

Forces

Mark Scheme



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1. A force is simply a push or a pull that acts upon an object, holding the power to change its speed, direction, or shape. For each of the following questions **circle** the letter of the correct answer.

- a) A heavy crate of weight 600 N is resting on the floor.

C – is the only correct answer.	1 mark
	Total: 1 mark

- b) A heavy metal ball is dropped from a tall building.

What happens to the acceleration of the ball as it falls, before it reaches terminal velocity?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) Which of the following is an example of a force.

D – is the only correct answer.	1 mark
	Total: 1 mark

- d) A rover sent to explore Mars has a mass of 150 kg.

What is the gravitational field strength (g) on Mars?

B – is the only correct answer.	1 mark
	Total: 1 mark

- e) An elephant has a weight of 60 kN. Its four feet have a total area of 0.75 m² in contact with the ground. Calculate the total pressure the elephant exerts on the ground.

D – is the only correct answer.	1 mark
	Total: 1 mark

- f) A suitcase of weight 150 N is resting on a flat floor.

A person leans on the suitcase, pushing vertically downwards with a force of 80 N.

The suitcase does not move or crush the floor beneath it.

D – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 6 marks)

2. A construction worker is moving a large, solid concrete block.

- a) The concrete block has a mass of 500 kg. Gravitational field strength (g) = 9.8 N/kg.
Calculate the weight of the concrete block.

Weight = mass $\times$ gravity $W = 500 \times 9.8$	1 mark
$W = 4900 \text{ (N)}$	1 mark
	Total: 2 marks

- b) The concrete block is resting flat on the ground. Calculate the pressure the block exerts on the ground.
Give the unit of pressure in your answer.

Calculate area: $\text{Area} = 1.4 \times 1.0$ $\text{Area} = 1.4 \text{ m}^2$	1 mark
Recall equation: Pressure = Force $\div$ area	1 mark
Substitute values: $P = 4900 \div 1.4$	1 mark
Calculate pressure: $P = 3500$	1 mark
Unit: Pa (Pascals) or N/m ²	1 mark
	Total: 5 marks

- c) A crane lifts the concrete block vertically into the air.
Calculate the distance the block was lifted.

Recall equation: Work done = Force $\times$ distance $W = F \times s$	1 mark
Substitute values: $58,800 = 4900 \times s$	1 mark
Rearrange & calculate: $S = 58800 \div 4900$ $S = 12 \text{ (m)}$	1 mark
	Total: 3 marks

- d) Later, a tractor drags a different block horizontally across the rough ground.
Calculate the frictional force acting against the block.

Force = work done $\div$ distance $\text{Force} = 15000 \div 5$ $F = 3000$	1 mark
	1 mark
	Total: 2 marks

(Total for Question 2 is 12 marks)

3. A family is driving a car along a straight, level motorway.

a) Calculate the resultant force acting on the car.

$4800 - 1200 = 3600 \text{ (N)}$	1 mark
	Total: 1 mark

b) The car, including the passengers, has a total mass of 1600 kg.

Calculate the acceleration of the car.

Force = mass $\times$ acceleration	1 mark
Substitute values: $3600 = 1600 \times a$	1 mark
Calculate acceleration: $a = 3600 \div 1600$ $a = 2.25$	1 mark
	Total: 3 marks

c) After accelerating, the car travels at a steady speed of 30 m/s for a distance of 4500 m.

Calculate the time taken for this part of the journey.

Distance = speed $\times$ time	1 mark
Substitute values: $4500 = 30 \times t$	1 mark
Calculate time: $T = 4500 \div 30$ $T = 150$	1 mark
	Total: 3 marks

d) A short time later, the car brakes sharply and stops.

Given that the mass of the car is 1600 kg, calculate the velocity of the car just before it braked.

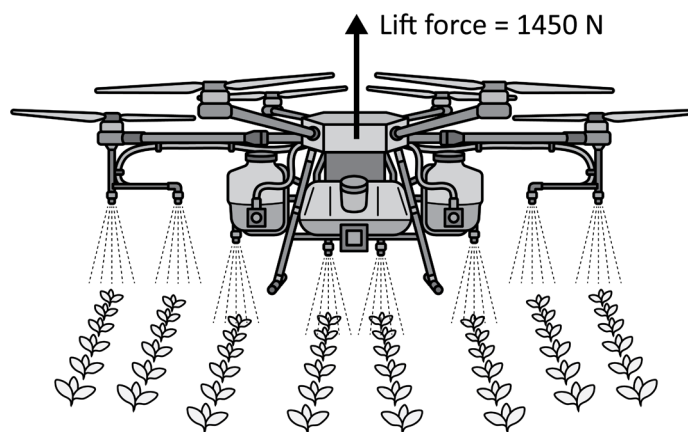
Momentum = mass $\times$ velocity	1 mark
Substitute values: $32,000 = 1600 \times v$	1 mark
Calculate velocity: $V = 32,000 \div 1600$ $V = 20$	1 mark
	Total: 3 marks

e) Explain why it can potentially be unsafe for a car to travel with a very high momentum.

An explanation to include two of the following:	
- It requires a much larger braking force to stop the car. - Which increases the stopping distance / increases the chance of a collision/skidding. - If it crashes, the change in momentum is very rapid. - This exerts a massive force on the passengers, causing severe injury.	
	Total: 2 marks

(Total for Question 3 is 12 marks)

4. A company is testing a delivery drone.



The total mass of the drone, including its full tanks of herbicide, is 120 kg.

The gravitational field strength (g) is 9.8 N/kg.

To climb the drone's rotors produce a constant upward lift force of 1450 N.

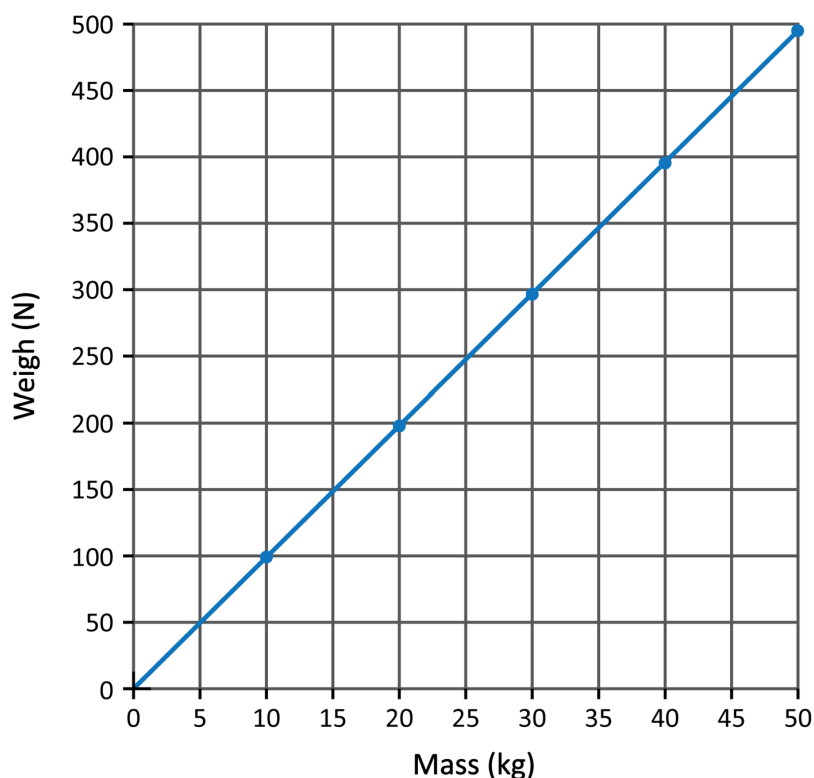
Calculate the upward acceleration of the drone.

You must show all of your working.

Calculate the weight of the drone $W = m \times g$ $W = 120 \times 9.8$ $\text{Weight} = 1176 \text{ N}$	1 mark
Calculate the resultant force $\text{Force} = \text{Lift force} - \text{weight}$ $\text{Resultant Force} = 1450 - 1176$ $\text{Resultant Force} = 274 \text{ N}$	1 mark
State or use Newton's Second Law: $F = m \times a$	1 mark
Substitute the values: $274 = 120 \times a$	1 mark
Calculate the final acceleration: $a = 274 \div 120$ $\text{Acceleration} = 2.28 \text{ (m/s}^2\text{)}$	1 mark
	Total: 6 marks

(Total for Question 4 is 6 marks)

5. A student investigates the relationship between the mass of an object and its weight on Earth. They measure the weight of several different masses and plot their results on the graph below.



- a) State the difference between mass and weight.

A difference to include the following:	
Mass is the amount of matter in an object / is measured in kg / does not change depending on location.	1 mark
Weight is the force of gravity acting on that mass / is measured in Newtons / changes depending on the gravitational field.	1 mark
	Total: 2 marks

- b) The student adds a new object to the scale. The object has a mass of 45 kg.

Use the graph to determine the weight of this object.

441 (N)	1 mark
Accept: any answer in the range of 435 N to 445 N.	
	Total: 1 mark

- c) The student states: "The graph shows that weight is directly proportional to mass."

Explain how the graph supports this statement.

An explanation to include:	
The graph is a straight line.	1 mark
The line passes through the origin (0,0).	1 mark
	Total: 2 marks

- d) Calculate the gradient of the line on the graph.
Show your working.

Gradient = change in y ÷ change in x	1 mark
490 ÷ 50	
Gradient = 9.8	1 mark
	Total: 2 marks

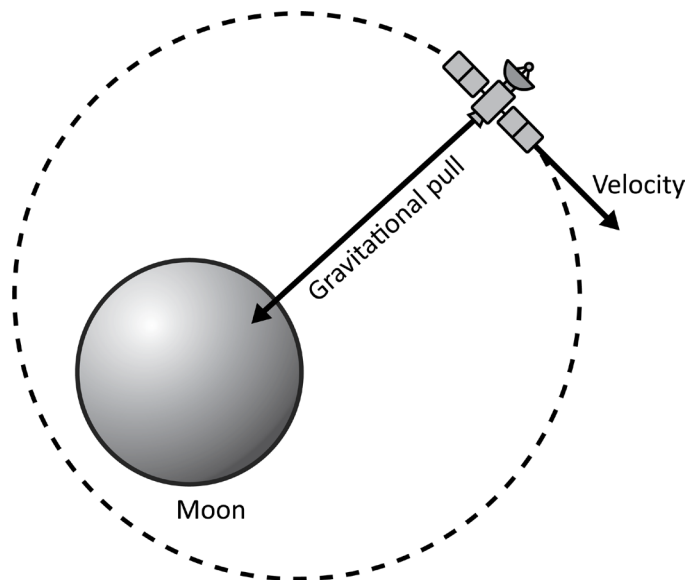
- e) The student takes the 45 kg object from part (b) and travels to the Moon.
The gravitational field strength (g) on the Moon is 1.6 N/kg.

Calculate the weight of the object on the Moon.

Recall equation:	
$W = m \times g$	1 mark
Calculation:	
$W = 45 \times 1.6$	
$W = 72 \text{ (N)}$	1 mark
	Total: 2 marks

(Total for Question 5 is 9 marks)

6. Space agencies send robotic probes to the moon for scientific research.



- a) During launch, a rocket carrying the satellite accelerates steadily from rest and reaches a speed of 6000 m/s after travelling a distance of 900,000 m.

Calculate the time, **in minutes**, it takes the rocket to reach this speed.

Distance = average speed $\times$ time	
$s = \frac{(u + v)}{2}$	1 mark
$900,000 = (0 + 6000) \times t$	1 mark
$t = 900,000 \div 3000$ $t = 300$ seconds $t = 5$ minutes	1 mark
	Total: 3 marks

- b) The satellite is now in a stable circular orbit around the Moon, as shown in the diagram.

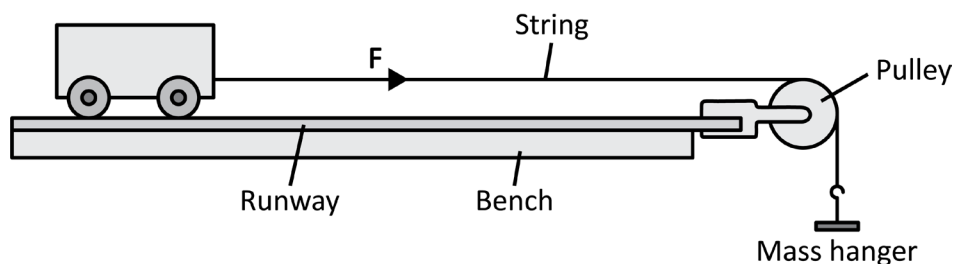
To keep the satellite in this exact orbit, its speed needs to stay at exactly 1600 m/s.

Suggest, by using ideas about gravitational and centripetal forces, why this specific speed must be maintained to keep it in a stable orbit.

A suggestion to include the following:	
The gravitational force (from the Moon) provides the centripetal force.	1 mark
If the speed is too high, the gravitational pull will not be strong enough to hold it (and it will fly off into space).	1 mark
If the speed is too low, the gravitational pull will be too strong (and it will crash into the Moon).	1 mark
	Total: 3 marks

(Total for Question 6 is 6 marks)

7. A student investigated how the acceleration of a trolley varies with the mass of the trolley. The figure below shows some of the equipment used.



- a) To change the mass of the trolley, the student added metal blocks to it.

Identify the piece of equipment the student should use to measure the mass of the trolley and the blocks.

(Top pan) balance / mass balance / scales.	1 mark
	Total: 1 mark

- b) Give **one** variable that must be a control variable in this specific investigation.

The (resultant) force acting on the trolley / the mass on the mass hanger / the weight of the mass hanger.	1 mark
Do not accept "the mass of the trolley" as this is the independent variable being changed.	
	Total: 1 mark

- c) In the original setup, the student used a manual stopwatch.

To improve accuracy, the teacher suggests attaching a piece of card to the trolley and using two light gates connected to a data logger.

Explain how the light gates and the card are used to calculate the acceleration of the trolley.

An explanation to include:	
The light gates measure the speed / velocity of the trolley at two different points.	1 mark
Award 1 mark for mentioning finding the speed at two points.	
The data logger measures the time taken to travel between the two light gates.	1 mark
Award 1 mark for finding the time between the gates.	
Acceleration is calculated using the change in speed divided by the time taken.	1 mark
Award 1 mark for using the correct equation linking speed/velocity and time to find acceleration.	
	Total: 3 marks

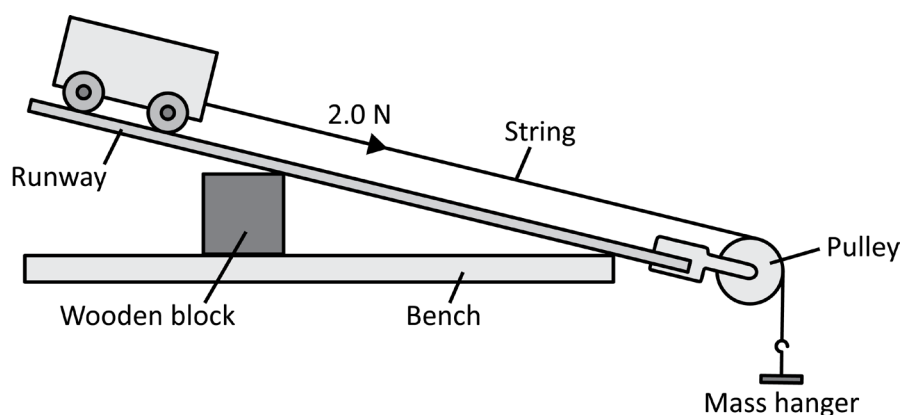
- d) For one specific mass, the student released the trolley three times and recorded the following values for acceleration:

$$2.15 \text{ m/s}^2 \quad 2.21 \text{ m/s}^2 \quad 2.18 \text{ m/s}^2$$

Calculate the uncertainty in these values of acceleration.

Range = $2.21 - 2.15 = 0.06$	1 mark
Uncertainty = $0.06 \div 2$	
Uncertainty = ± 0.03	1 mark
	Total: 2 marks

- e) Before taking any results, the student raised one end of the runway using a wooden block.



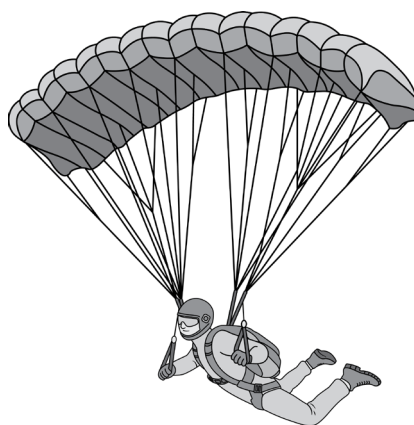
- f) The student adjusted the height of the wooden block until the trolley moved down the runway at a constant speed when given a small push.

Explain why the student adjusted the runway in this way.

An explanation to include the following:	
To compensate for / overcome friction (acting against the wheels/trolley).	1 mark
So that the only resultant force causing acceleration during the experiment is the tension/weight from the mass hanger.	1 mark
	Total: 2 marks

(Total for Question 7 is 9 marks)

8. The figure below shows a skydiver falling vertically towards the ground with an open parachute.



The skydiver is falling downwards at a constant vertical velocity (terminal velocity). Several upward and downward forces act on the skydiver as they fall.

- a) Explain how the forces keep the skydiver moving towards the ground at a constant vertical velocity.

Your answer should refer to all vertical forces acting on the skydiver.

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

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Identifies at least one correct force acting on the skydiver, or states a simple rule (e.g., "the forces are balanced").
Level 2	3 - 4	Identifies the opposing forces and states they are equal/balanced, but the link to resultant force or constant velocity may be incomplete or lack physical terminology.
Level 3	5 - 6	A clear, detailed, and logically structured explanation. Identifies both specific vertical forces and correctly explains that they are equal/balanced, linking a zero resultant force directly to Newton's First Law / constant velocity.

Indicative content:	
Identifying the forces: - Weight / gravity acts downwards on the skydiver. - Air resistance / drag acts upwards against the parachute/skydiver. Comparing the forces: - The upward force of air resistance is exactly equal in magnitude to the downward force of weight. - The forces are acting in opposite directions, so they balance out. Linking to motion: - Because the forces are balanced, the resultant force is zero. - According to Newton's First Law, an object with a zero resultant force will continue to move at a constant velocity (it will not accelerate or decelerate). Extra guidance: If students draw accurate, correctly labelled, equal-length arrows on the diagram, this can be credited as identifying and comparing the forces.	
	Total: 6 marks

- b) The skydiver has a mass of 85 kg. Gravitational field strength (g) = 9.8 N/kg.
The skydiver falls at a constant terminal velocity for a time of 40 seconds, covering 200 m.

Calculate the power dissipated against air resistance as the skydiver falls this distance.

Calculate weight: $W = m \times g$ $W = 85 \times 9.8$ Force = 833 N	1 mark
Calculate Work Done: $W = F s$ $W = 833 \times 200$ $W = 166,600 \text{ J}$	1 mark
Calculate power: $P = 166,600 \div 40$	1 mark
$P = 4165 \text{ W}$	1 mark
	Total: 4 marks

(Total for Question 8 is 10 marks)