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OCR GCSE PHYSICS A (J249): QUESTIONS BY TOPIC

Topic P2: Forces (H)

GCSE Physics A Higher Tier (J249) · Topic P2

84 questions · 308 marks · Mark schemes included

OCR GCSE (9–1) Physics A (Gateway Science) J249, June 2018 – June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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P2.3 FORCES IN ACTION

34 questions · 109 marks

69

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74. Q12		J249/03 Paper 3 June 2025	1	93
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QUESTIONS

84 questions · 308 marks · grouped by sub-topic, lowest tariff first



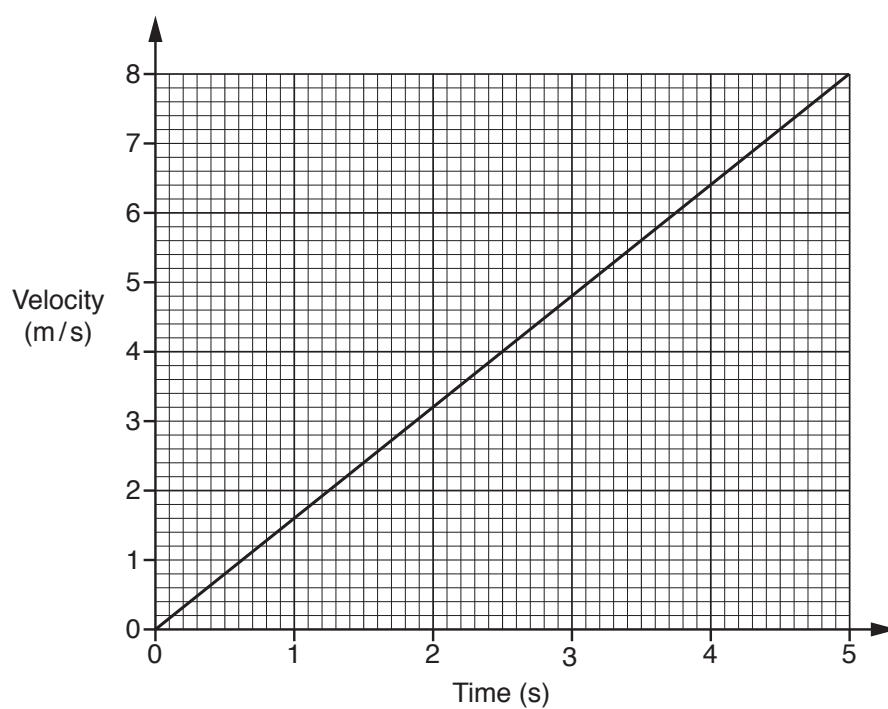
SUB-TOPIC P2.1

MOTION

30 questions in this sub-topic · 110 marks · lowest tariff first



9 Look at the velocity-time graph of an object.



What is the distance travelled by the object in 5s?

- A 0.63m
- B 1.6m
- C 20m
- D 40m

Your answer

[1]

12 Two cars head towards each other on a road.



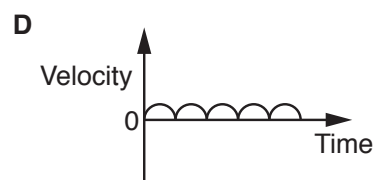
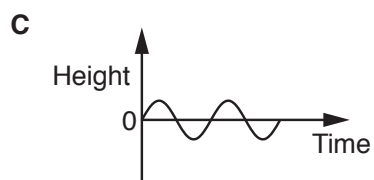
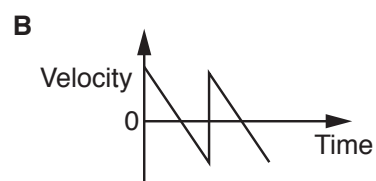
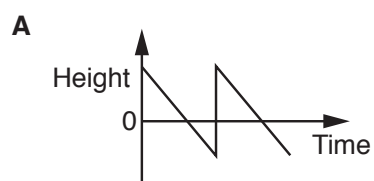
What velocity does the driver of car **Q** see car **P** travelling towards him at?

- A 10 m/s
- B 15 m/s
- C 25 m/s
- D 40 m/s

Your answer

[1]

13 Which graph shows a bouncing ball?



Your answer

[1]

7 A car accelerates from 0 to 60 mph (miles per hour) in about 9 seconds.

Use the relationship: $1 \text{ m/s} = 2.24 \text{ mph}$

Estimate the acceleration for this car in m/s^2 .

- A** 1 m/s^2
- B** 3 m/s^2
- C** 7 m/s^2
- D** 15 m/s^2

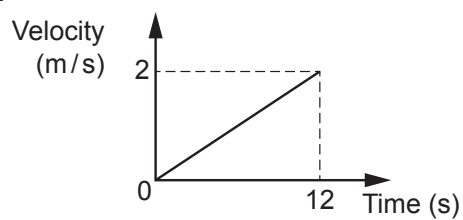
Your answer

[1]

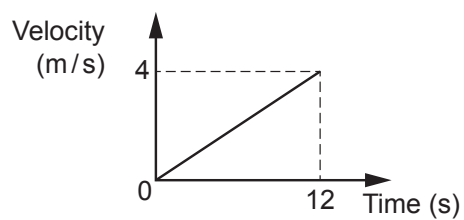


12 Look at the motion graphs.

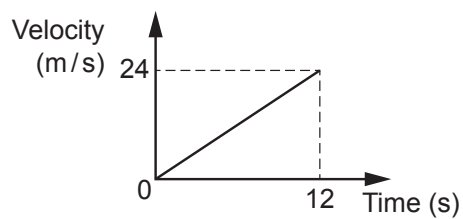
A



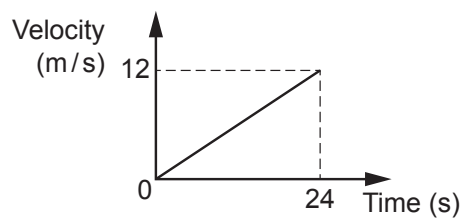
B



C



D



Which graph shows a journey with a distance of 24 m?

Your answer

[1]



4 Which row in the table shows realistic speeds?

	Speed (m/s)		
	Road cyclist	Gale force wind	Sound in air
A	40	12	1 000
B	6	24	340
C	20	6	760
D	15	55	250

Your answer

[1]



- 1 Four students measure the time it takes for a wave to travel the length of a ripple tank.

Each student collects three measurements of the time.

Student	Time taken (s)		
	1st measurement	2nd measurement	3rd measurement
A	2	2	1
B	2.1	2.1	2.4
C	2.1	2.0	2.2
D	2.11	2.49	2.23

Which student collected the **most** precise data?

Your answer

[1]



11 A car travels at a speed of 70 mph (miles per hour).

1 mile is approximately 1600 metres.

Convert 70 mph into m/s (metres per second).

A 2.6m/s

B 31m/s

C 112m/s

D 160m/s

Your answer

[1]



- 5 A stopwatch is used by a student for timing how long it takes a toy car to travel down a ramp.

The student repeats the experiment four times during a lesson, using the same equipment and method.

Attempt	1	2	3	4
Time taken (s)	2.6	2.4	2.5	2.5

Which words describe the student's results?

- A Repeatability and precise
- B Repeatability and reproducible
- C Reproducible and accurate
- D Reproducible and precise

Your answer

[1]



15 A student calculates braking distance using this equation:

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

What is the correct equation for braking distance?

- A** Braking distance = $(\text{final velocity})^2 - (\text{initial velocity})^2 - 2 \times \text{acceleration}$
- B** Braking distance = $\frac{(\text{final velocity})^2}{(\text{initial velocity})^2} - 2 \times \text{acceleration}$
- C** Braking distance = $2 \times \text{acceleration} \times ((\text{final velocity})^2 - (\text{initial velocity})^2)$
- D** Braking distance = $\frac{(\text{final velocity})^2 - (\text{initial velocity})^2}{2 \times \text{acceleration}}$

Your answer

[1]



- 11 There are 1609 m in a mile.
Which of these is approximately the same speed as 56 miles per hour?

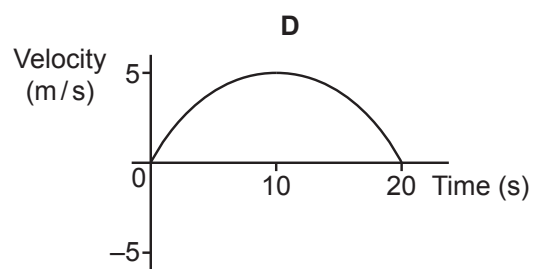
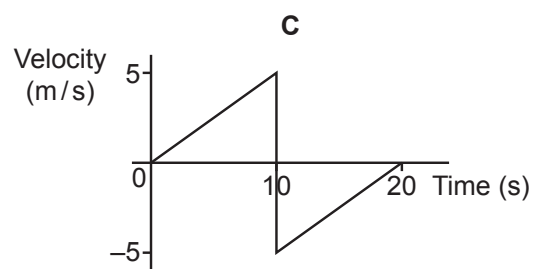
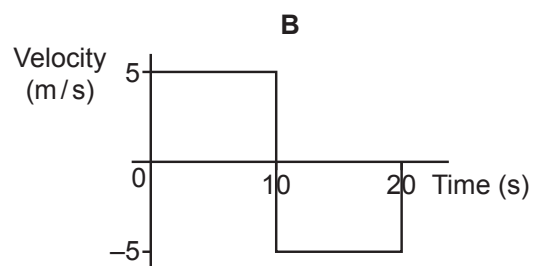
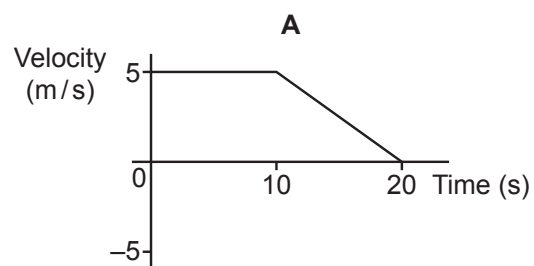
- A 25 m/s
- B 29 m/s
- C 52 m/s
- D 90 m/s

Your answer

[1]



13 Velocity–time graphs are drawn for four different objects.



Which object has the largest displacement?

Your answer

[1]

- 3 Four athletes run a race in different times.

Athlete	Time taken (s)
1	21.5
2	21.6
3	
4	21.5
Mean	21.4

What is the time taken by athlete 3?

- A** 21.0s
B 21.1s
C 21.4s
D 21.5s

Your answer

[1]

5 One mile is equal to 1609 metres.

How many miles are there in 5000 metres?

A 0.3218 miles

B 0.6782 miles

C 2.108 miles

D 3.108 miles

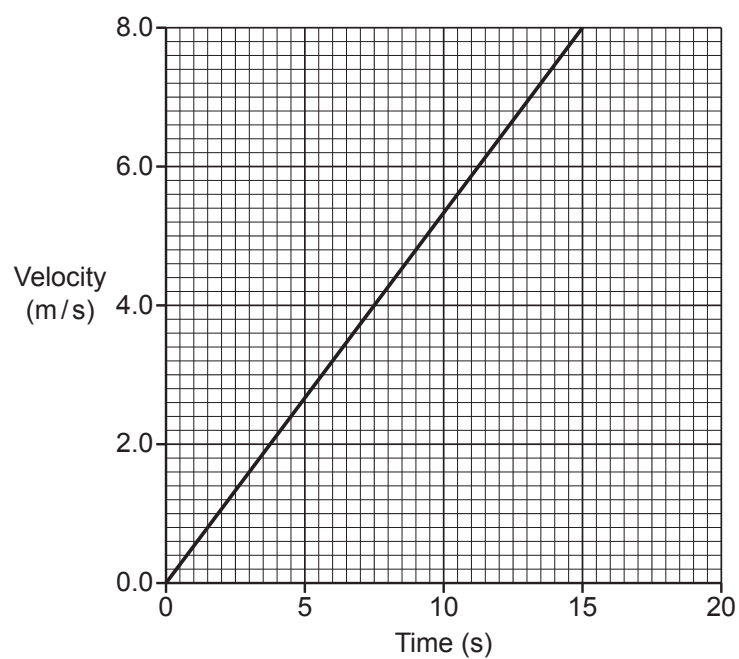
Your answer

[1]



13 A scientist draws a velocity–time graph for an object.

What is the distance travelled by the object in 15 s?



- A** 0.53 m
- B** 1.9 m
- C** 60 m
- D** 120 m

Your answer

[1]

15 A vehicle is travelling at 30 m/s.

The vehicle travels 75 m while decelerating to a stop.

What is the deceleration of the vehicle?

Use the Equation Sheet.

A 2.5 m/s²

B 6.0 m/s²

C 12 m/s²

D 24 m/s²

Your answer

[1]



14 A train accelerates from 20 m/s to 40 m/s in a distance of 1200 m.

What is the acceleration of the train?

Use the Equation Sheet.

A 0.17 m/s²

B 0.50 m/s²

C 0.67 m/s²

D 1.0 m/s²

Your answer

[1]

10 Which answer shows 800 km/h converted into m/s?

- A** 0.22m/s
- B** 13.3m/s
- C** 222m/s
- D** 13333m/s

Your answer

[1]



- 7 A toy train moves around a circular track at a constant speed.

Which row describes the displacement of the train from its starting point and the velocity of the train?

	Displacement	Velocity
A	changing	changing
B	changing	constant
C	constant	changing
D	constant	constant

Your answer

[1]



7 Which value could be the speed of a person running?

A 0.50 m/s

B 5.0 m/s

C 50 m/s

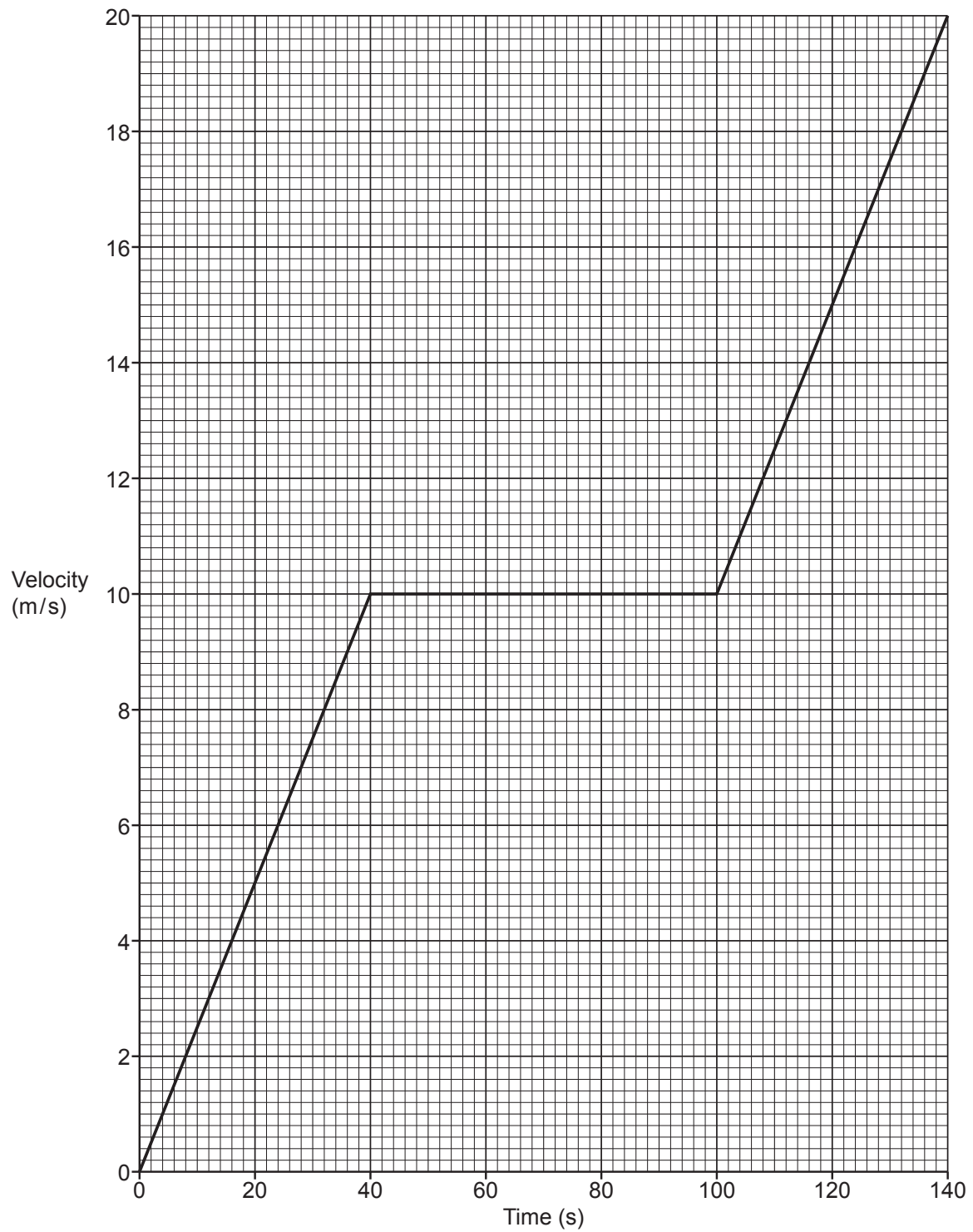
D 500 m/s

Your answer

[1]



22* The velocity–time graph shows part of a train's journey on a level straight track.



Use the graph to describe and explain the motion of the train between 0 and 140 seconds.

Include calculations of acceleration and distance in your answer.

Use the Equation Sheet.

[6]



- 17 A student drops a paper ball from a balcony 4.00 m high. Her friend measures the time taken for the paper ball to reach the ground.

- (a) Suggest the equipment used to measure the height of the balcony and the time taken for the paper ball to reach the ground.

Height

Time taken

[1]

- (b) They record their results in a table.

Attempt	1	2	3	4	5
Time taken (s)	1.84	2.08	2.02	2.08	1.98

- (i) Use the data in the table to calculate the mean, median and mode of their results.

Mean = ...

Median = ...

Mode = ...

[3]

- (ii) The results are not very precise. Explain how you can tell from the data in the table.

.....

..... [1]

- (iii) Suggest a possible source of error in the experimental method **and** how it could be improved.

Source of error

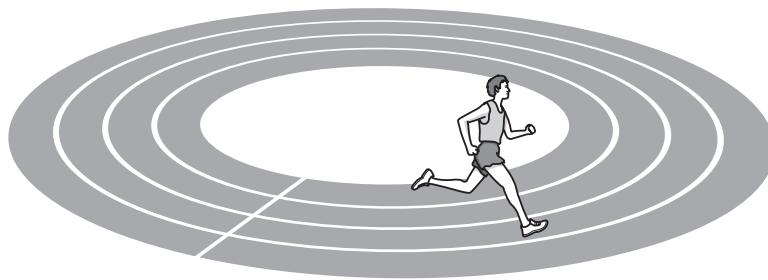
Improvement

.....

[2]



- 22** An athlete runs around a circular running track at a constant speed.



- (a)** Explain why the athlete's velocity is not constant.

.....
 [1]

- (b)** The work done by the athlete after completing one lap of the track is 3000 J. It takes the athlete 60 s to complete one lap.

Calculate the power of the athlete.

Power = ... W [3]

- (c)** After the lap, the athlete slows down from a velocity of 5 m/s to a velocity of 1 m/s. The deceleration of the athlete is 0.4 m/s^2 .

Calculate the time taken for the athlete to change velocity.

Use the equation: acceleration = change in velocity/time

Time taken = ... s [3]



22 A van travels along a road at a constant speed.

(a) The van brakes and decelerates at a constant rate:

- The initial speed of the van is 18 m/s .
- The deceleration of the van is 1.5 m/s^2 .

Calculate the time taken for the van to stop.

Use the equation: acceleration = change in velocity/time taken

Time = ... s **[3]**

(b) The same van travels on an **icy** road at 18 m/s .

Explain how the **stopping** distance changes.

Write about thinking and braking in your answer.

.....

.....

.....

.....

..... **[3]**

(c) If the van crashes, the time taken to stop is much smaller.

Explain why this is dangerous for the people in the van.

.....

.....

..... **[2]**



23 A student wants to find out the depth of a well.

She thinks that she can calculate this by dropping a stone into the well and timing how long it takes to hear the stone splash at the bottom.

(a) (i) Explain how she could use this measurement to find the depth of the well.

.....

.....

.....

.....

..... **[3]**

(ii) It takes 2.2 seconds for the stone to drop from rest and splash into the water at the bottom.

What is the speed of the stone when it hits the water?

Answer = ... m/s **[2]**

(b) Describe the motion of the stone as it falls.

Assume it does not reach terminal velocity.

Use a free body diagram to help you.

.....

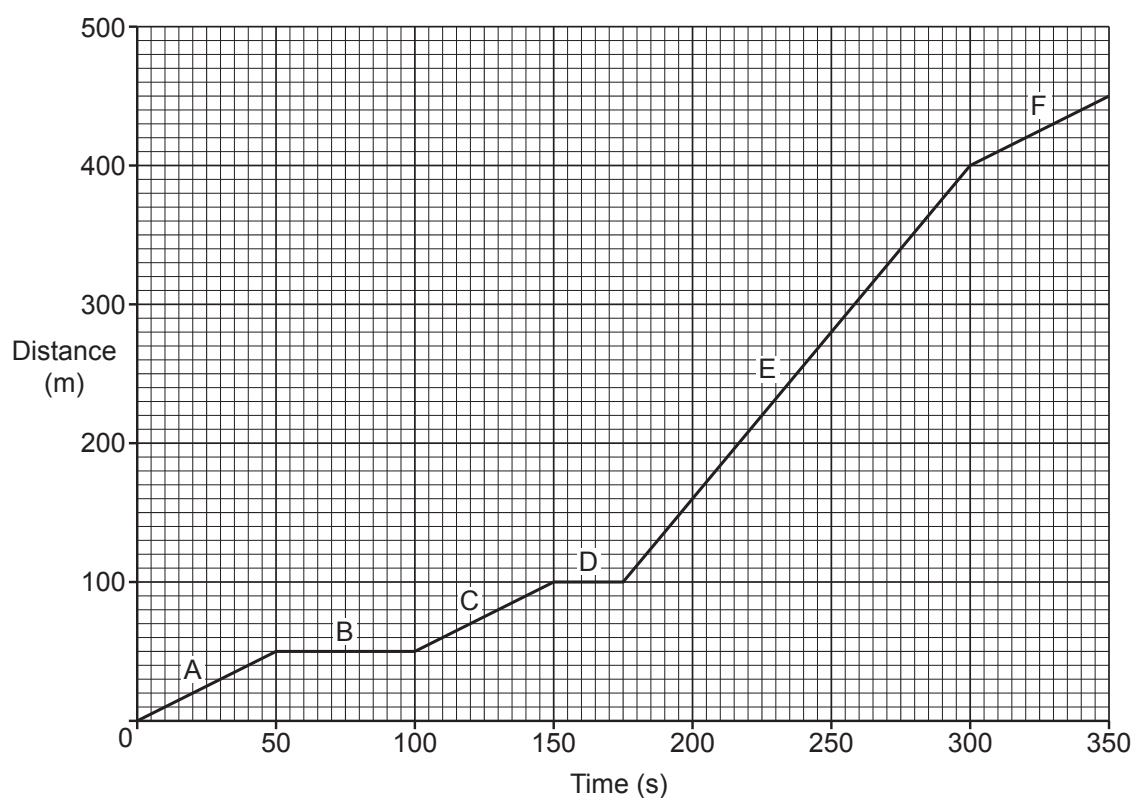
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..... **[4]**



16 A student travels to a friend's house. This is a distance–time graph of their journey.



(a) (i) State the total distance travelled by the student to their friend's house.

..... [1]

(ii) State the total time it takes the student to get to their friend's house.

..... [1]

(iii) Calculate the student's average speed during their journey.

Use the equation: distance travelled = speed $\times$ time

Average speed = ... m/s [3]



- (iv) State which section of the journey, **A–F**, is where the student travels fastest. Explain your answer.

Section

Explanation

..... [2]

- (v) Suggest what happens at sections **B** and **D** on the journey.

..... [1]

- (b) Suggest which equipment the student can use to measure the time and distance on their journey.

Time

Distance

..... [1]



16 Two students decide to determine the mean speed of cars passing outside their school.

- (a) Describe how the students will take the measurements they need to be able to calculate the mean speed of a car.

.....

.....

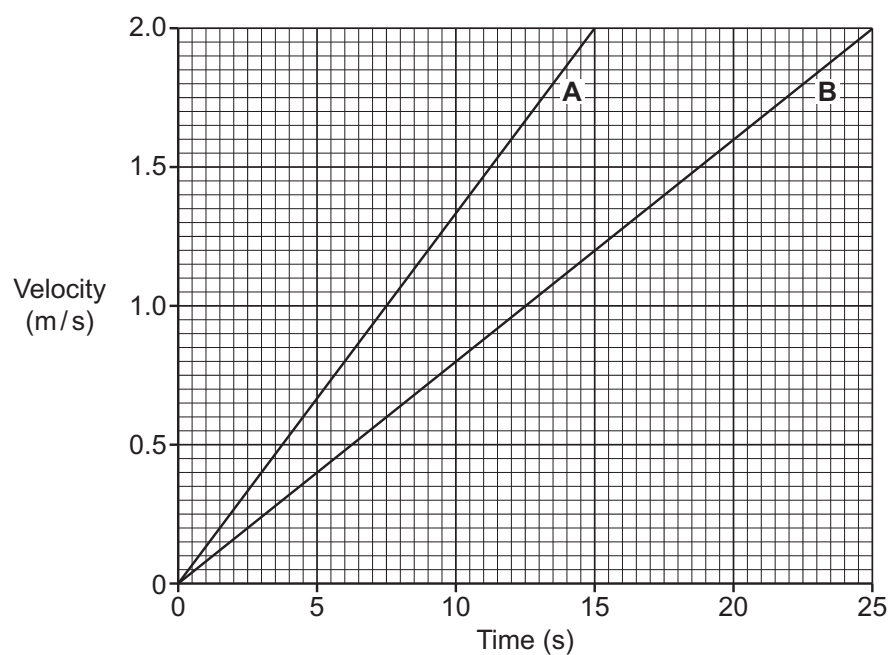
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..... [4]

- (b) The students also investigate the motion of two battery-powered toy cars, **A** and **B**. The velocity–time graph shows their results.



- (i) Which toy car, **A** or **B**, has the greater acceleration? Explain your answer.

Car

Reason

[1]

(ii) Use the graph to calculate the acceleration of car **B**.

Acceleration = ... m/s^2 [3]

(iii) Both cars have the same mass.

Suggest why it takes different amounts of time for them to reach their top speeds.

..... [1]



- 16 (a)** A teacher drops a ball from a height of 2.1 m. The ball hits the floor after 0.6 s.

Calculate the average speed of the ball as it falls.

Use the equation: distance travelled = average speed $\times$ time

Average speed = ... m/s [3]

- (b)** The teacher draws a free body force diagram for the ball as it falls.



- (i)** Label the two forces acting on the ball as it falls. [2]

- (ii)** Explain the motion of the ball as it falls.

.....

 [2]

- (c)** A lorry has a mass of 30 000 kg.

Calculate the force needed to accelerate the lorry at 3.0 m/s^2 .

Use the Equation Sheet.

Force = ... N [3]



21 A student investigates how the angle of a ramp affects the final speed of a trolley.

He uses light gates to record the speed of the trolley at the bottom of the ramp.

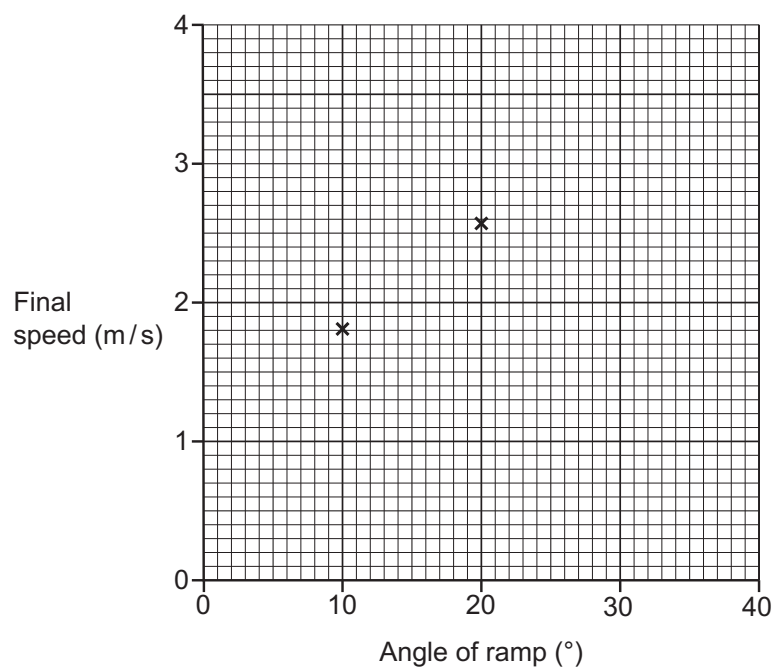
The student releases the trolley from rest at the same point on the ramp each time.

Look at his results.

Angle of ramp (°)	Final speed (m/s)			
	Attempt 1	Attempt 2	Attempt 3	Mean
10	1.81	1.80	1.81	1.81
20	2.58	2.56	2.57	2.57
30	3.1	3.11	3.11	3.11
40	3.52	3.51	3.50	3.51

(a) (i) Plot the results on the graph and draw a line of best fit.

Two results have been plotted for you.



[2]

- (ii) Describe the pattern shown by the results.

Use data from the table or graph in your answer.

.....

.....

.....

.....

.....

..... [3]

- (iii) Explain why the final speed changes when the angle of the ramp increases.

In your answer use ideas about energy.

.....

.....

..... [2]

- (iv) The student made a mistake when recording one of his results.

Identify the mistake **and** explain what he should have done.

.....

.....

..... [2]

- (v) The student thinks this data shows that his results are **reproducible**.

He is **not** correct.

Explain why.

.....

.....

..... [2]



- (b) (i) The mean final velocity for the ramp at a 40° angle is 3.51 m/s . The distance from the top of the ramp to the light gate at the bottom is 1.0 m .

Calculate the acceleration of the trolley when the ramp is at a 40° angle.

Give your answer to **2** decimal places.

Acceleration = ... m/s^2 [5]

- (ii) The trolley has a mass of 2.0 kg .

Calculate the kinetic energy of the trolley at a speed of 3.0 m/s .

Kinetic energy = ... J [3]



SUB-TOPIC P2.2

NEWTON'S LAWS

20 questions in this sub-topic · 89 marks · lowest tariff first



10 Which statement is equivalent to the mass of an object?

- A** The ratio of acceleration over force
- B** The ratio of force over acceleration
- C** The ratio of velocity over acceleration
- D** The ratio of displacement over acceleration

Your answer

[1]



- 1 A 2.0 kg object moves at a velocity of 40 m/s.

What is the momentum of the object?

Use the equation: momentum = mass $\times$ velocity

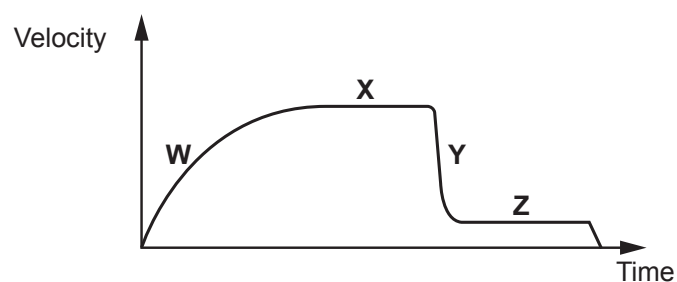
- A 20 kg m/s
- B 38 kg m/s
- C 42 kg m/s
- D 80 kg m/s

Your answer

[1]

- 14** A skydiver falls from a plane. His parachute opens and he lands safely.

Look at the velocity-time graph of his journey.



Which parts of the graph show balanced forces on the skydiver?

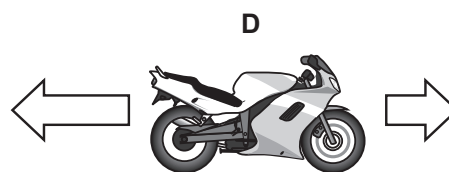
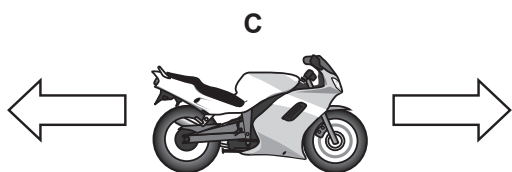
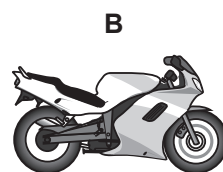
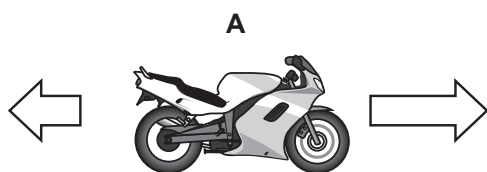
- A** X only
- B** Y and Z
- C** X and Z
- D** Y only

Your answer

[1]

3 A motorbike travels along a straight flat road.

The arrows represent the horizontal forces acting on the motorbike.



Which motorbike is travelling at a uniform velocity?

Your answer

[1]

7 Which statement is an example of Newton's third law?

- A Doubling the engine force on a car doubles its acceleration.
- B Doubling the engine force on a car halves its acceleration.
- C When a ball is rolling on a table it continues rolling at a steady speed.
- D When you clap your hands each hand experiences a force from the other hand.

Your answer

[1]



11 Which statement is an explanation of **inertia**?

- A It is a measure of how difficult it is to change the velocity of an object.
- B It is a measure of how difficult it is to electrically charge an object.
- C It is a measure of the energy of an object.
- D It is a measure of the power of an object.

Your answer

[1]



4 Estimate the force needed to accelerate a car at 1 m/s^2 .

- A 10 N
- B 100 N
- C 1000 N
- D 10000 N

Your answer

[1]

8 Which sentence correctly describes an object when it is moving in a circle at a constant speed?

- A** The object is accelerating as its velocity is changing.
- B** The object is accelerating as its velocity is constant.
- C** The object is not accelerating as acceleration is a scalar quantity.
- D** The object is not accelerating as its speed is constant.

Your answer

[1]



15 A 0.50 kg ball moving at 3.0 m/s to the right collides with a stationary 0.60 kg ball and stops.

What is the velocity of the 0.60 kg ball immediately after the collision?

Use the Equation Sheet.

- A** 0.90 m/s to the left
- B** 0.90 m/s to the right
- C** 2.5 m/s to the left
- D** 2.5 m/s to the right

Your answer

[1]



6 An object moves in a circular path at a constant speed.

Which description is correct?

- A** All of the forces acting on the object are balanced.
- B** The object moves with a constant velocity.
- C** The resultant force acts away from the centre of the circle.
- D** The resultant force acts towards the centre of the circle.

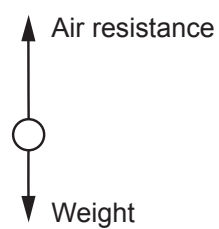
Your answer

[1]



- 9 A skydiver jumps out of a plane.

The vector diagram shows the forces acting on the skydiver at a time after they have jumped.



Which of the following describes the motion of the skydiver at this time?

- A Decreasing speed and moving downwards
- B Decreasing speed and moving upwards
- C Increasing speed and moving downwards
- D Increasing speed and moving upwards

Your answer ☐

[1]

13 Which sentence explains what is meant by the **inertia** of an object?

- A** It is a measure of how difficult it is to change the density of an object.
- B** It is a measure of how difficult it is to change the mass of an object.
- C** It is a measure of how difficult it is to change the velocity of an object.
- D** It is a measure of how difficult it is to change the weight of an object.

Your answer

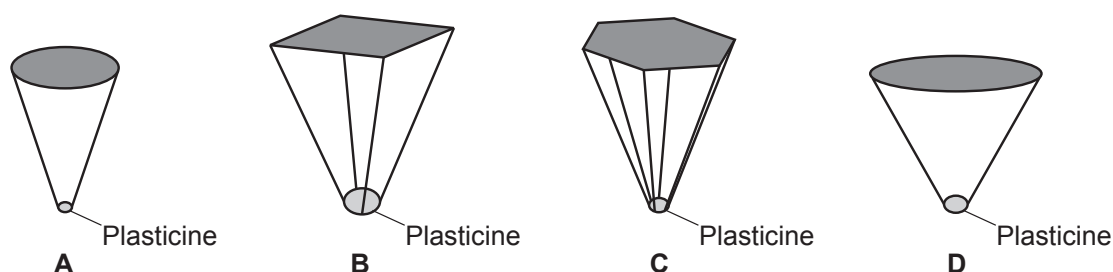
[1]



19* A student investigates how the surface area of a parachute affects the time taken for the parachute to fall.

The student drops parachutes with different surface areas from a height of approximately 2 m and records the time taken to fall using a stopwatch.

The diagram shows the parachutes used by the student.



Not to scale

The table shows the data obtained from the experiment.

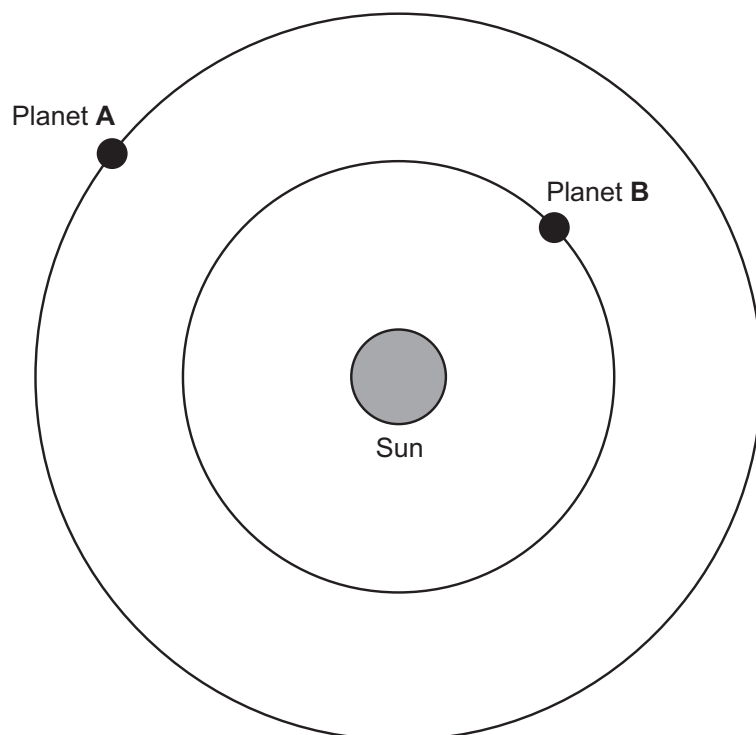
Parachute	Surface area of parachute (cm ²)	Time of fall (s)		
		Attempt 1	Attempt 2	Mean
A	10	0.84	1.04	0.94
B	15	1.02	1.18	1.1
C	20	1.09	1.11	1.1
D	30	1.2	1.3	1.25

Describe the trend shown in the student's results.

Explain how the experimental procedure could be improved.

..... [6

22 The diagram shows two planets orbiting the Sun in our Solar System.



(a) Read the two statements about planet **A**:

- The speed of planet **A** is constant.
- The velocity of planet **A** is changing.

Explain why these two statements are correct. Write about forces.

.....

.....

.....

.....

.....

.....

..... [3]

(b) The table shows data for the planets.

	Radius of orbit (metres)	Time to orbit Sun (years)	Mean orbital speed (km/s)
Planet A	2.28×10^{11}	1.88	24
Planet B	1.08×10^{11}	0.62	35

(i) Explain why the speed of a planet changes when the radius of orbit changes.

.....

.....

.....

..... [2]

(ii) Two students look at the data.

Student P says, 'The time to orbit the Sun is proportional to the radius of orbit.'

Student Q disagrees.

Use the data in the table to show that **Student Q** is correct.

.....

..... [2]

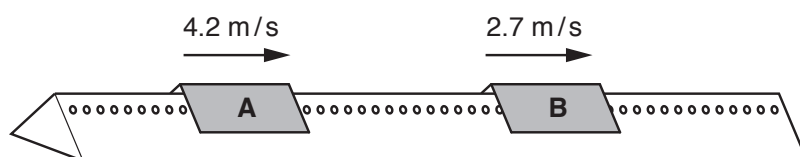


22 A student investigates collisions of trolleys on a horizontal airtrack.

- (a) Write down the **two** quantities involved with motion which are conserved during an elastic collision.

.....
 [2]

Trolley **A** has a mass of 2 kg. Trolley **B** has a mass of 2.5 kg.



- (b) (i) Calculate the **momentum** of each trolley.

Trolley **A** = ... kg m/s

Trolley **B** = ... kg m/s
 [3]

- (ii) The two trolleys collide and stick together after the collision. Use your answers to (b)(i) to calculate the **speed** of the combined trolleys after the collision.

Record your answer to **2** significant figures.

Answer = ... m/s [3]



- (b) The gradient of a tangent drawn to the curved line of the graph gives the acceleration of the shuttlecock at that time.

Draw a tangent to the curved line at 1.0 s.

Use this tangent to find the acceleration of the shuttlecock at 1.0 s.

Acceleration = ... m/s^2 [4]

- (c) Use the graph to find the approximate distance travelled by the shuttlecock during the 2.5 s of the experiment.

Distance = ... m [3]



20 Two skaters are standing, at rest, opposite each other on an ice rink.

Skater **A** has a mass of 40 kg and skater **B** has a mass of 50 kg.



Skater **A** pushes against skater **B** with a force of 30 N.

- (a) (i) What does Newton's third law tell us about the force that skater **A** experiences from skater **B**?

.....

 [2]

- (ii) Calculate the acceleration of skater **B** when they are pushed with the force of 30 N.

Use the equation: force = mass $\times$ acceleration

Acceleration = ... m/s^2 [3]

- (b) (i) State the total momentum of both skaters **before** skater **A** pushes skater **B**.

..... [1]

- (ii) After pushing skater **B**, skater **A** has a velocity of 2 m/s.

Calculate the momentum of skater **A**.

Use the equation: momentum = mass × velocity

Momentum = ... kg m/s [2]

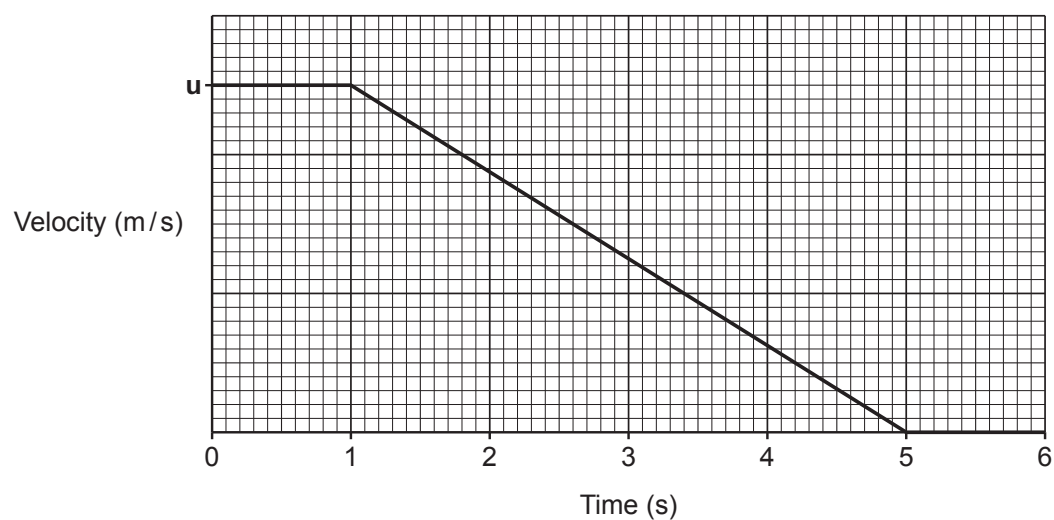
- (iii) Calculate the velocity of skater **B** after being pushed by skater **A**.

Velocity = ... m/s [3]



20

- (a) The graph shows how the velocity of car **A** changes when the driver sees a hazard in the road at time = 0 seconds.



The braking distance is 30 m.

Calculate the initial velocity **u** of car **A**.

Use the graph.

Initial velocity **u** = ... m/s [3]



(b) Car **B** brakes and comes to a stop.

(i) The deceleration of car **B** is 6 m/s^2 .

The initial speed of the car is 18 m/s .

Calculate the braking distance of car **B**.

Use the Equation Sheet.

Braking distance = ... m [3]

(ii) Estimate the force acting on car **B** when it decelerates at 6 m/s^2 .

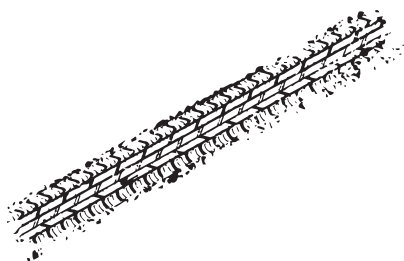
Use the equation: force = mass $\times$ acceleration

For the mass in the equation, use an estimate of the mass of car **B**.

Force = ... N [3]



(iii) The diagram shows a skid mark that car **B**'s tyre makes on the road when the car brakes.



The length of the skid mark is 25 m.

Suggest **two** reasons why the braking distance and the length of the skid mark are **not** the same.

1

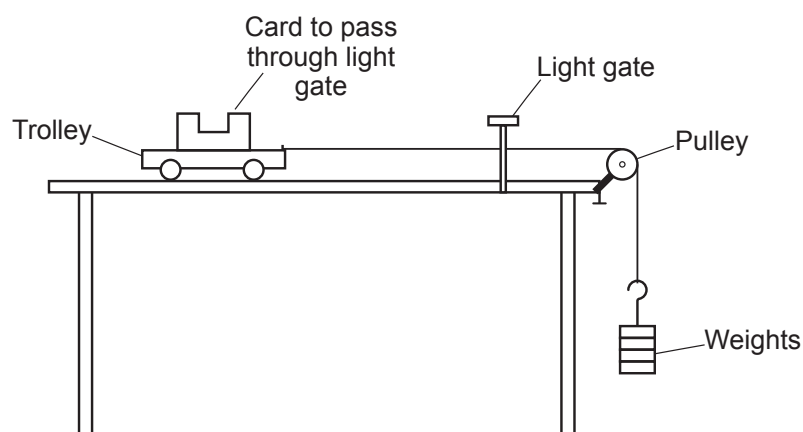
.....

2

.....

[2]

21 A student investigates the acceleration of a trolley.



The trolley is released from a fixed position and accelerates.

The accelerating force is provided by the weights attached to the trolley with string.

Acceleration is measured using a light gate and data logging equipment.

Look at the results from the experiment.

Force (N)	Acceleration
1.0	1.3
2.0	2.9
3.0	4
4.0	5.7
5.0	6.9

(a) The student has made **two** mistakes in their results table. Identify the two mistakes and suggest corrections to them.

Mistake 1:

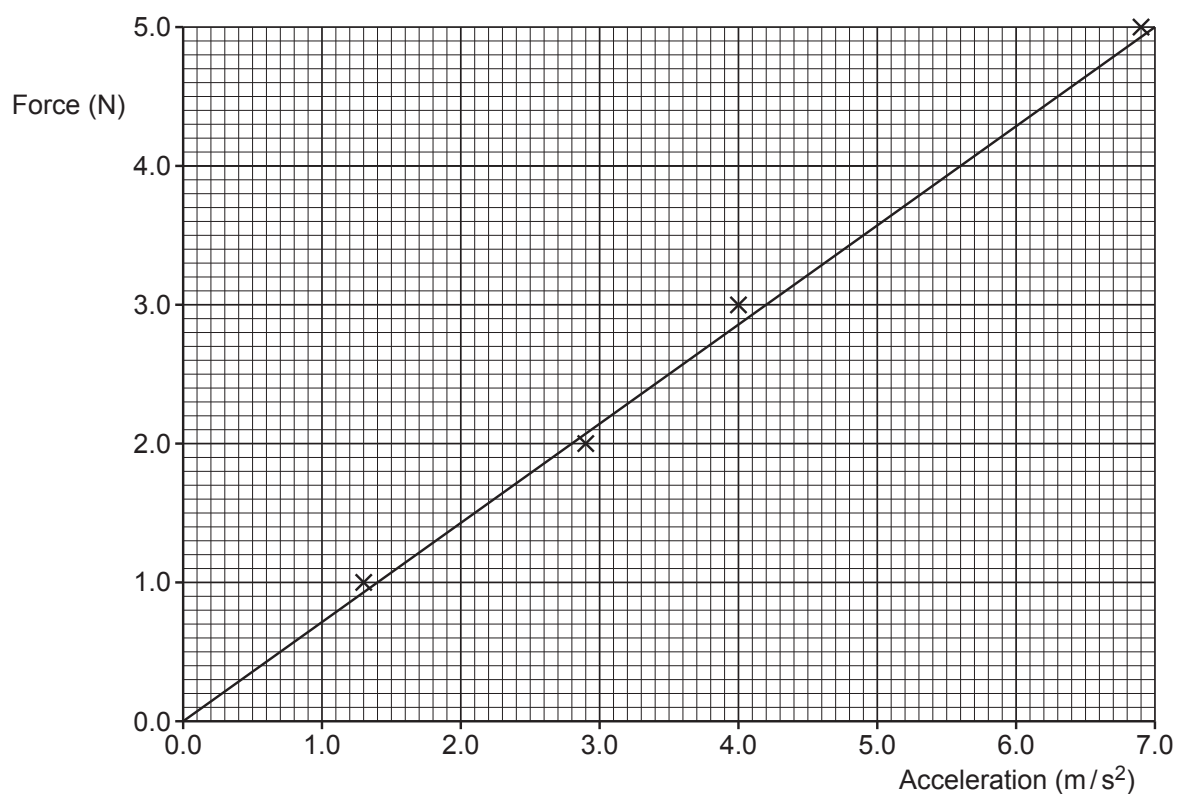
Correction 1:

Mistake 2:

Correction 2:

[4]

(b) The student plots the results on a graph.



(i) One point has not been plotted on the graph. Plot the missing point on the graph. [1]

(ii) Describe the relationship between the two variables on the graph.

.....

 [2]

(iii) Calculate the gradient of the graph and use this to determine the mass of the trolley.

Mass = ... kg [2]



- (iv) The actual mass of the trolley is lower than that found in the experiment. Suggest **two** reasons why.

Use ideas about forces and energy in your answer.

1

.....

2

.....

[2]

- (v) Suggest **two** ways the experiment could be improved.

1

.....

2

.....

[2]

- (c) (i) Describe the energy transfer as the trolley accelerates on the desk.

.....

.....

[1]

- (ii) The trolley moves a distance of 86 cm along the desk.

Calculate the work done when a force of 3.0 N is applied.

Use the equation: work done = force $\times$ distance

Give your answer to **2** significant figures.

Work done = ... J [4]



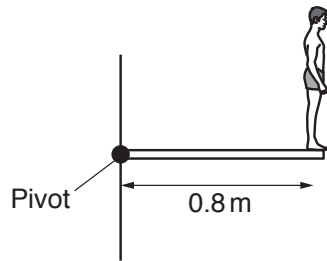
SUB-TOPIC P2.3

FORCES IN ACTION

34 questions in this sub-topic · 109 marks · lowest tariff first



- 4 A diver stands on a diving board. He weighs 400 N.



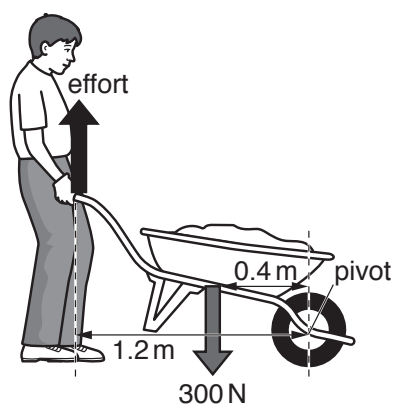
What is the moment of the force provided by the diver around the pivot?

- A 320 Nm anti-clockwise
- B 320 Nm clockwise
- C 500 Nm anti-clockwise
- D 500 Nm clockwise

Your answer

[1]

14 A man lifts a load using a wheelbarrow.



What is the effort needed to lift the load using the wheelbarrow?

- A 100 N
- B 120 N
- C 250 N
- D 144 N

Your answer

[1]

4 Which one of the following uses of forces causes a rotation?

- A** Lowering a book vertically from a shelf
- B** Opening a door
- C** Lifting a book vertically onto a shelf
- D** Sitting in the centre of a see-saw

Your answer

[1]



- 6** On the Moon, a 10 kg mass has a weight of 16 N.

What is the gravitational field strength on the Moon?

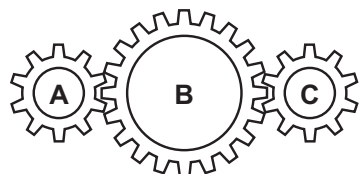
- A** 1.6 N/kg
- B** 6.0 N/kg
- C** 26 N/kg
- D** 160 N/kg

Your answer

[1]

10 A student investigates cogs and gears.

Cogs **A** and **C** have 10 teeth. Cog **B** has 20 teeth.



Cog **A** is turned 5 times.

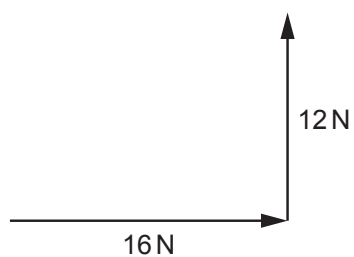
How many times does cog **C** turn?

- A** 5 times
- B** 10 times
- C** 20 times
- D** 50 times

Your answer

[1]

11 Two forces act at right angles to each other.



What is the magnitude of the resultant force?

- A 18 N
- B 20 N
- C 22 N
- D 24 N

Your answer

[1]

15 A spring stretches by 2.0 cm when a force is added.

The spring constant is 60 N/m.

Calculate the energy transferred to the spring when it is stretched.

A 0.012 J

B 0.024 J

C 120 J

D 240 J

Your answer

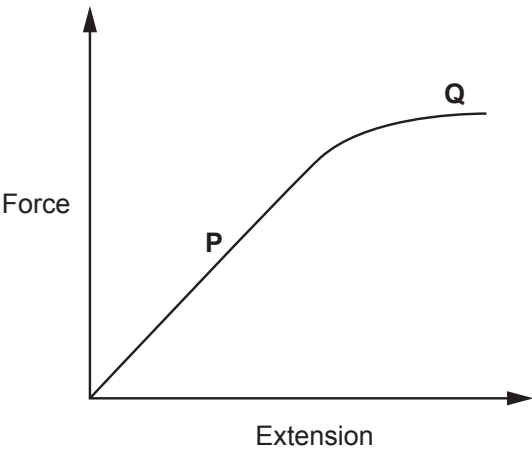
[1]

- 1 Which of the pairs are contact forces?
- A Air resistance and gravity
 - B Friction and gravity
 - C Magnetism and normal contact force
 - D Normal contact force and air resistance

Your answer

[1]

5 A student plots a force-extension graph for a material.



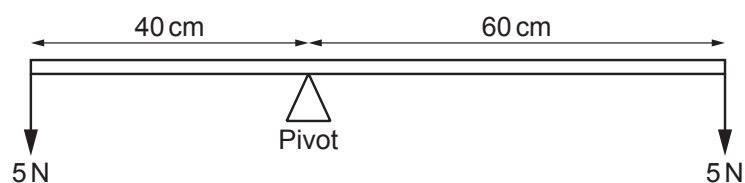
Which row in the table correctly identifies part **P** and part **Q** of the graph?

	Part P	Part Q
A	Elastic	Elastic
B	Elastic	Plastic
C	Plastic	Elastic
D	Plastic	Plastic

Your answer

[1]

- 7 A student sets up a balance using a ruler and a pivot.



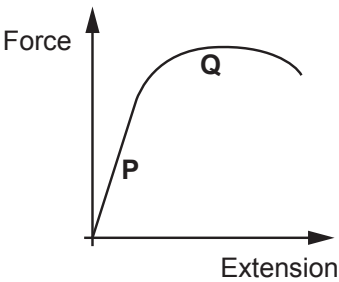
Which statement is correct?

- A There is a resultant turning force anti-clockwise of 200 N cm.
- B There is a resultant turning force clockwise of 100 N cm.
- C There is a resultant turning force clockwise of 300 N cm.
- D There is a resultant turning force of 0 N cm.

Your answer

[1]

5 The graph shows how a copper wire behaves when it is stretched.



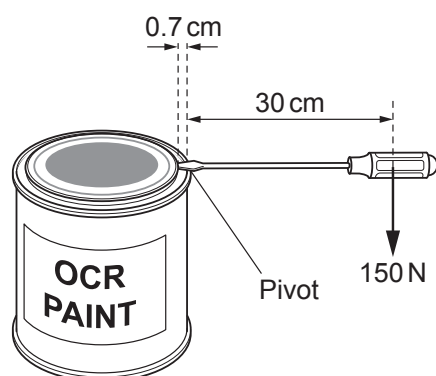
Which row in the table describes part **P** and part **Q** on the graph?

	Part P	Part Q
A	linear	elastic
B	linear	plastic
C	non-linear	elastic
D	non-linear	plastic

Your answer

[1]

- 7 A decorator uses a screwdriver as a lever to open a tin of paint. The edge of the tin acts as a pivot.



What is the clockwise moment of the screwdriver about the pivot?
Use the Data Sheet.

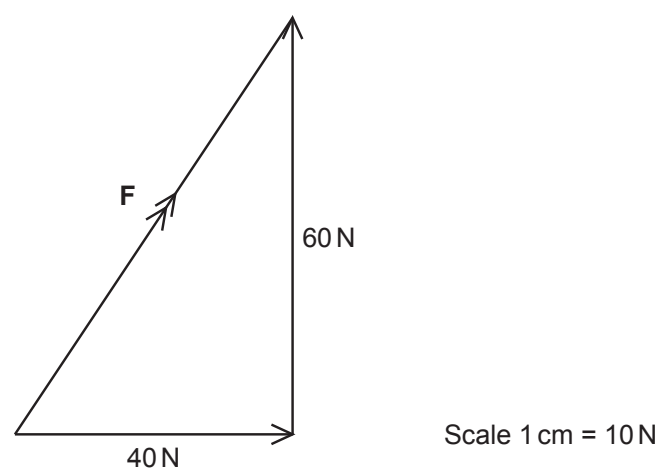
- A 5.0 Nm
- B 45 Nm
- C 46 Nm
- D 500 Nm

Your answer

[1]

12 Two forces, of magnitude 40 N and 60 N, act on an object.

A student draws a scale-diagram to determine the net force **F** acting on the object.



What is the net force **F** acting on the object?

- A** 7.2 N
- B** 20 N
- C** 72 N
- D** 100 N

Your answer

[1]

14 The energy stored in a stretched spring is 5 J.

What is the energy stored in the spring when the extension doubles?
Use the Data Sheet.

- A** 5 J
- B** 10 J
- C** 20 J
- D** 25 J

Your answer

[1]



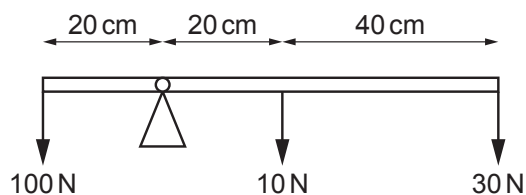
- 4 Which sentence is correct when a lever is used as a force multiplier?
- A The effort force and load force are both situated at the pivot.
 - B The effort force is closer to the pivot than the load.
 - C The load force and the effort force are the same distance from the pivot.
 - D The load is closer to the pivot than the effort force.

Your answer

[1]



- 9 A student investigates moments using a beam placed on a pivot as shown in the diagram. The student holds the beam.



What happens to the beam when the student releases it?

- A It rotates anti-clockwise with a net moment of 60 N cm.
- B It rotates anti-clockwise with a net moment of 600 N cm.
- C It rotates clockwise with a net moment of 2000 N cm.
- D It stays in equilibrium.

Your answer

[1]

13 0.090 J of energy is transferred when stretching a spring.

The spring constant of the spring is 50 N/m.

What is the extension of the spring?

Use the Equation Sheet.

A 0.0036 m

B 0.030 m

C 0.060 m

D 0.084 m

Your answer

[1]



4 The arrows on these scale diagrams represent forces acting on an elastic band.

In which diagram will the elastic band stretch?

A



B



C



D



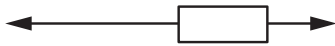
Your answer

[1]

7 The arrows on these scale diagrams represent forces.

Which diagram shows the **largest** net force?

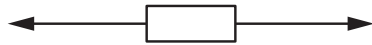
A



B



C



D



Your answer

[1]

11 A large rock on the dwarf planet Pluto has a mass of 200 kg and a weight of 124 N.

What is the gravitational field strength on Pluto?

Use the Equation Sheet.

- A** 0.62 N/kg
- B** 1.61 N/kg
- C** 76 N/kg
- D** 24 800 N/kg

Your answer

[1]



1 Which force is a **contact** force?

- A Electrostatic
- B Friction
- C Gravity
- D Magnetic

Your answer

[1]

- 3** An astronaut has a mass of 80 kg.

Calculate the weight of the astronaut on the Moon.

Use the Equation Sheet.

The gravitational field strength on the Moon is 1.6 N/kg .

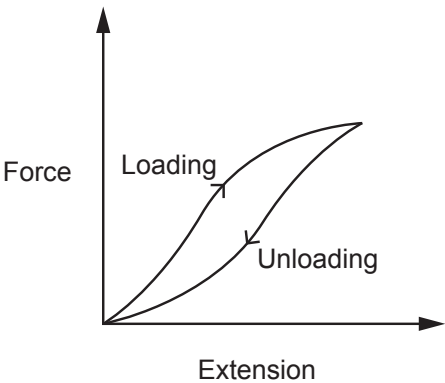
- A** 8.0 N
B 50 N
C 128 N
D 800 N

Your answer

[1]



4 The force–extension graph for a rubber band, during loading and unloading, is shown.



Which row describes the behaviour of the rubber band?

	Deformation	Obeys Hooke's Law?
A	elastic	no
B	elastic	yes
C	plastic	no
D	plastic	yes

Your answer ☐

[1]

12 Two forces act on an object.

One force has a magnitude of 5.0 N and the other force has a magnitude of 8.0 N.

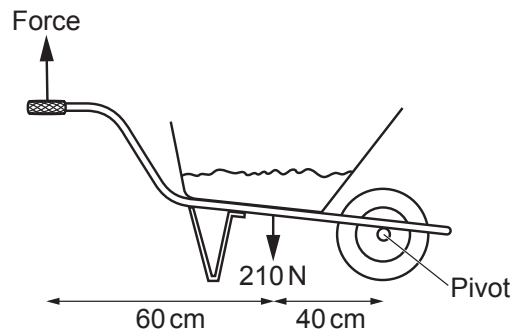
Which row shows the minimum resultant force and the maximum resultant force which could act on the object?

	Minimum resultant force (N)	Maximum resultant force (N)
A	3.0	8.0
B	3.0	13.0
C	5.0	8.0
D	5.0	13.0

Your answer ☐

[1]

- 15 A gardener lifts a load of 210 N using a wheelbarrow.



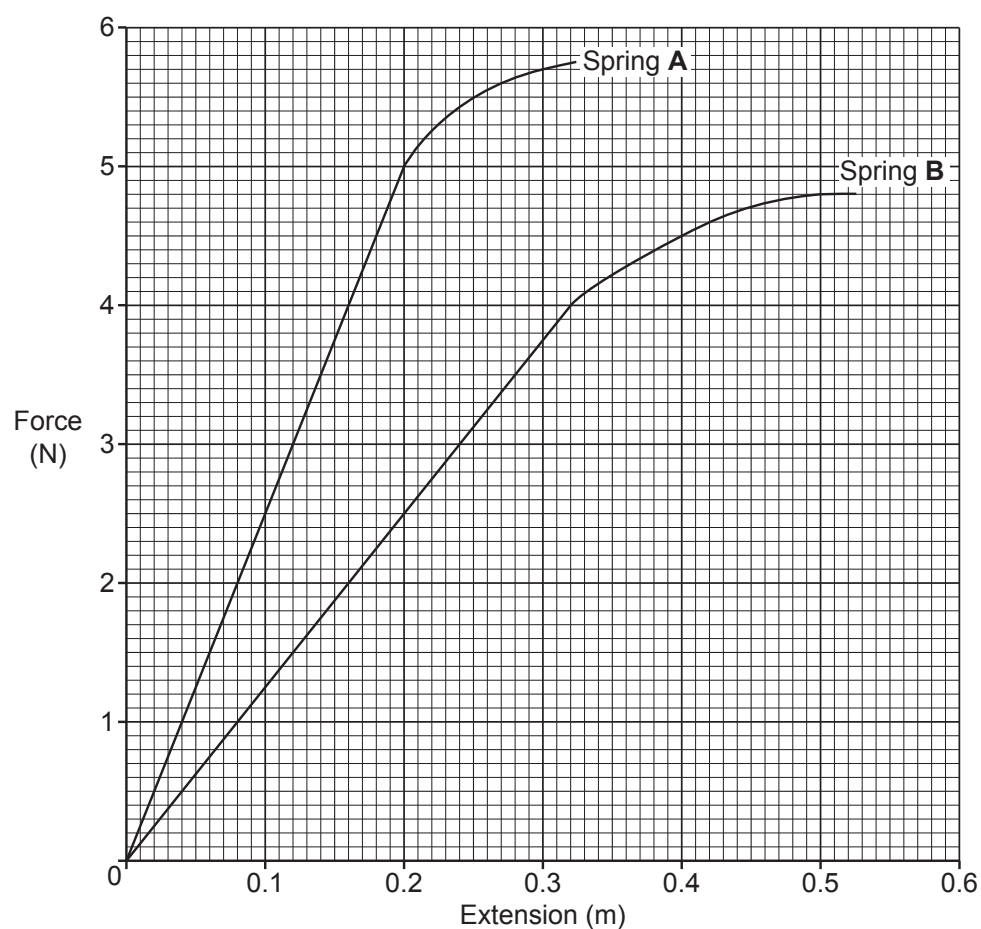
What is the minimum force the gardener exerts to lift the load in the wheelbarrow?

- A 84 N
- B 126 N
- C 140 N
- D 210 N

Your answer

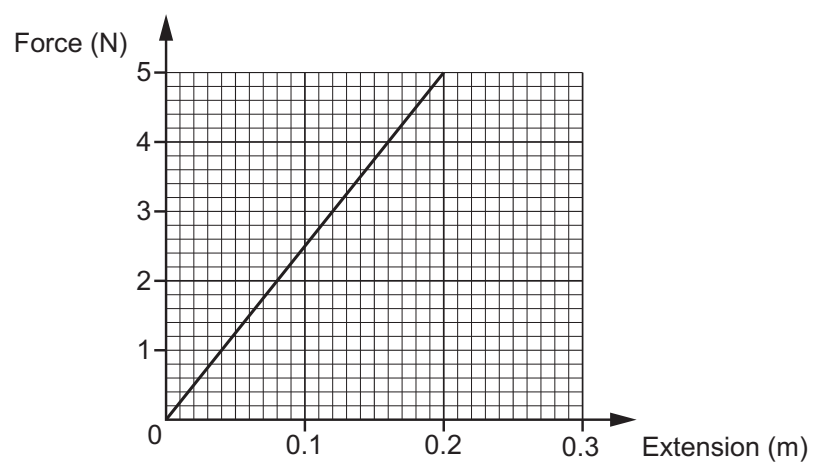
[1]

19* A student stretches two different springs and measures their extensions for different forces. They plot the results on a graph.



18 A student investigates how a spring stretches when a force is added.

Look at a graph of his results.



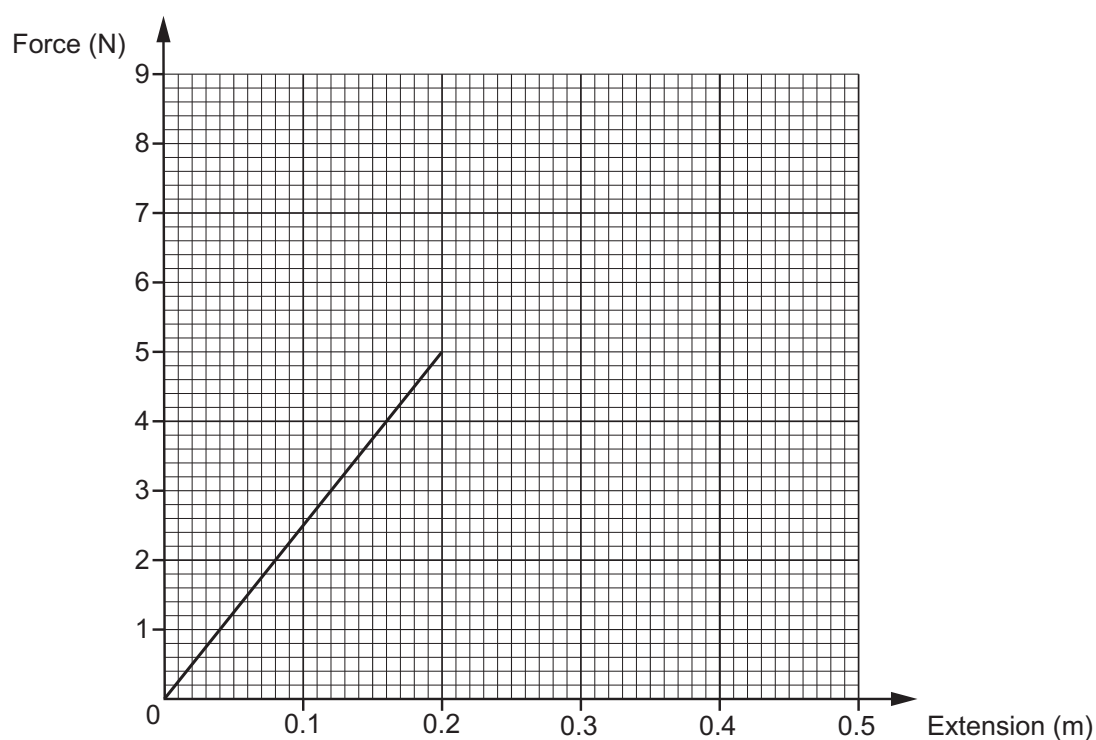
(a) Calculate the spring constant of the spring.

Spring constant = ... N/m **[3]**



(b) The student continues to load the spring until it passes its elastic limit.

Complete the force-extension graph and label the elastic limit.



[2]

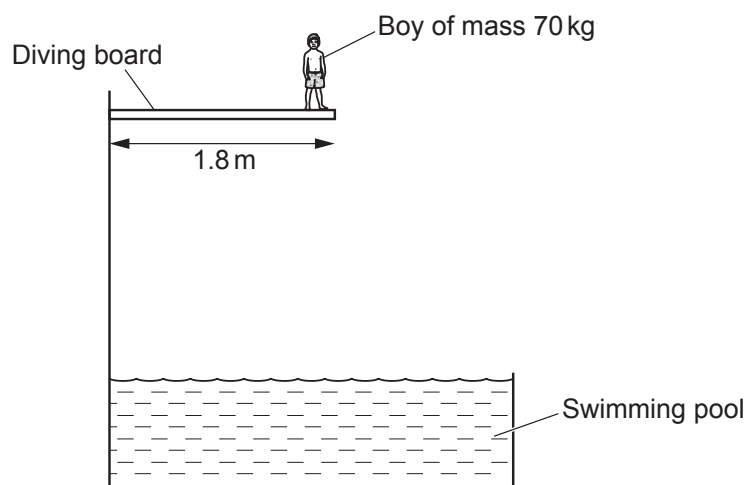
(c) The student puts a small load on the spring. It is in equilibrium.

Draw and label a free body force diagram for the load at the end of the spring.

[3]



- 22** A boy of mass 70 kg stands on the end of a diving board at a distance of 1.8 m from the wall.



- (a)** Calculate the moment of the boy standing on the diving board.
Gravitational field strength on Earth = 10 N/kg.

Moment = ... N m **[4]**

- (b)** The boy dives vertically into the swimming pool. The water in the pool is 3.2 m below the diving board.

Calculate the velocity of the boy when he enters the water.

Use an equation from the data sheet to help you.

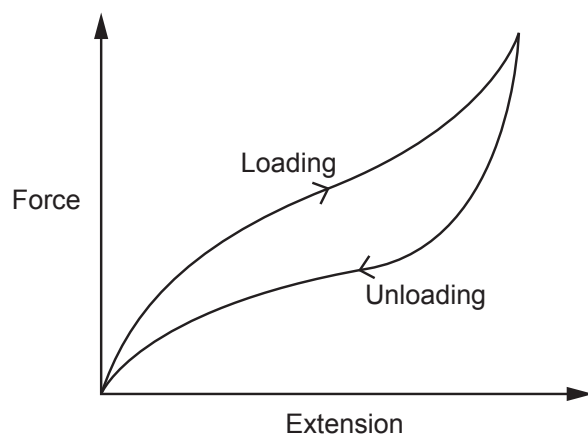
Gravitational field strength on Earth = 10 N/kg.

Velocity = ... m/s **[4]**

- 18** A teacher stretches an elastic band by increasing the force applied and measures the extension during loading.
The teacher then reduces the force applied and measures the extension during unloading.

Fig. 18.1 shows the force–extension graph of their results.

Fig. 18.1



- (a)** The teacher writes some facts about the experiment.

State if each fact is **correct** or **incorrect**. Put a **ring** around the correct option.
Explain your answers.

- (i)** The elastic band obeys Hooke's Law.

correct **incorrect**

Reason
..... **[1]**

- (ii)** The elastic band undergoes plastic deformation.

correct **incorrect**

Reason
..... **[1]**

- (iii)** There is a linear relationship between force and extension for the elastic band.

correct **incorrect**

Reason
..... **[1]**

- (b) A spring has a spring constant of 28 N/m .

Calculate the work done stretching this spring by 0.20 m .

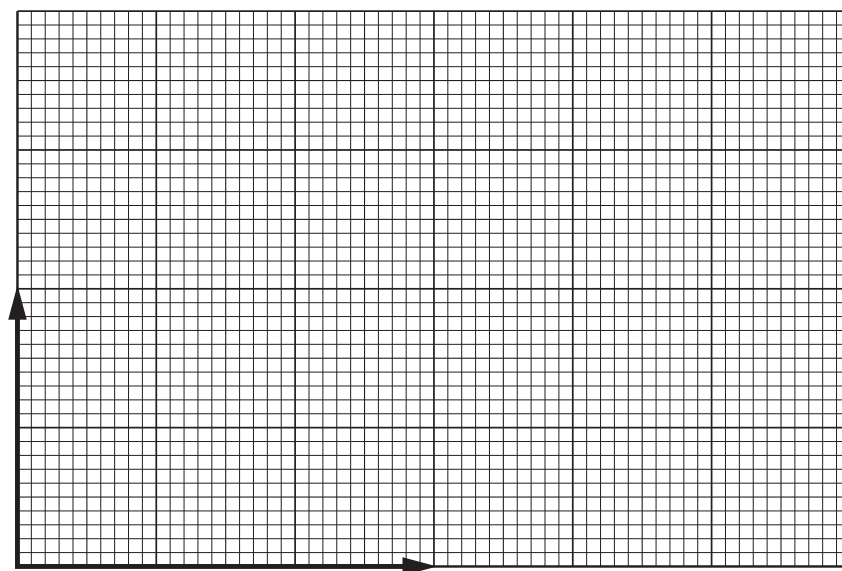
Use the Equation Sheet.

Work done = ... J [2]

- (c) The teacher pulls another object with two separate forces of 2.0 N and 3.0 N .
The forces act at right angles to each other.

Fig. 18.2 shows the two forces.

Fig. 18.2



Scale: $1 \text{ N} = 2 \text{ cm}$

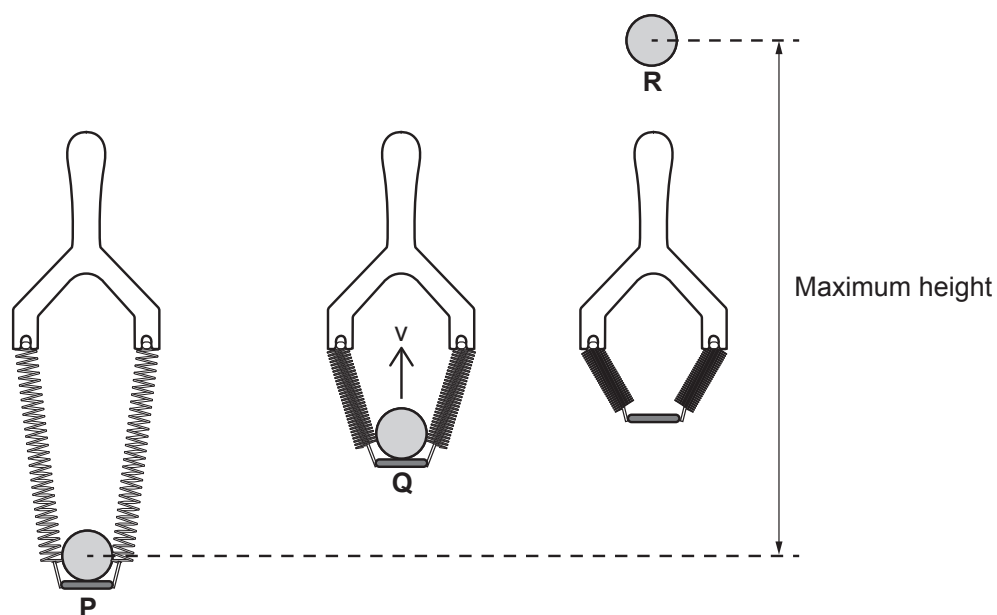
On **Fig. 18.2** draw the resultant force on the object.

Determine the magnitude of the resultant force.

Resultant force = ... N [3]

21 Two springs are used to make a catapult. The catapult is used to shoot a ball vertically upwards.

The diagram shows the ball and catapult at different stages:



(a) At **P** the extension of each spring is 0.2 m.

The spring constant of each spring is 40 N/m.

Calculate the **total** elastic potential energy stored in the springs at **P**.

Energy stored = ... J [3]

- (b) At **Q** the ball is released and has maximum kinetic energy. The springs have **no** extension at **Q**.

The kinetic energy of the ball at **Q** is **less** than the value of the elastic potential energy stored in the springs at **P**.

Explain why.

.....
.....
..... [2]

- (c) The springs are stretched to a new extension:

- The total energy stored in the two springs is 2.4 J.
- The mass of the ball is 0.050 kg.
- At **R** the ball reaches maximum height.

Calculate the maximum height reached by the ball.

Use the equation: potential energy = mass × height × gravitational field strength

Maximum height = ... m [4]

- (d) A student investigates how the mass of the ball affects its speed at **Q**.

Describe **one** factor the student should control in their investigation.

.....
..... [1]



17 An engineer investigates the properties of a spring.

This is their method:

- Carefully add different loads to the spring.
- Measure the extension of the spring for each load.
- Repeat the experiment three times for each load.

The table shows the engineer's results.

Load (N)	Extension (cm)			
	Test 1	Test 2	Test 3	Mean
100	2.1	2.2	2.2	
200	4.2	4.2	4.2	4.2
300	6.3	6.5	6.4	6.4
400	8.6	8.6	8.6	8.6
500	10.6	10.4	10.8	10.6

(a)

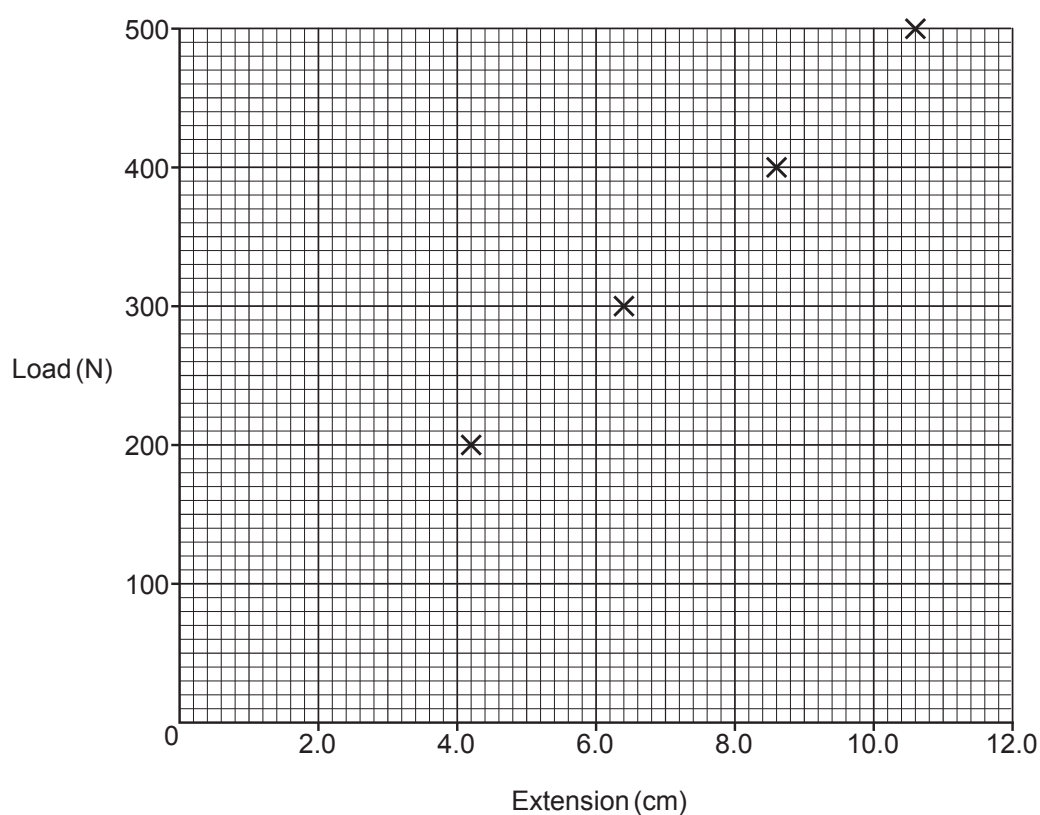
- (i) Calculate the missing value of the mean extension for a load of 100 N to a suitable degree of accuracy.

Mean = ... cm [1]



(ii) Plot the missing value on the graph for a load of 100 N.

Draw a line of best fit.



[2]

(iii) Calculate the gradient of the graph. Show your workings on the graph.

Gradient = ... N/cm [2]

(iv) Use your answer to (a)(iii) to determine the spring constant for the spring.

Spring constant = ... N/cm [1]

- (b) When the engineer repeats the experiment, they use the same method and the same equipment.

The engineer says the results show that the experiment is reproducible.

Suggest **two** reasons why the engineer is **incorrect**.

1

.....

2

.....

[2]

- (c) Identify **one** possible hazard for this experiment and the precaution the engineer should take.

Hazard

Precaution

.....

[2]



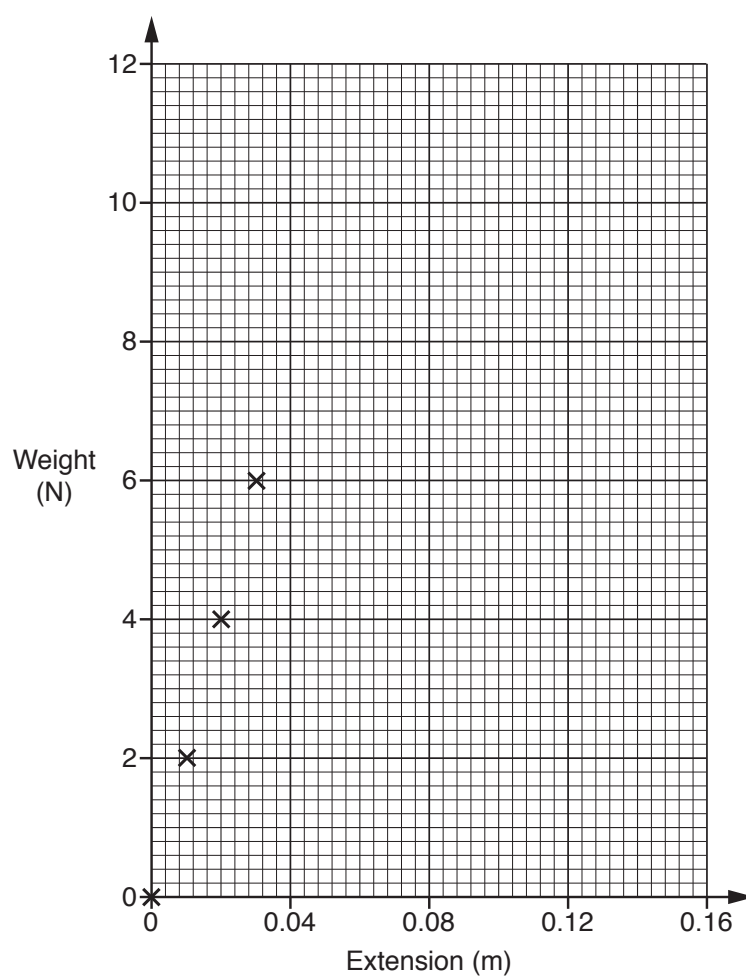
20 A student hangs a length of copper wire from the ceiling.

She adds weights to the bottom of the wire and measures the extension of the wire.

Look at a table of some of her results.

Weight (N)	Extension (m)
0	0
2	0.01
4	0.02
6	0.03
8	0.04
10	0.08
12	0.16

(a) (i) Plot the values on the graph. Some have been done for you.



[2]

(ii) Draw a line of best-fit on the graph. [1]

(iii) Describe **and** explain the shape of the graph.

.....

.....

.....

..... [3]

(b) Calculate the spring constant for the 0–6 N part of the graph.

Use the equation: Force = Spring constant $\times$ Extension

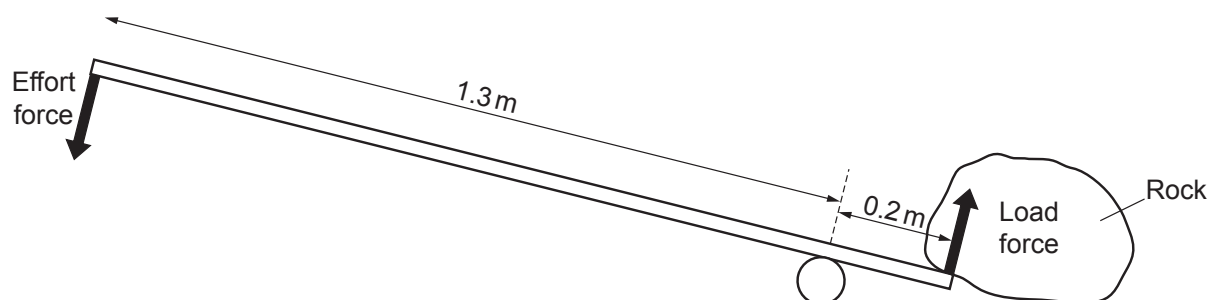
Answer = ... N/m [3]

(c) Calculate the work done in stretching the wire to 0.04 m.

Answer = ... J [2]



- 21 (a) A builder uses a lever to lift a rock.



- (i) Explain why the effort force needed to lift the rock is **less** than the load force.

.....
.....
..... [2]

- (ii) The effort force needed to lift the rock is 100 N.

Calculate the load force.

Load force = ... N [4]

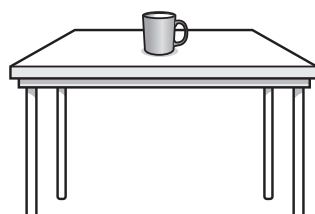
(b) The builder places a mug on a table.

(i) Describe the **two** forces in the interaction pair when the mug is placed on the table.

Force 1

Force 2 [2]

(ii) Draw and label the free body force diagram for the mug placed on the table.

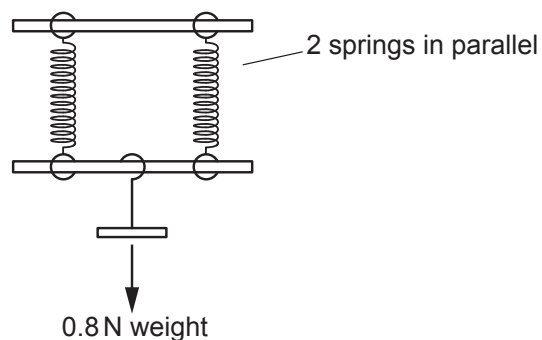


[3]

22 A student investigates the extension of springs in parallel.

The student attaches a 0.8 N weight to two, four, six and eight springs in parallel. They then measure the extension using a ruler.

The diagram shows the experiment with two springs in parallel.



The results are shown in the table.

Number of springs in parallel	Extension (cm)
2	1.2
4	0.6
6	0.4
8	0.3

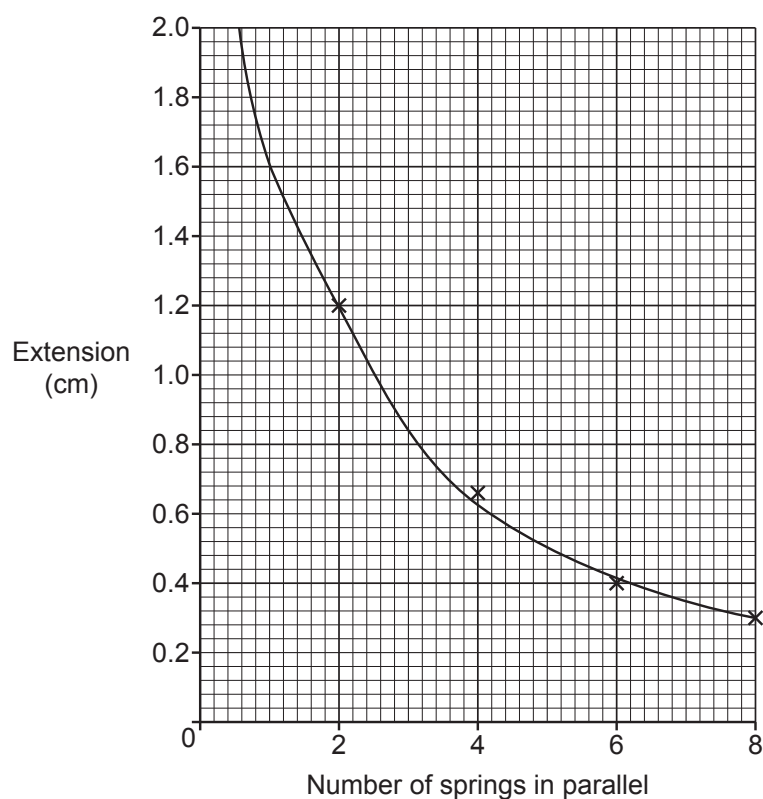
(a) (i) Explain why the student found it difficult to measure the extensions shown in the table.

.....
 [1]

(ii) Suggest how the student could change the experiment to produce extensions that are easier to measure.

.....
 [1]

(b) The graph shows these results.



(i) One point has been incorrectly plotted.

Circle the incorrectly plotted point and then plot it in the correct place.

[2]

(ii) Describe the relationship between the number of springs in parallel and their extension.

.....

 [2]

(c) Use the graph to calculate the spring constant for a single spring.

Use the equation: force exerted by a spring = extension $\times$ spring constant

Spring constant = ... N/m [5]



- (d) A manufacturer has a choice of three different springs to use in a mattress for a bed as shown in the table.

Mattress spring	Spring Constant (N/m)
R	6000
S	9000
T	12 000

Explain which mattress spring, **R**, **S**, or **T**, compresses the most when a person lies on it.

Mattress spring

Reason

.....

[1]



MARK SCHEMES

official Pearson Edexcel mark schemes



Question			Answer	Marks	AO element	Guidance
9			C ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
12			D ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
13			B ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
7			B✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
12				B ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
4			B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
1			C ✓	1	1.2	



Question			Answer	Marks	AO element	Guidance
11			B ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
5				A ✓	1	1.2	



Question			Answer	Marks	AO element	Guidance
15			D ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
11	A ✓	1	1.2	

Question	Answer	Marks	AO element	Guidance
13	A ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
3	A	1	1.2	

Question	Answer	Marks	AO element	Guidance
5	D	1	2.1	



Question	Answer	Marks	AO element	Guidance
13	C	1	2.1	



Question	Answer	Marks	AO element	Guidance
15	B	1	2.1	ALLOW 6.0 (m / s ²)



Question	Answer	Marks	AO element	Guidance
14	B	1	2.1	



Question	Answer	Marks	AO element	Guidance
10	C	1	1.2	



Question	Answer	Marks	AO element	Guidance
7	A	1	1.1	



Question	Answer	Marks	AO element	Guidance
7	B	1	1.1	



18	*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed explanation about why speed and velocity are different from each other AND Calculations of speed and velocity completed and are correct <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Detailed explanation about why speed and velocity are different from each other AND Calculation of speed OR velocity completed and is correct OR both equations stated/implied OR Explanation about why speed and velocity are different from each other AND Calculations of speed and velocity completed and are correct <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i>	6	1.1x4 2.1x2 AO1.1 Demonstrate knowledge and understanding of the difference between speed and velocity For example: • speed is a scalar • velocity is a vector • speed has magnitude only • velocity has magnitude and direction • speed depends on distance • velocity depends on displacement • speed is rate of change of distance • velocity is rate of change of displacement AO1.2 Recall of speed and velocity equations • speed = distance / time • velocity = displacement / time AO2.1 Apply knowledge and understanding of calculating speed and velocity For example: • speed = $3.0 / (0.5 \times 60)$ • speed = 0.10 (m/s) • velocity = $0.6 / (0.5 \times 60)$ • velocity = 0.02 (m/s)
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Question	Answer	Marks	AO element	Guidance
	Level 1 (1–2 marks) Explanation about why speed and velocity are different from each other. OR Calculation of speed or velocity completed and is correct OR Both equations stated/implied <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>			

22		Level 3 (5–6 marks) Detailed description and analysis of the v/t graph of the journey (including correct calculations of acceleration AND distance) <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Clear description and analysis of the v/t graph of the journey AND calculation of acceleration OR distance <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Basic description and analysis of the graph of the journey AND an attempt at a calculation OR correct calculations of acceleration or distance. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i> 0 marks No response or no response worthy of credit.	6	$2 \times 3.1a$ 2×2.2 2×2.1	AO 2.1: Description of the journey For example - as the time increases the velocity increases - the train accelerates/speeds up between the start and 40s - the train travels at a steady velocity from 40s to 100s - the train accelerates/speeds up between 100s and 140s - the train moves in one direction - the train does not change direction AO3.1a: Analysis of the journey For example - The train has a constant acceleration for the first and third stage - The train travels at a constant velocity/speed (zero acceleration) in the second stage - The acceleration in the first and third stage is the same AO 2.2: Calculations For example - The acceleration in the first and third stage is 0.25 m/s^2 - The distance in the first stage is 200m - The distance in the second stage is 600m - The distance in the third stage is 600m - Overall distance travelled is 1400m /1.4 km
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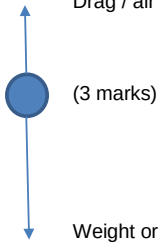


17	(a)	Tape measure / metre rule(r)/stick AND Stop clock/watch✓	1	1.2	IGNORE just ruler ALLOW light gates
	(b) (i)	Mean = 2(.00) ✓ Median = 2.02 ✓ Mode = 2.08 ✓	3	1.2 x 3	ALLOW 2.04 for mean (for ignoring 1.84) ALLOW 2.06 for median if 2.04 calculated for the mean
	(ii)	(They have a) wide spread/range / AW ✓	1	3.2a	ALLOW (they are) not all close together / don't have a small difference / not similar / AW ALLOW they are too different / have a big gap / not concordant / 0.24 gap / attempt 1 is very different / AW IGNORE not consistent
	(iii)	Improvement must be linked to error Error: Reaction time / difficulty in starting/stopping timer at exact time / AW ✓ Improvement: Video/record the drop (and replay using timings from the recording) / use an electronic timing method / use light gates / AW ✓ OR Error: Not dropping ball from exact height / AW Improvement: Indication of marking the point from where the ball should be dropped from / AW	2	3.3b 3.3a	Marks can be awarded for errors/improvements in either section IGNORE difficulty in timing without a reason IGNORE human error unless qualified ALLOW use larger distances (so that % error in time is reduced)

22	(a)	<u>direction</u> / <u>displacement</u> is changing / AW ✓	1	1.1	
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 50 (W) award 3 marks Power = energy / time ✓ 3000 / 60 ✓ 50 (W) ✓	3	1.2 2.1 2.1	
	(c)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 10 (s) award 3 marks (Rearrangement) $t = \text{change in velocity} / a$ ✓ $t = (1-5) / (-0.4)$ ✓ $t = 10 \text{ (s)}$ ✓	3	1.2 2.1 2.1	IGNORE negative signs

22	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 12.0 (s) award 3 marks (time =) change in velocity ÷ acceleration ✓ (time =) $(18 - 0) \div 1.5$ ✓ (time =) 12.0 (s) ✓	3	1 × 1.2 2 × 2.1	ALLOW 12 (s)
	(b)	Any one from: Thinking distance unchanged (by ice) ✓ Stopping distance = thinking distance + braking distance ✓ AND any two from: Friction/force between tyres and road reduced ✓ Initial kinetic energy of van is the same ✓ Since distance = work done ÷ force (or energy ÷ force) ✓ Braking distance becomes greater / stopping distance is greater ✓	3	1.1 2 × 2.1	
	(c)	Any two from: Acceleration will increase ✓ Force = mass × acceleration ✓ So greater force (acting on occupants) ✓ And this could lead to injury (of occupants of the van) ✓	2	2 × 2.1	ALLOW Higher ideas about momentum ALLOW Rate of change of momentum is greater ✓ ALLOW Force = rate of change of momentum ✓

23	(a)	(i)	initial speed is zero and - either acceleration due to gravity = 10 - or $g = 10$ ✓ use $a = (v-u) \div t$ to find the final speed / v ✓ use $v^2 - u^2 = 2as$ to find s ✓	3	3 x 1.1	IGNORE the idea of echoes and speed of sound ALLOW answers using $g = 9.8$ or 9.81 ALLOW $v = u + at$ ✓ ALLOW credit for higher level answers: Eg. three marks for answer in terms of $s = ut + \frac{1}{2}at^2$
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 22 (m/s) award 2 marks $10 = v (-0) / 2.2$ OR uses idea that stone gains 10m/s each second ✓ $V = 22$ (m/s) ✓	2	2 x 2.1	ALLOW 21.56 or 21.58 or 21.6 (if $g=9.8$ or 9.81) ✓✓

Question	Answer	Marks	AO element	Guidance
(b)	only 2 arrows drawn or directions of the two forces described – one upwards and one downwards ✓ Correctly names weight and air resistance / drag ✓ downward arrow longer than upward arrow / forces are unbalanced / resultant / net / overall force downwards ✓ so object accelerates / gets faster / increases velocity or speed ✓	4	2.1 1.1 2.1 1.1	Award marks for answer points given in diagrams or prose. ALLOW force of gravity or mg or gravitational pull for weight BUT DO NOT ALLOW merely 'gravity' IGNORE upthrust for this marking point only 

16	(a)	(i)	450 m ✓	1	2.2	
		(ii)	350 s ✓	1	2.2	ALLOW 5 minutes 50 s
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.3 (m/s) award 3 marks (Rearrangement) Speed = distance / time ✓ 450 / 350 ✓ 1.3 (m/s) ✓	3	1.2 2.2 2.2	ALLOW ECF from (a)(i) and(ii) ALLOW 1.2857 (m/s) ALLOW $s = d / t$
		(iv)	Section E ✓ Steepest <u>gradient</u> or <u>slope</u> ✓	2	2.2 1.1	ALLOW correct speeds calculated (1 m/s) and compared for sloped sections
		(v)	(The student) Stopped ✓	1	1.1	ALLOW any sensible answer related to stopping
	(b)		(Time) Watch / stopwatch / stopclock / timer AND (Distance) trundle wheel / (measuring) tape ✓	1	2.2	ALLOW mobile (phone) <u>timer</u> IGNORE mobile (phone) ALLOW metre rule ALLOW tracking / fitbit app on mobile to measure distance IGNORE ruler

16	(a)		Any four from: Mark two points (a distance apart / along the road) ✓ Measure distance (between those two points) ✓ Instrument to measure distance (between those two points) using tape measure / trundle wheel ✓ Measure time (between those two points) ✓ Instrument to measure time taken (between those two points) using a stopwatch / stop clock / timer / AW ✓	4	4 x 1.2	ALLOW set distance IGNORE ruler ALLOW metre rule IGNORE speed guns / camera IGNORE mobile phone on its own IGNORE light gates IGNORE calculations of mean speed
	(b)	(i)	A Because it has the steepest gradient / line / slope or greatest increase in speed in same time / smallest time for same increase in speed ✓	1	2.1	No mark for just A ALLOW $A = 0.13 \text{ m/s}^2$ and $B = 0.08 \text{ m/s}^2$ ALLOW velocity increases quicker
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.08 award 3 marks Acceleration = gradient ✓ 2.0 / 25 ✓ 0.08 (m/s ²) ✓	3	1.2 2.1 2.1	ALLOW acceleration = change in velocity / time ALLOW any two suitable numbers from the graph ALLOW 2 marks for an answer of 0.13(33) – candidate mistakenly calculated acceleration of car A.
		(iii)	(Motor in Car A) is more powerful / transfers energy faster / has a motor which supplies a larger force / OR A ✓	1	1.2	ALLOW idea that there is more drag / friction (acting on car B) / (car A) is more streamlined / has tyres with better grip ALLOW (Car A has) a larger / different current / p.d. / (driving) force ALLOW ECF choice of car from (b)(i) IGNORE bigger battery

16	(a)	First check the answer on answer line If answer = 3.5 (m/s) award 3 marks (average) speed = distance travelled ÷ time ✓ 2.1 ÷ 0.6 ✓ 3.5 (m/s) ✓	3	1.2 2.1 2.1	Correct rearrangement IGNORE triangles 2.1 ÷ 0.6 gains 2 marks
	(b)	(i) Upwards force arrow: <u>air</u> resistance / drag ✓ Downwards force arrow: weight / (force due to) gravity / gravitational force ✓	2	2 x 1.2	ALLOW friction of air / wind resistance DO NOT ALLOW upthrust ALLOW pull / attraction for force IGNORE Gravitational field strength
		(ii) (There is a) net / resultant / overall / unbalanced force downwards ✓ And any one from: Ball accelerates / speeds up / gets faster ✓ Ball speeds up so air resistance increases ✓ OR Acceleration of ball reduces / velocity of ball increases <u>until</u> forces are balanced ✓✓	2	3.2b 3.2a	ALLOW weight (force) is larger than the air resistance (force) ALLOW increase kinetic energy (store)
	(c)	First check the answer on answer line If answer = 90 000 (N) award 3 marks F = ma / force = mass x acceleration ✓ 30 000 x 3 ✓ 90 000 (N) ✓	3	1.2 2.1 2.1	ALLOW 90 kN

21	(a)	(i)	Both points correctly plotted ✓ Smooth curve correctly drawn ✓	2	1.2	ALLOW within ½ small square for plotting DO NOT ALLOW straight lines between data points IGNORE any line drawn for <10°
		(ii)	Increase in angle of ramp increases speed (at bottom ramp) OR ✓ Increase is not linear/doubling angle does not double final speed / AW ✓ Reference to quantitative data for two calculations, for example, increase from 10° to 20° the speed increases by 0.76 whilst 20° to 30° the speed increases by 0.54 ✓	3	3.1a 3.1a 3.1b	IGNORE correlation ALLOW Not directly proportional / Not constant increase NOTE comparison of two increases required NOTE Speed increase from 0° to 10° is 1.81 and speed increase from 30° to 40° is 0.40
		(iii)	(Increase in angle) increases potential energy of the trolley/more work is done raising trolley to that point on the ramp ✓ This increases the / more kinetic energy at the bottom of the ramp ✓	2	1.1x2	ALLOW more PE is transferred to KE
		(iv)	Attempt 1 at 30° (is only recorded to 1 decimal place)/ 3.1 ✓ Student should record data to a consistent number of decimal places or 2 dp / the reading should be recorded as 3.10 / AW ✓	2	3.3a 3.3b	ALLOW only recorded to 2 significant figures ALLOW should be recorded to 3 significant figures NOT same accuracy

Question	Answer	Marks	AO element	Guidance
	(v) Any two from: Reproducible means that the results can be reproduced by someone else ✓ Only one student has collected this data ✓ The experiment is repeatable (as the repeated readings are close together) ✓	2	2.2x2	NOT experiment can be repeated
(b)	(i) FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 6.16 (m/s²) award 5 marks $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 3.51^2 \div (2 \times 1.0)$ ✓ $a = 6.16005$ (m/s ²) ✓ $a = 6.16$ (m/s ²) (2 decimal places) ✓	5	2.1 1.2 2.1 2.1 1.2	 NOTE must be rearranged ALLOW Any number which rounds to 6.16 ALLOW one mark for any calculated answer to 2dp
	(ii) FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 9 (J) award 3 marks kinetic energy (J) = 0.5 x mass (kg) x (speed (m/s)) ² / KE = ½ mv ² / KE = 0.5mv ² ✓ KE = 0.5 x 2.0 x 3.0 ² ✓ KE = 9 (J) ✓	3	1.2 2.1 2.1	



Question				Answer	Marks	AO element	Guidance
10				B ✓	1	1.1	



Question				Answer		Marks	AO element	Guidance	
1				D ✓		1	2.1		



Question				Answer	Marks	AO element	Guidance
14				C ✓	1	2.1	

Question				Answer	Marks	AO element	Guidance
3			C		1	2.1	



Question				Answer	Marks	AO element	Guidance
7				D	1	2.1	



Question				Answer	Marks	AO element	Guidance
11				A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
4			C ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
8	A	1	1.2	



Question	Answer	Marks	AO element	Guidance
15	D	1	2.1	



Question	Answer	Marks	AO element	Guidance
6	D	1	1.1	

Question	Answer	Marks	AO element	Guidance
9	A	1	2.1	



Question	Answer	Marks	AO element	Guidance
13	C	1	1.1	



19*		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed explanation of why car A is safer than car B AND good estimation of deceleration of car A / quantitative comparison of decelerations <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Detailed explanation of why car A is safer than car B AND an attempt at estimation/comparison of decelerations OR Good estimation of deceleration of car A / quantitative comparison of decelerations AND a basic explanation of why car A is safer than car B <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Basic explanation of why car A is safer than car B OR An attempt at estimation/comparison of decelerations	6	3 × 2.1 3 × 1.1 AO2.1 Applies knowledge and understanding of scientific ideas to estimate acceleration Estimation of acceleration using distance or time - car B has a higher/double acceleration - Use of $a = (v^2 - u^2)/2s$ $a = (-)14^2 / 2 \times$ (their value of distance) - Use of $a = (v - u) / t$ $a = 14/$ (their value of time) AO1.1 – Demonstrates knowledge and understanding why car A is safer than car B (Smaller force) reduces risk of (serious) injury to driver/passengers Explanation - Increased stopping distance/time for car A means deceleration of car A is half/less than car B / ORA - Car A slows down over a longer distance/time - Smaller acceleration / smaller rate of change of momentum for car A / ORA - So force acting on car A is half/less than car B / ORA - Since $F = ma$ / $F =$ rate of change of momentum - Greater distance/time for (kinetic) energy to be dissipated - Since $W = Fd$ / same KE transferred / same KE dissipated over a longer distance/time
		<i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit</i>		

19		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Description of the trend shown in the results and detailed suggestions with reasoning to improve the experimental procedure. OR Detailed description of the trend shown in the results and suggestions to improve the experimental procedure <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Detailed description of the trend shown in the results OR Detailed suggestions to improve the experimental procedure OR Description of the trend shown in the results and suggestions to improve the experimental procedure <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Basic description of the trend shown in the results. OR Basic suggestions to improve the experimental procedure.	6	3.1a x 2 3.3b x 4	AO3.1a Analyses the results to interpret the trend shown by the results. For example, - as the area increases, time to fall increases ORA - the relationship is not linear / proportional - numerical analysis justifying non-linear AO3.3b Analyses the information to improve experimental procedures. For example, - Repeat readings more than twice (and take a mean) - Take more values for the area (4 values is not enough) - Record acceleration data to a consistent number of decimal places/significant figures - Use the same number of strings on the parachutes - Drop over a longer distance - Drop over an exact distance, not 'about' 2m - Measure drop height to the nearest cm using a ruler - Improve timing method e.g., video the drop and calculate time more accurately - Use the same mass/weight/size load on the parachutes – it varies - Use the same shape of parachute – some of these are circular and others are square - Use a wider range of areas - Sensible description of method to determine the area of the parachute - Ignore anomalous data points
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Question	Answer	Marks	AO element	Guidance
	<i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i> 0 marks <i>No response or no response worthy of credit.</i>			IGNORE constant intervals



22	(a)	Any three from: (Speed is constant because) (resultant) force is perpendicular to direction of motion / (resultant) force is a centripetal force / there is no displacement in direction of force ✓ No work is done on the planet ✓ (Velocity is changing because) the direction is changing ✓ (Resultant force) provided by gravitational pull of the sun (causes the direction of motion to change) ✓ (So) planet is accelerating ✓	3	3 × 1.1	ALLOW (resultant) force is always towards the Sun/centre of circle ALLOW velocity is a vector and speed is a scalar ALLOW force provided by the gravity of the Sun
	(b) (i)	Smaller radius or closer to the Sun means larger (gravitational/centripetal) force/pull ✓ (smaller radius or closer to Sun or larger gravitational/centripetal force means) larger acceleration/speed ✓ OR Closer orbits have a lower GPE ✓ (closer orbits have) higher KE ✓	2	2 × 1.1	ALLOW ORA in each case ALLOW smaller radius means more gravity

Question	Answer	Marks	AO element	Guidance
22 (b) (ii)	Any two from: (A statement explaining that if proportional, you would expect:) e.g. $T = kr$ OR $T \div r = k$ OR $T_A \div r_A = T_B \div r_B$ OR $r_A \div T_A = r_B \div T_B$ OR $T_A \div T_B = r_A \div r_B$ OR $T_B \div T_A = r_B \div r_A$ / ORA ✓ Correct calculation of k or ratio of variables ✓ (Idea that) planet A is (approximately) double the radius of B but (approximately) triple the time (to orbit the Sun) ✓ BUT Statement (comparing two correctly calculated values) showing values are not equal or k is not constant ✓✓ Correct calculation of k from planet A (or B) and used to show that this k does not give correct value for the other planet ✓✓	2	2 × 3.1b	ALLOW all numbers substituted correctly in any version for 2 marks. e.g. $k = T_A \div r_A = 1.88 \div 2.28 \times 10^{11} = 8.25 \times 10^{-12}$ $k = T_B \div r_B = 0.62 \div 1.08 \times 10^{11} = 5.74 \times 10^{-12}$ e.g. $T_A \div r_A = 8.25 \times 10^{-12} \neq T_B \div r_B = 5.74 \times 10^{-12}$ $r_A \div T_A = 1.21 \times 10^{11} \neq T_B \div r_B = 1.74 \times 10^{11}$ $T_A \div T_B = 3.03 \neq r_A \div r_B = 2.11$ $T_B \div T_A = 0.330 \neq r_B \div r_A = 0.474$

22	(a)		momentum ✓ kinetic energy or KE ✓	2	2 x 1.1	IGNORE mass conserved If more than two answers mark the first two answers (unless one of them is mass). Eg 'KE, mass, momentum' ✓✓ Eg. PE, KE, momentum ✓
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINES If answers = 8.4 (kgm/s) and 6.75 / 6.8 (kgm/s) award 3 marks 2 x 4.2 2.5 x 2.7 ✓ A: 8.4 (kgm/s) ✓ B: 6.75/6.8 (kgm/s) ✓	3	1.2 2.2 2.2	8.4 and 6.7 scores ✓✓ (incorrect rounding of one of the values)
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 3.4 (m/s) award 3 marks (8.4 + 6.75) ÷ 4.5 ✓ 3.37 / 3.366666667 (m) ✓ 3.4 (rounding to 2 sf) ✓	3	2.2 2.2 1.2	ECF for momentum values eg. (A + B) ÷ 4.5 Wrong answer but evidence of correct rounding ✓ Eg. 6.75 to 6.8 ✓

23	(a)	Any three from: As velocity /speed increases air resistance increases✓ (until) the weight balances the air resistance ✓ No net / resultant force ✓ No acceleration (so no further increase in velocity)✓	3	1.2x3	ALLOW drag for air resistance ALLOW equal / equilibrium
	(b)	First check the tangent drawn and the answer on the answer line If appropriate tangent drawn and answer between 2.5 – 3.5 (m/s²) award 4 marks Tangent drawn at $t = 1.0 \text{ s}$ ✓ Triangle drawn on tangent OR <u>two</u> suitable points on tangent indicated OR Δx and Δy indicated ✓ Correct substitution of two data points into $\Delta y \div \Delta x$ ✓ Acceleration = $2.87 \text{ (m/s}^2\text{)}$ ✓	4	2.1 2.1 1.1 2.1	ALLOW any attempt at tangent at 1.0s which does not pass below the curve (judge by lack of gap) IGNORE size of triangle (assessed in Q 17) e.g., $\frac{8.0-2.4}{1.95-0} = 2.87$ DO NOT ALLOW one data point e.g., (1.0, 5.3) ALLOW max three marks for answer expressed as a fraction
	(c)	First check the answer on the answer line If answer between 12 and 14 (m) award 3 marks Areas on graph indicated OR distance = area under graph/curve ✓ Clear evidence of use of appropriate readings taken from graph to determine area using a suitable method✓ Distance between 12.0 and 14.0 (m) ✓	3	2.1 2.2 2.1	DO NOT ALLOW $2.5 \times 7 = 17.5$ or $7^2(-0^2) = 2as$ At least a minimum of three areas added Suitable methods include: counting squares (any size), dividing the area under the graph into triangles, rectangles or trapeziums

Question			Answer	Marks	AO element	Guidance
						For example, finding a 1cm x 1cm square as 0.25 m^2 or a 2 mm x 2mm square as 0.01m^2 and then multiplying this by the number of squares counted



20	(a)	(i)	Equal / 30N ✓ Opposite (direction) ✓	2	2 x 1.1	IGNORE backwards
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = $(-)0.6 \text{ (m/s}^2\text{)}$ award 3 marks $a = F / m$ ✓ 30 / 50 ✓ $0.6 \text{ (m/s}^2\text{)}$ ✓	3	1.2 2.1 2.1	Correct rearrangement of equation Correct substitution of numbers IGNORE sign ALLOW one mark for 0.75 (incorrect mass)
	(b)	(i)	Zero / 0 (kgm/s)	1	2.1	IGNORE units
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 80 (kg m / s) award 2 marks = 40×2 = 80 (kg m / s)	2	2 x 2.1	IGNORE sign
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = $(-)1.6$ award 3 marks Momentum before = momentum after ✓ $80 = 50 V_B$ ✓ 1.6 (m/s) ✓	3	1.2 2.1 2.1	ALLOW ECF from (b)(ii) but not from (b)(i) ALLOW $0 = (40 \times 2) + 50 V_B$ or $0 = 80 + 50 V_B$ ALLOW $V_B = -80/50$ IGNORE sign

20	(a)	First check the answer on the answer line If answer = 15 (m / s) award 3 marks Evidence for use of area under line / distance = area under (v-t) graph ✓ $30 = \frac{1}{2} \times u \times 4$ OR $u = 2 \times 30 \div 4$ ✓ (u =) 15 (m / s) ✓	3	3 × 2.2	ALLOW e.g. $5u \div 2$ OR $0.5 \times b \times h$ ALLOW evidence seen on graph ALLOW use of higher level answers using SUVAT equations of motion e.g. $s = (u + v)t \div 2$
	(b)	(i) First check the answer on the answer line If answer = 27 (m) award 3 marks Select and rearrange: (distance =) final velocity² – initial velocity² ÷ 2 × acceleration OR $(s =) v^2 - u^2 \div 2 \times a$ ✓ Substitution: $(s =) -18^2 \div -12$ OR $18^2 \div 12$ OR $324 \div 12$ ✓ (s =) 27 (m) ✓	3	1.2 2 × 2.1	ALLOW correct substitution into unrearranged equation for 1 mark e.g. $0 - 18^2 = 2 \times -6 \times s$ OR $18^2 - 0 = 2 \times 6 \times s$ ALLOW d for s ALLOW -27 (m) ALLOW other correct use of SUVAT equations of motion

Question	Answer	Marks	AO element	Guidance
	(ii) First check the answer on the answer line If answer = 2400 – 21 000 (N) award 3 marks Estimation of mass of car = 1500 (kg) ✓ (F =) 1500×6 ✓ (F =) 9000 (N) ✓	3	1.1 2 × 2.1	ALLOW 2 marks for force correctly calculated if mass is outside of range ALLOW 400 - 3500 (kg) ALLOW candidate's mass estimate × 6 for 1 mark ALLOW candidate's mass estimate × 6 correctly calculated for 2 marks
	(iii) Any two from: Skid mark may not have clear start or end ✓ Skid mark may be curved / difficult to measure ✓ (Idea that) car may not have produced a skid for whole of braking (distance) / AW ✓ (Idea that) skid mark only occurs when the wheels stop turning ✓	2	2 × 3.2a	ALLOW skid marks don't appear as soon as braking starts / deceleration is not always large enough to produce skids marks

21	(a)		Mistake 1: Unit for acceleration is missing ✓ Correction 1: Unit should be m/s/s or m/s² or ms⁻² ✓ Mistake 2: Acceleration at 3.0 N is only recorded to 1 significant figure ✓ Correction 2: Acceleration should be recorded to 2 significant figures /4.0 (m/s²) ✓	4		ALLOW sig. fig. for d.p. throughout ALLOW answers in any order 3.2a 3.3b ALLOW include units for acceleration 3.2a 3.3b ALLOW not recorded to 1 decimal place (like the others) ALLOW should be recorded to 1 d.p./same number of d.p.
	(b)	(i)	Point correctly plotted at (5.7 m/s ² , 4N) within ½ a small square ✓	1	2.2	
		(ii)	Force is (directly) proportional to acceleration ✓✓ OR Maximum of one mark from: Linear relationship (through the origin)✓ As force increases, acceleration increases / OR A ✓	2	2x3.1a	ALLOW (directly) proportional to each other / they are (directly) proportional ALLOW $y = mx + c$, $c = 0$ so $y = mx$ IGNORE positive correlation
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.7, 0.71 or 0.72 (kg) award 2 marks Change in y / change in x or $5(.0)/7(.0)$ ✓ (mass =) $0.7(0) / 0.71 / 0.72$ (kg) ✓	2		2.2 ALLOW eg 4.3/6.0, 4.0/5.6 etc. to within +/- ½ small square 2.2

Question	Answer	Marks	AO element	Guidance
				ALLOW other answers between 0.65 and 0.75 only if workings shown using correct values read from the graph to within +/- ½ small square ✓✓
	(iv) Any two from: Not all of the energy is transferred to the trolley / energy is transferred/lost to other stores It assumes all of the force on the trolley is equal to the weight added on the string ✓ Friction on the pulley / between the wheels and the surface ✓ Mass of the string/card is ignored ✓ The card on the trolley was not measured properly✓ The card on the trolley did not pass through the light gates vertically/at 90° ✓	2	2x3.2a	ALLOW energy is transferred/lost to the surroundings/due to friction/air resistance ✓ ALLOW table is not smooth / friction in the wheels

Question			Answer	Marks	AO element	Guidance
		(v)	Any two from: Compensate for/reduce friction, e.g. by raising the ramp / use a linear air-track / oil/grease pulley ✓ Repeat the experiment and calculate the mean ✓ Measure the acceleration between two points which are further apart ✓ Use different equipment (to check if it produces similar results) ✓ Use equipment with higher resolution/precision ✓ Use string/card with less mass/weight ✓	2	2x3.3b	ALLOW repeat to remove/identify anomalies ALLOW use lighter string/card / subtract mass of card/string (from measurements) ALLOW use a pulley with less mass to reduce energy wasted when turning pulley / AW
	(c)	(i)	Gravitational (potential energy store) to kinetic (energy store) ✓	1	2.1	ALLOW kinetic (energy store) to thermal (energy store) / gravitational (potential energy) to thermal (energy) ALLOW KE for kinetic energy / GPE for gravitational (potential) energy / heat for thermal IGNORE just potential energy / PE
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.6 (J) award 4 marks 86cm = 0.86 m ✓ (Work done =) $3(.0) \times 0.86$ ✓ (Work done =) 2.58 (J) ✓ (Work done =) 2.6 (J) ✓	4	1.2 2.1 2.1 1.2	ALLOW ecf for missing or incorrect unit conversion e.g. 260 (J) for 3 marks, 258 (J) for 2 marks



Question				Answer	Marks	AO element	Guidance
4				B ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
14			A ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
4				B ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
6				A ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
10				A ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
11				B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
15			A ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
1				D	1	1.1	



Question				Answer	Marks	AO element	Guidance
5				B	1	1.2	



Question				Answer	Marks	AO element	Guidance
7				B ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
5	B ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
7	B ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
12	C ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
14			C ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
4	D	1	1.1	



Question	Answer	Marks	AO element	Guidance
9	D	1	2.1	



Question	Answer	Marks	AO element	Guidance
13	C	1	2.1	ALLOW 0.060 (m)



Question	Answer	Marks	AO element	Guidance
4	D	1	2.2	



Question	Answer	Marks	AO element	Guidance
7	D	1	1.1	



Question	Answer	Marks	AO element	Guidance
11	A	1	2.1	



Question	Answer	Marks	AO element	Guidance
1	B	1	1.1	



3	C	1	2.1	A: 80÷10 B: 80÷1.6 C: 80×1.6 D: 80×10
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Question	Answer	Marks	AO element	Guidance
4	A	1	2.2	



Question	Answer	Marks	AO element	Guidance
12	B	1	1.2	



15	A	1	2.1	A: 210×0.4 B: 210×0.6 C: $(210 \times 0.4) \div 0.6$ D: vertically balanced forces
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19*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) A detailed description AND explanation of the behaviour of both springs, including correct calculation of spring constant or work done. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) A basic description and explanation of the behaviour of both springs including correct calculation of spring constant or work done OR A detailed description and explanation of the behaviour of both springs. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) A basic description or explanation of both springs OR A detailed description or explanation of one spring. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i>	6	1.1x1 2.2x1 3.1bx2 3.2bx2 AO1.1 Demonstrate knowledge of Hooke's Law to describe the springs For example: - spring A obeys Hooke's law until 5N / 0.20 m - spring B obeys Hooke's law until 4N / 0.32 m - up to the elastic limit both springs obey Hooke's law - after the elastic limit both springs are permanently deformed AO3.2b Analyse and draw conclusions from the graphs to describe the behaviour of both springs For example: - spring A has a higher spring constant - spring B has a lower spring constant - both springs have a linear section - both springs have a non-linear section - more work is done stretching spring A up to elastic limit - less work is done stretching spring B up to elastic limit - breaking force comparison AO3.1b Evaluate the graphs using data and calculations For example - spring A has a spring constant of 25N/m - spring B has a spring constant of 12.5 N/m - attempt at calculating the work done in stretching the springs, using $E = \frac{1}{2} k x^2$ or $E = \frac{1}{2} Fx$ in specific regions
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Question	Answer	Marks	AO element	Guidance
	0 marks No response or no response worthy of credit.			AO2.2 Apply understanding of the shape of the graphs to explain the behaviour of the springs For example - up to the elastic limit both springs exhibit elastic behaviour - after the elastic limit Hooke's law is not obeyed - up to the elastic limit the extension is reversible - after the elastic limit the extension is plastic - plastic deformation cannot be reversed - linear section demonstrates Hooke's law being obeyed

18	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 25 (N/m) award 3 marks Recall and rearrange: spring constant = force exerted by a spring ÷ extension ✓ = $5 \div 0.2$ ✓ = 25 (N/m) ✓	3	1.2 2.1 2.1	ALLOW any other correct pair of points from the graph – points to be read to $\pm \frac{1}{2}$ a small square Final answer between 24 and 26 (N/m) scores three marks
	(b)	Line curves and gradient decreases ✓ Point at the end of the linear section of the line labelled 'elastic limit' ✓	2	2x1.2	IGNORE poorly drawn curves/thick lines DO NOT ALLOW curve with negative gradient at any point
	(c)	A downwards arrow labelled weight/load ✓ An upwards arrow labelled tension ✓ <u>Two</u> equal length arrows (by eye), one vertically up and one vertically down ✓	3	3x2.2	DO NOT ALLOW labels pointing to apparatus ALLOW gravity/gravitational force DO NOT ALLOW mass ALLOW force from spring NOTE this mark may not be scored if more than two arrows are drawn



22	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1260 or 1300 (Nm) award 4 marks (Force = $70 \times 10 =$) 700 (N) ✓ (Moment =) force x distance ✓ (Moment =) 700×1.8 ✓ (Moment =) 1260 (Nm) ✓	4	ALLOW ecf for using mass not weight e.g. 3 marks for an answer of 126 (Nm), 2 marks for 70×1.8 ALLOW ecf for incorrect calculation of force ALLOW ecf for converting 1.8m to 180cm e.g. 3 marks for 126 000 (Nm) 2.1 1.2 2.1 2.1
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 8 (m/s) award 4 marks $u = 0$ or $v^2 = (u^2 +) 2as$ ✓ $v^2 = 2 \times 10 \times 3.2$ or $v = \sqrt{2 \times 10 \times 3.2}$ ✓ $v^2 = 64$ ✓ $v = 8$ (m/s) ✓ OR alternative method: $mgh = \frac{1}{2} mv^2$ ✓ $(70 \times) 10 \times 3.2 = \frac{1}{2} (x 70) \times v^2$ ✓ $64 = v^2$ ✓ $v = 8$ (m/s) ✓	4	1.2 2.1 2.1 2.1 $v^2 - u^2 = 2as$ does not score a mark

18	(a)	(i)	Incorrect <u>and</u> Force is not proportional to extension ✓	1	1.2	ALLOW line is not straight (through the origin) / not linear / gradient not constant / is a curve IGNORE faster / slower etc.
		(ii)	Incorrect <u>and</u> It returns to its original length / shape (when force is removed) ✓	1	1.2	ALLOW it returns to (an extension of) zero
		(iii)	Incorrect <u>and</u> Line is not straight (through the origin) / line does not have constant gradient / line is a curve ✓	1	1.2	ALLOW force is not proportional to extension IGNORE not linear IGNORE faster / slower etc.
	(b)		First check the answer on answer line If answer = 0.56 (J) award 2 marks ($W = \frac{1}{2} kx^2$) $W = \frac{1}{2} \times 28 \times 0.20^2$ ✓ $W = 0.56$ (J) ✓	2	2.1 2.1	IGNORE $28 \times 0.20 = 5.6$ and 1.12
	(c)		Correct resultant line drawn (connecting 0,0 and 6,4) ✓ Length of resultant line = 7.2 (cm) ✓ But Resultant force = 3.6 (N) ✓✓	3	3 x 1.2	Independent mark ALLOW ECF for resultant drawn from (0,4) to (6,0) ALLOW 7.0 – 7.4 (cm) IGNORE '–' sign ALLOW 3.5 – 3.7 (N) ALLOW ($\sqrt{2^2 + 3^2} =$) 3.6 for two marks

21	(a)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.6 (J) award 3 marks (Energy transferred in stretching =) $\frac{1}{2} \times 40 \times 0.2^2$ ✓ (Energy transferred in stretching =) 0.8 (J) ✓ (Total energy transferred in stretching =) $2 \times 0.8 = 1.6$ (J) ✓	3	1 × 1.2 2 × 2.1	
	(b)		Any two from: Not all of the elastic (potential) energy is converted into kinetic energy ✓ Some energy is converted to gravitational potential energy (store) ✓ Total energy (in a system) must be constant / mention of conservation of energy ✓	2	2 × 2.1	ALLOW Some energy converted to thermal energy store/surroundings for 1 mark. ALLOW Kinetic energy = elastic (potential) energy – gravitational potential energy for 2 marks
	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.8 (m) award 4 marks (Height =) potential energy ÷ (mass × gravitational field strength) OR EPE = GPE ✓ g = 10 N/kg ✓ (Height =) $2.4 / (0.05 \times 10)$ ✓ (Height =) 4.8 (m) ✓	4	2 × 1.2 2 × 2.1	ALLOW Use of 9.8 N/kg and 9.81 N/kg for g Use of 9.8 or 9.81 gives 4.9 (m) (to 2SF) ALLOW POT (power of ten) error for incorrect conversion of mass for 3 marks
	(d)		Ensure springs extended by the same length each time / use the same springs / same spring constant ✓	1	3.3a	ALLOW constant diameter of the ball IGNORE Use the same equipment.

17	(a)	(i)	2.2 ✓	1	1.2	ALLOW 2.17 IGNORE 2.16666666, $\frac{13}{6}$, 2.16, 2.17
		(ii)	Point correctly plotted (within $\frac{1}{2}$ a small square) ✓ Suitable straight line of best-fit drawn ✓	2	1.2 x2	ECF from part (a)(i) Line must cover 100 to 500 (or 200-500 if plot missing) DO NOT ALLOW thick (more than a square) or multiple lines
		(iii)	First check the answer on the answer line If answer = 45 - 48 (N / cm) award 2 marks Gradient = $\frac{\text{change in y-axis}}{\text{change in x-axis}}$ OR Suitable triangle drawn against line on graph OR Two values clearly indicated on the graph ✓ Gradient = 46 (N/cm) ✓	2	2.1 x2	ALLOW recognisable attempt at calculating a gradient (e.g., triangle drawn against line, values successfully taken from the graph) ✓ $\Delta\text{extension} \geq 4$ (cm) or two large squares ALLOW ECF for correctly calculated gradient from candidate's line
		(iv)	Same answer as candidate's answer to (a)(iii)	1	2.1	ALLOW correct conversion to N/m if unit (N/m) is written by candidate ALLOW rounding to a minimum of 2sf
	(b)		Any two from: The experiment has not been completed by someone else (who obtained similar values) ✓ The experiment has not been completed using different equipment (and obtained similar values) ✓ The experiment has not been completed using a different method (and obtained similar values) ✓	2	3.2a x2	IGNORE Not checked on its own

Question		Answer	Marks	AO element	Guidance
	(c)	Hazard: The springs could fly off / break / snap ✓ Precaution: Wear face/eye protection or complete the experiment behind a safety screen ✓ OR Hazard: Falling / heavy load ✓ Precaution: stand away from the experiment / protective shoes ✓	2	3.3a x2	Mark response as a whole IGNORE gets hurt unqualified ALLOW any reasonable injury e.g., spring flicks into eye. IGNORE "be careful with" / "protective equipment"

20	(a)	(i)	All three points correctly plotted ✓✓ OR two points correctly plotted ✓	2	2 x 2.2	Points should be + / - ½ square or less (by eye)
		(ii)	straight line up to 0.04, 8 and curved line consistent with points plotted past this point ✓	1	3.1a	ALLOW ecf from part ai for misplotted points ALLOW straight part of graph drawn without ruler. DO NOT ALLOW dot-to-dot for curve Single line should be thin (less than ½ square thick) and continuous to gain the mark.
		(iii)	Initially the extension increases steadily / linearly / uniformly / (directly) proportionally / elastically / AW ✓ (then the) wire reaches its elastic limit ✓ the extension increases plastically / by more for each (2N) weight added (past this point) / AW ✓	3	3.1a 1.2 3.1a	ALLOW gradient is steady up to 8N ALLOW initially obeys Hooke's law IGNORE limit of proportionality (as this is an AO3 answer for an AO1 question) ALLOW Hooke's law not obeyed after 8N
	(b)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 200 (N/m) award 3 marks $k = F \div x$ ✓ $k = 6 \div 0.03$ ✓ (or equivalent correct expression from 0 to 6N) $k = 200$ (N/m) ✓	3	1.2 2.1 2.1	IGNORE $F=kx$ Substitution into correctly rearranged formula ✓✓

Question	Answer	Marks	AO element	Guidance
(c)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.16 (J) award 2 marks $E = 0.5 \times 200 \times 0.04^2$ ✓ $E = 0.16$ (J) ✓	2	1.2 2.1	ALLOW ecf from part b ALLOW area under graph method: $0.5 \times 8 \times 0.04$ ✓ BUT area under graph method used to calculate 0.16 scores ✓✓

21	(a)	(i)	The effort force is further from the pivot ✓ The effort force has to move further ✓	2	1.1 x 2	
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 650 (N) award 4 marks Moment = force x (perpendicular) distance (from pivot) ✓ Clockwise moment = anticlockwise moment ✓ $0.2F = 100 \times 1.3$ or $F = 130 / 0.2$ ✓ $F = 650$ (N) ✓	4	1.2 1.2 2.1 2.1	ALLOW in any form e.g. 100×1.3 , 130 (N), $F \times 0.2$
	(b)	(i)	The force of the mug on the table ✓ The force of the table on the mug ✓	2	1.1 x 2	ALLOW gravity / force due to gravity / gravitational force ALLOW normal contact force
		(ii)	Upwards force arrow and downwards force arrow ✓ Arrows drawn of equal length ✓ Upwards force arrow labelled normal contact force and downwards force arrow labelled weight ✓ Arrows drawn of equal length ✓	3	1.1 2.1 1.1	DO NOT ALLOW more than two arrows ALLOW gravity / force due to gravity / gravitational force

22	(a)	(i)	Any one from: extensions / readings are close to the smallest measurement the ruler can make / AW ✓ rulers can only measure to the nearest mm ✓	1	3.3a	ALLOW extensions / readings are very small ✓ ALLOW difficult to measure extensions accurately with a ruler ✓
		(ii)	Use a larger mass / weight / force (to increase the extension) ✓	1	3.3b	ALLOW bigger for larger (BOD) ALLOW use springs with smaller <u>spring constants</u>
	(b)	(i)	Correct point identified / point at 4 springs ✓ Correct new point plotted at (4, 0.6) ✓	2	3.2a 1.2	
		(ii)	As number of springs increases, extension decreases ✓ or extension is inversely proportional to the number of springs ✓✓	2	2 x 3.1a	ALLOW As the number of springs doubles, the extension halves ✓✓
	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 50 award 5 marks Correct reading from the graph of 1.6 cm ✓ Correct conversion to 0.016 m ✓ Spring constant = force / extension ✓ 0.8 / 0.016 ✓ 50 (N / m) ✓	5	2.2 1.2 1.2 2.2 2.2	ALLOW ECF 0.012 m for reading 1.2 cm from graph Correct rearrangement of equation ECF 0.8 / 0.012 ALLOW 4 marks for 0.5 or 5 or any other power of ten error ALLOW ECF 4 marks for 67 ECF ALLOW 3 marks for 0.67 or 6.7 or any other power of ten error
	(d)		R and As it requires the least force or weight to compress it (by a metre) / lowest spring constant ✓	1	3.2b	No mark if S or T chosen ALLOW less stiff