A Level AQA Physics

8 Materials – answers

Question	Answers	Extra information	Mark	AO	Spec reference
01.1	Young modulus = gradient $\frac{(1200-600)\times 10^{6}}{4.4-2.9}=\frac{600}{1.5}$ $= 400$ MPa	Evidence of conversion of strain to decimal Answer	1 1	2	3.4.2.2
01.2	Below 250% strain, the stiffness is increasing; above 250%, it is constant		1	2	3.4.2.2
01.3	Weight of car = 1200 kg × 9.8 N kg^{-1} = 11 7600 N Steel: yield stress is 250 MPa $\sigma=\frac{F}{A}$ $A=\frac{F}{\sigma}=\frac{11\,760}{250\,000\,000}=7.2\times10^{-6}\ m^{2}$ $d=2\sqrt{\frac{A}{\pi}}=2\sqrt{\frac{7.2\times10^{-6}}{\pi}}=7.7\times10^{-3}$ m Silk: yield stress is 1650 MPa $\sigma=\frac{F}{A}$ $A=\frac{F}{\sigma}=\frac{11\,760}{1\,650\,000\,000}=4.7\times10^{-5}\ m^{2}$ $d=2\sqrt{\frac{A}{\pi}}=2\sqrt{\frac{4.7\times10^{-5}}{\pi}}=3.0\times10^{-3}$ m The diameter of the silk is less than half that of steel	Manipulation of equations Answers Comment	1 1 1 1	2	3.4.2.2
01.4	Assume length of cable = 1 m Weight = mg, $m=\rho V=\rho\pi r^{2}=\rho\pi\left(\frac{d}{2}\right)$ For steel: weight = $7800\pi\left(\frac{7.7\times10^{-3}}{2}\right)^{2}\times 9.8=3.5$ N For silk: weight = $1300\pi\left(\frac{3.0\times10^{-3}}{2}\right)^{2}\times 9.8=0.09$ N A steel cable has $\frac{3.5}{0.09}=40$ times the weight of a silk cable	Use a length, or length cancels in ratio at the end Correct use of weight and density equations Ratio	1 1 1	2	3.4.2.1 3.4.2.2

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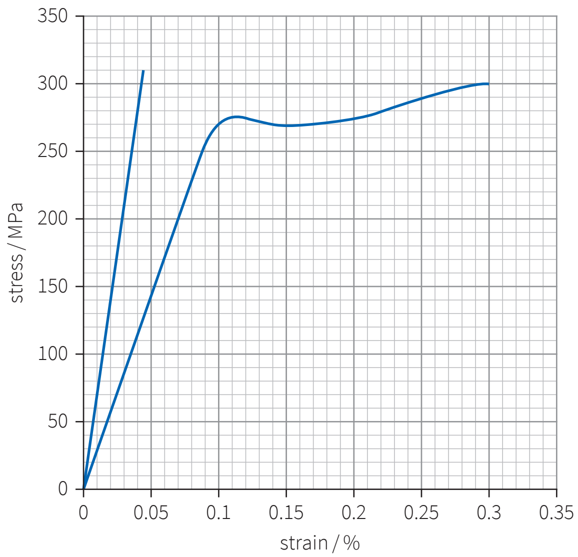
02.1	Using a vernier scale attached to the wire viewed through a microscope		1	1	WS
02.2	250 N = limit of proportionality 275 N = yield point		1 1	2	3.4.2.2
02.3	The cross-sectional area of the wire is decreasing/there is 'necking' of the wire So the Young modulus is calculated from the initial section where the area is constant because the values of stress plotted used that area		1 1	3	3.4.2.2
02.4	The material stretches beyond the yield point/shows plastic flow		1	2	3.4.2.2
02.5		Line with twice the gradient Line does not curve, stops abruptly	1 1	3	3.4.2.2

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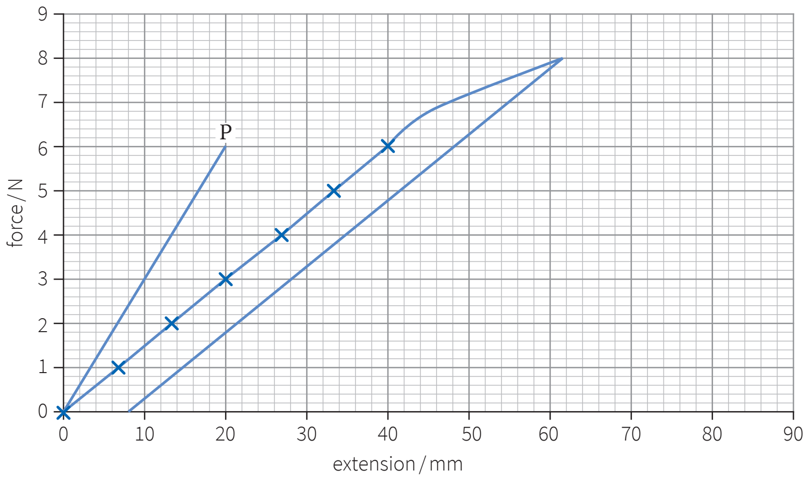
OXFORD Revise

Question	Answers	Extra information	Mark	AO	Spec reference
03.1/ **03.2/** **03.4**		**03.1** Correct graph intersecting (40, 6) Straight line through origin **03.2** Curved line up to force of 8 N Unloading curve parallel to loading curve **03.4** Line of twice the gradient going through (20, 6)	1 1 1 1 1	2	3.4.2.2
03.3	Energy $= \frac{1}{2}F\Delta l = \frac{1}{2} 6 \times 40 \times 10^{-3} = 0.12$ J		1	2	3.4.2.1
03.4	For springs in parallel, the same force will produce half the extension Energy $= \frac{1}{2}F\Delta l = \frac{1}{2} 6 \times 20 \times 10^{-3} = 0.06$ J The energy stored is halved		1 1	2	3.4.2.1

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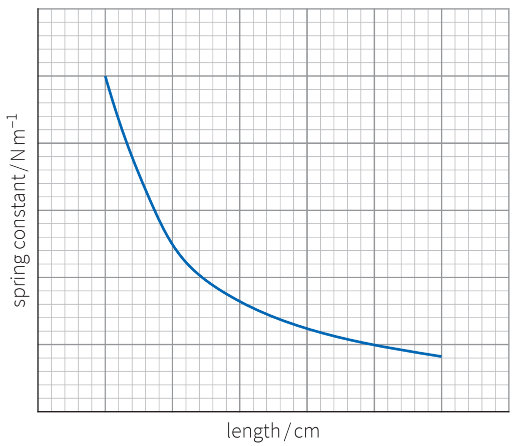
04.1	Measure the original length of the spring (when it is taut but not stretched) Add known weight to the spring and find the new length, then subtract the original length to find the extension Record length, force, and extension. Repeat and find the mean extension Attach the weight to a higher point 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 $k = \frac{F}{x}$ for each length Plot a graph of spring constant (y-axis) against length (x-axis)	Measuring extension Repeat measurements per length Changing length to give sufficient range Calculating k Correct axes for graph	1 1 1 1 1	1	3.4.2.1
04.2		Axes correctly labelled Correct shape (inverse relationship, do not allow straight line with negative)	1 1		3.4.2.1
04.3	As the length increases, the extension increases for the same force $k = \frac{F}{x}$, so the spring constant decreases		1 1	1	3.4.2.1
04.4	strain = $\frac{\text{extension}}{\text{length}}$, 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	1	3.4.2.1

OXFORD Revise

Question	Answers	Extra information	Mark	AO	Spec reference
04.5	Example suggestion: stress = $\frac{\text{force}}{\text{area}}$, which could be modelled by having lots of springs in parallel So the extension and spring constant depend on the number of springs for a given force, which is analogous to area		1 1	3	3.4.2.1
05.1	Area = πr^2 $= \pi(0.11 \times 10^{-3})^2 = 3.8 \times 10^{-8}\,\text{m}^2$ $\sigma = \frac{F}{A} = \frac{36\,\text{N}}{3.8 \times 10^{-8}\,\text{m}^2} = 9.5 \times 10^8\,\text{Pa}$ Strain $\varepsilon = \frac{\Delta l}{l_0} = \frac{0.66}{3.6} = 0.18$ Young modulus = $\frac{\sigma}{\varepsilon}$ $= \frac{9.5 \times 10^8\,\text{Pa}}{0.18} = 5.2 \times 10^9\,\text{Pa}$	Calculation of area Calculation of stress Calculation of strain Answer	1 1 1 1	2	3.4.2.2
05.2	Energy = $\frac{1}{2}F\Delta l = \frac{1}{2}36 \times 0.66 = 11.88\,\text{J}$ Mass of line $m = \rho V$ $1.15\,\text{g cm}^{-3} = 1150\,\text{kg m}^{-3}$ So, $m = \rho V = 1150\,\text{kg m}^{-3} \times (3.8 \times 10^{-8}\,\text{m}^2 \times 3.6\,\text{m}) = 1.57 \times 10^{-4}\,\text{kg}$ Assuming all of the energy stored is transferred to a kinetic energy store $E = \frac{1}{2}mv^2$ OR $v = \sqrt{\frac{2E}{m}}$ $= \sqrt{\frac{2 \times 11.88}{1.57 \times 10^{-4}\,\text{kg}}}$ $= 388\,\text{m s}^{-1}$	Calculation of energy Calculation of mass Use of equation for kinetic energy Answer	1 1 1 1	3	3.4.2.2 3.4.1.8
05.3	If some energy is not transferred to the kinetic store, the speed would be smaller		1	3	3.4.2.1

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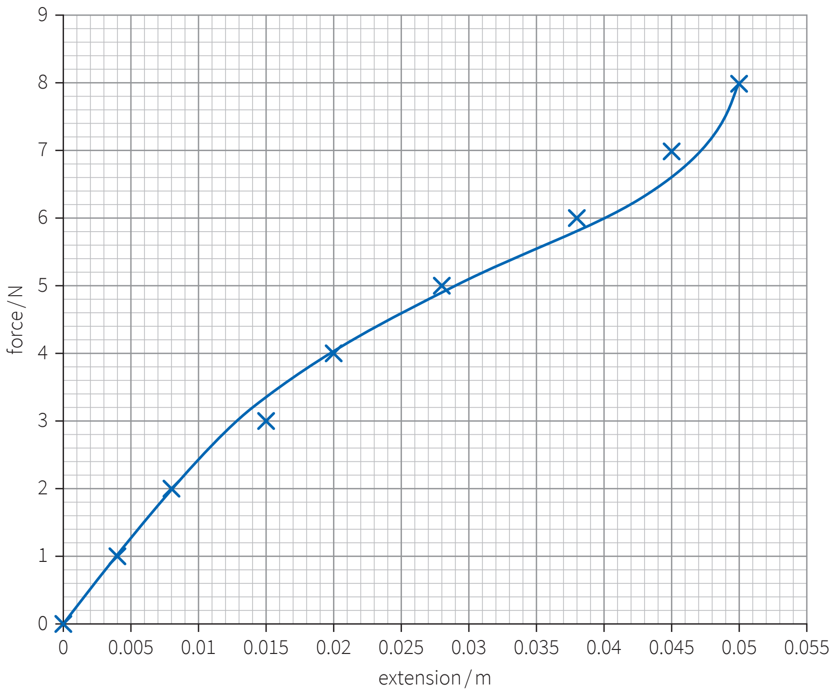
05.4	If the weight is halved, the energy is halved Speed is proportional to $\sqrt{E}$, so the speed is reduced by $\frac{1}{\sqrt{2}}$		1 1	2	3.4.2.2 3.4.1.8
06.1	Material A because there will be a small strain for a large stress	Do not award marks for just F and x without stress/strain	1	2	3.4.1.1
06.2	Energy = area under graph by counting squares 		1	2	3.4.2.1
	1 square = 1 N × 0.005 m = 5×10^{-3} J, 42 squares (approximately) 0.21 J Allow area of triangle approximation = $\frac{1}{2} \times 0.05 \times 8 = 0.20$ J	Allow 40–44 squares	1		

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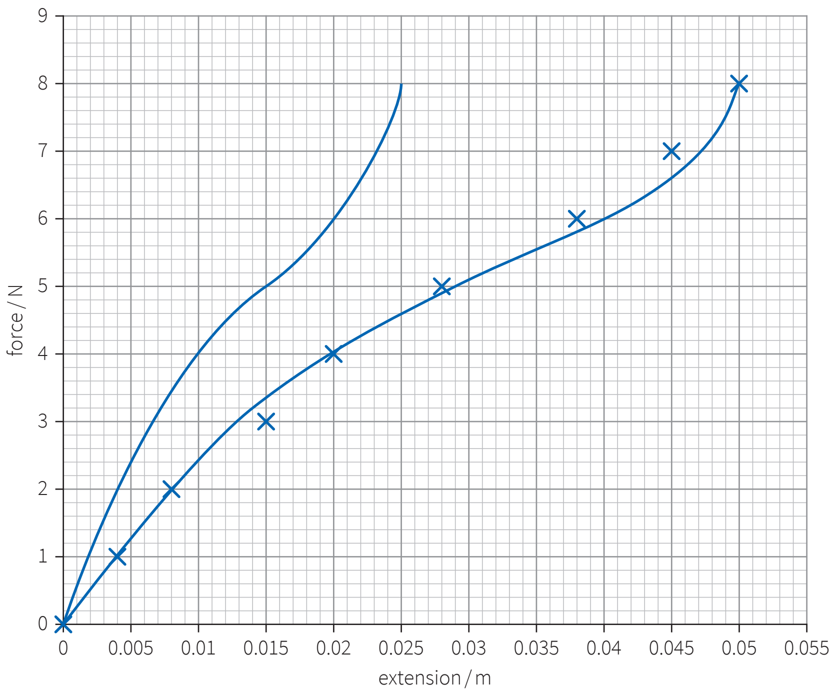
Question	Answers	Extra information	Mark	AO	Spec reference
06.3	Mass of cord = density × volume = density × length × area $= 1.15\,\text{g cm}^{-3} \times 100\,\text{cm} \times \pi \times (0.05\,\text{cm})^2$ = 0.2875 g $= 2.9 \times 10^{-4}\,\text{kg}$ Energy $= \frac{1}{2}mv^2$ $v = \sqrt{\frac{2E}{m}}$ $= \sqrt{\frac{2 \times 4.2\times10^{-3}\,\text{J}}{2.9\times10^{-4}\,\text{kg}}}$ $= 29(.3)\,\text{m s}^{-1}$	Use of density equation with consistent units	1 1 1	2	3.4.2.1 3.4.1.8
06.4		Approximately half the extension for each force Same shape	1 1	2	3.4.2.2

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Question	Answers	Extra information	Mark	AO	Spec reference
06.5	Initial gradient $= \frac{2\,\text{N}}{0.008\,\text{m}} = 250\,\text{N m}^{-1}$ Young modulus $= \frac{\sigma}{\varepsilon} = \frac{\left(\frac{F}{A}\right)}{\left(\frac{x}{l}\right)} = \left(\frac{F}{x}\right)\left(\frac{l}{A}\right)$ $= \frac{250}{\pi\,(0.005)^2}$ $= 3.2(3.183) \times 10^6\,\text{N m}^{-2}$		1 1 1	2	3.4.2.2
06.6	In equilibrium: $R_X + R_Y = m_{total}\,g$ $R_X + R_Y = (0.1 + 0.2 + 0.05) \times 9.81 = 3.43\,\text{N}$ Clockwise moments about brick X: $0.1 \times 9.81 \times 0.45 + 0.2 \times 9.81 \times 0.55 + 0.05 \times 9.81 \times 0.5 = 0.441 + 1.08 + 0.245 = 1.77\,\text{N m}$ Anticlockwise moment $= 1 \times R_Y$ $R_Y = 1.77\,\text{N}$ $R_X = 3.43 - 1.77\,\text{N} = 1.67\,\text{N}$	Resolving forces vertically Taking moments Answers (both forces correct)	1 1 1	2	3.4.1.2
07.1	The (average +) diameter The extension for each increase in load Plot stress $= \frac{\text{load}}{\text{area}}$ on the y-axis Against strain $= \frac{\text{extension}}{\text{original length}}$ on the x-axis	Alternative Plot load versus extension	1 1 1 1	2	3.4.2.2
07.2	The strain will be too small/smaller than the actual value Calculated Young modulus will be larger than value calculated with correct measurement		1 1	2	3.4.2.2
07.3	Estimate of uncertainty = ± 2 mm % uncertainty $= \frac{2 \times 10^{-3}\,\text{m} \times 100}{60.0 \times 10^{-2}\,\text{m}} = 0.3\%$	Accept values between 1 mm and 3 mm	1 1	1 2	3.1.2

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Question	Answers	Extra information	Mark	AO	Spec reference
07.4	Strain = 0.1×10^{-2} Stress = Young modulus × strain = 1.5×10^{11} Pa × 10^{-3} = 1.5×10^{8} Pa $= \frac{F}{A} = \frac{1000\text{ N}}{A}$ $A = \frac{1000\text{ N}}{1.5 \times 10^{8}\text{ Pa}} = 6.6 \times 10^{-3}\text{ m}^2$ Diameter = $3 \times \sqrt{\frac{6.6 \times 10^{-3}\text{ m}^2}{\pi}} = 1.5 \times 10^{-3}$ m		1 1 1	2	3.4.2.2
07.5	The force is shared by two wires Maximum weight is 2000 N, so two people = 1400 N		1 1	3	3.4.2.2
07.6	$v^2 = u^2 + 2as$ 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	3.4.1.3
07.7	Lower The drop of paint 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		3.4.1.4

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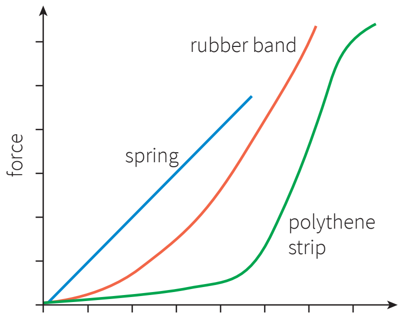
Question	Answers	Extra information	Mark	AO	Spec reference
08.1	Assume all the energy stored in the tendons is transferred to a gravitational potential energy store $\frac{1}{2}F\Delta l = mgh$ And $F = kx$, so $mgh = \frac{1}{2}kx^2$ So $k = \frac{2\,mgh}{x^2}$ Estimation of extension of tendon = 1 mm Assume height = 10 × 0.02 m = 0.2 m $k = \frac{2 \times 7 \times 10^{-6} \times 9.81 \times 0.2}{(10^{-3})^2}$ = 27(.44) N m^{-1}	Conservation of energy Substitution for F Estimation of extension (based on size of frog) Calculation	1 1 1 1	2	3.1.4.8 3.4.2.2
08.2	 	Straight-line graph labelled spring Curved-line graph labelled rubber Line labelled polythene	1 1 1	1	3.4.2.1
08.3	Rubber bands They are not permanently deformed when the load is removed		1 1	3	3.4.2.1
08.4	$h = \frac{kx^2}{2mg}$ The mass of the human is much bigger $\left(\frac{70\text{ kg}}{7\text{ g}} = 10^4\right)$, 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 **04.1**	1 1	2	3.4.2.2

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OXFORD Revise

Question	Answers	Extra information	Mark	AO	Spec reference
08.5	Energy stored = $mgh = \frac{1}{2}kx^2$, mass of human ~70 kg $x = \sqrt{\frac{2\,mgh}{k}}$ $x = \sqrt{\frac{2 \times 70 \times 9.81 \times 1.5}{27}}$ $x = 8.7$ 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	3	3.1.4.8 3.4.2.2
08.6	Power = $\frac{\text{energy}}{\text{time}}$ $= \frac{mgh}{\text{time}}$ $= \frac{70 \times 9.81 \times 1.5}{1.2} = 860(858)$ W Which is about the same power as a microwave oven	 Answer Comment	 1 1	2	3.4.1.7

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OXFORD Revise

Skills box answers

Question	Answer
1	$E = \dfrac{l}{A \times \text{gradient}}$ $E = \dfrac{2.82\text{ m}}{\pi\left(\frac{0.32\times10^{-3}}{2}\right)^2\text{m}^2 \times 0.281\times10^{-3}\text{ m N}^{-1}} = 1.25\times10^{11}\text{ Pa}$ %uc in gradient = $\dfrac{(0.315-0.281)\times10^{-3})\text{ m N}^{-1}}{0.281\times10^{-3}\text{ m N}^{-1}} \times 100\% = 12.1\%$ %uc in diameter = $\dfrac{0.01\text{ mm}}{0.32\text{ mm}} \times 100\% = 3.1\%$ %uc in area = 2 × 3.1% = 6.2 % %uc in length = $\dfrac{0.01\text{ m}}{2.82\text{ m}} \times 100\% = 0.35\%$ therefore %uc in E = (12.1 + 6.2 + 0.35)% = 18.7% uc in E = 18.7% of 1.25×10^{11} Pa = ± 0.23×10^{11} Pa so $E = 1.3\times10^{11}$ Pa ± 0.2×10^{11} Pa
2	The elastic limit has been exceeded. The wire has not returned to its original length on removing the load.
3	Rearranging the equation for the Young modulus to obtain the equation of a straight line ($y = mx + c$) gives $F = \left(\dfrac{AE}{l}\right)e$. The gradient is therefore equal to $\dfrac{AE}{l}$.