Forces and Moments - Mark Scheme

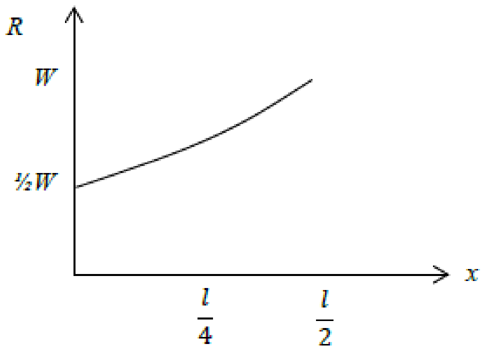
Q1.

Question Number	Answer		Mark
(a)	• Use of $\Sigma F = 0$, seen or implied	(1)	
	• $F = 11$ N	(1)	
	• Use of moment of force = Fx (with any corresponding force and known distance from an end, A or midpoint)	(1)	
	• Use of the principle of moments	(1)	
	• $x = 0.86$ m	(1)	5
	<u>Example of calculation</u> $F_A + F_B = 8.5\text{ N} + 14\text{ N} = 22.5\text{ N}$ $F_A = F_B$ $2F = 22.5\text{ N}$ $F = 11.25\text{ N}$ if moments taken from the left end $(11.25\text{ N} \times 0.15\text{ m}) + (11.25\text{ N} \times x) = (8.5\text{ N} \times 0.35\text{ m}) + (14\text{ N} \times 0.60\text{ m})$ $x = 0.861$ m if moments taken from midpoint $(11.25\text{ N} \times 0.45\text{ m}) = (11.25\text{ N} \times x) + (8.5\text{ N} \times 0.25\text{ m})$ $x = 0.261$ m so distance = 0.261 m + 0.6 m = 0.861 m if moments taken from A $(8.5\text{ N} \times 0.20\text{ m}) + (14\text{ N} \times 0.45\text{ m}) = (11.25\text{ N} \times x)$ $x = 0.711$ m so distance = 0.711 + 0.15 m = 0.861 m		
(b)	The moment (of B) must be the same	(1)	
	For a smaller distance (from the left end of the shelf), the (normal contact) force must increase	(1)	2
	Total for question		**7**

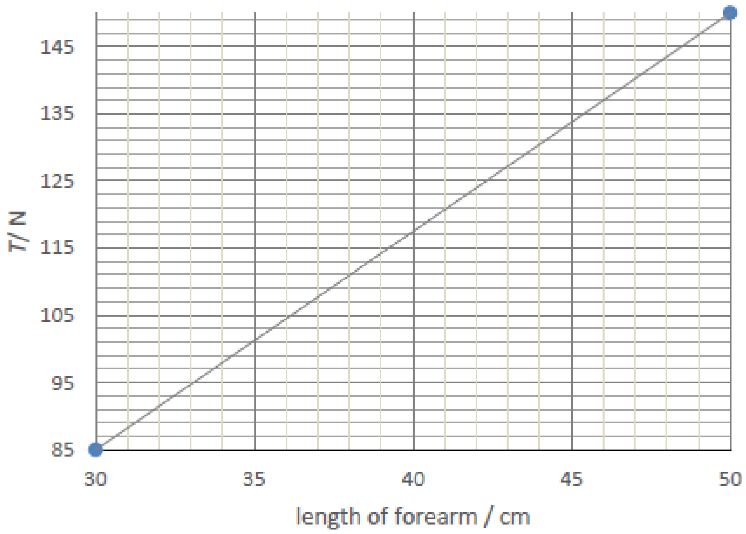
Q2.

Question Number	Answer	Mark
	B is the correct answer A is not correct as they are the units for force. C is not correct as they are the units for momentum. D is not correct as they are the units for power.	**(1)**

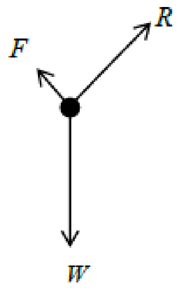
Q3.

Question Number	Answer	Mark
(a)	• Point at which weight is taken to act. (1)	**(1)**
(b)	• Gradient everywhere positive (1) • Stops at R = weight/W/mg at l/2 (1) • Starts at R = ½ weight/0.5W/0.5mg etc. (1) 	**(3)**
(c)	• Centre of gravity/mass is not above the shelf. **Or** Line of action of weight does not pass through the shelf. (1) • There is a net moment clockwise. **Or** No anticlockwise moment to balance moment of weight. (1)	**(2)**

Q4.

Question Number	Answer		Mark
(a)	• Estimate of length of forearm 30 – 50 (cm)	(1)	
	• Use of trig to determine the perpendicular component of the tension **Or** see $T\sin70$ **Or** see $T\cos20$	(1)	
	• Use of moment = Fx with a corresponding force and distance	(1)	
	• Use of the principle of moments	(1)	
	• Value for T in range 85 N to 150 N (l = 30 cm, T = 85 N and l = 50 cm, T = 150 N)	(1)	5
	<u>Example of calculation</u> (for l = 0.40 m) $(0.04\text{ m} \times T \times \sin70) = (0.31\text{ m} \times 4.5\text{ N}) + (0.20\text{ m} \times 15\text{ N})$ T = 117 N 		
(b)	• The forearm is not uniform/symmetrical	(1)	
	• The centre of gravity is not in the middle	(1)	2
	Total for question		**7**

Q5.

Question Number	Answer		Mark
(a)	• Weight/W/mg labelled • (Normal) reaction/contact force (accept R/N/C) • Friction/F • Lengths $R<W$ **and** $F<W$ (-1 off total for each additional arrowed line and MP4 conditional on MP1, 2 **and** 3) (do not accept components of forces, even if both given and accept correct direction/size by eye) 	(1) (1) (1) (1)	4
(b)(i)	• Initially friction/drag negligible/small/less (as the velocity is low) • See $mg\sin\theta$ **Or** $W\sin\theta$ • $mg\sin\theta = ma$ and the masses cancel (so a independent of m)	(1) (1) (1)	3
(b)(ii)	• As velocity increases, air resistance increases • Until frictional forces = component of weight down slope • Resultant force = 0 **and** there is no more acceleration (at max velocity) (MP2 allow frictional forces = $mg\sin\theta$)	(1) (1) (1)	3
(b)(iii)	• A larger person would have a greater area/volume • The air resistance would be greater (accept drag)	(1) (1)	2

(c)(i)	See $\theta = \tan^{-1} 0.2$ **and** $\theta = 11.3°$ **Or** see $\tan\theta = 0.2$ **and** $\theta = 11.3°$	**(1)**	**1**
(c)(ii)	**Either** (Energy) Use of $E_k = ½\, mv^2$ Use of trig to determine the component of weight along the slope or the vertical height in terms of L Use of $E_{grav} = mg\Delta h$ (to determine E_{grav}) **Or** use of $W = F\Delta s$ Use of of $E_k = E_{grav} + W$ (to determine $L = 120$ m **Or** (forces) Use of trig to determine the component of weight along the slope or the vertical height in terms of L Use of resultant force = $mg\sin 11.3° + 240$ N Use of $\Sigma F = ma$ to determine a Use of $v^2 = u^2 + 2as$ with their a (not 9.81) to determine s $L = 120$ m <u>Example of calculation</u> $E_k = ½ \times 95 \text{ kg} \times (33 \text{ m s}^{-1})^2 = 51728 \text{ J}$ $51728 \text{ J} = (95 \text{ kg} \times 9.81 \text{ N kg}^{-1} \times \sin 11.3° \times L) + (240 \text{ N} \times L)$ $L = 122$ m	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question		**18**

Q6.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as force per unit length has no meaning. C is not the correct answer as this is the gravitational force. D is not the correct answer as this is gravitational potential.	**(1)**

Q7.

Question Number	Answer	Mark
	D is the correct answer A is not the correct answer as the velocity is not constant at all times. B is not the correct answer as the velocity is still not constant at all times. C is not the correct answer as the air resistance does not act in the opposite direction to gravity when an object travels upwards.	**(1)**

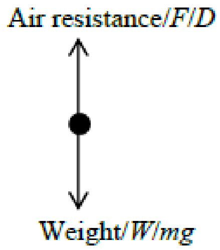
Q8.

Question Number	Answer	Mark
	C is the correct answer A is not correct as it ignores the weight of the table. B is a correct equation since $R_c=W_c$, but it is not an instance of the third law. D is a correct equation but it is not an instance of the third law.	**(1)**

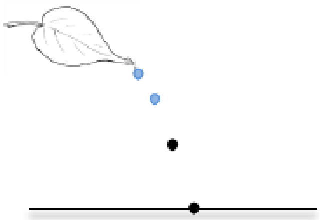
Q9.

Question Number	Answer	Mark
	C is the correct answer This is because W_c should have been drawn in the centre of the cube.	**(1)**

Q10.

Question Number	Answer	Mark
(a)(i)	Explanation • Terminal velocity is the constant/maximum velocity the rain reaches **Or** terminal velocity is the velocity when acceleration = 0 (1) • When weight = Drag (+ upthrust) **Or** when forces is equilibrium **Or** when resultant force = 0 (accept when the total upward force = total downward force) (1) Diagram • Weight and air resistance (and upthrust) only drawn with correct directions (arrowed lines must touch dot, and labels included) (1) • Arrow lengths of weight and air resistance same length (if upthrust drawn, upthrust line + drag line = weight line) (MP4 dependent on MP3) (1)  	4

(a)(ii)	• Use of $A = \pi r^2$ and $V = \frac{4}{3}\pi r^3$ (1) • Use of $\rho = \frac{m}{V}$ and $W = mg$ (1) • Use of $W = F$ (1) • $v = 6.5 - 7.0\ \mathrm{m\ s^{-1}}$ (1) <u>Example of calculation</u> $A = \pi \times (0.002)^2 = 1.26 \times 10^{-5}\ \mathrm{m^2}$ $V = \frac{4}{3}\pi \times (0.002\ \mathrm{m})^3 = 3.35 \times 10^{-8}\ \mathrm{m^3}$ $m = 1000\ \mathrm{kg\ m^{-3}} \times 3.35 \times 10^{-8}\ \mathrm{m^3} = 3.35 \times 10^{-5}\ \mathrm{kg}$ $W = 3.35 \times 10^{-5}\ \mathrm{kg} \times 9.81\ \mathrm{N\ kg^{-1}} = 3.29 \times 10^{-4}\ \mathrm{N}$ $3.29 \times 10^{-4}\ \mathrm{N} = 0.45 \times 1.2\ \mathrm{kg\ m^{-3}} \times 1.26 \times 10^{-5}\ \mathrm{m^2} \times v^2$ $3.29 \times 10^{-4}\ \mathrm{N} = 6.80 \times 10^{-6} \times v^2$ $v = 6.96\ \mathrm{m\ s^{-1}}$	4

(b)(i)	• Vertical displacement increasing • Horizontal displacement constant (same as first two drops) (Mark all added drops but there must be a minimum of 2 additional drops to award MP1 &2) 	(1) (1)	2
(b)(ii)	• Use of $s = ut + ½ at^2$ with $u = 0$ (accept use of t = 0.2 s, 0.25 s, 0.75 s, 1.0 s) • See 0.8 s for the time since the drop left the leaf • $s = 3.1$ m <u>Example of calculation</u> $s = ½ \times 9.81 \text{ N kg}^{-1} \times (0.8 \text{ s})^2 = 3.14 \text{ m}$	(1) (1) (1)	3
	Total for question		**13**