



1)

(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 = $1480 \times 9.8(1)$ / total weight = 14520 (N) net force = 1480×1.8 / net force = 2664 (N) tension = $14520 + 2664$ tension = $1.7(2) \times 10^4$ (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 = $1908 + 10400 = 1.23 \times 10^4$ (N) 2 marks if mass of cable and people are omitted tension = $900 + 4905 = 5.8 \times 10^3$ (N) Note: 4 marks for 'tension = $(m(g + a)) = 1480 \times (9.81 + 1.8)$ '
(ii)	stress = $\frac{1.72 \times 10^4}{3.8 \times 10^{-4}}$ / stress = $\frac{(b)(i)}{3.8 \times 10^{-4}}$ stress = $4.5(3) \times 10^7$ (Pa)	C1 A1	Possible ecf from (i) Note: A tension of 1.7×10^4 (N) gives an answer of $4.4(7) \times 10^7$ (Pa)
Total		7	

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 = $\frac{0.35 \times 10^{-3}}{1.2} = 2.9(2) \times 10^{-4}$	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	

3)

(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)		<p>Measurement:  Diameter Any <u>two</u> from:</p> <ul style="list-style-type: none"> original / initial length (Not: final length) extension / initial <u>and</u> final lengths weight / mass <p>Equipment:  Micrometer / vernier (calliper) (for the diameter of the wire) Any <u>two</u> from:</p> <ul style="list-style-type: none"> Ruler / (metre) rule / tape measure (for measuring the original length / extension) Travelling microscope (for measuring extension) Scales / balance (for measuring the mass & <i>mg</i> equation is used or for measuring weight) / Newtonmeter (for the weight of hanging masses) / 'known' weights used <p>Determining Young modulus:</p> <ul style="list-style-type: none"> 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) 	<p>B1</p> <p>B1 X 2</p> <p>B1</p> <p>B1 x 2</p> <p>B1</p> <p>B1</p>	<p>The term <i>diameter</i> to be included and spelled correctly to gain the mark</p> <p>The term <i>micrometer / vernier (calliper)</i> to be included and spelled correctly to the gain mark. (ALLOW: Micrometer is used to measure area / radius / thickness – as BOD)</p> <p>Allow: 'known masses & <i>mg</i> equation' but not 'known masses'</p> <p>Allow: stress = F/A <u>and</u> strain = x/L</p> <p>Special case for determining Young modulus: Gradient from force-extension graph is $\frac{EA}{L}$ B1 Young modulus = gradient $\times L/A$ B1</p>
Total			10	

4)

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

5)

a	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">X</td> <td style="text-align: center;">Y</td> </tr> <tr> <td style="text-align: center;">✓</td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">✓</td> </tr> <tr> <td style="text-align: center;">✓</td> <td></td> </tr> </table>	X	Y	✓			✓	✓		B1	All 3 ticks correctly placed for 1 mark
X	Y										
✓											
	✓										
✓											
b(i)	Material is permanently deformed / longer when stress / force is removed (wtte)	B1	Note: The answer must make reference to stress or forces <u>removed</u>								
b(ii)1	(stress = force/area) force = $3.00 \times 10^9 \times 1.02 \times 10^{-7}$ force = 306 (N) or 310 (N)	C1 A1	Allow: Any subject Allow: 2 marks for a bald 306 (N) or 310 (N)								
b(ii)2	$(E = \text{stress/strain})$ strain = $\frac{1.20 \times 10^9}{1.30 \times 10^{11}}$ / strain = 9.23×10^{-3} extension = $9.23 \times 10^{-3} \times 0.500$ extension = $4.6(15) \times 10^{-3}$ (m)	C1 A1	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								
Total		6									

6)

(a)	<p>Material X It is a brittle material No plastic deformation / It is elastic / It returns to same length when stress / force is removed</p> <p>Material Y It is a polymeric / polymer (material) It is elastic / It returns to same length when stress / force is removed</p> <p>X obeys Hooke's law / Y does not obey Hooke's law</p>	B1 B1 B1 B1 B1	<p>Use ticks on Scoris to show where the marks are awarded ↗ Brittle must be spelled correctly to gain the mark.</p> <p>Allow: rubber / 'elastic band' Allow: energy 'lost' (when unloaded)</p>
(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 = $0.98(1)/\text{extension}$	B1 B1 B1	<p>Allow: $k = (0.1 \times 9.8)/\text{extension}$ Allow: $k = 1.0$ (N)/extension</p>

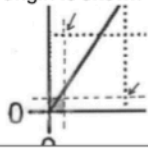
7)

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 ' <i>extension</i> ' is spelled correctly Note: If ' <i>change in length</i> ' or ' Δ length' used instead of ' <i>extension</i> ', then <i>length</i> must be spelled correctly Allow: stress \propto strain as BOD (stress or stain must be spelled correctly)
	ii	$p \rightarrow 10^{-12}$ $n \rightarrow 10^{-9}$ $k = \frac{F}{x} \quad / \quad k = \frac{210 \times 10^{-12}}{0.16 \times 10^{-9}}$ 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	$E = \text{gradient} / E = \text{stress/strain (linear section)}$ $E = \frac{70 \times 10^6}{0.8 \times 10^{-3}}$ $E = 8.8 \times 10^{10}$ (Pa) or 8.75×10^{10} (Pa) unit: N m ⁻² or Pa	C1 A1 B1	Allow: An answer in the range $(8.3 \text{ to } 9.1) \times 10^{10}$ (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 6.0×10^n is not used
Total			9	

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	B1	✍ polymer/polymeric/rubber must be spelled correctly to gain the first B1 mark Not: 'Monomer'
		Any <u>one</u> from: <ul style="list-style-type: none"> 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) 	B1	Allow: material/graph shows 'hysteresis'
		The aeroplane/tyres do not bounce (too much on landing)	B1	Allow: Material 'absorbs' energy/material gets hot (AW)
Total			10	

9)

(a)	(i)	The material is brittle.	B1	The term brittle to be included and spelled correctly to gain the first B1 mark.
		The material is also elastic.	B1	Allow 'does not show plastic (deformation)'
	(ii)	Straight line through origin followed by correct curve to show plastic behaviour.	B1	Note: Tolerance for the origin is shown below
		Straight line has greater gradient than X.	B1	
(b)	(i)	$\text{strain} = \frac{1.8 \times 10^7}{2.0 \times 10^{11}}$ (Any subject)	C1	The mark is for the correct use of $\text{strain} = \frac{\text{stress}}{E}$
		$\text{strain} = 9.0 \times 10^{-5}$	A1	Allow 1 sf answer Ignore any unit given
	(ii)	$1.8 \times 10^7 = \frac{T}{\pi (2.6 \times 10^{-2})^2}$ (Any subject)	C1	The mark is for the correct use of $\text{stress} = \frac{F}{A}$
		tension = 3.8×10^4 (N)	A1	
	(iii)	$2T \sin 12 = W$	C1	
		weight = $2 \times 3.8 \times 10^4 \times \sin 12$ (Any subject)	C1	Possible ecf from (ii)
		weight = 1.6×10^4 (N)	A1	Allow 2 marks for 7.9×10^3 (N); factor of 2 omitted Special case: Using $\cos 12$ instead of $\sin 12$ gives 7.4×10^4 (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	

10)

a		pressure and stress or pressure and Young modulus or stress and Young modulus or moment (of a force) and torque (of a couple)	B1	Allow other correct combinations Allow the following: <ul style="list-style-type: none"> e.m.f. and p.d. Any two from frequency, activity, decay constant and Hubble constant because of the s^{-1} Ignore any units given (even if incorrect) Special case: Allow quantities with no units, e.g. strain and efficiency. Not any combination of length, distance and extension
b	i	x-component = 6.0 (N) and y-component = 2.0 (N)	B1	Allow 1 sf answers Allow tolerance ± 0.1 N Not x-component = 2.0 (N) and y-component = 6.0 (N)
	ii	resultant components are 8.0 (N) and 5.0 (N) $F^2 = 8.0^2 + 5.0^2$ force = 9.4 (N)	C1 C1 A1	Allow: 1 sf values for this C1 mark Possible ecf from (b)(i) with x-components = 2 + b(i) and y-component = 3 + b(i). Note: Answer is 9.43 to 3sf Not an answer left in square root form, e.g. $\sqrt{89}$ Allow full credit for a scale drawing; marks awarded as below: <ul style="list-style-type: none"> A dot / cross / mark at 8.0, 5.0 (± 0.1) C1 Line drawn from 0,0 to 8.0, 5.0 C1 force = 9.4 ± 0.1 (N) A1

11)

a		The material is <u>elastic</u> / strain is zero when stress is <u>removed</u> / returns to its original shape when force is <u>removed</u> / there is no <u>plastic</u> deformation	B1	The term elastic / remove(d) / plastic must be spelled correctly to gain this mark Ignore 'polymeric' Not 'it is ductile <u>and</u> 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 = $\frac{16}{0.012 \times 0.018 \times 10^{-3}}$ or 7.41×10^7 (Pa)	C1	Alternative: $x = \frac{FL}{EA}$ (Any subject) C1 extension = $\frac{16 \times 0.15}{7.1 \times 10^{10} \times (0.012 \times 0.018 \times 10^{-3})}$ C1 extension = 1.6×10^{-4} (m) A1
		strain = $\frac{7.41 \times 10^7}{7.1 \times 10^{10}}$ or 1.04×10^{-3}	C1	
		extension = $1.04 \times 10^{-3} \times 0.15$	A1	
		extension = 1.6×10^{-4} (m)	B1	
	ii	(breaking) stress = same $\frac{F}{\pi \times (0.60 \times 10^{-2})^2} = 7.41 \times 10^7$	C1	Allow other correct methods Possible ecf from (b)(i)
		force = 8.4×10^3 (N)	A1	
Total			9	

12)

(a)		weight = $2.8 \times 10^4 \times 9.81$ or 2.75×10^5 (N)	C1	If g is omitted do not award the first mark but allow ECF for a possible maximum of 3/4 marks. Use FT on the calculation. Allow: 3 marks for 93 (mm) – factor of 4 omitted Alternative approach: weight = $2.8 \times 10^4 \times 9.81$ or 2.75×10^5 (N) C1 extension = $\frac{FL}{AE}$ any subject C1 extension = $\frac{0.25 \times 2.75 \times 10^5 \times 32}{4.5 \times 10^{-4} \times 2.1 \times 10^{11}}$ C1 extension = 23 (mm) A1
		stress in each cable = $\frac{1}{4} \times \frac{2.75 \times 10^5}{4.5 \times 10^{-4}}$	C1	
		or 1.53×10^8 (Pa)		
		strain = $\frac{1.53 \times 10^8}{2.1 \times 10^{11}}$ or 7.28×10^{-4}	C1	
		extension = $7.52 \times 10^{-4} \times 32$ or 0.023 (m)		
		extension = 23 (mm)	A1	
(b)		Extension will increase	B1	Allow: the tension increases to cause the acceleration Allow: Net force is upwards so tension / force in the cables increases
		The tension > weight (for acceleration)	B1	
Total			6	