MATERIALS MECHANICS ANSWERS OCR A LEVEL YEAR 1

1.

Question		Expected Answers	Marks	Additional Guidance
(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 permanently deformed'
	(ii)	50 times (stronger)	B1	
	(iii)	Less mass / less weight / lighter Stronger / greater tensile strength	B1 B1	
		Total	**9**	

2.

uestion		Expected Answers	Marks	Additional Guidance
(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**	

3.

Question		Expected Answers	Marks	Additional Guidance
(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 $\propto$ extension / constant gradient (graph)	B1	**Not** 'force $\propto$ length'
(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**	

4.

Question		Expected Answers	Marks	Additional Guidance
(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 **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 **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 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* 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**	

5.

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**	

6.

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**	

7.

Question	Answer	Marks	Guidance
(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 = $\frac{100}{\pi \times (2.8\times10^{-4})^2}$ (= 4.06×10^8 Pa) strain = $\frac{4.0\times10^{-3}}{1.60}$ (= 2.5×10^{-3}) $E = \frac{4.06\times10^{8}}{2.5\times10^{-3}}$ 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) $E = \frac{100\times1.60}{\pi\times(2.8\times10^{-4})^2\times4.0\times10^{-3}}$ 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)	$½ kx^2 = ½ mv^2$ 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**	