Unit 1: Mechanics and Materials - Mark scheme

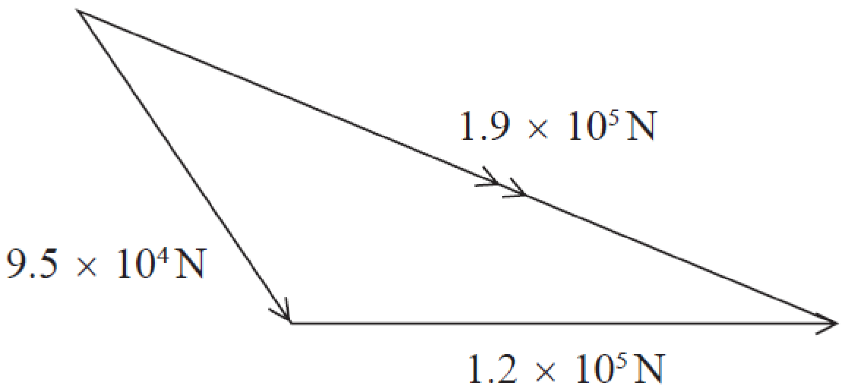
Question number	Answer	Mark
1	A	1
2	D	1
3	B	1
4	B	1
5	A	1
6	B	1
7	B	1
8	C	1
9	D	1
10	D	1

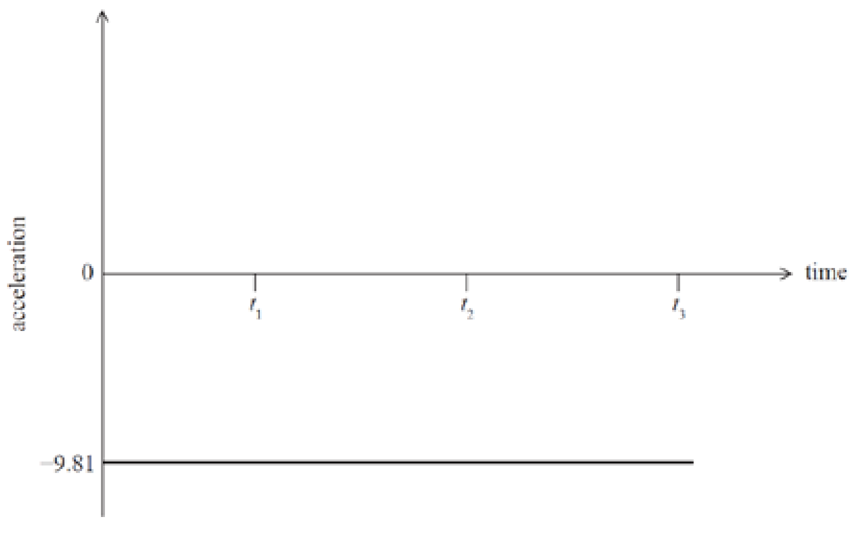
Question number	Answer	Mark
11	**Either** • Additional measurement: diameter of wire (1) • Plot a graph of the applied weight on the y-axis against the extension on the x-axis (1) • Calculate the gradient of linear region (1) • Calculate the cross-sectional area of the wire using $\pi d^2/4$ (1) • $E = \text{gradient} \times \frac{\text{original lenth}}{\text{cross sectional area}}$ (1) **Or** • Additional measurement: diameter of wire (1) • Calculate the cross-sectional area of the wire using $\pi d^2/4$ (1) • Calculate the stress for each applied force using force/area **and** the strain using $\frac{\text{extension}}{\text{original lenth}}$ (1) • Plot a graph of stress on the y-axis against strain on the x-axis (1) • Gradient of linear region = E (1)	5
	Total for Question 11	**5**

Question number	Answer		Mark
12(a)	• As the spring is released it extends and applies a force to trolley B • Then due to N3, trolley B applies an equal and opposite force to trolley A	(1) (1)	2
12(b)	**Either** • Total initial momentum = 0 • $0.1v_A - 0.2v_B = 0$ • $v_A = 2v_B$ so trolley A has the greater speed **Or** • Total initial momentum = 0 • Trolleys will have equal and opposite momenta • Lighter trolley A has the greater speed	(1) (1) (1) (1) (1) (1)	3
	Total for Question 12		**5**

Question number	Answer		Mark
13	• Use of trig to determine the initial vertical velocity **Or** see 20cos 75 **Or** see 20cos15 • Use of equation(s) of motion to determine the time for either the first ball or the second ball • Use of $t_2 - t_1$ using candidate's values for t_1 and t_2 • Time difference = 2.9 s Example of calculation If t_1 and t_2 represent the time for the balls to travel from child P to Q Equation for first ball $0 = (20\text{ m s}^{-1}\times\sin 75)t_1 + (\frac{1}{2}gt_1^2)$ $t_1 = 3.94$ s Equation for second ball $0 = (20\text{ m s}^{-1}\times\sin 15)t_2 + (\frac{1}{2}gt_2^2)$ $t_2 = 1.06$ s $t_1 - t_2 = 3.94\text{ s} - 1.06\text{ s} = 2.88$ s	(1) (1) (1) (1)	**4**
	Total for Question 13		**4**

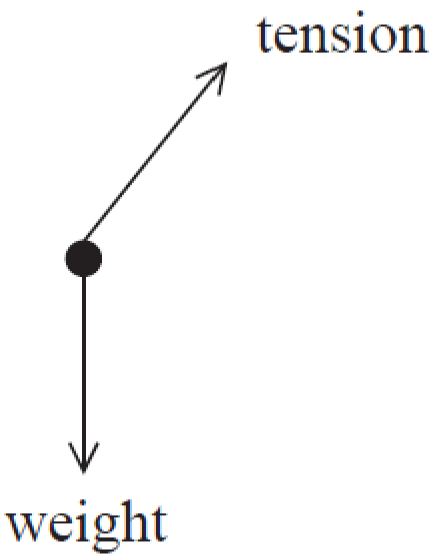
Question number	Answer		Mark
14(a)	The point through which the weight appears to act	(1)	**1**
14(b)	• Measurement of the perpendicular distance of the line of action of the weight from O • Use of $W = mg$ • Use of moment = force × perpendicular distance from the pivot • Moment = 0.023 N m Example of calculation Perpendicular distance = 1.3 cm Weight of triangle = 0.180 kg × 9.81 N kg^{-1} = 1.77 N Moment of weight of the triangle = 1.77 N × (0.013 m) = 0.023 N m	(1) (1) (1) (1)	**4**
14(c)	• The centre of gravity is now vertically below O • **Or** the perpendicular distance of the weight from O is now zero • So there is no longer a moment for the weight about O	(1) (1)	**2**
	Total for Question 14		**7**

Question number	Answer		Mark
15(a)	• Construction of correct (shape) vector diagram with resultant • 9.5×10^4 N and 1.2×10^5 N sides labelled with directions Magnitude of resultant force • 1.9×10^5 N ± 0.2 N Direction of resultant force • 24° to the direction of the 1.2×10^5 N force **Or** 31° to the direction of the 9.5×10^4 N force 	(1) (1) (1) (1)	4
15(b)(i)	• Use of $\Delta W = F\Delta s$ **and** $P = \frac{W}{t}$ • $P = 4.8 \times 10^5$ W Example of calculation Power = $\frac{1.2 \times 10^5 \text{ N} \times 4.0 \text{ m}}{1 \text{ s}} = 4.8 \times 10^5$ W	(1) (1)	2
15(b)(ii)	• Use of efficiency = $\frac{\text{useful power output}}{\text{total power input}}$ MP1: accept use of a single power for the boat • Efficiency = 0.25 or 25 % ecf for candidate's power from (b)(i) Example of calculation Efficiency = $\frac{4.8 \times 10^5 \text{ W}}{2 \times 950 \times 10^3 \text{W}} = 0.25$	(1) (1)	2
	Total for Question 15		**8**

Question number	Answer	Mark
16(a)	When the ball is in the air it always has a constant negative/downward acceleration (1) **Any 3 from** • At t_1: the ball reaches the maximum height **Or** the ball changes its direction (1) • From t_1 to t_2: the ball is falling (1) • At t_2: the ball bounces (1) • From t_2 to t_3: the ball moves upwards to its maximum height (1) • At t_1 and t_3: The height of the ball is the same (1)	**4**
16(b)	• Straight, horizontal line (1) • Drawn at −9.81 (m s^{-2}) (Accept −9.8 or −10 for the acceleration (MP2) (1) 	**2**
	Total for Question 16	**6**

Question number	Answer	Mark
17(a)	• Use of $V = \pi r^2 h$ (1) • Use of $\rho = m/V$ (1) • Use of $W = mg$ (1) • W = 26.3 N (1) <u>Example of calculation</u> $V = \pi \times (0.06\ \text{m})^2 \times 0.03\ \text{m} = 3.39 \times 10^{-4}\ \text{m}^3$ $m = 7900\ \text{kg m}^{-3} \times 3.39 \times 10^{-4}\ \text{m}^3 = 2.68\ \text{kg}$ $W = 2.68\ \text{kg} \times 9.81\ \text{N kg}^{-1} = 26.3\ \text{N}$	**4**
17(b)(i)	• Use of $E_{grav} = mg\Delta h$ (1) • Using $\Delta h =$ 0.19 m + 0.06m (1) • Use of E_{grav} = 6.6 J (1) <u>Example of calculation</u> $E_{grav} = 26.3\ \text{N} \times (0.19\ \text{m} + 0.06\ \text{m}) = 6.58\ \text{J}$	**3**
17(b)(ii)	• Use of $\Delta E_{el} = ½\ F\Delta x$ (1) • $F =$ 220 N (1) <u>Example of calculation</u> 6.58 J = ½ F × 0.06 m F = 219.3 N	**2**
17(b)(iii)	• Use of $F = k\Delta x$ (1) • k = 3700 N kg^{-1} (1) <u>Example of calculation</u> 220 = k × 0.06 m k = 3667 N kg^{-1}	**2**
	Total for Question 17	**11**

Question number	Answer	Mark
18(a)(i)	• Kevlar is stiffer **Or** greater Young modulus (1) • so the extension is much smaller (under the same load) (1) • Kevlar has a greater breaking stress (1) • so is stronger (1) MP2 is conditional on MP1 and MP4 is conditional on MP3	**4**
18(b)(i)	• A thinner casing could be used with Kevlar to provide the same stress/strength as a thicker casing made of steel (1) • Kevlar is more suitable because it has a greater breaking stress **Or** Kevlar is more suitable because it is stronger (1) • For the same thickness of casing the weight of the cable using Kevlar would be much less than using steel for the casing (1) • Kevlar would be more suitable than steel for the casing MP5 is dependent on gaining MP2 and MP4 (1)	**4**
18(b)(ii)	• upthrust = $\rho_w Vg$ **Or** weight of sample = $\rho_K Vg$ (1) • 'Apparent' weight = weight of sample – upthrust (1) • Use of weight of sample – upthrust (1) • Apparent weight = 31 N (1) Example of calculation Apparent weight = (1400 kg m^{-3} × 8.5 x 10^{-3} m^3 × 9.81 N kg^{-1}) – (1030 kg m^{-3} × 8.5 × 10^{-3} m^3 × 9.81 N kg^{-1}) = 30.9 N	**4**
	Total for Question 18	**12**

Question number	Answer	Mark
19(a)	• Weight/W/mg labelled (1) • Tension/T (1)  	2
19(b)	• $T\cos\theta = mg$ (1) • $T\sin\theta = $ ma (1) • Combining the two equations eg $\tan\theta = a/g$ (1) • $a = 1.4 \text{ m s}^{-2}$ (1) <u>Example of calculation</u> Resultant force in vertical direction $T\cos 8° = (0.050 \text{ kg} \times 9.81 \text{ N kg}^{-1})$ Resultant force in horizontal direction $T\sin 8° = (0.050 \text{ kg})a$ $\tan 8° = \frac{0.050 \text{ kg} \times a}{0.050 \text{ kg} \times 9.81 \text{ N kg}^{-1}}$ $a = 1.38 \text{ m s}^{-2}$	4

Question number	Answer	Mark
19(c)	This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.	6

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
54	3
3–2	2
1	1
0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Question number	Answer	Mark
19(c) ***Continued***	**Indicative content** • For the yo-yo to accelerate with the train there must be a horizontal force acting on it • A horizontal force on the yo-yo is provided by the horizontal component of the tension in the string • The string could never be completely vertical because there must be a horizontal force • The yo-yo has a weight so there always has to be a vertical force acting on it • The tension in the string provides the vertical component of force • The string could never be completely horizontal because there must be a vertical force Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points, which is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	
	Total for Question 19	**12**