

PHYSICS



EXAM QUESTION PACK

TOPIC 9: FORCES AND THEIR EFFECTS (PACK 1)

SCORE

/78

PERCENTAGE

%

STEMUP

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Q1.

A student investigates moments of forces.

Figure 14 shows the apparatus used.

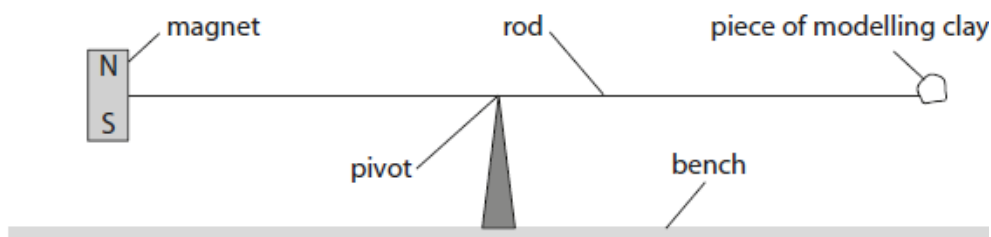


Figure 14

The pivot is under the centre of the rod.

A magnet is fixed to one end of the rod.

A piece of modelling clay is fixed to the other end of the rod.

The system is in equilibrium.

(a) The student fixes a coil to the bench under the magnet as shown in Figure 15.

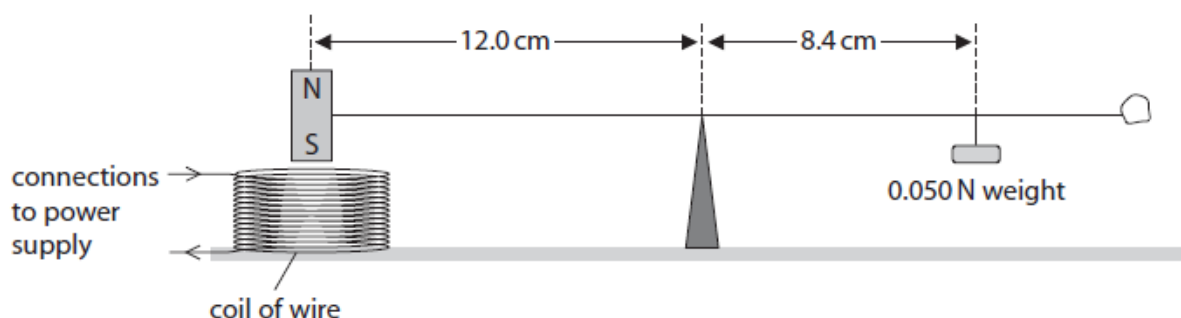


Figure 15

The coil of wire is connected to a d.c. power supply so that there is a current in the coil.

To bring the system back into equilibrium, the student hangs a 0.050 N weight on the rod, 8.4 cm away from the pivot, as shown in Figure 15.

Calculate the size of the force between the magnet and the coil.

(3)

force = ... N

(b) Describe how the student could develop the investigation to determine if the size of the force between the magnet and the coil is directly proportional to the size of the current in the coil.

(4)

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(Total for question = 7 marks)

Q2.

Figure 14 show a rack and pinion system, used on a mountain railway.

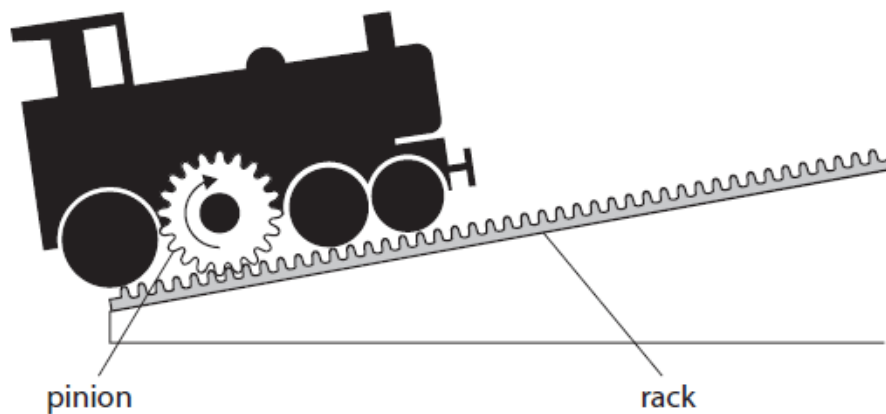


Figure 14

The teeth on the rack are 8.0 cm apart.

Calculate how far along the rack the train moves when the pinion turns through one complete revolution.

(2)

distance = ... m

(Total for question = 2 marks)

Q3.

Figure 3 is a diagram of the forces acting on a swing.

The swing is not moving.

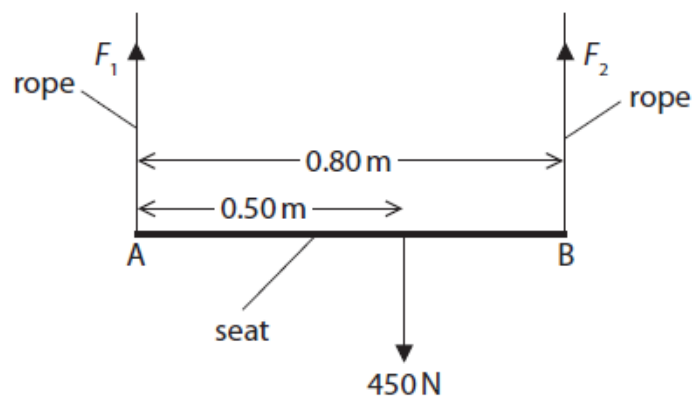


Figure 3

The seat of the swing, AB, is 0.80 m long.

A person of weight 450 N sits on the seat.

The person's weight acts at a distance of 0.50 m from A as shown in Figure 3.

Ignore the weight of the seat.

The upward forces exerted by the ropes on the seat are F_1 and F_2 .

Calculate the force F_2 by taking moments about A.

(3)

force F_2 = ... N

(Total for question = 3 marks)

Q4.

Figure 8 shows a bicycle.

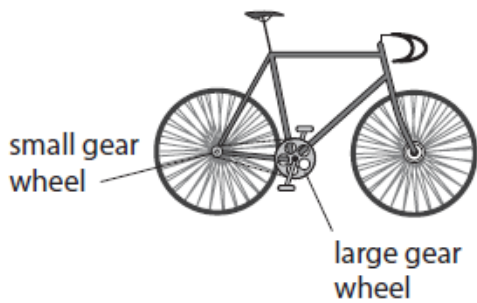


Figure 8

(i) The rider uses the pedals to make the large gear wheel turn.

The large gear wheel moves the chain.
The chain turns the small gear wheel.

The large gear wheel has 48 teeth.

The small gear wheel has 12 teeth.

The large gear wheel turns 2 times each second.

Calculate the number of times that the small gear wheel turns each second.

(2)

..... turns each second

(ii) Oil is applied to the wheel of a bicycle at the point shown in Figure 9.

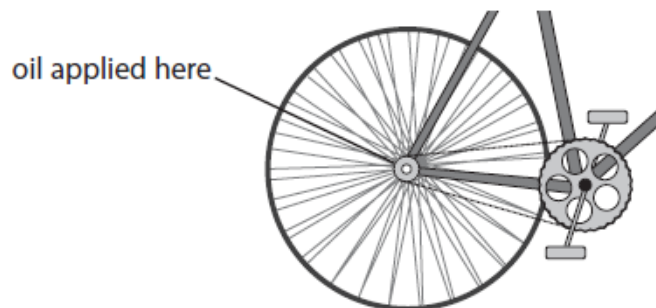


Figure 9

Explain how the oil improves the efficiency of the bicycle.

(3)

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(Total for question = 5 marks)

Q5.

Figure 13 shows a toy that a student makes for a nursery school.

for a nursery school. The rod hangs by a string from the ceiling.

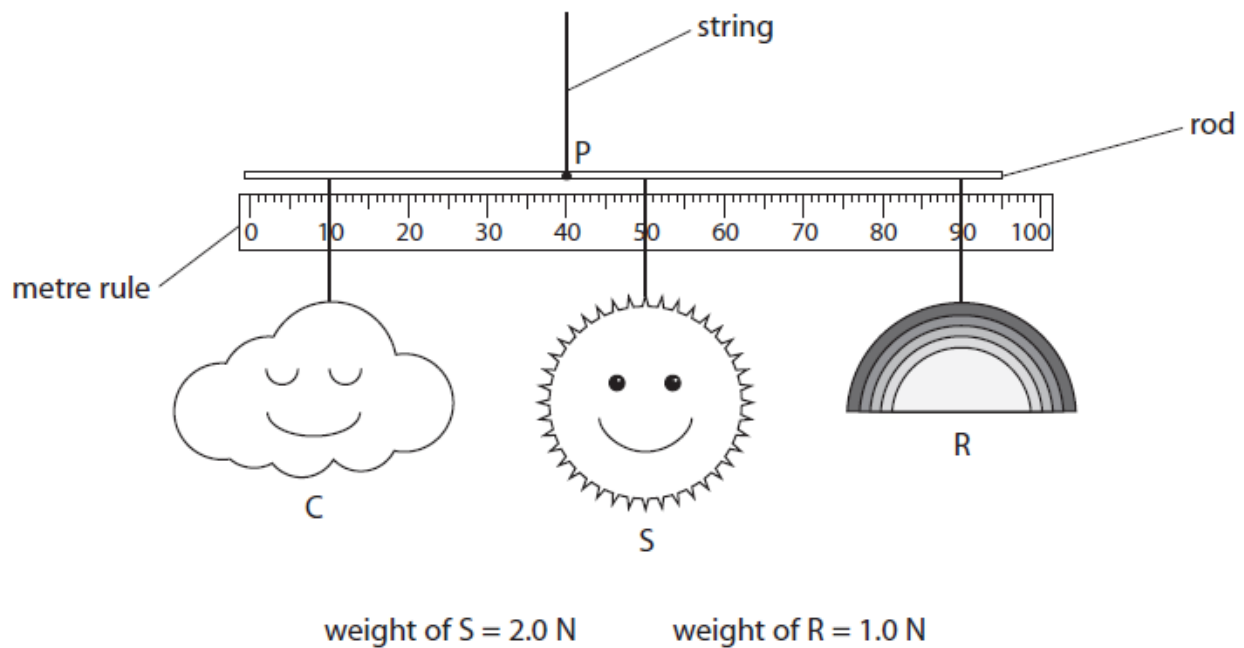


Figure 13

(i) The moment of C about point P is 0.60 Nm.

Calculate the weight of C.

Use the equation

$$\text{moment} = F \times d$$

(2)

weight of C N

(ii) Show that the total moment of S and R about P is 0.70 N m.

(2)

(iii) Using the data in the question and the principle of moments, determine if the toy shown in Figure 13 is in equilibrium.

The rod is very light so its weight can be ignored.

(3)

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(Total for question = 7 marks)

Q6.

Figure 12 shows three toy animals hanging from a rod.

The rod hangs from the ceiling by a string tied to the centre of the rod.

The system is in equilibrium.

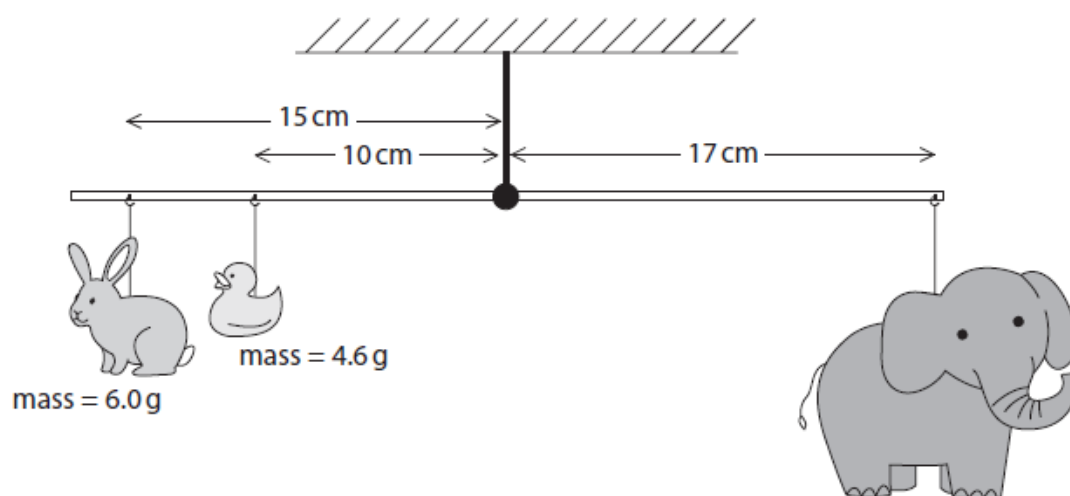


Figure 12

Use the principle of moments to calculate the mass of the toy elephant.

(4)

mass = ... g

(Total for question = 4 marks)

Q7.

Figure 14 shows a demolition ball of mass 400 kg.

The ball is used to demolish a wall.

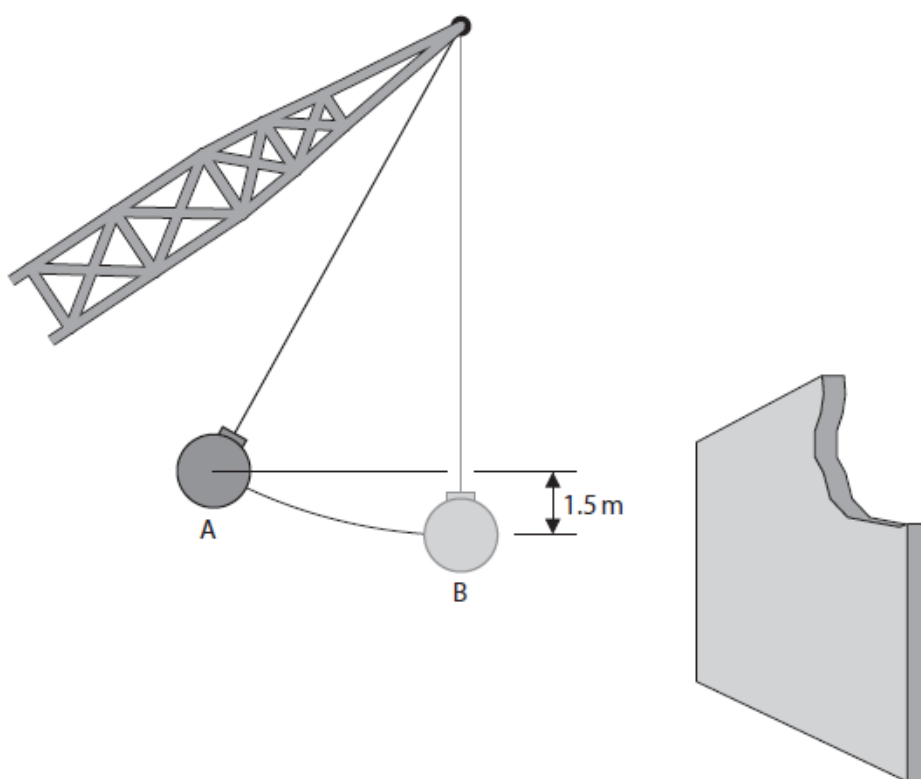


Figure 14

As the ball swings from A to B, it moves through a vertical height of 1.5 m.

(i) Calculate the change in gravitational potential energy.

Take gravitational field strength, g , to be 10 N/kg.

(3)

(ii) The heavy ball comes to rest soon after smashing into the wall. In doing this, the temperatures of the ball, wall and surroundings all increase slightly.

Explain this observation.

(2)

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(iii) Which of these quantities of the ball changes in **both** magnitude and direction while the ball is swinging?

Put a cross (☒) in the box next to your answer.

(1)

- ☐ **A** gravitational potential energy
- ☐ **B** velocity
- ☐ **C** the gravitational force acting
- ☐ **D** kinetic energy

(Total for question = 6 marks)

Q8.

Figure 8 shows a demolition ball of mass 400 kg.

The ball is used to demolish a wall.

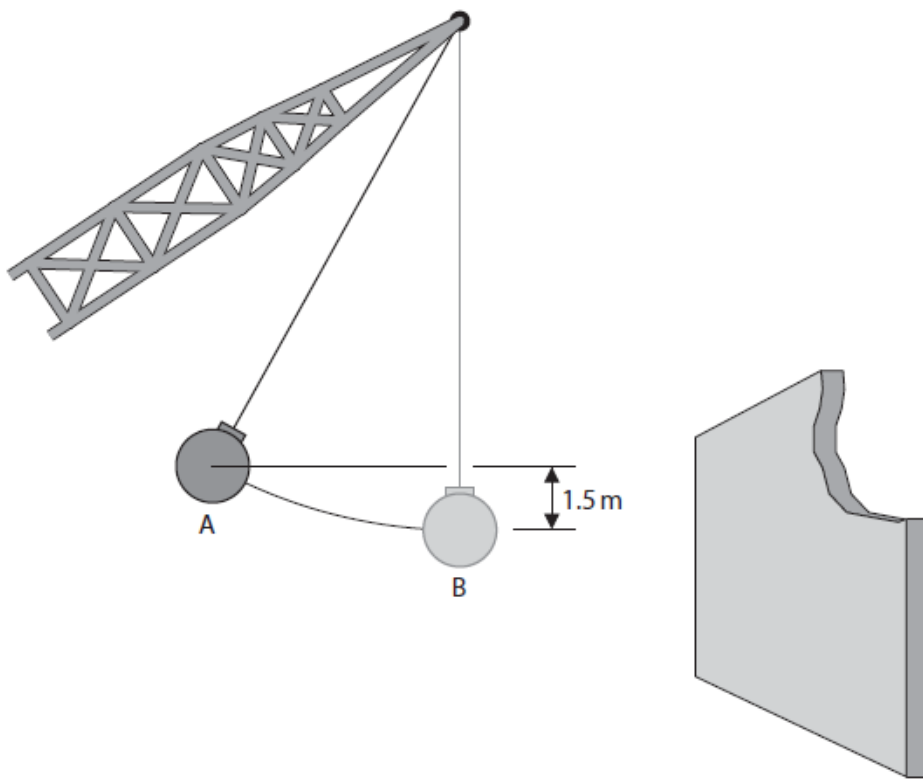


Figure 8

As the ball swings from A to B, it moves through a vertical height of 1.5 m.

(i) Calculate the change in gravitational potential energy.

Take gravitational field strength, g , to be 10 N/kg.

(3)

(ii) The heavy ball comes to rest soon after smashing into the wall. In doing this, the temperatures of the ball, wall and surroundings all increase slightly.

Explain this observation.

(2)

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(iii) Which of these quantities of the ball changes in **both** magnitude and direction while the ball is swinging?

Put a cross ☒ in the box next to your answer.

(1)

☒ **A** gravitational potential energy

☐ **B** velocity

- ☐ **C** the gravitational force acting
- ☐ **D** kinetic energy

(Total for question = 6 marks)

Q9.

Some forces act at a distance.

One example is the gravitational attraction between the Moon and the Earth.

Describe an example of another type of force acting at a distance, where the force is **not** gravitational.

(2)

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(Total for question = 2 marks)

Q10.

Some forces act at a distance.

One example is the gravitational attraction between the Moon and the Earth.

Describe an example of another type of force acting at a distance, where the force is **not** gravitational.

(2)

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(Total for question = 2 marks)

Q11.

A student investigates moments of forces.

Figure 14 shows the apparatus used.

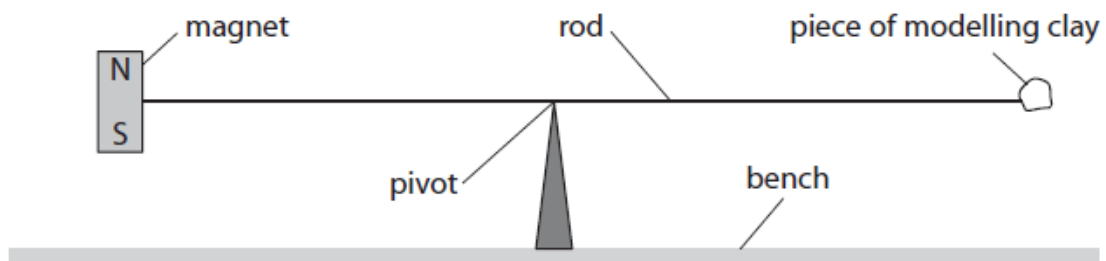


Figure 14

The pivot is under the centre of the rod.

A magnet is fixed to one end of the rod.

A piece of modelling clay is fixed to the other end of the rod.

The system is in equilibrium.

The student reverses the direction of the current in the coil.

Describe how the student can bring the system back into equilibrium without making any changes to the magnet.

(2)

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(Total for question = 2 marks)

Q12.

Figure 7 shows a drone.



© Liubov Kotliar/123RF

Figure 7

The drone has four spinning blades.

The upward force produced enables the drone to rise in the air.

The speed at which the blades spin is measured in turns per minute.

Figure 8 shows how the upward force produced by the four blades depends on the speed at which the blades spin.

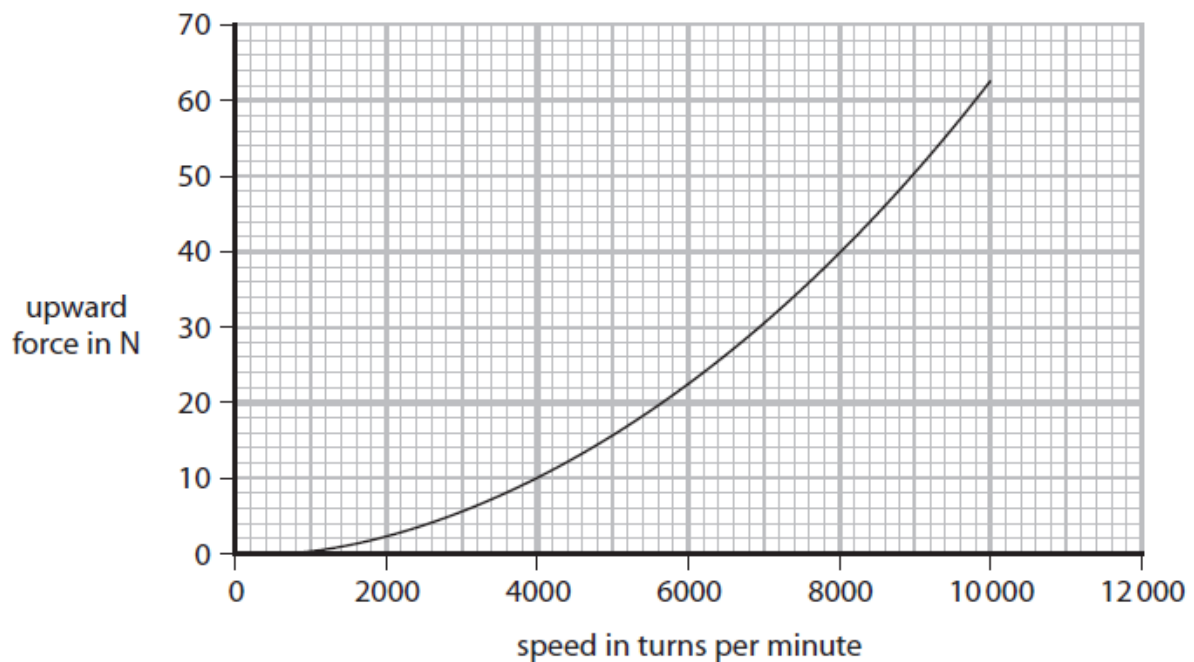


Figure 8

Describe the relationship between upward force and speed shown by this graph.

(2)

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(Total for question = 2 marks)

Q13.

Figure 4 shows a drone.



© Liubov Kotliar/123RF

Figure 4

The drone has four spinning blades.

The upward force produced enables the drone to rise in the air.

The speed at which the blades spin is measured in turns per minute.

Figure 5 shows how the upward force produced by the four blades depends on the speed at which the blades spin.

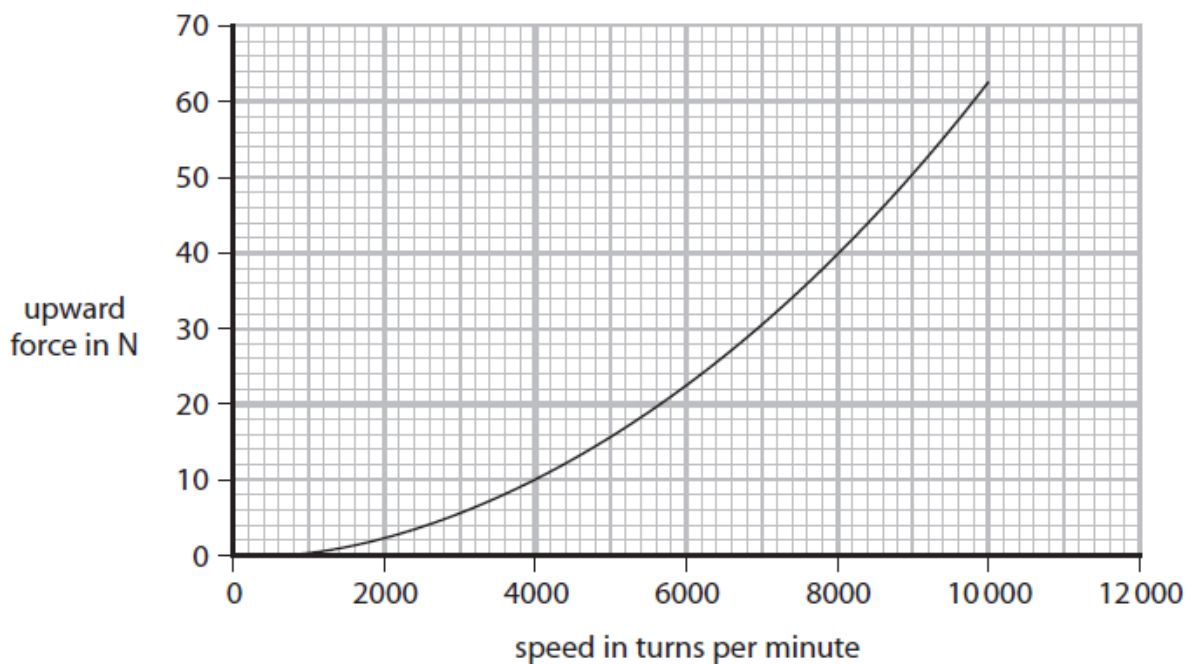


Figure 5

Describe the relationship between upward force and speed shown by this graph.

(2)

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(Total for question = 2 marks)

Q14.

Figure 23 shows two small boats pulling a much larger ship.

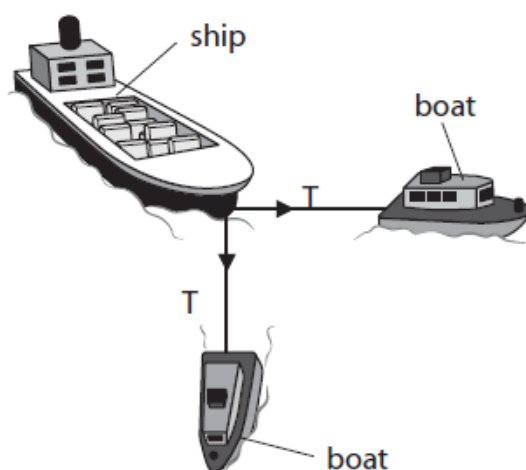


Figure 23

The ship is connected to the boats with ropes.

The tension, T , in each of the ropes has a magnitude of 20 kN.

The ropes are at right angles to each other.

Draw a vector diagram and use it to determine the resultant force that the boats exert on the ship.

(4)

magnitude of resultant force on the ship = ... kN

(Total for question = 4 marks)

Q15.

Figure 14 shows two small boats pulling a much larger ship.

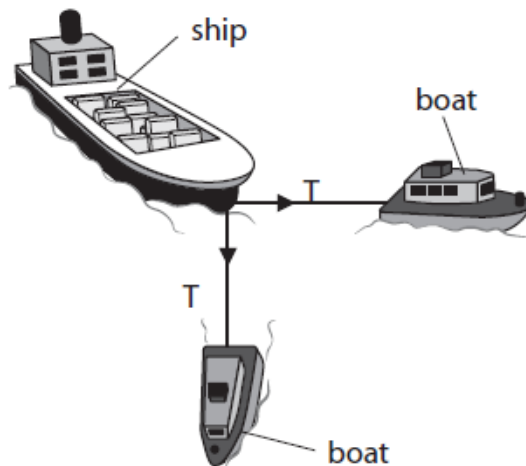


Figure 14

The ship is connected to the boats with ropes.

The tension, T , in each of the ropes has a magnitude of 20 kN.

The ropes are at right angles to each other.

Draw a vector diagram and use it to determine the resultant force that the boats exert on the ship.

(4)

magnitude of resultant force on the ship = ... kN

(Total for question = 4 marks)

Q16.

Figure 7 shows two astronauts in space pushing at a satellite.

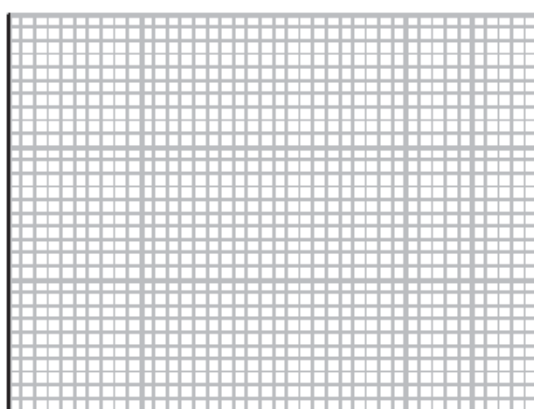


Figure 7

(i) The force F_1 is 3.0 N and the force F_2 is 2.0 N, acting at right angles to each other.

Draw a vector diagram to scale showing these forces.

(2)



(ii) Use the diagram in (i) to estimate the magnitude of the resultant force acting on the satellite.

(2)

resultant force = ... N

(Total for question = 4 marks)

Q17.

Figure 4 shows two astronauts in space pushing at a satellite.

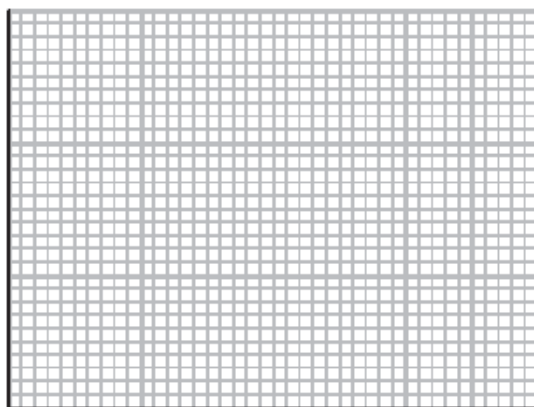


Figure 4

(i) The force F_1 is 3.0 N and the force F_2 is 2.0 N, acting at right angles to each other.

Draw a vector diagram to scale showing these forces.

(2)



(ii) Use the diagram in (i) to estimate the magnitude of the resultant force acting on the satellite.

(2)

resultant force = ... N

(Total for question = 4 marks)

Q18.

*Figure 24 shows a wooden block connected to a weight by a string. The string goes over a pulley.

The surfaces of the table and the wooden block are both rough.

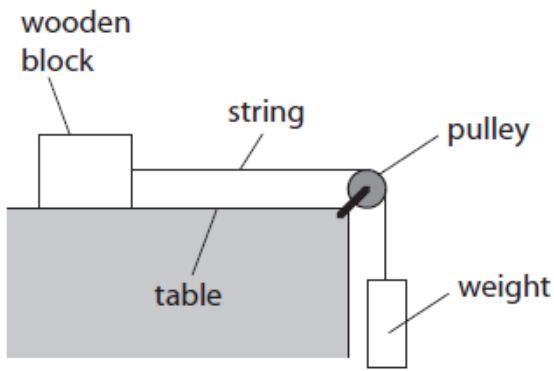


Figure 24

The wooden block moves across the table at a constant horizontal velocity.

Several vertical and horizontal forces act on the wooden block as it moves.

Explain how the forces keep the wooden block moving across the table at a constant horizontal velocity.

Your answer should refer to all forces acting on the wooden block.

You may add to the diagram to help with your answer.

(6)

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(Total for question = 6 marks)

Q19.

Figure 15 shows a wooden block connected to a weight by a string. The string goes over a pulley.

The surfaces of the table and the wooden block are both rough.

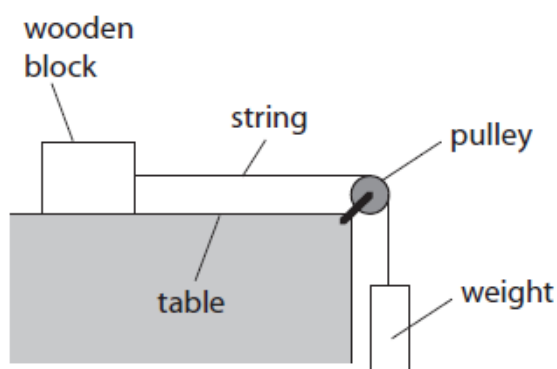


Figure 15

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Several vertical and horizontal forces act on the wooden block as it moves.

Explain how the forces keep the wooden block moving across the table at a constant horizontal velocity.

Your answer should refer to all forces acting on the wooden block.

You may add to the diagram to help with your answer.

(6)

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(Total for question = 6 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
a	recall and substitution (1) (force x 12.0 =) 0.050 x 8.4 rearrangement (1) (force =) $\frac{0.050 \times 8.4}{12.0}$ evaluation (1) (force =) 0.035 (N)	allow substitution and rearrangement in either order award full marks for the correct answer without working. if no other marks scored then award 1 mark for answers that round to 29 (eg 28.57) (substitution mark)	(3) AO2

Question number	Answer	Additional guidance	Mark
b	a description to include four of the following measure the value of current (1) measure force or distance(1) vary the current (1) restore equilibrium of system (1) calculate ratio between force and current or distance and current (1) if ratio is the same then they are proportional (1)	accept calculate for measure increase weight or move (existing) weight to new position plot a graph of force / distance against current graph would be a straight line (through the origin)	(4) AO3

Q2.

Question number	Answer	Additional guidance	Mark
	counting teeth on the pinion (1) evaluation (1) 1.6 (m)	allow between 18 and 22 inclusive 20 x 0.08 ecf number of teeth answer in range 1.44 to 1.76 scores 2 marks award full marks for the correct answer without working power of 10 error scores 1 mark maximum	(2) A03.1

Q3.

Question number	Answer	Additional guidance	Mark
	any correct moment (1) 450×0.50 or 225 or $0.80 \times F_2$ substitution into prin. of moment equation (1) $450 \times 0.50 = 0.80 \times F_2$ evaluation (1) 280 (N) (for question at end)	allow 450×0.3 moment taken about B allow statement of prin. of moments accept numbers which round to 280 such as 281.25 award full marks for correct answer without working.	(3)

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	(In every second), distance moved by chain around large gear = distance moved by chain around small gear (1) $2 \times 48 = \text{turns} \times 12$ rearrangement and evaluation (1) 8 (turns each second)	accept use of gear ratio seen or implied e.g. 4:1 or 4/1 or 48:12 or 48/12 or converse e.g. 1:4 award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation linking reduces friction/amount of thermal energy transferred (1) extra useful energy is available/less input energy is required (1) efficiency = useful energy transferred (by the bicycle) ÷ total energy supplied (to the bicycle) (1)	(oil provides) lubrication less energy wasted allow for the last two mark points; either less input energy is required to produce the same output for 2 marks or more output energy is available for the same input energy for 2 marks	(3)

Q5.

Question number	Answer	Additional guidance	Mark
(i)	substitution and rearrangement (1) (force = $\frac{\text{moment}}{\text{distance}}$) = $\frac{0.6}{3 \times 10^{-1}}$ evaluation (1) 2(.0) (N)	reject $0.6 \times 3 = 1.8$ award full marks for the correct answer without working ignore significant figures 2(.0) to any other power of ten scores 1 mark maximum	(2) AO2.1

Question number	Answer	Additional guidance	Mark
(ii)	correct calculation of one moment (1) correct calculation of second moment and adding of moments seen (1)	show that question either 2×0.1 or 1×0.5 seen $2(.0) \times 0.1(0) + 1(.0) \times 0.5$ scores 2 marks $0.2 + 0.5$ scores 2 marks accept calculations in alternative units (e.g. N cm) if correct conversion(s) seen if no other marks scored, the addition of two other moments can score 1 mark maximum	(2) AO2.1

Question number	Answer	Additional guidance	Mark
(iii)	explanation linking three from: {sum of / total } clockwise moments = {sum of / total } anticlockwise moments (1) for a system in equilibrium / balance (1) clockwise and anticlockwise moments compared (1) so rod not in equilibrium (1)	about the same point / about a point e.g. clockwise moment > anticlockwise moment or reverse argument $0.7 > 0.6$ $0.7 \neq 0.6$ rod will rotate clockwise MP4 can only be scored if MP3 awarded	(3) A03.2

Q6.

Question Number:	Answer	Additional Guidance	Mark
	recall clockwise moment = anticlockwise moment (1) moment = force x (perpendicular) distance (1) substitution (1) $m \times 17 = (6 \times 15) + (4.6 \times 10)$ rearrangement and evaluation (1) $m = 8.0 \text{ (g)}$	calculations need not include g (which cancels out from all terms) substitution and rearrangement in either order $m \times 17 = 90 + 46$ $m = \frac{(6 \times 15) + (4.6 \times 10)}{17}$ $m = 136 / 17$ award full marks for correct answer without working	(4) AO 1 1 AO 2 1

Q7.

Question number	Answer	Additional guidance	Mark
(i)	Recall GPE = $m \times g \times \Delta h$ (1) Substitution = $400 \times 9.8 \times 1.5$ (1) Evaluation = 5900 (J) (1) (which is nearly 6000 J)	accept 5880 (J)	(3)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that combines identification – knowledge (1 mark) and reasoning (1 mark) - energy is dissipated/scattered (1) - into the surroundings (1)	energy from a loss of ball's PE / its gain in KE ends up as (kinetic) energy of molecules (of ball / wall / air)	(2)

Question number	Answer	Mark
(iii)	B velocity	(1)

Q8.

Question number	Answer	Additional guidance	Mark
(i)	Recall GPE = $m \times g \times \Delta h$ (1) Substitution = $400 \times 9.8 \times 1.5$ (1) Evaluation = 5900 (J) (1) (which is nearly 6000 J)	accept 5880 (J)	(3)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that combines identification – knowledge (1 mark) and reasoning (1 mark) - energy is dissipated/scattered (1) - into the surroundings (1)	energy from a loss of ball's PE / its gain in KE ends up as (kinetic) energy of molecules (of ball / wall / air)	(2)

Question number	Answer	Mark
(iii)	B velocity	(1)

Q9.

Question number	Answer	Additional guidance	Mark
	An answer that combines the following points of understanding to provide a logical description: named force (acting at a distance) (1) situation (1)	e.g. magnetic force between two (magnetic) poles	(2)

Q10.

Question number	Answer	Additional guidance	Mark
	An answer that combines the following points of understanding to provide a logical description: named force (acting at a distance) (1) situation (1)	e.g. magnetic force between two (magnetic) poles	(2)

Q11.

Question number	Answer	Additional guidance	Mark
	move the (position of) the (0.050 N) weight (1) to the other side of the pivot/3.6 cm from the magnet (1)	adjust mass of modelling clay reduce (mass of modelling clay) by taking some away add (additional) weight between pivot and magnet scores 2 marks	(2) AO3

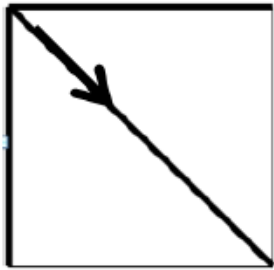
Q12.

Question number	Answer	Additional guidance	Mark
	(upward) force increases with speed (1) relationship is non-linear (1)	allow reverse argument changing rate / increases exponentially/ initially no upward force (until 1000 turns per minute)	(2)

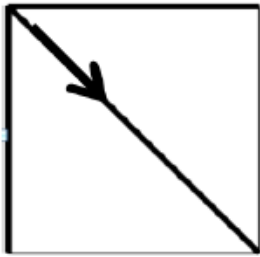
Q13.

Question number	Answer	Additional guidance	Mark
	(upward) force increases with speed (1) relationship is non-linear (1)	allow reverse argument changing rate / increases exponentially/ initially no upward force (until 1000 turns per minute)	(2)

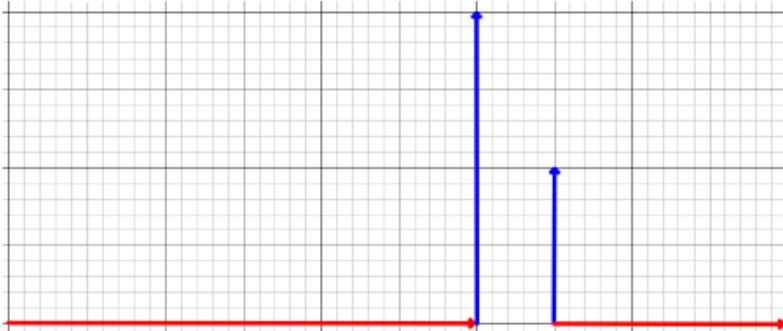
Q14.

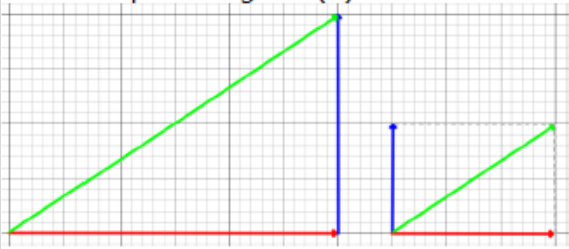
Question number	Answer	Additional guidance	Mark
	Scale drawing two lines at right angles (1) a correct scaling (for example 10kN equivalent to 1 cm) / a completed square or triangle(1) diagonal in correct direction (1) 28 kN (1)	 judge by eye accept answers from 25 kN to 30 kN accept use of Pythagoras award full marks for correct answer without working.	(4)

Q15.

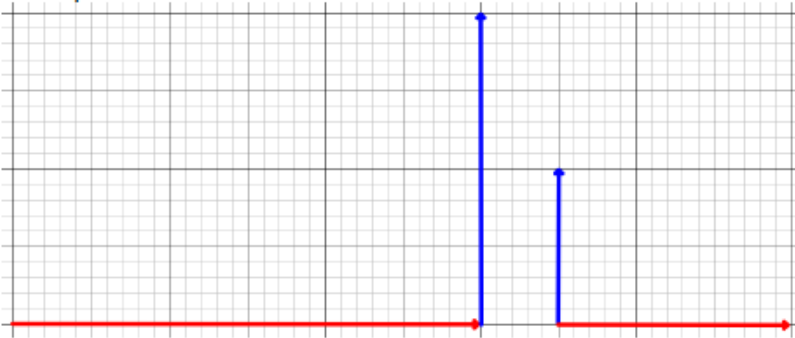
Question number	Answer	Additional guidance	Mark
	Scale drawing two lines at right angles (1) a correct scaling (for example 10kN equivalent to 1 cm) / a completed square or triangle(1) diagonal in correct direction (1) 28 kN (1)	 judge by eye accept answers from 25kN to 30 kN accept use of Pythagoras award full marks for correct answer without working.	(4)

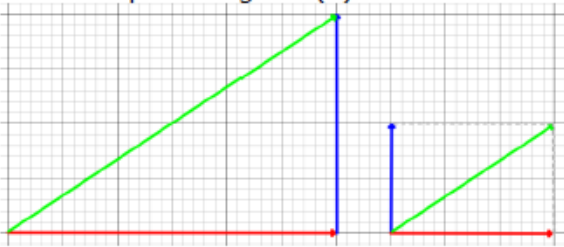
Q16.

Question number	Answer	Mark
(i)	- two vector arrows at right angles representing the forces (1) - two vector arrows in proportion (1) examples: 	(2)

Question number	Answer	Additional guidance	Mark
(ii)	- drawing shows a completed triangle or parallelogram (1)  - Evaluation 3.6 N (1)	± 0.2 N may be calculated using Pythagoras theorem	(2)

Q17.

Question number	Answer	Mark
(i)	- two vector arrows at right angles representing the forces (1) - two vector arrows in proportion (1) examples: 	(2)

Question number	Answer	Additional guidance	Mark
(ii)	• drawing shows a completed triangle or parallelogram (1)  • Evaluation 3.6 N (1)	±0.2 N may be calculated using Pythagoras theorem	(2)

Q18.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A01 Horizontal forces • tension in the string/pull of the string • tension is one of the horizontal forces acting on the wooden block • friction between the table and the wooden block • friction acts in the opposite direction to the tension • friction opposes motion • the force due to friction is equal to the force provided by the tension • the forces are balanced /equal and opposite • no resultant force, so the block moves at a constant (horizontal) velocity	(6)

	Vertical forces • (normal) reaction (force) upwards between the table and the wooden block • contact force • weight of block downwards • the weight (force of gravity) and the (normal) reaction are equal and opposite / balanced • the block does not move up or down • tension caused by the force due to gravity on the weight • vertical forces on the block do not affect horizontal velocity. labels on the diagram should be considered when marking candidates do not have to indicate the forces as horizontal and vertical	
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Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • <u>Presents an explanation with some structure and coherence. (AO1)</u>
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> Elements of physics present i.e. isolated knowledge of principles two unconnected statements from any section	<u>Possible candidate responses</u> contact force weight pulls block friction tension in string weight acts downward reaction
Level 2	3–4	<u>Additional guidance</u> Some knowledge of principles with a logical connection made in one section and statement from the other section OR Detailed knowledge of principles with logical connections made in one section	<u>Possible candidate responses</u> There is friction between the table and the block and this opposes motion weight of block acts downwards

Level 3	5–6	<u>Additional guidance</u> Detailed knowledge of principles with logical connections made in one section and statement from the other section	<u>Possible candidate responses</u> Friction and tension are equal and opposite there is no resultant /no acceleration The weight (of the block) and the(normal) reaction are equal and opposite
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Q19.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A01 Horizontal forces • tension in the string/pull of the string • tension is one of the horizontal forces acting on the wooden block • friction between the table and the wooden block • friction acts in the opposite direction to the tension • friction opposes motion • the force due to friction is equal to the force provided by the tension • the forces are balanced /equal and opposite • no resultant force, so the block moves at a constant (horizontal) velocity Vertical forces • (normal) reaction (force) upwards between the table and the wooden block • contact force • weight of block downwards • the weight (force of gravity) and the (normal) reaction are equal and opposite / balanced • the block does not move up or down • tension caused by the force due to gravity on the weight • vertical forces on the block do not affect horizontal velocity. labels on the diagram should be considered when marking candidates do not have to indicate the forces as horizontal and vertical	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> Elements of physics present i.e. isolated knowledge of principles two unconnected statements from any section	<u>Possible candidate responses</u> contact force weight pulls block friction tension in string weight acts downward reaction
Level 2	3–4	<u>Additional guidance</u> Some knowledge of principles with a logical connection made in one section and statement from the other section OR Detailed knowledge of principles with logical connections made in one section	<u>Possible candidate responses</u> There is friction between the table and the block and this opposes motion weight of block acts downwards
Level 3	5–6	<u>Additional guidance</u> Detailed knowledge of principles with logical connections made in one section and statement from the other section	<u>Possible candidate responses</u> Friction and tension are equal and opposite there is no resultant /no acceleration The weight (of the block) and the(normal) reaction are equal and opposite