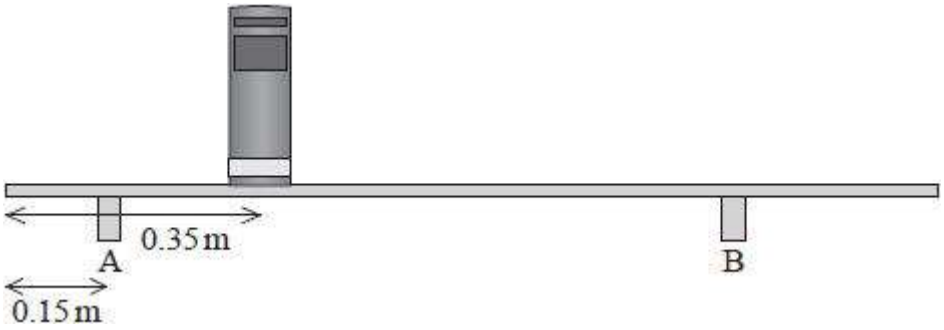
Questions

Q1.

Two brackets, A and B, support a shelf of length 1.2 m. Bracket A is positioned 0.15 m from the left-hand end of the shelf. A book is placed 0.35 m from the left-hand end of the shelf as shown.



(a) The normal contact forces of each bracket on the shelf are equal.

Determine the distance of bracket B from the left-hand end of the shelf.
weight of book = 8.5 N
weight of shelf = 14 N

(5)

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Distance = ...

(b) Bracket B is moved closer to the left-hand end of the shelf.

Explain the effect on the magnitude of the normal contact force of bracket B on the shelf.

(2)

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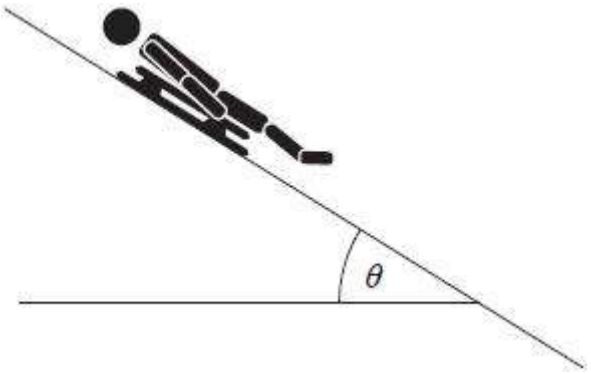
(Total for question = 7 marks)

Q2. The luge is an event at the Winter Olympics. An athlete lies on a small sledge and races down an icy track, feet first.

Source: www.wtop.com

(a) An athlete accelerates down a straight section of the track as shown. The track is at an angle θ to the horizontal.



Draw a free-body force diagram for the sledge and athlete.
You should consider the relative sizes of the forces when drawing your diagram.

(4)

(b) The mass of the athlete is one of the factors that affects her time to complete the race.

(i) Explain why the mass of the athlete has little effect on the initial acceleration.

(3)

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(ii) Explain, in terms of forces, why the athlete reaches a maximum velocity.

(3)

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(iii) It is stated that the maximum speed is greater for athletes of greater mass.
Suggest why this is only correct up to a certain mass.

(2)

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(c) After the finish line there is a straight, uphill section of track for the sledge to decelerate in. The maximum permitted gradient of this section is 20 %.

(i) Show that a track with a gradient of 20% is at an angle to the horizontal of about 11°.

(1)

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(ii) An athlete reaches the finish line at a velocity of 33 m s^{-1}. She then applies a minimum braking force of 240 N as she moves along the uphill section of track to help her come to a stop.
Calculate the minimum uphill length of track *L* that should be available for braking. You should ignore all frictional forces other than those applied by the athlete.
mass of sledge and athlete = 95 kg

(5)

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L = ...

Q3. All quantities may be expressed in terms of SI base units.

Which of the following are the base units for the moment of a force?

(1)

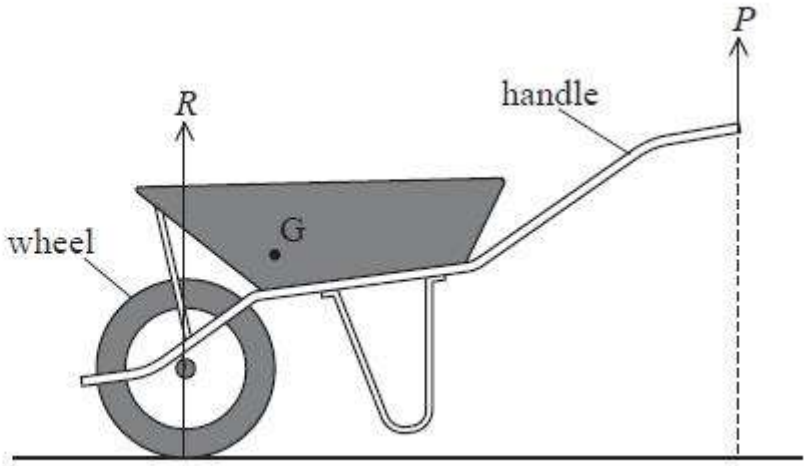
- ☒ **A** kg m s^{-2}
- ☒ **B** kg m^2 s^{-2}
- ☒ **C** kg m s^{-1}
- ☒ **D** kg m^2 s^{-3}

Q4.

A woman supports a stationary wheelbarrow by exerting an upward force *P* on the handles. An upward force *R* from the ground acts on the wheel, as shown.

The centre of gravity G of the wheelbarrow is marked on the diagram.

(Source: © Cavan Images/Alamy Stock Photo)



(a) Explain, by considering moments about G, why *P* is less than *R*.

(3)

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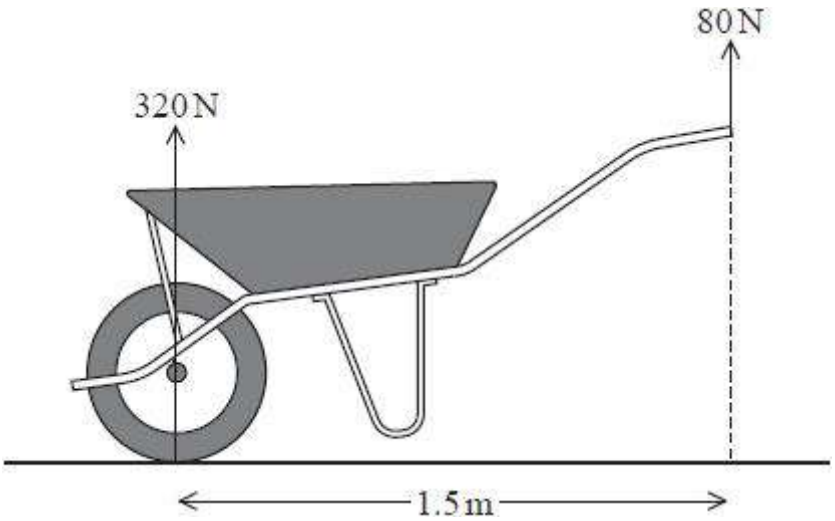
(b) The horizontal distance between the centre of the wheel and the handles is 1.5 m.

The magnitudes of *P* and *R* are as shown.



Determine the horizontal distance between the centre of gravity of the wheelbarrow and the centre of the wheel.

(4)

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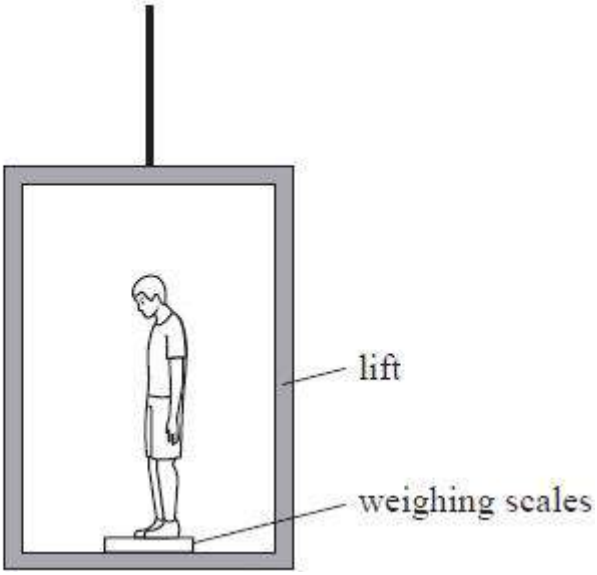
Horizontal distance = ...

(Total for question = 7 marks)

Q5. Which of the following statements describes the gravitational field strength acting on a body at a point?

- ☒ **A** gravitational force per unit length
- ☒ **B** gravitational force per unit mass
- ☒ **C** gravitational potential energy per unit length
- ☒ **D** gravitational potential energy per unit mass

Q6. * A student of weight 600 N is standing on weighing scales in a lift. The scales are calibrated to give readings in newtons.



The lift moves upwards at constant velocity, then decelerates to rest. As the lift moves, the student looks at the readings on the scales.

Explain the readings on the scales.

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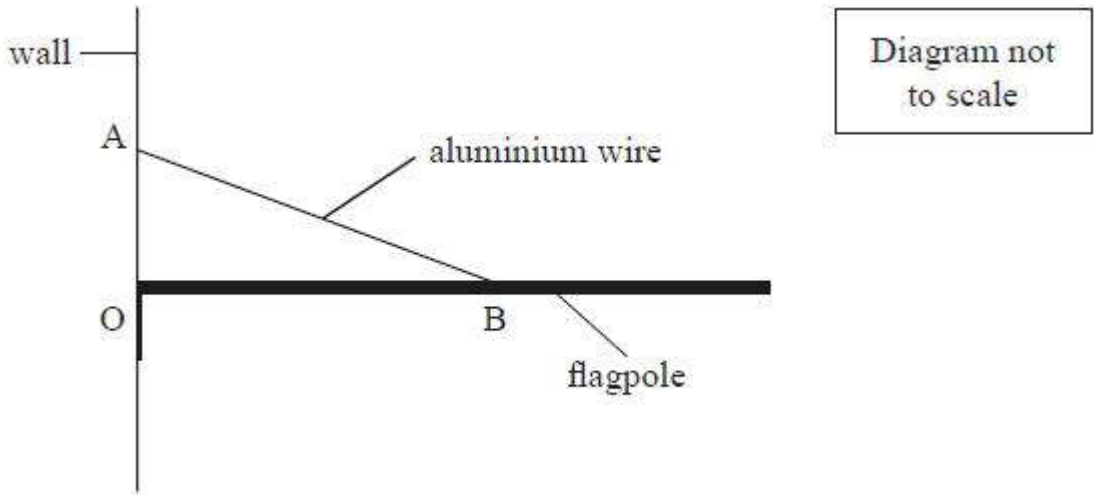
(Total for question = 6 marks)

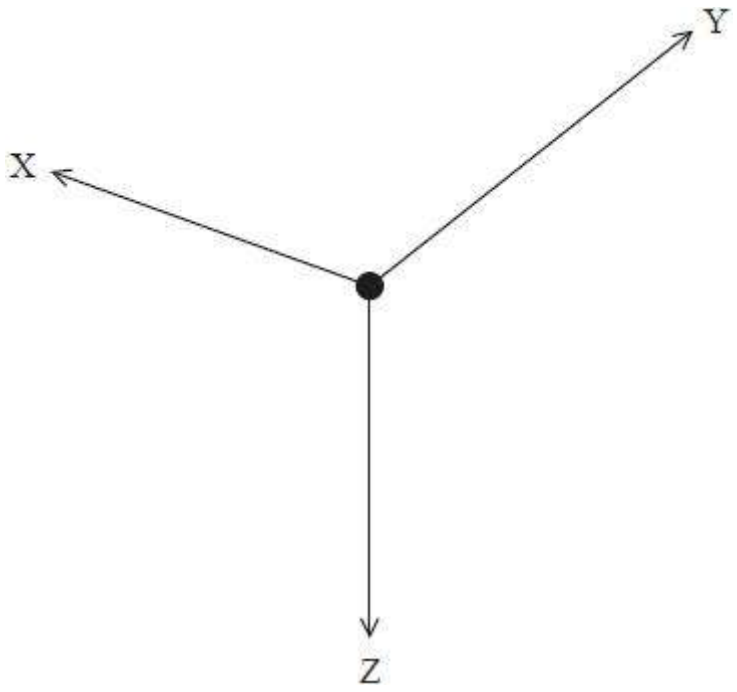
Q7. A uniform, horizontal flagpole is connected by a hinge to a wall at position O. An aluminium wire connects the pole to the wall at A, as shown.



(a) A free-body force diagram for the flagpole is shown below.

Identify the forces X, Y and Z.

(3)



X .....

Y .....

Z .....

(b) The aluminium wire will break if the tension in the wire exceeds 350 N.

The wire is attached to the flagpole at B, 0.8 m from the wall.
The wire is at an angle of 20° to the flagpole.
Assess whether the wire will break. You should use the principle of moments, taking moments about O.
length of flagpole = 1.2 m
mass of flagpole and flag = 15 kg

(3)

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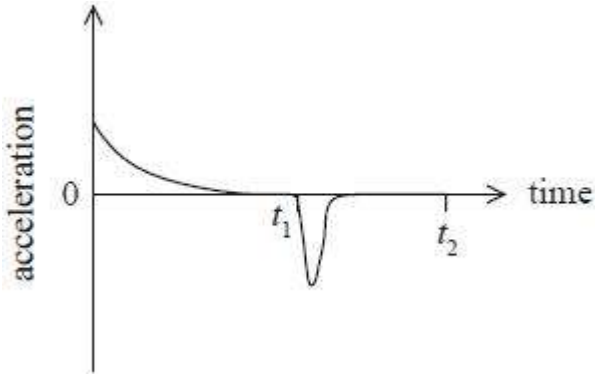
(Total for question = 6 marks)

Q8.

* A skydiver jumps from an aeroplane and accelerates until she reaches terminal velocity. At a time t_1, she opens a parachute and a second, lower terminal velocity is reached before landing safely at time t_2.

The acceleration-time graph for the motion of the skydiver is shown.



Explain the shape of the graph. You should refer to the forces acting on the skydiver.

(6)

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(Total for question = 6 marks)

Q9. The photograph shows a person riding a unicycle. The unicycle moves at a constant speed on a horizontal surface. The vertical forces *R* and *W* act as shown.

The magnitude of each force is represented by the length of the arrow on the photograph.

(a) Assess whether forces *R* and *W* are a Newton's third law pair of forces.

(3)

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(b) Explain the motion of the unicycle. Your answer should make reference to all of the forces acting on the unicycle.

(2)

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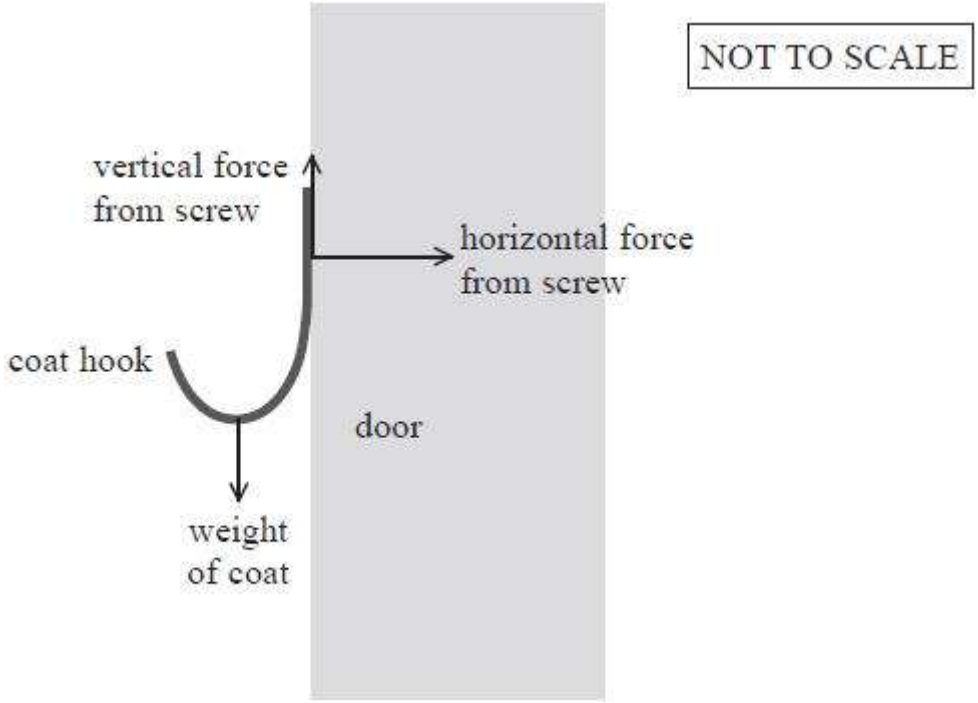
(Total for question = 5 marks)

Q10. A coat hook is attached to a smooth door by a screw as shown.

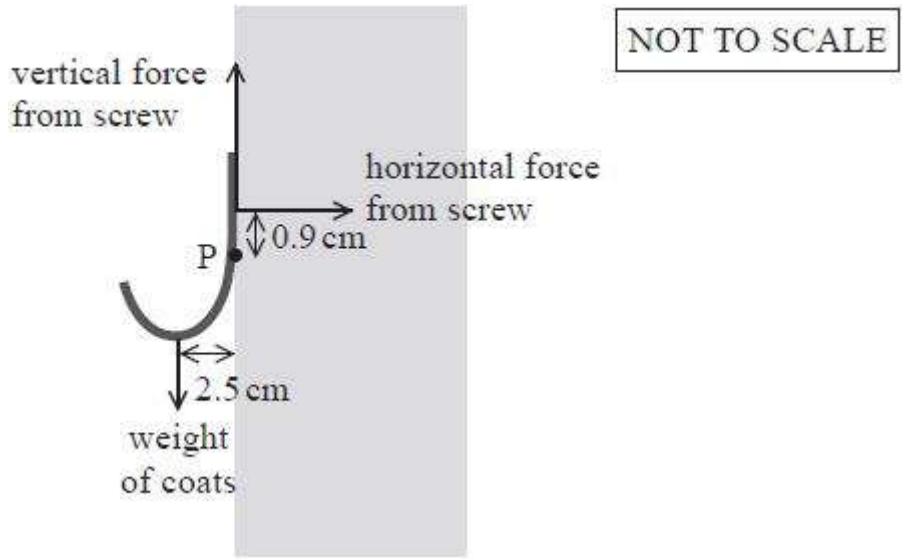
(a) The diagram below shows three of the forces that act on the coat hook when a coat is hung from it. The weight of the coat hook may be neglected.



Add a labelled arrow to the diagram to show the additional force required for the coat hook to be in equilibrium.

(2)

(b) If too many coats are hung on the coat hook, the hook will rotate and pull the screw out of the door. Point P is the position of the pivot as shown.



The maximum horizontal force from the screw is 150 N.

The mass of one coat is 2.6 kg.

Deduce whether a person could hang more than two of these coats from the hook.

(4)

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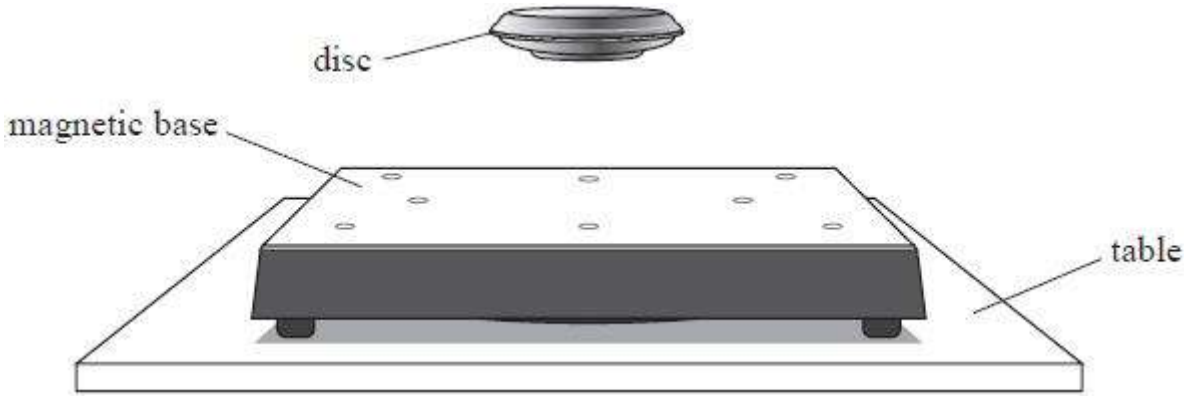
(Total for question = 6 marks)

Q11. A disc of mass *m* is held stationary by a force *F* exerted by a magnetic base, as shown.



(a) The free-body force diagram for the disc is shown below.

The two forces shown are equal in magnitude and opposite in direction.
Give two reasons why these forces are **not** a Newton's 3rd law pair.

(2)

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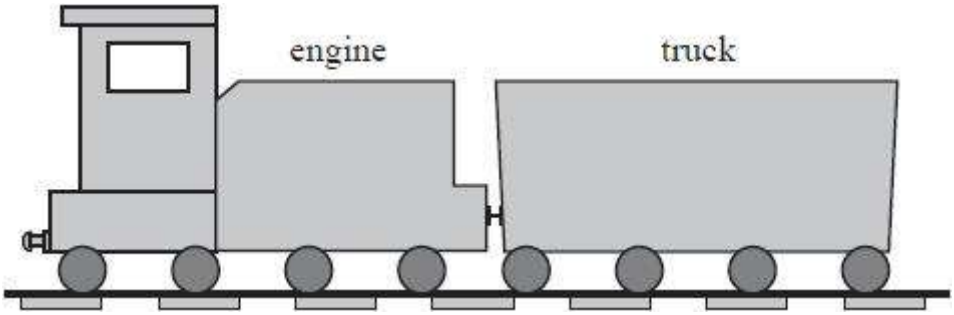
(b) The magnetic base has weight W and rests on a horizontal table.

Complete the free-body force diagram below for the magnetic base.

(2)

(Total for question = 4 marks)

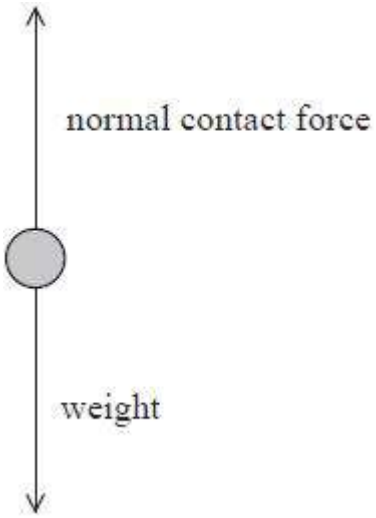
Q12. A railway engine is pushing a truck along horizontal rails at a constant velocity, as shown.



The engine exerts a forward force of 1.2×10^5 N on the truck. The engine also exerts a net backwards force of 1.5×10^5 N on the rails.

(a) Complete the free-body force diagram to show all the forces acting on the engine.

(4)



(b) A student suggests that the weight and the normal reaction force form a Newton's third law pair of forces.

Explain why the student's suggestion is **not** correct. Your answer should include reference to the features of a Newton's third law pair of forces.

(5)

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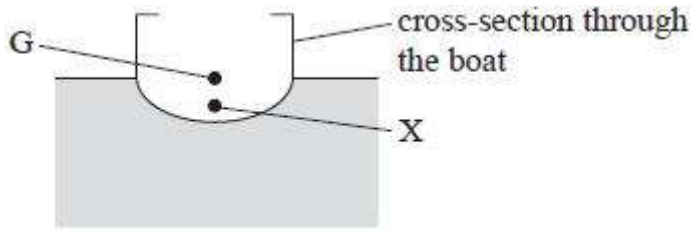
(Total for question = 9 marks)

Q13. For a boat to maintain a constant upright position in the water, the weight *W* and upthrust *U* should have the same line of action.

W acts through G, the centre of gravity of the boat.

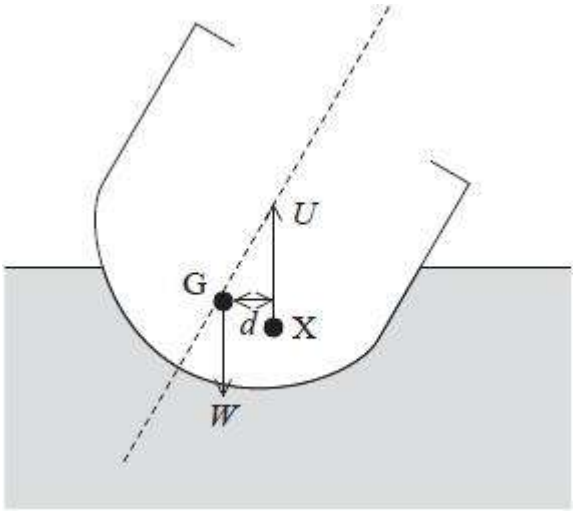
U acts through X, the centre of gravity of the volume of water displaced by the boat.

G and X are shown on the diagram.



(a) A sudden gust of wind applies a force to the side of the boat, causing it to tilt.

The lines of action of *W* and *U* move apart a distance *d*, as shown below.



(i) Explain the effect of the moment *Ud*.

(2)

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(ii) Explain what would happen to the boat in windy weather if the centre of gravity G were higher.

(3)

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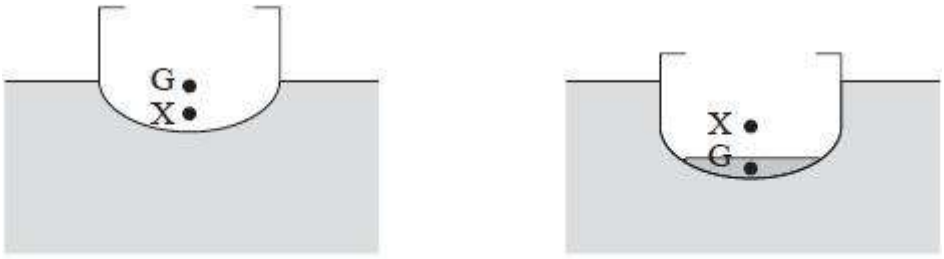
(b) Some boats use a ballast tank, which is a refillable tank of water in the base of the boat, to improve stability.



Ballast tank empty

Ballast tank full

(i) Explain why the position of X for the ship when it has a full ballast tank is lower than when the ship has an empty ballast tank.

(4)

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(ii) Explain a disadvantage of using a full ballast tank when the boat is moving through the water.

(2)

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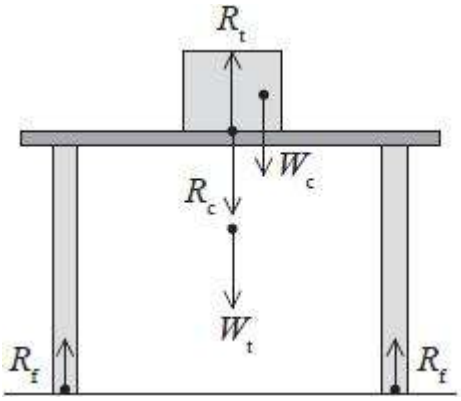
(Total for question = 11 marks)

Q14. A uniform solid cube is placed on a table. The diagram shows the forces acting on the table and on the cube.



R_c = reaction force of cube on table
R_f = reaction force of floor on table
R_t = reaction force of table on cube
W_c = weight of cube
W_t = weight of table

The table has four legs.

Which of the following statements is correct according to Newton's third law?

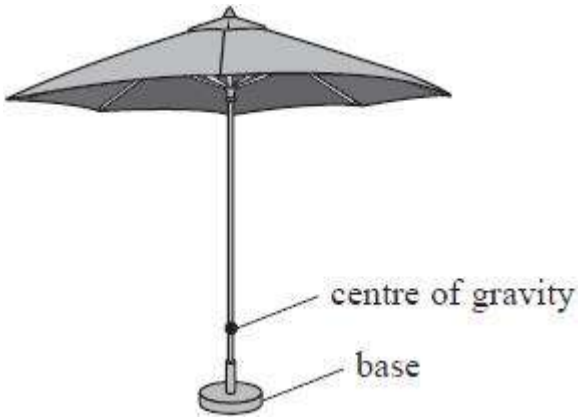
(1)

- ☒ **A** $4R_f = R_c + R_t$
- ☒ **B** $4R_f = R_c + W_t$
- ☒ **C** $R_c = R_t$
- ☒ **D** $R_t = W_c$

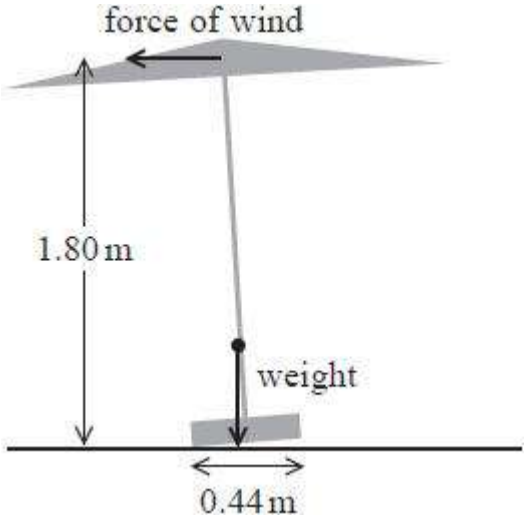
(Total for question = 1 mark)

Q15.

A large parasol has been set up on a windy day. The centre of gravity of the parasol is vertically above the centre of the base. The bottom of the parasol starts to lift from the ground as shown. The weight of the parasol is 110 N.



(a) The force of the wind is 14 N in a horizontal direction.



Explain why the parasol will topple. Your answer should include a calculation.

(4)

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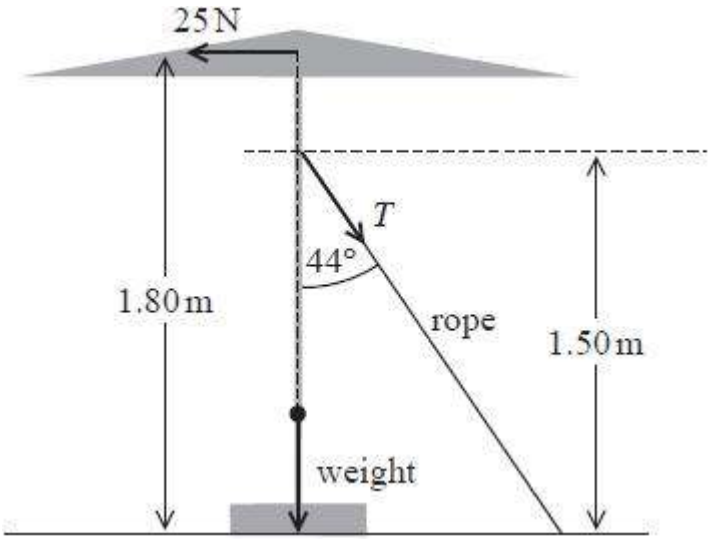
(b) To prevent the parasol from toppling, a rope is attached to the parasol at 1.50 m from the ground as shown. The rope makes an angle of 44° to the vertical.



The horizontal force from the wind is now 25 N.
Determine, by taking moments about the centre of the base, the vertical force that the base exerts on the ground.
Assume that the force which the ground exerts on the base acts through the midpoint of the base.

(5)

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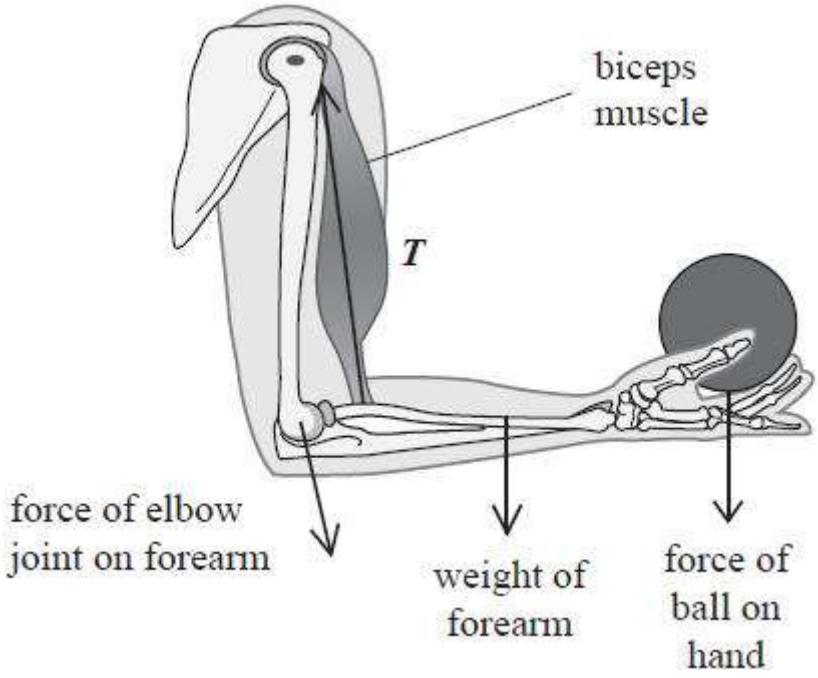
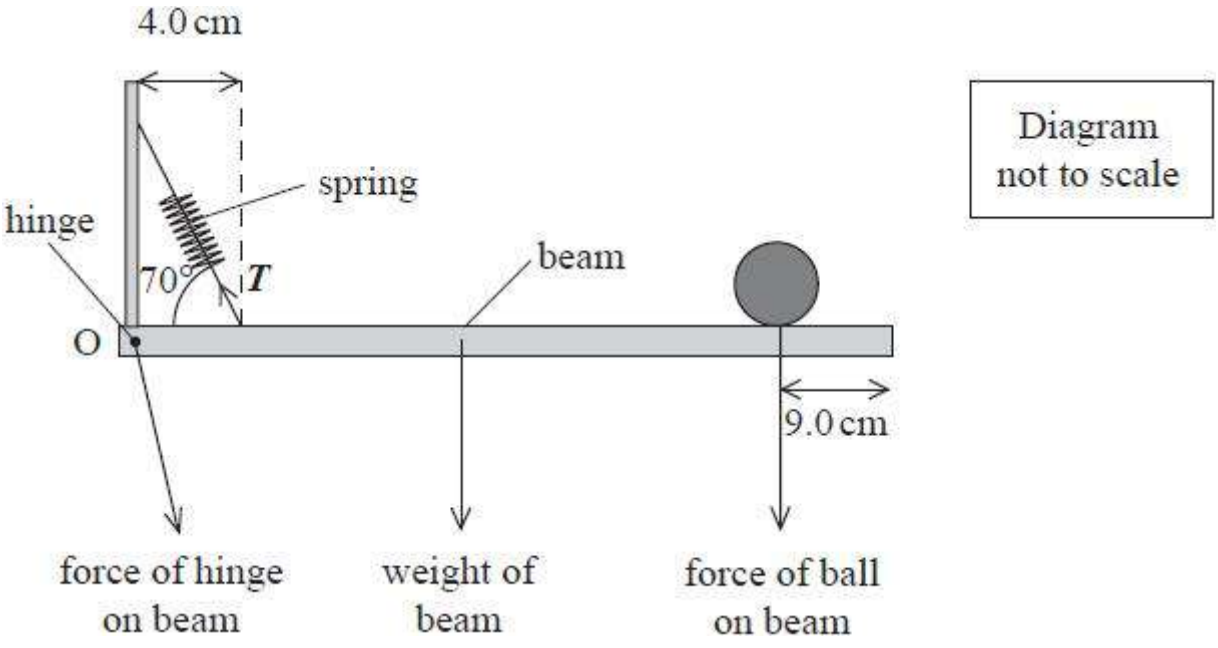
Force exerted on the ground = ...

(Total for question = 9 marks)

Q16. Muscles move body parts by contracting and relaxing. For the forearm to hold a ball in the position shown, the biceps muscle contracts, creating a tension *T* in the muscle as shown.



A student modelled the forces on the forearm using a uniform beam and spring arrangement as shown below. The length and weight of the beam were the same as the length and weight of the forearm.



(a) It can be assumed that the biceps muscle acts as a spring at an angle of 70° to the beam, 4.0 cm from the pivot O.
Determine the magnitude of *T*. You will need to estimate the total length of the forearm and hand.
force of ball on beam = 4.5 N
weight of beam = 15 N

(5)

Estimate of total length of forearm and hand = ...

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T = ...

(b) Explain a limitation of using a beam to model the forearm.

(2)

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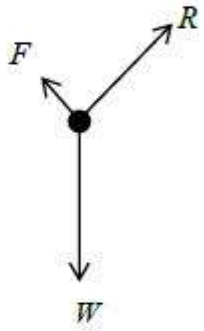
(Total for question = 7 marks)

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
	Example of calculation $F_A + F_B = 8.5$ N + 14 N = 22.5 N $F_A = F_B$ $2F = 22.5$ N $F = 11.25$ N if moments taken from the left end (11.25 N × 0.15 m) + (11.25 N × x) = (8.5 N × 0.35 m) + (14 N × 0.60 m) $x = 0.861$ m if moments taken from midpoint (11.25 N × 0.45 m) = (11.25 N × x) + (8.5 N × 0.25 m) $x = 0.261$ m so distance = 0.261 m + 0.6 m = 0.861 m if moments taken from A (8.5 N × 0.20 m) + (14 N × 0.45 m) = (11.25 N × 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
(a)	• Weight/W/mg labelled	**(1)**	
	• (Normal) reaction/contact force (accept R/N/C)	**(1)**	
	• Friction/F	**(1)**	
	• Lengths $R<W$ **and** $F<W$	**(1)**	**4**
	(-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)		
			
(b)(i)	• Initially friction/drag negligible/small/less (as the velocity is low)	**(1)**	
	• See $mg\sin\theta$ **Or** $W\sin\theta$	**(1)**	
	• $mg\sin\theta = ma$ and the masses cancel (so a independent of m)	**(1)**	**3**
(b)(ii)	• As velocity increases, air resistance increases	**(1)**	
	• Until frictional forces = component of weight down slope	**(1)**	
	• Resultant force = 0 **and** there is no more acceleration (at max velocity)	**(1)**	**3**
	(MP2 allow frictional forces = $mg\sin\theta$)		
(b)(iii)	• A larger person would have a greater area/volume	**(1)**	
	• The air resistance would be greater (accept drag)	**(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 $E_k = ½ mv^2$ **(1)** Use of trig to determine the component of weight along the slope or the vertical height in terms of L **(1)** Use of $E_{grav} = mg\Delta h$ (to determine E_{grav}) **Or** use of $W = F\Delta s$ **(1)** Use of of $E_k = E_{grav} + W$ (to determine **(1)** $L = 120$ m **(1)** **Or** (forces) Use of trig to determine the component of weight along the slope or the vertical height in terms of L **(1)** Use of resultant force = $mg\sin 11.3° + 240$ N **(1)** Use of $\Sigma F = ma$ to determine a **(1)** Use of $v^2 = u^2 + 2as$ with their a (not 9.81) to determine s **(1)** $L = 120$ m **(1)** Example of calculation $E_k = ½ \times 95$ kg $\times$ (33 m s^{-1})^2 = 51728 J 51728 J = (95 kg $\times$ 9.81 N kg^{-1} $\times$ sin 11.3° $\times$ L) + (240 N $\times$ L) $L = 122$ m	5
	Total for question	18

Q3.

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)

Q4.

Question Number	Answer	Mark
(a)	Moments due to force on wheel and force on handle must be equal (magnitude about any point) (1) Moment is force times (perpendicular) distance [accept "$F\ x$" but no other symbols unless in question or defined by candidate] (1) [Accept for MP1 and MP2 Force × (perpendicular) distance must be same for both moments] Handle is futher from centre of gravity than wheel (so less force for equal moment) [NB independent mark] (1)	3
(b)	Uses weight = 400 N (1) **Or** Uses x and $(1.5 - x)$ (1) Use of moment = Fx about a stated point (1) [accept pivot point clearly indicated on diagram] (1) Use of principle of moments $x = 0.3$ m <u>Example calculation</u> Weight = 320 + 80 = 400 N Taking moments about line of action of 320 N force 400 N × x = 80 N × 1.5 m x = 120 Nm ÷ 400 N = 0.30 m	4
	Total for question	7

Q5.

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)

Q6.

Question Number	Answer	Mark
*	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 and lines of reasoning.	**6**

IC points	IC mark	Max linkage mark available	Max final mark
6 or more	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

	Marks
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

Indicative content:

IC1 The force of the lift/scales on the student is the reading on the scales
Or
The reaction/contact force is the reading on the scales

IC2 At constant speed, the resultant force on the student is zero
Or
Weight/W = Reaction/R

IC3 At constant speed the reading on the scales would be 600 N.
Or
At rest the reading on the scales would be 600 N

IC4 As lift decelerates reaction is less than weight

IC5 As the lift decelerates there is a resultant downward force (on the student).

IC6 As the lift decelerates the reading on the scales will be less than 600 N (because the upward force on the student is less than his weight)

	Total for question	**6**

Q7.

Question Number	Answer		Mark
(a)	• X is the force (or pull or tension) of the wire (on the flagpole) (accept tension in the wire)	(1)	3
	• Y is force (or reaction or push, ignore "normal") of the hinge (or wall) (on the flagpole).	(1)	
	• Z is weight or force of gravity (of/on the flagpole)	(1)	
(b)	• Use of moment of a force = Fx	(1)	3
	• Use of the principle of moments	(1)	
	• $T = 323$ (N) < 350 (N) so wire will not break **Or** Moment of weight about hinge = 88.3 (Nm) < 95.8 (Nm), max poss from wire **Or** Correct conclusion based on comparison of student's value with 350 N or 95.8 Nm MP3 depends on MP1 and MP2 being seen	(1)	
	Example of calculation $(15\text{ kg} \times 9.81\text{ N kg}^{-1} \times 0.6\text{ m}) - (T \sin 20° \times \frac{2}{3} \times 1.2\text{ m}) = 0$ $T = (15\text{ kg} \times 9.81\text{ N kg}^{-1} \times 0.6\text{ m}) \div (0.8\text{ m} \times \sin 20°)$ $= 88.29\text{ Nm} \div 0.2736$ $T = 322.7\text{ N}$ max available moment = $350\text{ N} \times 0.8\text{ m} \times \sin 20° = 95.77\text{ Nm} > 88.29\text{ Nm}$		
	Total for question		6

Q8.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*</td><td>
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.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th><th>Linkage marks available</th></tr>
<tr><td>6</td><td>4</td><td>2</td></tr>
<tr><td>5</td><td>3</td><td>2</td></tr>
<tr><td>4</td><td>3</td><td>1</td></tr>
<tr><td>3</td><td>2</td><td>1</td></tr>
<tr><td>2</td><td>2</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning
</td><td>6</td></tr>
<tr><td></td><td>
Indicative content

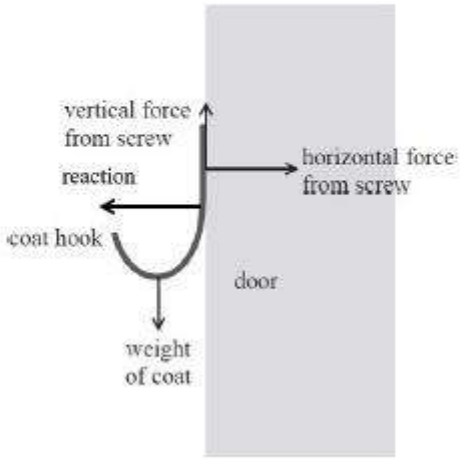
• Acceleration is maximum (or acceleration = g) initially
• As velocity increases the air resistance increases
• Resultant force decreases until it becomes zero and diver reaches terminal velocity
Or
(Eventually) forces balance and the diver reaches terminal velocity
• At t_1 the air resistance increases or is greater then the weight
• Skydiver decelerates or the resultant force is now upwards/negative
• Second terminal velocity is lower because air resistance = weight at a lower velocity.

Ignore mention of upthrust.
</td><td></td></tr>
<tr><td></td><td>Total for question</td><td>6</td></tr>
</table>

Q9.

Question Number	Answer		Mark
(a)	• States that W is the weight of the rider (and unicycle) and R is the push/reaction force (from the ground)	(1)	3
	• R and W are different types of force **Or** R and W act on the same object **Or** R and W are not equal.	(1)	
	• They are **not** a N3 pair of forces	(1)	
	MP3 conditional on MP2		
(b)	• The resultant force acting in the vertical direction is zero so the unicycle will remain at that height **Or** The resultant force acting in the vertical direction is zero so zero acceleration in the vertical direction	(1) (1)	2
	• The unicycle moves at a constant (forward) speed because the resultant horizontal force is zero or horizontal forces are balanced (because forward frictional force balances backward drag forces)		
	Total for question		5

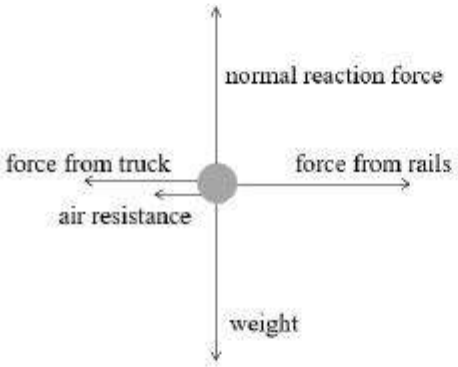
Q10.

Question Number	Answer		Mark
(a)		(1)	
	Horizontal arrow pointing to the left labelled "reaction (force from the wall on the hook)"	(1)	2
	Arrow drawn below screw and not lower than last point of contact between hook and wall MP2 depends upon MP1		
(b)	Use of moment of force = $F x$	(1)	
	Use of principle of moments	(1)	
	Use of $W = m g$	(1)	
	Correct calculation leading to conclusion no (as maximum is two coats)	(1)	4
	Example of calculation $150 \text{ N} \times 0.009 \text{ m} = W \times 0.025 \text{ m}$ $W = 1.35 \text{ N m} \div 0.025 \text{ m} = 54.0 \text{ N}$ $m = 54.0 \text{ N} \div 9.81 \text{ N kg}^{-1} = 5.50 \text{ kg}$ $5.50 \text{ kg} \div 2.6 \text{ kg} = 2.12 \therefore$ two coats max, so no.		
	Total for question		**6**

Q11.

Question Number	Answer	Mark
(a)	The forces act on the same object. **(1)** They are different types of force. **(1)**	2
(b)	Downward arrow labelled magnetic force (from disc) **Or** Downward arrow labelled *F*. **(1)** Upward arrow labelled (normal) reaction / contact / *R* / *N* / **and** arrow length approximately equal to *F* + *W*. **(1)** 	2
	Total for question	**4**

Q12.

Question Number	Answer		Mark
(a)	Force from truck to the left [accept 1.2×10^5 (N)]	(1)	
	Air resistance to the left [accept 3.0×10^4 (N)][do not accept "viscous drag"]	(1)	
	Force from rails to the right [accept 1.5×10^5 (N)]	(1)	
	[withhold one mark if more forces than three][if magnitudes used ignore names of forces]	(1)	4
	Total length of arrows towards the left equals length of arrow to the right [to within 2 mm using measuring tool][dependent on any three horizontal forces, do not check unless lengths look close by eye]		
			
(b)	A Newton's third law pair of forces		
	• Forces of equal magnitude that act in opposite directions [do not accept "equal and opposite reaction"][accept act for equal times]	(1)	
	• Same type of force	(1)	
	• (Acting on) different bodies	(1)	
		(1)	
	These two forces both act on the engine [accept "on the same body"]	(1)	5
	One force is gravitational [do not accept "weight"]and the other is a contact force		
	Total for question		**9**

Q13.

Question Number	Answer	Mark
(a)(i)	(This moment) causes an anti-clockwise rotation/motion (about G) **Or** This moment is anti-clockwise (about G) (1) Returning/maintaining the boat to/in an upright/initial position **Or** Reducing the tilt of the boat **Or** opposing/balancing the moment caused by the wind (1)	**(2)**
(a)(ii)	The distance *d* is reduced **Or** *W*/G moves to the right of *U*/X (1) The (anti-clockwise) moment is reduced **Or** The moment becomes/is clockwise (1) The boat would be less stable **Or** The boat will tilt further **Or** The boat could turn over (1)	**(3)**
(b)(i)	When filled with water/ballast, the weight/mass (of the boat) increases (1) Upthrust equals the weight (of the boat) (because the boat is floating) **Or** Upthrust increases (because the boat is floating) (1) Boat moves downwards in the water **Or** The volume/amount of displaced water increases (1) Centre of gravity of displaced water is lower (1)	**(4)**
(b)(ii)	Greater (surface) area of boat in contact with water **Or** greater cross-sectional area in water (in direction of travel) (1) There a greater resistance/drag/friction (on the boat). (1) (ignore references to greater risk of flooding)	**(2)**
	Total for question	**11**

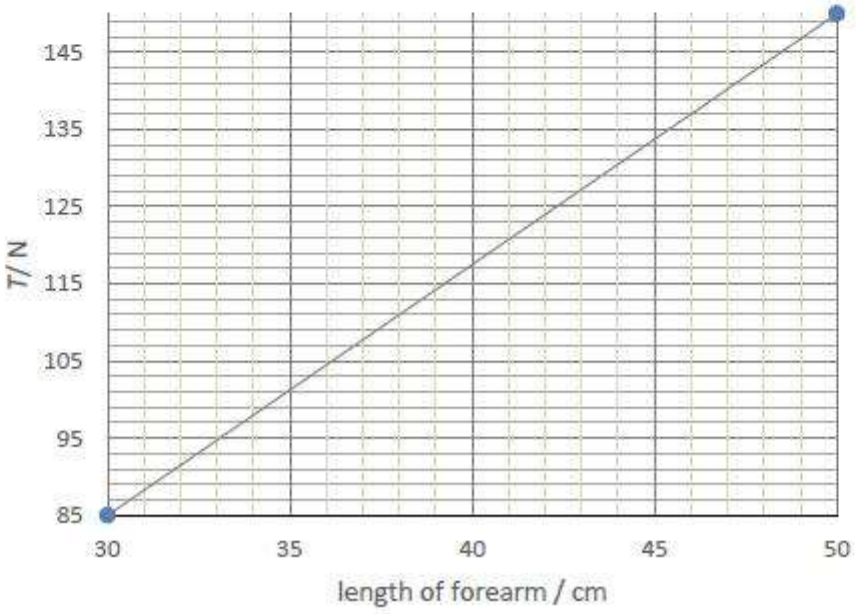
Q14.

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)**

Q15.

Question Number	Answer		Mark
(a)	Use of moment = $F x$	**(1)**	
	Anticlockwise moment = 25.2 (Nm)		
	and (maximum) clockwise moment = 24.2 (Nm)	**(1)**	
	As angle to the ground increases, clockwise moment from the weight decreases		
	Or	**(1)**	
	If line of action of weight moves outside base cannot regain equilibrium.	**(1)**	**4**
	25.2 > 24.2 ∴ blows over		
	<u>Example of calculation</u>		
	moment from wind = 14 N × 1.8 m = 25.2 N m		
	moment from weight = 110 N × 0.22 m = 24.2 N m		
	25.2 > 24.2 ∴ blows over		
(b)	Horizontal component = T × sin 44°		
	Or		
	Distance to line of action of T = 1.5 × sin 44°	**(1)**	
	Equates clockwise to anticlockwise moments about centre of base to determine T	**(1)**	
	Use of trigonometry to calculate vertical component of tension	**(1)**	**5**
	Adds weight to vertical component		
	Force exerted on the ground = 141 N	**(1)**	
		(1)	
	<u>Example of calculation</u>		
	Horizontal component of tension = T × sin 44°		
	CWM = 1.5 m × T × sin 44° = 1.04 m × T		
	ACWM = 25 N × 1.8 m = 45.0 N m		
	1.04 m × T = 45.0 N m		
	T = 45.0 N m ÷ 1.04 m = 43.2 N		
	Vertical component of T = 43.2 N × cos 44° = 31.1 N		
	Total downward force = 110 N + 31.1 N = 141.1 N		
	Total for question		**9**

Q16.

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 $T\sin 70$ **Or** see $T\cos 20$	(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**
	Example of calculation (for l = 0.40 m) (0.04 m × T × sin70) = (0.31 m × 4.5 N) + (0.20 m × 15 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