-2}) or 8.75 (m s^{-2})
			a = 2.8/0.80	C1	**Allow** this C1 mark for a = 8.75 – 5.25
			acceleration = 3.5 (m s^{-2})	A1	**Note**: $a = \frac{7.0+4.2}{0.80} = 14$ (m s^{-2}) scores 1 mark **Note**: $a = \frac{14 \times 0.80}{0.80} = 14$ (m s^{-2}) scores zero
			2 $E = \frac{1}{2} Fx$ or $E = \frac{1}{2} kx^2$ or 1.75 (J) or 0.63 (J)	C1	**Note**: Using $E = Fx$ scores zero because of wrong physics
			ratio = $\left(\frac{0.50}{0.30}\right)^2 = 2.8$	A1	**Note**: Answer to 3 sf is 2.78 **Allow** fractions (Ignore any units given for the ratio)
		(iii)	The <u>resultant</u> force (on the trolley) is smaller (AW)	B1	
		(iv)	The acceleration decreases Correct reasoning, eg: For the same (net force) F, a = F/m (therefore a is smaller) For the same (net force) F, $a \propto 1/m$ (therefore a is smaller)	M1 A1	**Allow**: $F = ma$. As m increases then a must decrease because F is constant
			Total	**10**	

8 **(a)** Fig. 8.1 shows the stress against strain graph obtained from a test on a sample of wire of a ductile material.

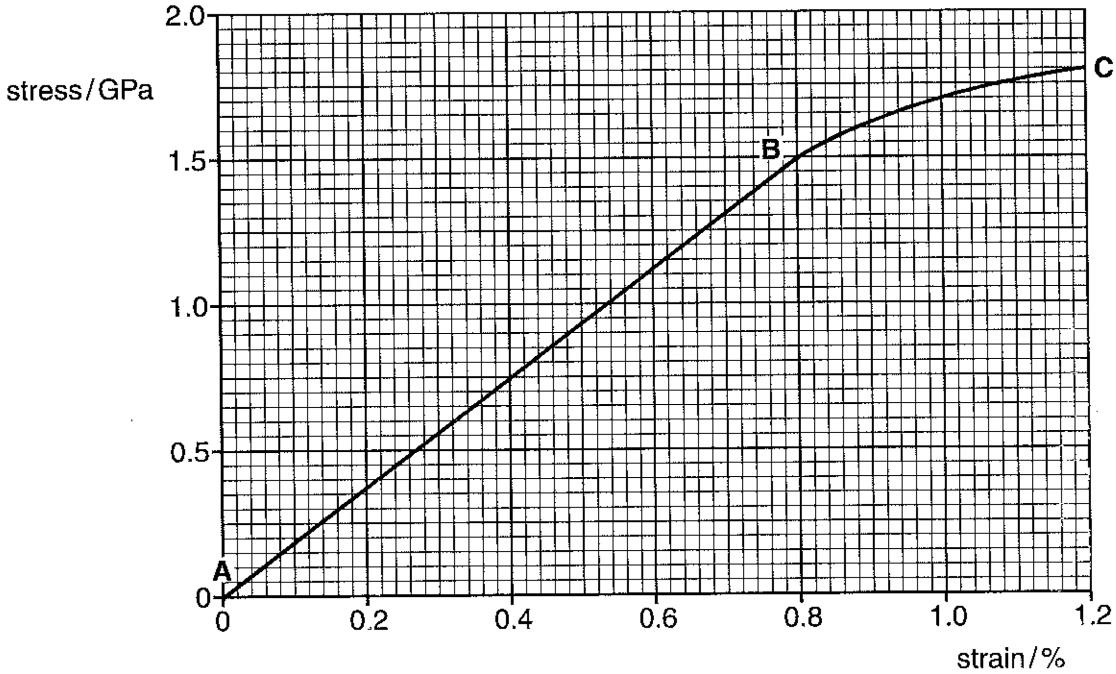


Fig. 8.1

(i) Use Fig. 8.1 to determine the Young modulus of the material.

Young modulus = ... Pa **[3]**

(ii) Use Fig. 8.1 to describe the behaviour of the material

1 in section **AB**

....

.... **[1]**

2 in section **BC**.

....

.... **[1]**

(iii) State and explain the effect on the linear section **AB** of the graph when a sample of the same wire, but of twice the original length is used.

....

....

.... [2]

(b) Fig. 8.2 shows a force against extension graph for an elastic material. The work done on this material during loading (upward arrow) is equal to the energy returned by the material when the load is removed (downward arrow).

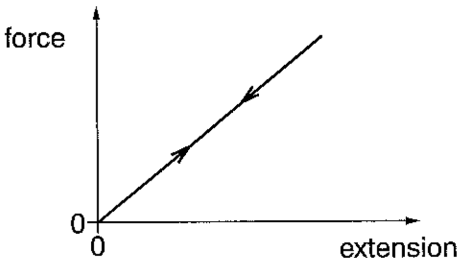


Fig. 8.2

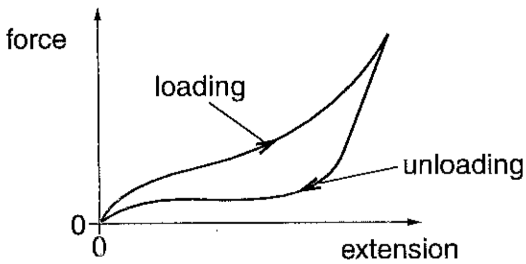


Fig. 8.3

Fig. 8.3 shows the force against extension graph for a material used to make aeroplane tyres. Aeroplane tyres experience sudden impact forces during landing.

Identify the type of material from Fig. 8.3. Describe the properties of this material and suggest why this material is suitable for aeroplane tyres.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

....

....

....

.... [3]

[Total: 10]

END OF QUESTION PAPER

Question			Answer	Marks	Guidance
8	(a)	(i)	Young modulus = gradient (in the linear region) $E = 1.5 \times 10^9/0.008$ $E = 1.9 \times 10^{11}$ (Pa)	C1 C1 A1	**Allow**: (E =) stress/strain for this C1 mark **Note**: Deduct 1 mark for incorrect value or omission of the prefix G. Also deduct another mark for incorrect conversion of 0.80% strain.
		(ii)	**1** Obeys Hooke's law/elastic (behaviour) (AW)	B1	**Allow**: stress $\propto$ strain
		(ii)	**2** Plastic (deformation) (AW)	B1	
		(iii)	No change (to the linear section)/gradient is the same because the Young modulus is the same (and independent of length)	M1 A1	
	(b)		Polymer or polymeric or rubber Any <u>one</u> from: • The material is elastic/there is no strain when the stress is removed/material returns to its original size or shape when forces are removed (AW) • The work done on the material > energy returned back by the material or area under loading graph > area under unloading graph (AW) The aeroplane/tyres do not bounce (too much on landing)	B1 B1 B1	✎ ***polymer/polymeric/rubber*** must be spelled correctly to gain the first B1 mark **Not**: 'Monomer' **Allow**: material/graph shows 'hysteresis' **Allow**: Material 'absorbs' energy/material gets hot (AW)
			Total	**10**	

3 **(a)** Fig. 3.1 shows the stress against strain graph for a metal **X** up to its breaking point.

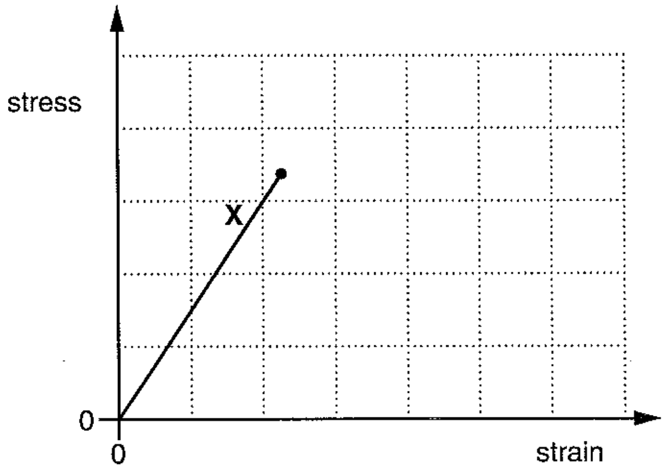


Fig. 3.1

(i) Use Fig. 3.1 to state the physical properties of this metal.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

.... **[2]**

(ii) On the axes of Fig. 3.1, sketch a graph for a ductile material, having a larger Young modulus value than the metal **X**, up to its breaking point. **[2]**

(b) Fig. 3.2 shows a stationary cable car.

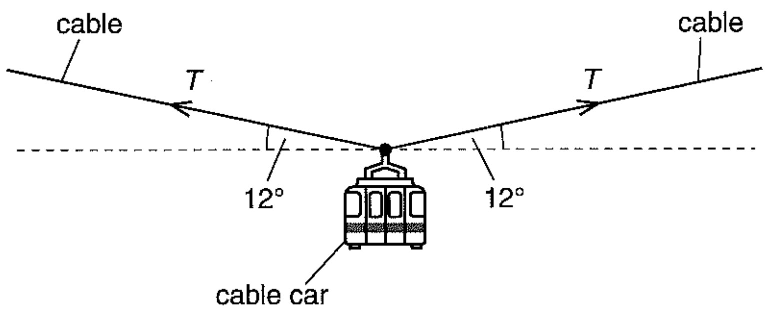


Fig. 3.2

The cable on both sides of the car is at an angle of 12° to the horizontal. The radius of the cable is 2.6×10^{-2} m. The stress in the cable is 1.8×10^{7} Pa. The Young modulus of the material of the cable is 2.0×10^{11} Pa.

(i) Calculate the strain experienced by the cable.

strain = ... **[2]**

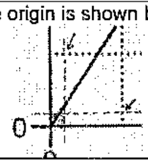
(ii) Calculate the tension T in the cable.

T = ... N **[2]**

(iii) Calculate the weight of the cable car.

weight = ... N **[3]**

[Total: 11]

Question			Answers	Marks	Guidance
3	(a)	(i)	The material is brittle. The material is also elastic.	B1 B1	✎**The term *brittle* to be included and spelled correctly to gain the first B1 mark.** **Allow** 'does not show plastic (deformation)'
		(ii)	Straight line through origin followed by correct curve to show plastic behaviour. Straight line has greater gradient than **X**.	B1 B1	**Note:** Tolerance for the origin is shown below 
	(b)	(i)	strain = $\frac{1.8\times10^{7}}{2.0\times10^{11}}$ (Any subject) strain = 9.0×10^{-5}	C1 A1	The mark is for the correct use of strain = stress ÷ E **Allow** 1 sf answer **Ignore** any unit given
		(ii)	$1.8\times10^{7} = \frac{T}{\pi\times(2.6\times10^{-2})^{2}}$ (Any subject) tension = 3.8×10^{4} (N)	C1 A1	The mark is for the correct use of stress = $\frac{F}{A}$
		(iii)	$2T\sin12 = W$ weight = $2 \times 3.8 \times 10^{4} \times \sin12$ (Any subject) weight = 1.6×10^{4} (N)	C1 C1 A1	 Possible ecf from **(ii)** **Allow** 2 marks for 7.9×10^{3} (N); factor of 2 omitted **Special case:** Using cos12 instead of sin12 gives 7.4..$\times 10^{4}$ (N), allow maximum of 2 marks **Allow** full credit for correct calculation using the sine or the cosine rule **Allow** full credit for an answer using a correct scale drawing: Correct sketch of vector diagram C1; correct vector diagram drawn to scale C1; weight = $(1.6 \pm 0.2) \times 10^{4}$ (N) A1
			Total	**11**	

7 A light spring of unextended length 2.0 cm is hung from a fixed point. An object of weight 3.0 N is hung from the other end of the spring. Fig. 7.1 shows the length of the spring when the object is in equilibrium.

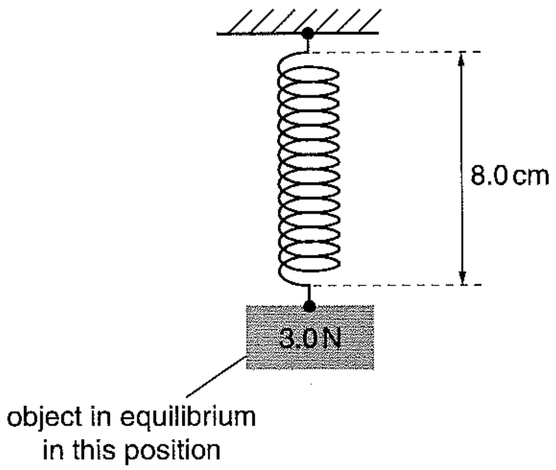


Fig. 7.1

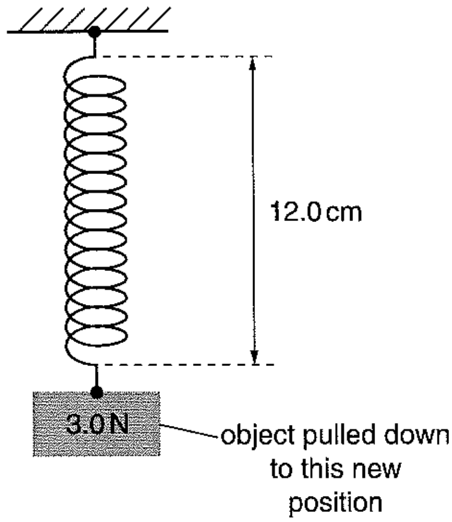


Fig. 7.2

(a) Show that the force constant of the spring is $50\,\mathrm{N\,m^{-1}}$.

[1]

(b) The object is pulled vertically downwards. Fig. 7.2 shows the new length of the spring.

(i) Calculate the change in the elastic potential energy ΔE in the spring.

ΔE = ... J **[3]**

(ii) The object is released from its position shown in Fig. 7.2. Calculate the initial upward acceleration *a* of the object.

a = ... $m\,s^{-2}$ **[3]**

[Total: 7]

END OF QUESTION PAPER

Question			Answers	Marks	Guidance
7	(a)		force constant = $\frac{3.0}{0.06}$ (Any subject) force constant = 50 (N m^{-1})	M1 A0	**Not** 3.0/6.0 = 50 (N m^{-1}) **Note:** There is no mark for the answer because it is given on the paper; the mark is for the working.
	(b)	(i)	(E_i =) ½ × 50 × 0.06^2 or ½ × 3.0 × 0.06 or 0.09 (J) (E_f =) ½ × 50 × 0.10^2 or ½ × 5.0 × 0.10 or 0.25 (J) ΔE = 0.25 – 0.09 ΔE = 0.16 (J)	C1 C1 A1	**Special case** '½ × 50 × (0.10 - 0.06)^2 = 0.04 (J)' mark or '½ × 50 × (0.12 - 0.08)^2 = 0.04 (J)' scores 1
		(ii)	tension in spring = 50 × 0.10 or tension in spring = 5.0 (N) net force = 5.0 – 3.0 and mass of object = 3.0/9.81 a = 2.0/(0.3058..) a = 6.5 (m s^{-2})	C1 C1 A1	**Special case:** 5.0/(3.0/9.81) = 16.35 (m s^{-2}) scores 1 mark because of the first C1 mark **Note:** a = 16.35 – 9.81 = 6.5(4 m s^{-2}) scores full marks
			Total	**7**	

Answer **all** the questions.

1 In each of the following questions a description of a graph is given.

Insert the correct labels for the axes on the dotted lines in Fig. 1.1 to Fig. 1.4.

The first one has been completed for you.

The area under the graph shown in Fig. 1.1 is equal to the elastic potential energy of a spring.

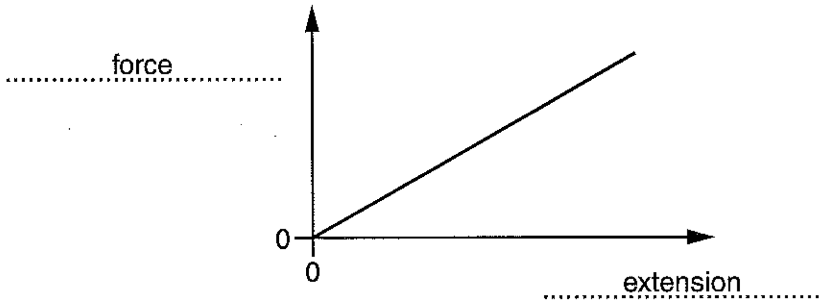


Fig. 1.1

(a) The area under the graph shown in Fig. 1.2 is equal to the displacement of a ball.

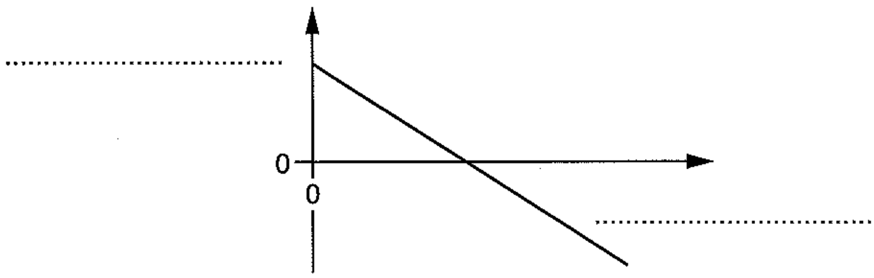


Fig. 1.2

[1]

(b) The gradient of the graph shown in Fig. 1.3 is the Young modulus of a material.

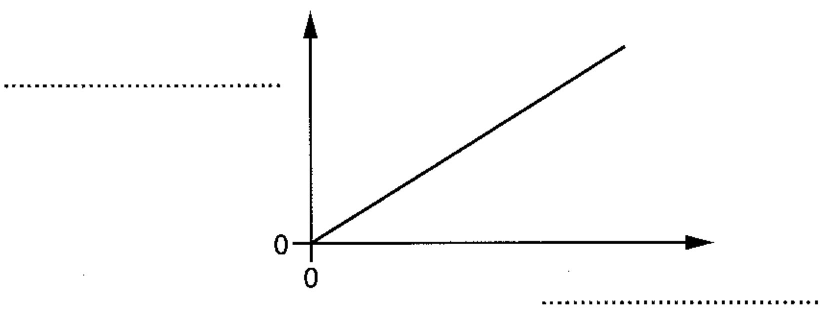
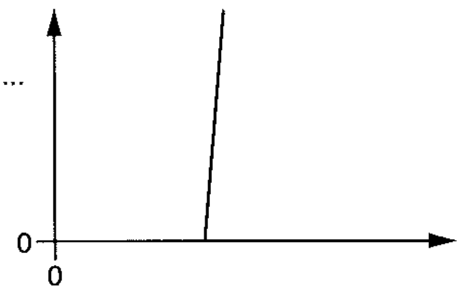


Fig. 1.3

[1]

(c) The gradient of the graph shown in Fig. 1.4 is the force constant of a wire.

....



....

Fig. 1.4

[1]

Turn over for next question

Question			Answer	Marks	Guidance
1	a		velocity against time	B1	**Not** 'speed' for velocity **Not** time against velocity Ignore units
	b		stress against strain	B1	Ignore units
	c		force / load / tension against length (of wire)	B1	**Not** force against extension **Not** 'weight' for force **Not** 'distance' for length Ignore units
			Total	**3**	

8 **(a)** Fig. 8.1 shows a graph of stress against strain for rubber.

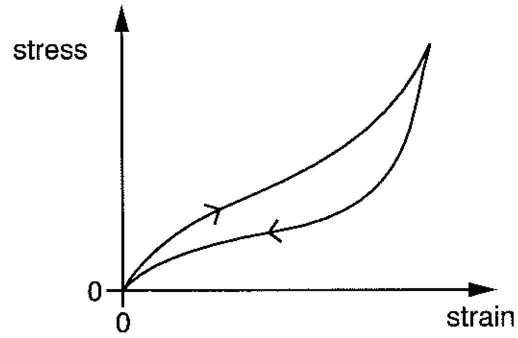


Fig. 8.1

Use Fig. 8.1 to describe the main physical properties of this material.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

.... [3]

(b) Fig. 8.2 shows a metal strip pulled from its ends until it breaks.

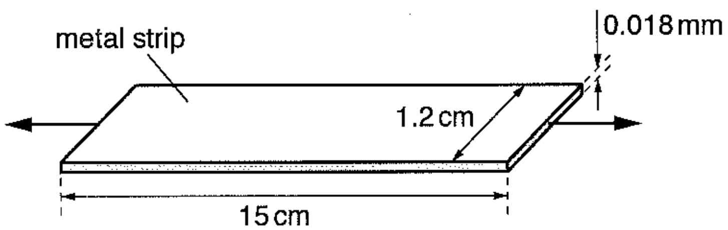


Fig. 8.2

The strip is 15 cm long, 1.2 cm wide and 0.018 mm thick. The breaking force for this strip is 16 N. The Young modulus of the metal is 7.1×10^{10} Pa.

(i) Calculate the extension of the metal strip when it breaks. State one assumption made in your calculation.

extension = ... m **[3]**

assumption: ....

.... **[1]**

(ii) Calculate the breaking force of a rod of radius 0.60 cm made from the same metal.

breaking force = ... N **[2]**

END OF QUESTION PAPER

Question			Answer	Marks	Guidance
8	a		The material is elastic / strain is zero when stress is removed / returns to its original shape when force is removed / there is no plastic deformation	B1	✎ The term **elastic / remove(d) / plastic** must be spelled correctly to gain this mark **Ignore** 'polymeric' **Not** 'it is ductile and elastic'
			It does not obey Hooke's law	B1	**Allow**: Stress is not proportional to strain / force is not proportional to extension
			The loading and unloading graphs are different (AW)	B1	**Allow**: It shows hysteresis / heat produced (when loaded and unloaded)
	b	i	(breaking) stress = $\frac{16}{0.012\times0.018\times10^{-3}}$ or 7.41×10^7 (Pa)	C1	**Alternative:** $x=\frac{FL}{EA}$ (Any subject) C1
			strain = $\frac{7.41\times10^7}{7.1\times10^{10}}$ or 1.04×10^{-3}	C1	extension = $\frac{16\times0.15}{7.1\times10^{10}\times(0.012\times0.018\times10^{-3})}$ C1
			extension = $1.04 \times 10^{-3} \times 0.15$		extension = 1.6×10^{-4} (m) A1
			extension = 1.6×10^{-4} (m)	A1	
			assumption: Hooke's law obeyed / elastic limit is not exceeded / not plastically deformed / (cross-sectional) area is the same / thickness is the same / width is the same / no 'necking' / material is brittle	B1	
		ii	(breaking) stress = same $\frac{F}{\pi\times(0.60\times10^{-2})^2}=7.41\times10^7$	C1	**Allow** other correct methods Possible ecf from **(b)(i)**
			force = 8.4×10^3 (N)	A1	
			Total	**9**	