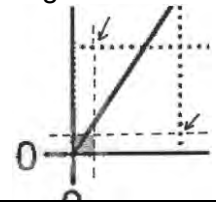
Question			Expected Answers	Marks	Additional Guidance
1	(a)	(i)	It has maximum / large / increased <u>stress</u> at this point	B1	**Allow**: it has 'same force but thinner/smaller area' **Not**: Thin / small area
		(ii)	The tape has (permanent) extension / deformation when the force / stress is removed (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 <u>two</u> from: • original / initial length (**Not**: final length) • extension / initial <u>and</u> final lengths • weight / mass **Equipment:** ✎ Micrometer / vernier (calliper) (for the diameter of the wire) Any <u>two</u> 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 **Determining Young modulus:** • stress = force/(cross-sectional) area <u>and</u> 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 X 2 B1 B1 × 2 B1 B1	**The term *diameter* to be included and spelled correctly to gain the mark** **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' **Allow:** stress = *F*/*A* <u>and</u> 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**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)		elastic potential (energy) / strain (energy)	B1	**Note**: The candidates do not need to include 'energy' since it is in the stem of the question **Not**: 'stored energy' / 'elastic energy'
	(b)	(i)	strain = $\frac{0.35\times10^{-3}}{1.2} = 2.9(2)\times10^{-4}$	B1	
		(ii)	stress = $1.9 \times 10^{11} \times 2.92 \times 10^{-4}$ (= 5.55×10^{7} Pa) tension = $5.55 \times 10^{7} \times 1.4 \times 10^{-7}$ tension = 7.8 (N)	C1 A1	Possible ecf from **b(i)** **Allow**: Bald answer scores 2 marks
	(c)	(i) 1	10^{-9} (m)	B1	
		(i) 2	Material does not return to original length / shape/ size when the force / stress is removed	B1	There must be reference to stress / force removed to score this mark **Note**: If there is no reference to unloading then allow 'material is <u>permanently</u> deformed'
		(ii)	50 times (stronger)	B1	
		(iii)	Less mass / less weight / lighter Stronger / greater tensile strength	B1 B1	
			Total	**9**	

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**	

Question			Answer	Marks	Guidance
4	(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 left 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) a = 2.8/0.80 acceleration = 3.5 (m s^{-2})	C1 C1 A1	**Allow**: (net force =) $14 \times [0.50 - 0.30] = 2.8$ (N) **Allow**: acceleration of either 5.25 (m s^{-2}) or 8.75 (m s^{-2}) **Allow** this C1 mark for $a = 8.75 - 5.25$ **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) ratio = $\left(\frac{0.50}{0.30}\right)^2 = 2.8$	C1 A1	**Note**: Using $E = Fx$ scores zero because of wrong physics **Note**: Answer to 3 sf is 2.78 **Allow** fractions (Ignore any units given for the ratio)
		(iii)	The resultant 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**	

Question			Answer	Marks	Guidance
5	(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**	