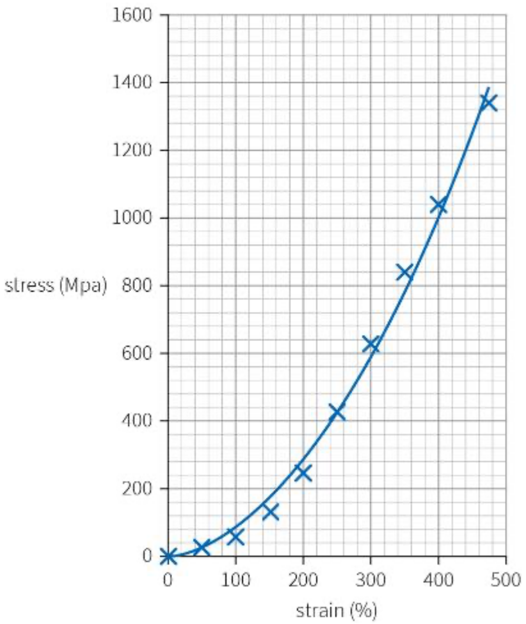
A Level OCR Physics

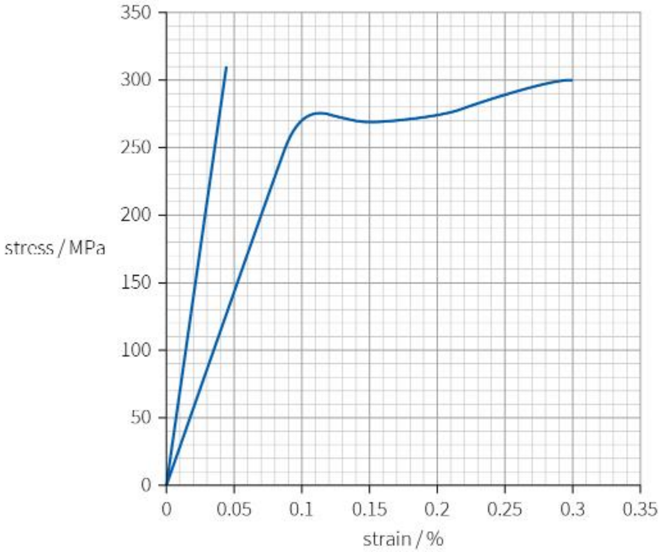
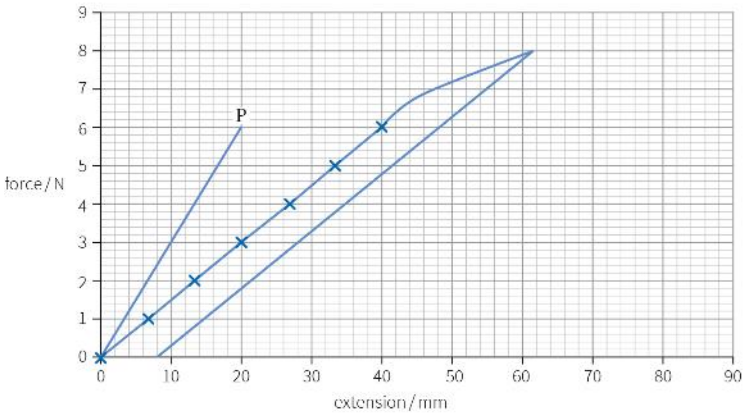
Chapter 8 Materials

Question	Answers		Extra information	Mark	AO	Spec reference
1(a)	Stress = force/area $= 4\ \text{N}/1.62\times10^{-8}\ \text{m}^2$ $= 2.47\times10^{8}\ \text{N/m}^2$ = 247 MPa Graph with final point plotted and line of best fit  		 Answer	 1 1	2	3.4.2
(b)	YM = gradient $= \dfrac{(1200-600)\times10^{6}}{4.4-2.9} = \dfrac{600}{1.5}$ = 400 MPa		Evidence of conversion of strain to decimal Answer	1 1	2	3.4.2

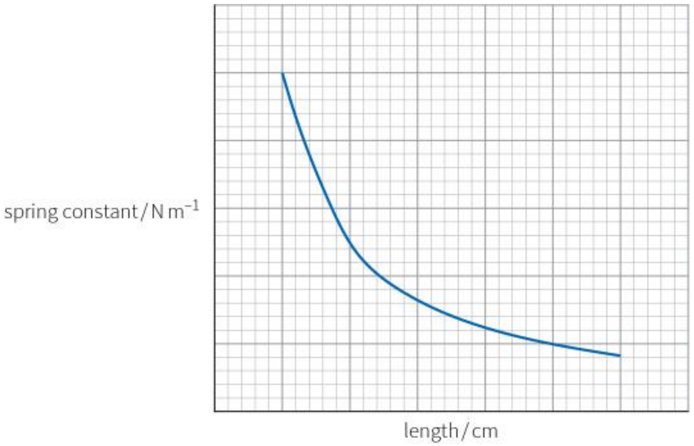
Question	Answers		Extra information	Mark	AO	Spec reference
(c)	Below 250% strain the stiffness is increasing, above 250% it is constant			1	2	3.4.2
(d)	Weight of car = 1200 kg × 9.8 N/kg = 11 7600 N Steel: Yield stress is 250 MPa $\sigma = \frac{F}{A}$ $A = \frac{F}{\sigma} = \frac{11760}{250\ 000\ 000} = 7.2 \times 10^{-6}\ \text{m}^2$ $d = 2\sqrt{\frac{A}{\pi}} = 2\sqrt{\frac{7.2 \times 10^{-6}}{\pi}} = 7.7 \times 10^{-3}\ \text{m}$ silk: Yield stress is 1650 MPa $\sigma = \frac{F}{A}$ $A = \frac{F}{\sigma} = \frac{11760}{1650\ 000\ 000} = 4.7 \times 10^{-5}\ \text{m}^2$ $d = 2\sqrt{\frac{A}{\pi}} = 2\sqrt{\frac{4.7 \times 10^{-5}}{\pi}} = 3.0 \times 10^{-3}\ \text{m}$ The diameter of the silk is less than half that of steel.		Manipulation of equations Answers Comment	1 1 1 1	2	3.4.2
(e)	Assume length of cable = 1 m Weight = mg, $m = \rho V = \rho \pi r^2 = \rho \pi \left(\frac{d}{2}\right)^2$		Use a length, or length cancels in ration at the end. Correct use of weight and density equations	1 1	2	3.4.2

Question	Answers		Extra information	Mark	AO	Spec reference
	For steel: weight $= 7800\pi\left(\frac{7.7 \times 10^{-3}}{2}\right)^2 \times 9.8 = 3.5$ N, For silk: weight $= 1300\pi\left(\frac{3.0 \times 10^{-3}}{2}\right)^2 \times 9.8 = 0.09$ N A steel cable has 3.5/0.09 = 40 times the weight of a silk cable.		Ratio	1		
(f)	The yield stress is higher, but the tensile stress is bigger, so ultimately it takes more force to break a cable of the same area.			1	3	3.4.2
2(a)	**Level 3 (5–6 marks)** Clear description and analysis. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some description and some analysis. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description and limited analysis **or** limited description **or** limited analysis. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*		**Indicative scientific points may include:** Description • Measure the diameter of the wire in several places • Average readings to determine diameter • Clamp two wires from a stand, one as reference wire • Add 5 N to reference wire to keep it taut • Load the other wire with weights (F) in even increments until the wire breaks • Each time measure the difference in the lengths and record the extension	6	1	3.4.2

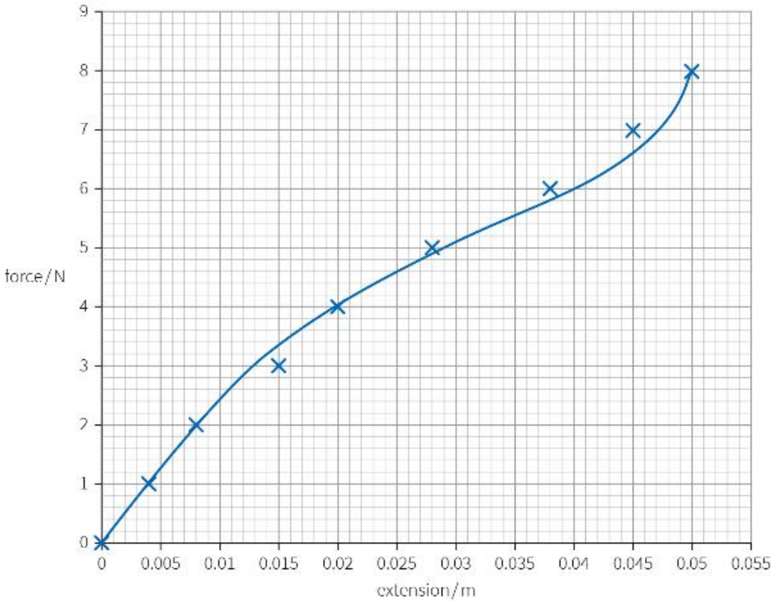
Question	Answers		Extra information	Mark	AO	Spec reference
	0 marks No response (NR) or no response worthy of credit (0).		• Use a microscope/Vernier scale to measure the length • Calculate the extension by subtracting the length of the reference wire from the length of the test wire • Wear safety googles • Tray of sand to catch weights if they fall • Ensure the wires are vertical Analysis • Calculate the cross-sectional area using $A = \pi r^2$ • Calculate the stress using $\sigma = F/A$ • Convert to MPa by dividing by 10^6 • Calculate strain using $\varepsilon = x/l$ • Convert to a percentage by multiplying by 100 • Plot a graph of σ against ε or graph consistent with candidate's suggested relationship			
(b)	The cross-sectional area of the wire is decreasing/ there is 'necking' of the wire So the YM is calculated from the initial section where the area is constant because the values of stress plotted used that area			1 1	3	3.4.2

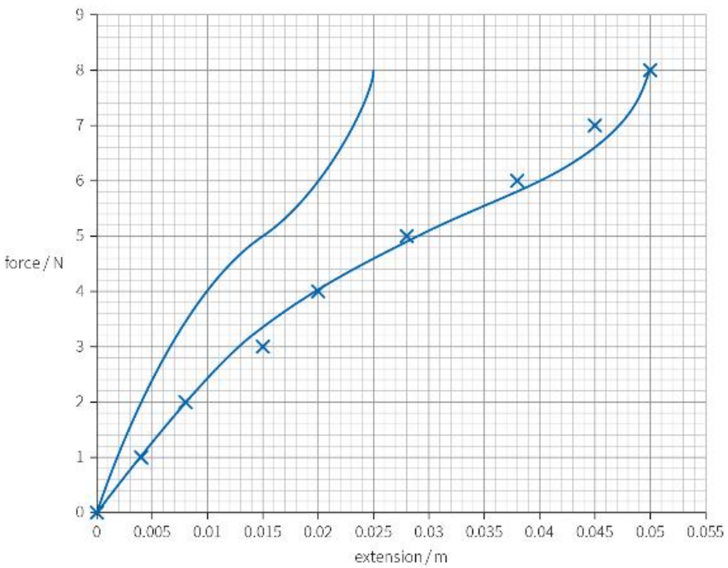
Question	Answers		Extra information	Mark	AO	Spec reference
(c)	The material stretches beyond the yield point/ shows plastic flow			1	2	3.4.2
(d)			Line with twice the gradient Line does not curve, stops abruptly	1 1	3	3.4.2
3(a)/(b)/(d)			3(a) Correct graph intersecting (32,8) Straight line through origin 3(b) Curved line up to force of 9 N Unloading curve parallel to loading curve 3(d) line of twice the gradient going through (18,8)	1 1 1 1 1	2	3.4.2

Question	Answers		Extra information	Mark	AO	Spec reference
(c)	Energy = $\frac{1}{2}F\Delta l = \frac{1}{2}8 \times 32 \times 10^{-3} = 0.12(8)J = 0.13J$			1	2	3.4.2
(d)	For springs in parallel the same force will produce half the extension Energy = $\frac{1}{2}F\Delta l = \frac{1}{2}8 \times 16 \times 10^{-3} = 0.065J$ The energy stored is halved.			1 1	2	3.4.2
4(a)	**Level 3 (5–6 marks)** Clear description and analysis. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some description and some analysis. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description and limited analysis **or** limited description **or** limited analysis. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response (NR) or no response worthy of credit (0).		Measure the original length of the spring when it is taut but not stretched Add known weight to the spring and find the new length, subtract the original length to find the extension Record length, force and extension. Repeat and find the mean extension Attach the weight to a higher point on the spring, and repeat to find the mean extension with the same weight Repeat until the top of the spring is reached Use at least 6 different lengths Calculate the spring constants using k = F/x for each length Plot a graph of spring constant (*y*-axis) against length (*x*-axis)	6	1	3.4.1 WS

Question	Answers		Extra information	Mark	AO	Spec reference
(b)			Axes correctly labelled Correct shape (inverse relationship, do not allow straight line with negative)	1 1		3.4.1
(c)	As the length increases the extension increases for the same force $K = F/x$, so the spring constant decreases			1 1		3.4.1
(d)	Strain = extension/length, so gives the proportion by which the sample extends for a given force Which is dependent on the material and not on the length of the sample			1 1		3.4.1
(e)	Example suggestion: Stress = force/area, which could be modelled by having lots of springs in parallel So the extension, and spring constant, depends on the number of springs for a given force, which is analogous to area			1 1		3.4.2
5(a)	Area = πr^2 $= \pi(0.16 \times 10^{-3})^2 = 8.0 \times 10^{-8}\,\text{m}^2$		Calculation of area Calculation of stress	1 1	2	3.4.2

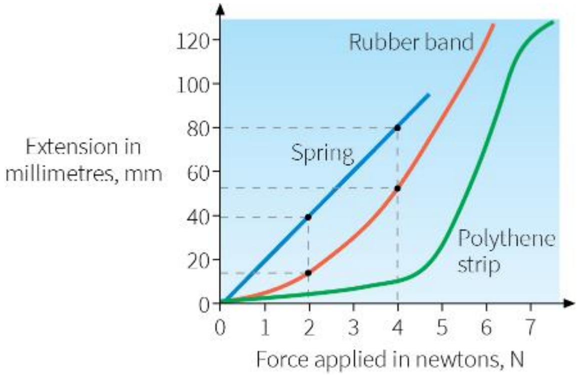
Question	Answers		Extra information	Mark	AO	Spec reference
	$\sigma = \frac{F}{A} = \frac{52N}{8.0\times10^{-8}m^2}$ = 6.5×10⁸ Pa Strain $\varepsilon = \frac{\Delta l}{l_0} = \frac{0.43}{2.7} = 0.16$ $YM = \frac{\sigma}{\varepsilon}$ $= \frac{6.5\times10^8\ \text{Pa}}{0.16} = 4.1\times10^9\ \text{Pa}$		Calculation of strain Answer	1 1		
(b)	Energy = $\frac{1}{2}F\Delta l = \frac{1}{2}52\times0.43 = 11.18$ J Mass of line $m = \rho V$ 1.21 g cm^{-3} = 1210 kg m^{-3} = 1210 kg m^{-3} × (8.0 ×10^{-8} m^2 × 2.7 m) = 2.6 × 10^{-4} kg Assuming all of the energy stored is transferred to a kinetic energy store $E = \frac{1}{2}mv^2$ $v = \sqrt{\frac{2E}{m}}$ $= \sqrt{\frac{2\times11.18}{2.6\times10^{-4}\ \text{kg}}}$ = 293 m/s		Calculation of energy Calculation of mass Use of equation for k.e. Answer	1 1 1 1	2	3.4.2

Question	Answers		Extra information	Mark	AO	Spec reference
(c)	If some energy is not transferred to the kinetic store the speed would be smaller.			1	2	3.4.2
(d)	If the weight is halved the energy is halved Speed is proportional to $\sqrt{E}$, so the speed is reduced by $\frac{1}{\sqrt{2}}$			1 1	2	3.4.2
6(a)	Material A because there will be a small strain for a large stress		Do not award marks for just F and x without stress/strain	1	2	3.4.2
(b)	Energy = area under graph by counting squares  1 square = 1 N × 0.005 m = 5×10^{-3} J, 42 squares (approximately) 0.21 J		Allow 40–44 squares/ 4.0×10^{-3} J – 4.4×10^{-3} J	1 1	2	3.4.2

Question	Answers		Extra information	Mark	AO	Spec reference
(c)	Mass of cord = density × volume = density × length × area = 1.15 g/cm^3 × 100 cm × π × (0.05 cm)^2 = 0.9032 g = 9.0 × 10^{-4} kg Energy = ½ mv^2 $v = \sqrt{\frac{2E}{m}}$ $= \sqrt{\frac{2 \times 0.21\,J}{9.0 \times 10^{-4}\ \text{kg}}}$ = 22(21.6) m/s		Use of density equation with consistent units	1 1 1	2	3.2.4 3.3.2
(d)			Approximately half the extension for each force Same shape	1 1	2	3.4.1

Question	Answers		Extra information	Mark	AO	Spec reference
(e)	Initial gradient = 2 N/0.0075 m = 267 N/m $YM = \frac{\sigma}{\varepsilon} = \frac{F/A}{x/l}$ $= \frac{F/A}{x/l} = \frac{F}{x}.\frac{l}{A}$ $= \frac{267.\ 1}{\pi(0.005)^2}$ = 3.4 (3.395) ×10^6 N/m^2	Allow 250–280 N m^{-1}		1 1 1	2	3.4.2
(f)	In equilibrium: $R_A + R_B = m_{total}\ g$ $R_A + R_B$ = (0.1 + 0.2 + 0.05) × 9.81 = 3.43 N Clockwise moments about brick A: (0.1 × 9.81 × 0.45) + (0.2 × 9.81 × 0.55) + (0.05 × 9.81 × 0.5) = 0.441 + 1.08 + 0.245 = 1.77 Nm Anticlockwise moment = 1 × R_B R_B = 1.77 N R_B = 3.43 − 1.77 N = 1.67 N		Resolving forces vertically Taking moments Answers (both forces correct)	1 1 1	2	3.2.3
7(a)	The diameter to calculate cross-sectional area The extension for each increase in load Plot stress = load/area on the *y*-axis Against strain = extension/original length on the *x*-axis		Alternative Plot load vs extension	1 1 1 1	2	3.4.2
(b)	The strain will be too small/smaller than the actual value Calculated YM will be larger than value calculated with correct measurement			1 1	2	3.4.2
(c)	Estimate of uncertainty = +/− 2 mm % uncertainty = (2×10^{-3} m × 100)/60.0×10^{-2} m) = 0.3%		Accept values between 1 mm and 3 mm	1 1	1 2	WS

Question	Answers		Extra information	Mark	AO	Spec reference
(d)	Strain = 0.1 × 10^{-2} Stress = YM × strain = 1.5×10^{11} Pa ×10^{-3} = 1.5×10^{8} Pa = F/A = 1000 N / A A = 1000 N/ 1.5×10^{8} Pa = 6.6×10^{-6} m^2 Diameter = 2 × √(6.6×10^{-6} m^2/π) = 2.9×10^{-3} m			1 1 1	2	3.4.2
(e)	The force is shared by two wires Maximum weight is 2000 N, so two people = 1400 N			1 1	3	3.4.2
(f)	$v^2 = u^2 + 2as$ Assuming acceleration is 9.81 m s^{-2} / no air resistance $v = \sqrt{2as}$ $v = \sqrt{2 \times 9.81 \times 12}$ = 15(.3) m s^{-1}		Correct assumption Use of equation of motion Answer to 2 d.p.	1 1 1	2	3.1.2
(g)	Smaller The drop will reach terminal velocity faster than the brush because the weight is less The brush will accelerate for a longer time reaching a larger speed			1 1 1		3.2.2
8(a)	Assume all the energy stored in the tendons is transferred to a gravitational potential energy store $\frac{1}{2}F\Delta l = mgh$ And $F = kx$, so $mgh = \frac{1}{2}kx^2$		Conservation of energy Substitution for F Estimation of extension (based on size of frog)	1 1 1	2	3.3.2 3.4.2

Question	Answers		Extra information	Mark	AO	Spec reference
	So $k = \frac{2mgh}{x^2}$ Estimation of extension of tendon – 1 mm Assume height = 10 × 0.02 m = 0.2 m $k = \frac{2 \times 7 \times 10^{-3} \times 9.81 \times 0.2}{{10^{-3}}^2}$ = 27(.44) kN/m		Calculation	1		
(b)	 		Straight line graph labelled spring Curved line graph labelled rubber Line labelled polythene	1 1 1	1	3.4.1
(c)	Rubber bands, They are not permanently deformed when the load is removed			1 1	3	3.4.1
(d)	$h = \frac{kx^2}{2mg}$ The mass of the human is much bigger (70 kg/7 g = 10^4), so either the extension of the tendon would have to be 100 times bigger, or the tendons would need to be 10 000 times stiffer to produce the same height.		Credit for any reason showing a link to the physical quantities used in part 8(a)	1 1	2	3.4.1

Question	Answers		Extra information	Mark	AO	Spec reference
(e)	Energy stored = $mgh = \frac{1}{2}kx^2$, mass of human ~ 70 kg $x = \sqrt{\frac{2mgh}{k}}$ $x = \sqrt{\frac{2 \times 70 \times 9.81 \times 1.5}{27}}$ x = 8.7 m The springs in the robot must have springs that are much stiffer than those of the tendon		Use of conservation of energy Answer Sensible comment	1 1 1	2/3	3.3.2 3.4.2
(f)	Power = energy/ time = mgh/time = 70 × 9.81 × 1.5/1.2 = 860 (858) W Which is about the same power as a microwave oven		Answer Comment	1 1	2	3.3.3