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OCR GCSE PHYSICS A (J249): QUESTIONS BY TOPIC

Topic P2: Forces (F)

GCSE Physics A Foundation Tier (J249) · Topic P2

84 questions · 320 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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QUESTIONS

84 questions · 320 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC P2.1

MOTION

35 questions in this sub-topic · 113 marks · lowest tariff first



8 An object travelled 800 m in 40 seconds.

Use the equation: distance travelled (m) = speed (m/s) × time (s)

What is the speed of the object?

- A** 0.05 m/s
- B** 20 m/s
- C** 840 m/s
- D** 32 000 m/s

Your answer

[1]



11 Which is a scalar?

- A** Acceleration
- B** Displacement
- C** Force
- D** Speed

Your answer

[1]



4 Estimate the typical cruising speed of a jet airliner.

- A 25 m/s
- B 250 m/s
- C 2500 m/s
- D 25 000 m/s

Your answer

[1]



5 A student experiments with a model parachute and collects some results.

She drops the parachute from a height of 4 m three times and takes **three** results of the time taken.

The three results are:

3.25 s

3.00 s

3.08 s

What is the mean of the three results?

A 3.00 s

B 3.08 s

C 3.11 s

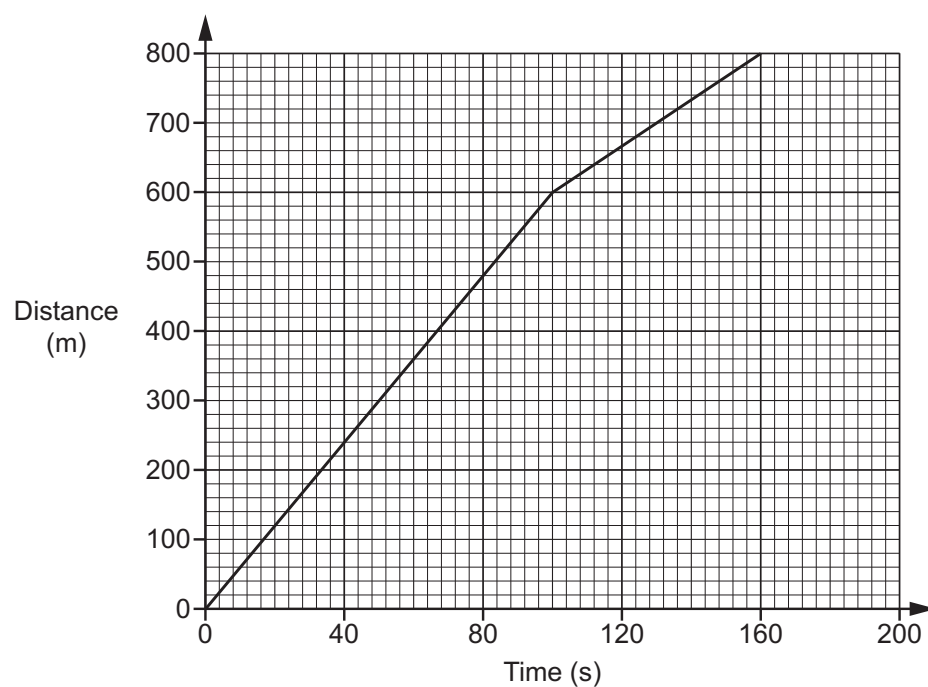
D 3.25 s

Your answer

[1]



8 Look at the distance-time graph for a journey to school.



What is the average speed for the journey?

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

- A 0.2m/s
- B 5.0m/s
- C 6.0m/s
- D 50m/s

Your answer

[1]

12 A car travels at 72 km/h.

How fast is this in metres per second (m/s)?

- A** 1.2 m/s
- B** 20 m/s
- C** 120 m/s
- D** 1200 m/s

Your answer

[1]



3 A cyclist travels 750 m in 50 seconds.

Calculate the speed of the cyclist.

Use the equation: $\text{speed} = \text{distance} / \text{time}$

A 0.015 m/s

B 15 m/s

C 37.5 m/s

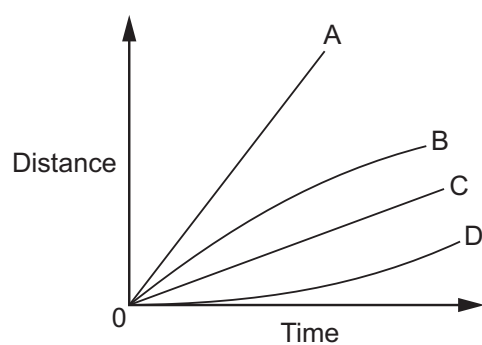
D 375 m/s

Your answer

[1]



8 Look at the distance-time graph.



Which line shows the largest average speed?

Your answer

[1]

- 9** A girl runs twice around a 400 m circular track.

What is the final displacement of the girl from her starting point?

- A** 0 m
- B** 200 m
- C** 400 m
- D** 800 m

Your answer

[1]



7 The speed of the wind is measured to be 5.555 m/s .

What is 5.555 m/s written to **2** significant figures?

- A 5.5 m/s
- B 5.55 m/s
- C 5.56 m/s
- D 5.6 m/s

Your answer

[1]



9 A car travels at a speed of 60 mph (miles per hour).

1 mph = 0.45 m/s.

Convert 60 mph into m/s (metres per second).

A 0.45 m/s

B 7.5 m/s

C 27 m/s

D 130 m/s

Your answer

[1]

4 Which row in the table correctly identifies a scalar and a vector?

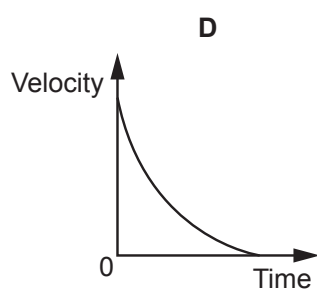
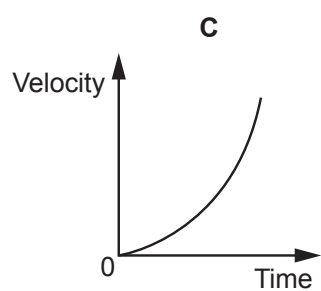
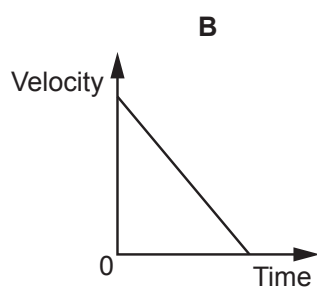
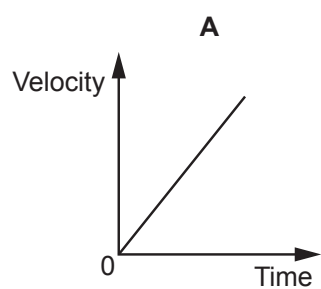
	Scalar	Vector
A	Displacement	Distance
B	Displacement	Velocity
C	Distance	Speed
D	Speed	Velocity

Your answer

[1]



9 Four velocity–time graphs are shown for a moving ball.



Which graph shows the ball being dropped from a height? Ignore the effects of air resistance.

Your answer

[1]

- 5** A bird flies at an average speed of 5.0 m/s for 240 s .

What is the distance travelled by the bird?

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

- A** 0.8 m
- B** 20 m
- C** 48 m
- D** 1200 m

Your answer

[1]

7 What is a good estimate for the speed of an Olympic sprinter?

- A 1 m/s
- B 3 m/s
- C 10 m/s
- D 30 m/s

Your answer

[1]

- 6 The time taken for four students to run a race is recorded.

Student	Time taken (s)
1	21.5
2	21.6
3	21.0
4	21.5

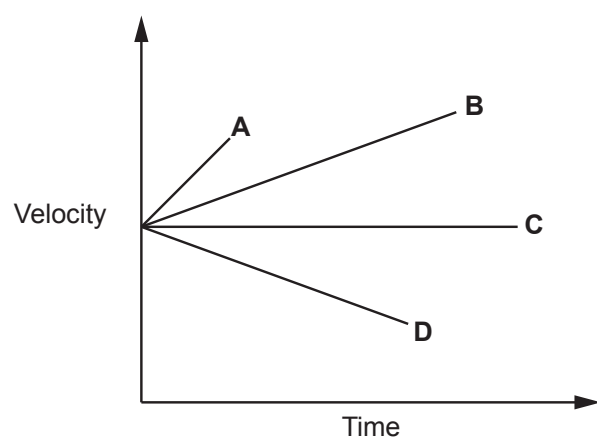
What is the mean time taken by the students?

- A** 16.0s
B 21.4s
C 21.5s
D 85.6s

Your answer

[1]

- 8 The velocity–time graph shows how the velocity of four different vehicles changes.



Which vehicle has the **greatest** acceleration?

Your answer

[1]

- 3 A teacher calculates the average speed of a student swimming the length of a pool.

The teacher measures:

- the distance of one length of the pool
- the time for the student to swim one length of the pool.

Which measuring instruments should the teacher use?

	Distance	Time
A	30 cm ruler	analogue clock
B	30 cm ruler	stopwatch
C	trundle wheel	analogue clock
D	trundle wheel	stopwatch

Your answer

[1]

10 A car travels at a constant speed. The car travels 32 km in 20 minutes.

How long does it take the car to travel 128 km?

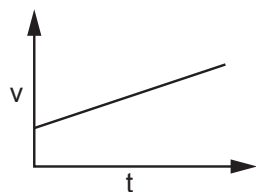
- A** 60 minutes
- B** 80 minutes
- C** 100 minutes
- D** 116 minutes

Your answer

[1]



13 A teacher draws a graph showing the relationship between time, t , and velocity, v .



What information does the gradient tell us?

- A** Acceleration
- B** Distance travelled
- C** Final velocity
- D** Start velocity

Your answer

[1]

- 14** A cyclist starts at an initial velocity of 0.0 m/s and accelerates at 1.4 m/s^2 for a distance of 20 m .

What is the **final velocity** of the cyclist?

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

- A** 5.3 m/s
- B** 7.5 m/s
- C** 28 m/s
- D** 56 m/s

Your answer

[1]

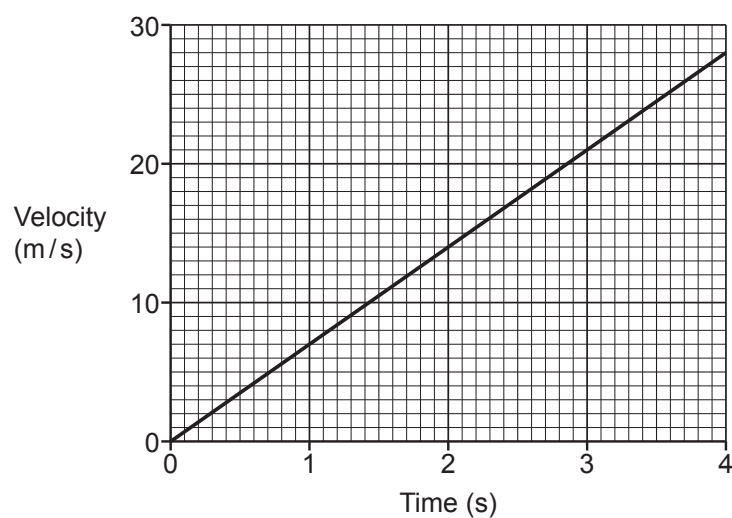
- 6** Which statement about some typical values of speed is correct?
- A** The speed of a car is greater than the speed of a jet plane flying.
 - B** The speed of a car is greater than the speed of sound in air.
 - C** The speed of a runner is greater than the speed of a jet plane flying.
 - D** The speed of sound in air is greater than the speed of the wind.

Your answer

[1]



10 A teacher draws a velocity–time graph for a moving object.



What is the **acceleration** of the object?

Use the equation: $\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$

- A 7.0 m/s²
- B 7.5 m/s²
- C 56 m/s²
- D 112 m/s²

Your answer

[1]

- 10 The table shows the speed of a person walking and the speed of an aeroplane flying.

Object	Speed (m/s)
Aeroplane	150
Person	1.5

What is the ratio of aeroplane's speed : person's speed?

- A 1 : 10
- B 1 : 100
- C 10 : 1
- D 100 : 1

Your answer

[1]

13 A league is an old unit of distance.

One league is approximately equal to 4800 m.

What is 4 leagues in metres?

A $1.92 \times 10^2 \text{ m}$

B $1.92 \times 10^3 \text{ m}$

C $1.92 \times 10^4 \text{ m}$

D $1.92 \times 10^5 \text{ m}$

Your answer

[1]



23 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

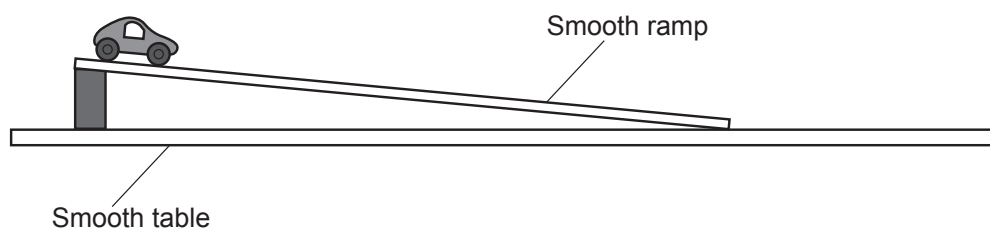
Improvement

.....

[2]

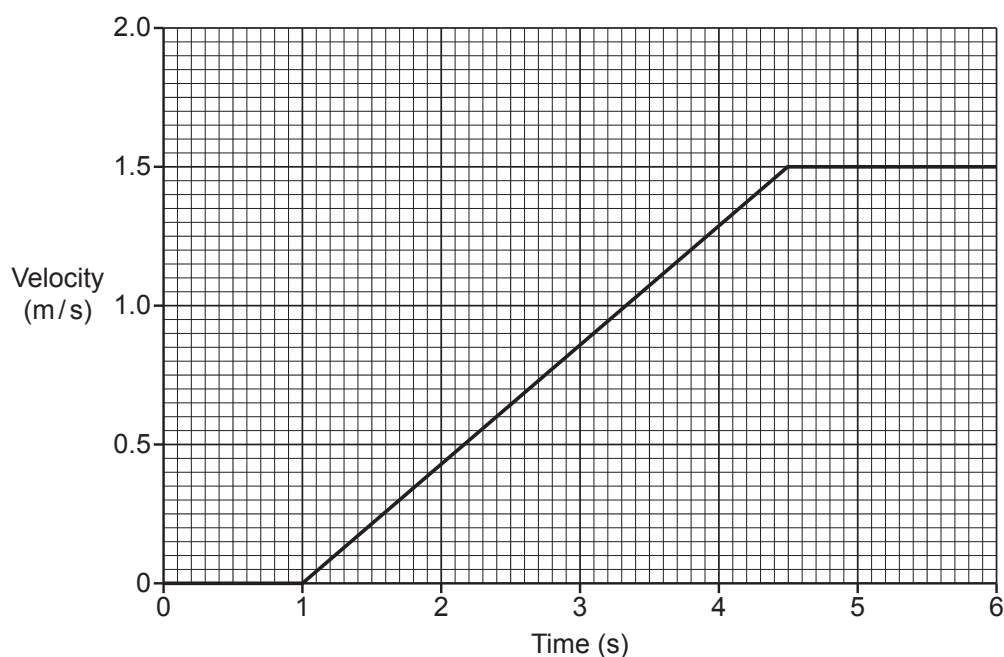


- 16 The diagram shows a toy car rolling down a smooth ramp onto a smooth table where it travels at a constant velocity.



- (a) (i) Suggest the equipment the student uses to measure the **distance travelled** by the car on the ramp.
..... [1]
- (ii) Suggest the equipment the student uses to measure the **time** it takes the car to roll down the ramp.
..... [1]

(b) This is the velocity–time graph for the car.



(i) State the time the car starts to move.

..... [1]

(ii) State the time the car reaches the bottom of the ramp.

..... [1]

(iii) Describe how the acceleration of the car will change if the ramp is made steeper.

..... [1]

(iv) Draw a line on the graph to show the acceleration of the car if the ramp is made steeper.

[1]

(c) Velocity and speed are different quantities.

Complete the sentence about velocity. Use words from the list.

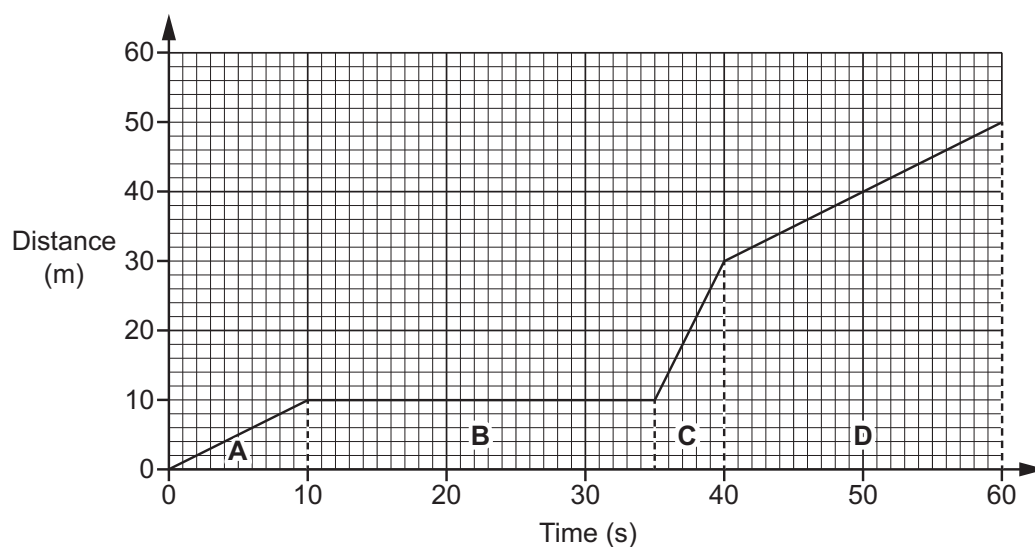
acceleration	direction	energy	force	magnitude
--------------	-----------	--------	-------	-----------

Velocity is a vector quantity because it has and [2]



16 A student investigates motion graphs.

(a) Look at a distance-time graph for the movement of a dog in a park.



(i) How far did the dog move in the park?

Distance = ... m [1]

(ii) How long was the dog in the park?

Time = ... s [1]

(iii) Name a piece of apparatus the student could use to accurately measure the distance the dog moved.

..... [1]

(b) The distance-time graph has four sections: **A**, **B**, **C** and **D**.

(i) Which section of the graph shows the **greatest** speed?

Tick (✓) **one** box.

A	☐
B	☐
C	☐
D	☐

Explain your answer.

.....

.....

..... [2]

(ii) Which section of the graph shows **zero** speed?

Tick (✓) **one** box.

A	☐
B	☐
C	☐
D	☐

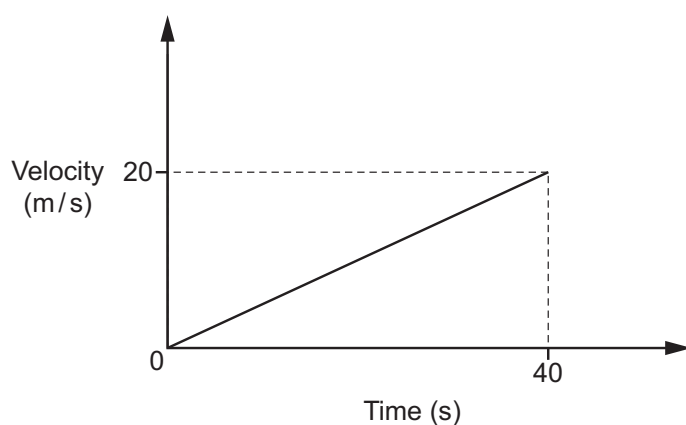
Explain your answer.

.....

.....

..... [2]

(c) The student draws a velocity-time graph for a boat accelerating.



Acceleration is the gradient of a velocity-time graph.

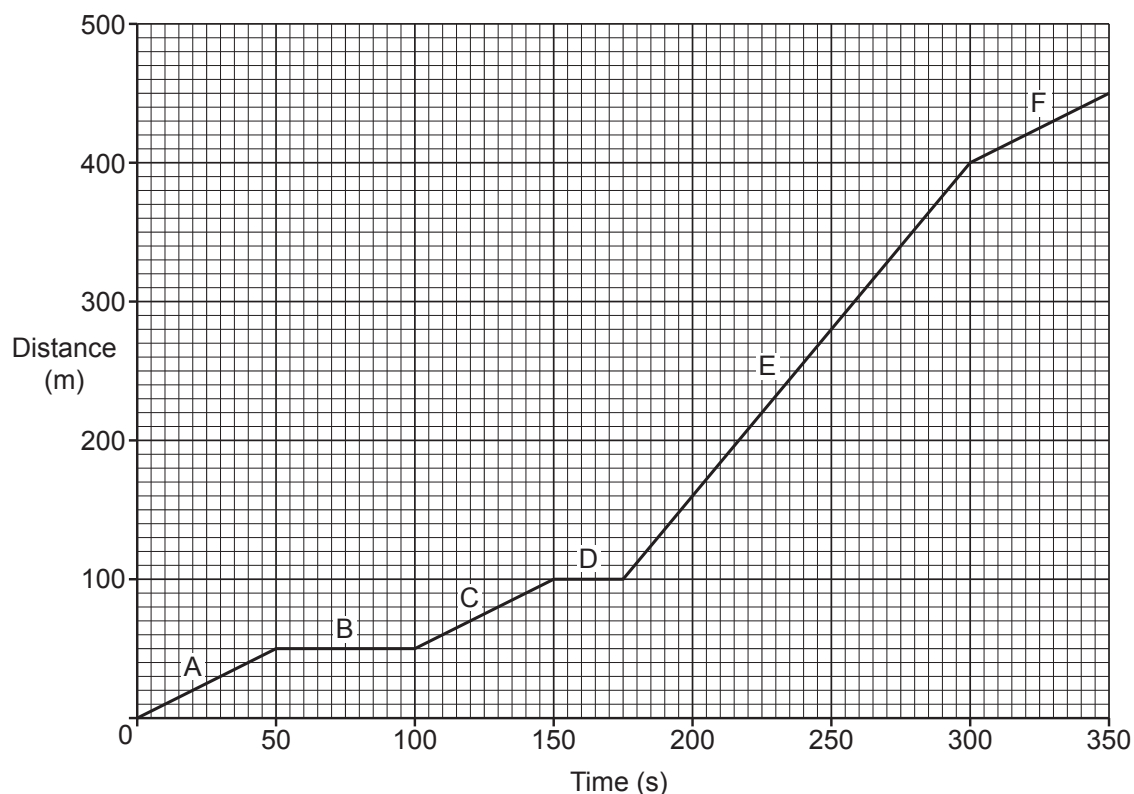
Calculate the acceleration of the boat.

Use the equation: $\text{acceleration} = \text{change in velocity} \div \text{time}$

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



23 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

.....

23



(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

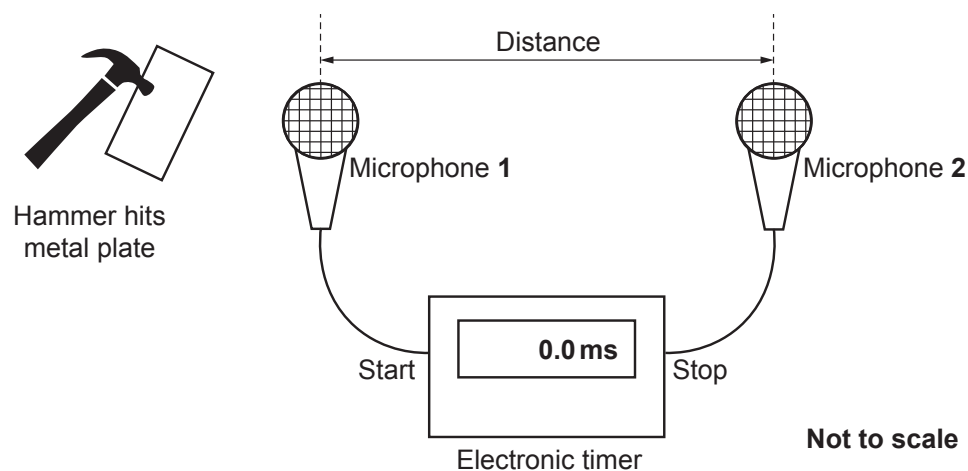
Distance

..... [1]



21 A student measures the speed of sound.

They use this equipment:



This is the student's method:

- A sound is created when the hammer hits the metal plate.
- When the sound reaches microphone 1, the electronic timer starts.
- When the sound reaches microphone 2, the electronic timer stops.
- This process is repeated several times.

(a) They record the time displayed on the timer in a table:

Measurement	Time (ms)
1	6.7
2	6.3
3	6.7
4	6.6

Calculate the mean time.

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

Mean time = ... ms [2]



(b) They do **not** place the hammer and plate **between** the two microphones.

Suggest **one** reason why.

.....
 [1]

(c) Another student repeats the same experiment.

These are the student's measurements:

- The distance between the microphones is 2.4 m.
- The mean time measured is 7.5 ms.

(i) Calculate the speed of sound.

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

Speed of sound = ... m/s [4]

(ii) Describe how the student can measure the distance between the microphones.

.....
 [1]

(iii) The student looks up the speed of sound on a reliable website. They find the value for the speed of sound is 330 m/s.

Suggest why this is different from your value calculated in **21(c)(i)**.

.....
 [1]



23 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.

.....

.....

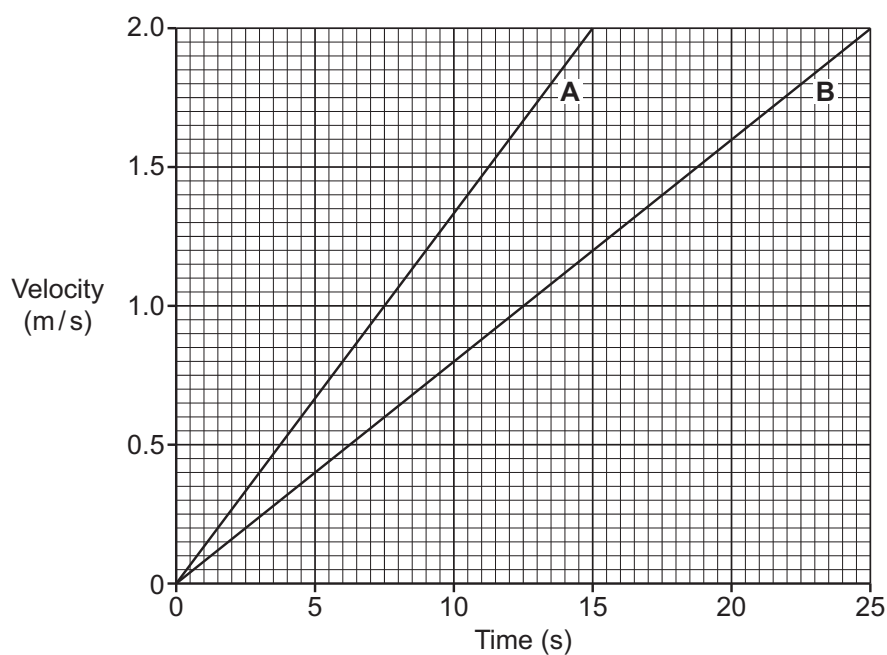
.....

.....

.....

..... [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.

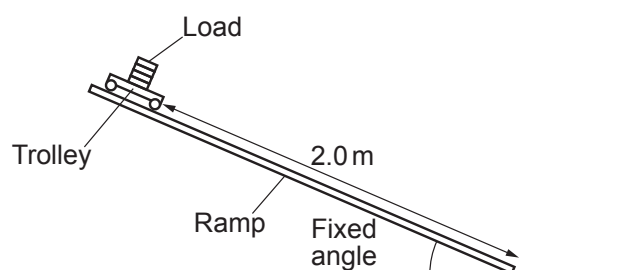
Suggest why it takes different amounts of time for them to reach their top speeds.

..... [1]



- 21** A student investigates the average speed at which a trolley with different loads travels down a ramp.

Look at the diagram of her experiment.



She releases the trolley from a distance of 2.0 m from the bottom of the ramp.

The student uses a stop-clock to measure the time it takes to reach the bottom of the ramp.

She calculates the average speed. Look at her results.

Load (N)	Time taken (s)	Average speed (m/s)
20	2.3	0.87
40	2.4	0.83
60	2.3	0.87
80	2.4	0.83

- (a)*** Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment.

.....

.....

.....

.....

.....

.....

(b) For one experiment the trolley starts from rest and reaches a final speed of 2 m/s.

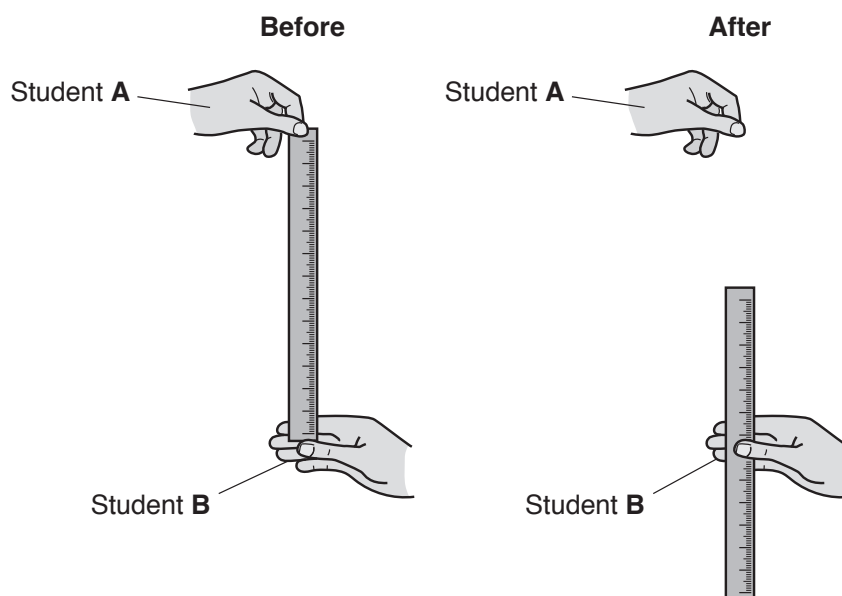
The ramp length is 2.0 m.

Calculate the acceleration of the trolley.

Acceleration = ... m/s² [4]



19 (a) The diagram shows a ruler being used to estimate a student's reaction time.



(i) Describe how the ruler can be used to estimate student **B**'s reaction time.

.....

.....

.....

..... [2]

(ii) Why do the students repeat the experiment several times?

.....

..... [1]

(iii) Student **B** is very tired when they try this experiment.

Suggest how this might affect student **B**'s reaction time.

.....

..... [1]

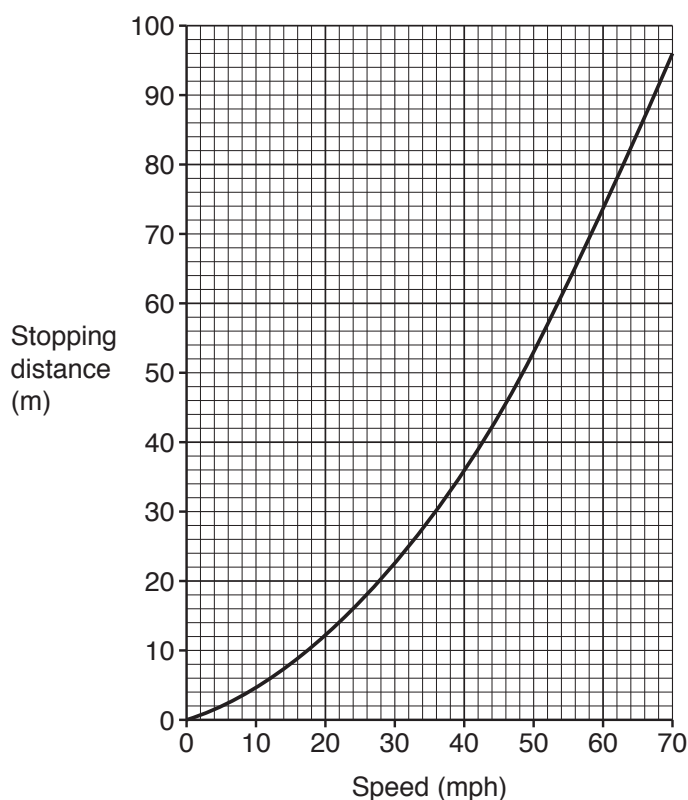
(b) The driver of a car makes an emergency stop.

The thinking distance is 9 m. The braking distance is 14 m.

(i) Calculate the total stopping distance of the car.

Stopping distance = ... m [1]

(ii) This graph shows how this driver's stopping distance changes with speed.



- A car is travelling at 50 mph.
- There is a barrier in the road 40 m in front of the car.
- The driver makes an emergency stop.

Use the graph to work out if the car hits the barrier.

Explain how you obtained your answer.

.....

.....

.....

..... [2]

- (iii) State one factor, other than speed, that affects braking distance.

Explain how this factor changes braking distance.

Factor

Explanation

.....

.....

[3]

- (c) (i) A car travels at a speed of 13 m/s. The car takes 4 s to stop after the brakes are applied.

Calculate the deceleration of the car.

Use the equation: acceleration = change in velocity ÷ time

Deceleration = ... m/s² [2]

- (ii) The braking system of the car in (c)(i) is changed. The same car travelling at 13 m/s now takes 0.4 s to stop after the brakes are applied.

The driver says, 'The new braking system is ten times safer.'

Do you agree with the driver? Explain your answer.

Yes ☐

No ☐

.....

.....

.....

..... [2]

- (iii) Suggest **one** safety feature in a car that can reduce injury in a crash.

..... [1]



SUB-TOPIC P2.2

NEWTON'S LAWS

25 questions in this sub-topic · 99 marks · lowest tariff first



1 What is the gravitational field strength at the Earth's surface?

- A 10 N/kg
- B 16 N/kg
- C 50 N/kg
- D 230 N/kg

Your answer

[1]



9 Which of the following is Newton's Third Law?

- A** For every action there is an equal and opposite reaction.
- B** What goes up must come down.
- C** The acceleration that a resultant force produces depends on the size of the force and mass of the object.
- D** An object will continue to stay at rest or move with uniform speed unless a force acts on it.

Your answer

[1]



10 On Mars the gravitational field strength is 4.0 N/kg .

How much would a 60 kg person weigh on Mars?

Use the equation: $\text{weight} = \text{mass} \times \text{gravitational field strength}$

A 15 N

B 64 N

C 240 N

D 600 N

Your answer

[1]

11 The acceleration of a car is 2 m/s^2 . The mass of the car is 1000 kg .

Calculate the resultant force on the car.

- A** 20 N
- B** 200 N
- C** 2000 N
- D** 20 000 N

Your answer

[1]



2 A skydiver falls from a plane.



What is the name of the **downward** force in the diagram?

- A Drag
- B Electrostatic
- C Mass
- D Weight

Your answer

[1]

- 6** On the Moon the gravitational field strength is 1.6 N/kg .

Calculate the gravity force for an 80 kg astronaut.

Use the equation: gravity force = mass $\times$ gravitational field strength

- A** 50 N
- B** 128 N
- C** 800 N
- D** 1280 N

Your answer

[1]



11 Four cars of the same mass are shown here.

A



B



C



D



Which car will accelerate?

Your answer

[1]

3 A student does an experiment to measure the acceleration in free fall of an object.

Which of their results is closest to the accepted value?

A 8.8m/s^2

B 9.8m/s^2

C 10.8m/s^2

D 11.8m/s^2

Your answer

[1]

8 Which force is **not** a contact force?

- A** Air resistance
- B** Friction
- C** Gravitational
- D** Tension

Your answer

[1]

2 Which is a **contact** force?

- A Electrostatic
- B Gravity
- C Magnetism
- D Upthrust

Your answer

[1]



3 All objects have a gravitational field that causes attraction.

Which property affects the gravitational field strength of an object?

- A** Charge
- B** Mass
- C** Specific heat capacity
- D** Temperature

Your answer

[1]



2 Which force is a **non-contact** force?

- A Drag
- B Friction
- C Magnetic
- D Tension

Your answer

[1]



- 4 Which statement describes the gravitational field between two planets?
- A It can be attractive or repulsive and depends on the mass of the planets.
 - B It can be attractive or repulsive and does not depend on the mass of the planets.
 - C It is always attractive and depends on the mass of the planets.
 - D It is always attractive and does not depend on the mass of the planets.

Your answer

[1]



- 5 A student draws a free body force diagram of an object falling through water.



What is the correct label for the **downwards** force?

- A Air resistance
- B Upthrust
- C Water resistance
- D Weight

Your answer

[1]

12 Four objects **A**, **B**, **C** and **D** are accelerating.

Which object has the greatest resultant **force**?

Use the equation: $\text{force} = \text{mass} \times \text{acceleration}$

	Mass (kg)	Acceleration (m/s^2)
A	5	2
B	5	4
C	10	0.5
D	20	0.25

Your answer

[1]

12 Which value is a typical acceleration of a family car?

- A** 2.5 m/s^2
- B** 25 m/s^2
- C** 250 m/s^2
- D** 2500 m/s^2

Your answer

[1]



22 This question is about force, mass and acceleration.

(a) A car starts from rest and accelerates at 3 m/s^2 .

Use the equation: $\text{Acceleration} = \text{Change in velocity} \div \text{Time taken}$

Calculate the **velocity** of the car after 4 s.

Answer = ... m/s [2]

(b) A roller coaster car moves down a slope with an acceleration of 5 m/s^2 .

The force on the roller coaster car is 4000 N.

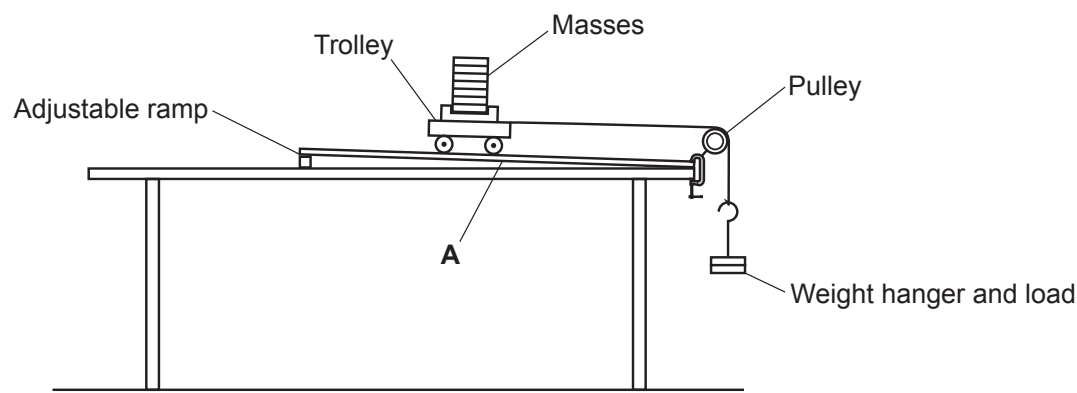
Calculate the **mass** of the roller coaster car.

Answer = ... kg [3]



22* A student does an experiment to investigate how the resultant force on an object affects the acceleration of the object (Newton's second law).

The diagram shows some of the equipment the student uses.



This is their method:

- Release the trolley from position **A** on the ramp.
- Measure the acceleration using light gates and a data logger (**not** shown in the diagram).
- Repeat for three different loads by moving masses from the trolley to the weight hanger.

These are their results:

Load (N)	Acceleration (m/s^2)
2	1.5
4	3.12
8	6

21 The diagram shows a swimmer in a pool.



(a) Their forward force is 50 N and the resistive force is 50 N.

(i) Describe the motion of the swimmer.

..... [1]

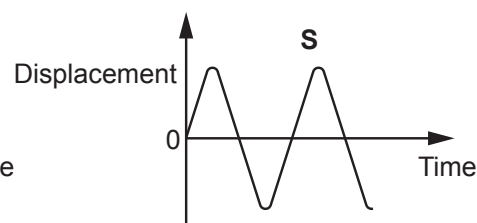
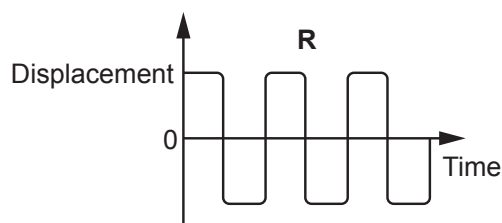
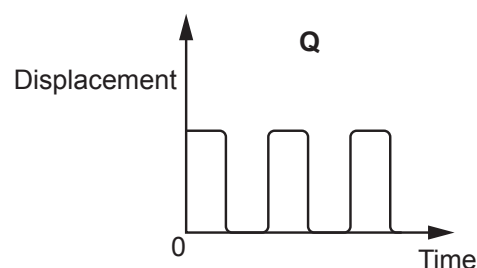
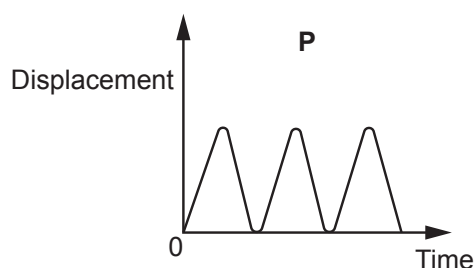
(ii) Explain what happens to the swimmer if their forward force increases but the resistive force remains constant.

.....

 [2]

(b) The swimmer swims from one end of the pool to the other end at a constant speed. They then turn round and swim back at the same constant speed.

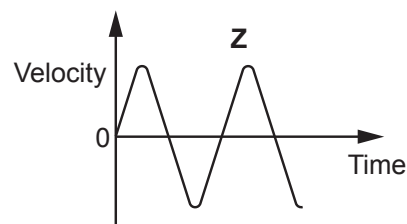
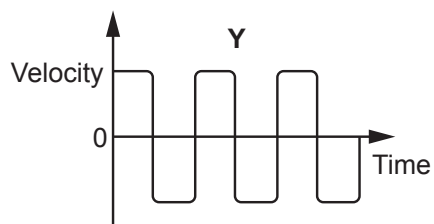
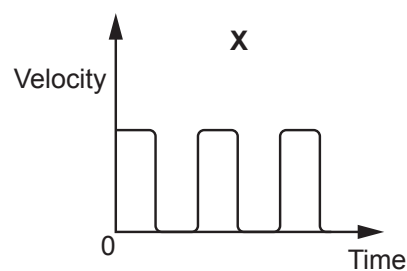
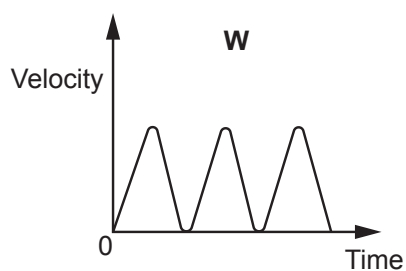
(i) Here are 4 displacement–time graphs, **P**, **Q**, **R** and **S**.



Which displacement–time graph shows the swimmer swimming to the end of the pool and back several times?

..... [1]

(ii) Here are 4 velocity–time graphs, **W**, **X**, **Y** and **Z**.



Which velocity–time graph shows them swimming to the end of the pool and back several times?

..... [1]

(c) The swimmer has a mass of 75 kg. Calculate their weight.

Use the equation: gravitational force = mass $\times$ gravitational field strength

Weight = ... N [3]



21 Different planets have different gravitational field strengths at their surface.

Planet	Gravitational field strength (N/kg)
Earth	10
Mars	3.7
Venus	8.8

(a) (i) On which planet's surface would an astronaut have the greatest weight?

Surface

Explanation

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

(ii) Which property of a planet affects its gravitational field strength?

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

(b) (i) On Earth the astronaut has a weight of 600 N. Their feet have a total area of 0.3 m^2 in contact with the ground.

Calculate the pressure they exert on the ground.

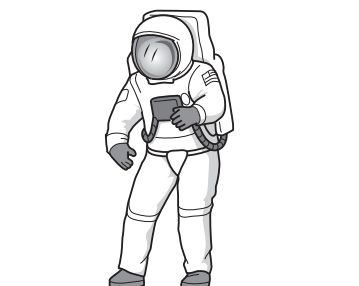
Pressure = ... N/m^2 **[3]**



(ii) The astronaut is standing on the ground. Two forces acting on them are:

- The force exerted by the Earth (their weight).
- The force exerted by the ground (normal contact force).

Draw and label a free body force diagram for the astronaut.



[3]

20 This question is about the acceleration and deceleration of cars.

(a) A student wants to estimate a typical value for the accelerating force on a car.

The student writes down **three** possible values for the car's acceleration.

$$3 \text{ m/s}^2$$

$$50 \text{ m/s}^2$$

$$100 \text{ m/s}^2$$

(i) Put a ring around the value the student should use as the car's acceleration. [1]

(ii) The car has a mass of 1800 kg.

Use the value for the acceleration you chose in **(a)(i)** to estimate the accelerating force on a car.

Use the equation: force = mass × acceleration

Force = ... N [2]

(b) In a crash, the change in velocity of a car is 18 m/s.

The time for the crash is 0.15 s.

Calculate the deceleration of the car.

Use the equation: acceleration = $\frac{\text{change in velocity}}{\text{time}}$

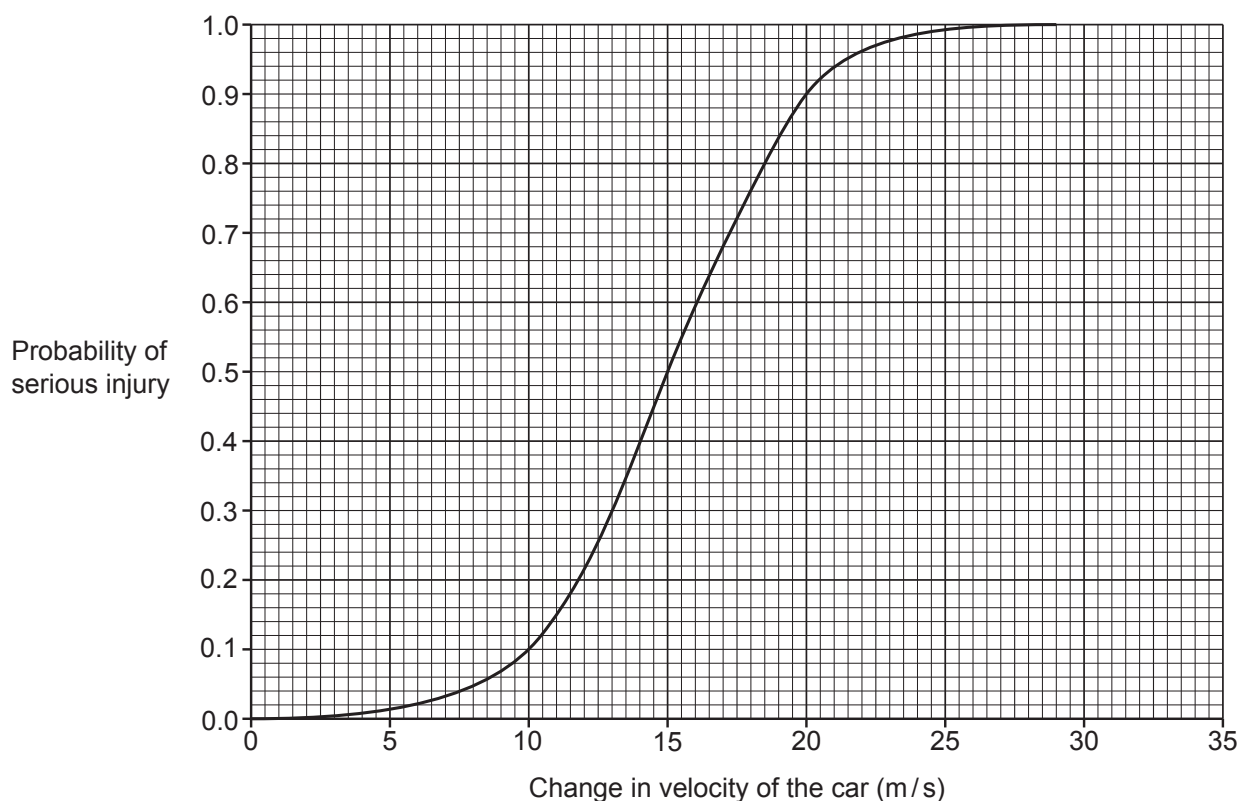
Deceleration = ... m/s² [2]



(c) In America, many cars have a 'black box' fitted.

The 'black box' records the change in velocity of the car if it crashes and comes to a stop.

The graph shows how the probability of serious injury to passengers in the car varies with the change in velocity of the car.



(i) Describe how the probability of serious injury changes as the change in velocity of the car increases from 10 m/s to 20 m/s.

Use values from the graph.

.....

.....

.....

.....

..... [3]

(ii) Use the graph to estimate the minimum change in velocity which **definitely** causes serious injury.

Change in velocity = ... m/s [1]

19 A toy car travels around a race track. After one lap it is back at the start position.

(a) Explain why the velocity of the toy car is different from its speed as it travels around the track.

.....

 [2]

(b) The mass of the toy car is 5 kg and it has an acceleration of 4 m/s^2 .

(i) Calculate the force needed to accelerate the toy car.

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

Force = ... N [2]

(ii) Suggest why the **actual** force needed would be more than in part **(b)(i)**.

..... [1]

(c) (i) Another toy car requires a constant force of 30 N to move it along a surface.

Calculate the work done on the car when it moves a distance of 50 m.

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

Work done = ... J [2]

(ii) Calculate the power output of this toy car if the work is done over 75 seconds.

Use your answer from **(c)(i)**.

Power = ... W [3]



- 22 (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]

20 (a) Objects can interact in many ways. Pairs of forces arise when objects interact.

Write down **one** type of force involved when objects interact.

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

(b) A book rests on a table.

Draw a free body force diagram to show the forces acting on the book.

Use arrows to represent the forces.

[4]

(c) A teacher uses an air-track for motion experiments. Using the air-track means that there is no friction between the glider and the air-track.

The teacher places the glider on the horizontal air-track and gives it a small push to start it moving.

Explain the motion of the glider.

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

(d) A presenter on a car TV programme says:

“The car maker has reduced the mass of this car and it now has better acceleration.”

(i) Explain why the presenter is correct.

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

(ii) A car accelerates from 5 m/s to 25 m/s in 4 seconds.

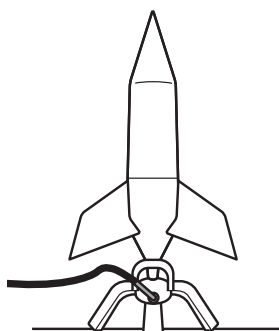
Calculate the acceleration of the car.

Use the equation: Acceleration = Change in speed $\div$ Time taken

Answer = ... m/s² [3]



19 The diagram shows a water rocket on the ground.



(a)

(i) The rocket is stationary on the ground.

What are the names of the upwards force and the downwards force on the rocket?

Use words from the list.

normal contact force

tension

thrust

weight

Upwards force:

Downwards force:

[2]

(ii) The rocket lifts off the ground when water is pushed out of the bottom of the rocket.

Explain how Newton's third law applies to the rocket as it lifts off the ground.

Use ideas about the force of the water and the force of the rocket.

.....

 [2]

(iii) Describe the conditions needed for the rocket to accelerate upwards.

Use ideas about the upwards force and the downwards force.

.....
 [1]

(b)

(i) The rocket has a mass of 5.0 kg and rises a vertical distance of 45 m.

Calculate the gravitational potential energy gained by the rocket.

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

Gravitational field strength = 10 N/kg

Gravitational potential energy = ... J [2]

(ii) A different water rocket does 12 500 J of work in 5 seconds when it rises upwards.

Calculate the power of this water rocket.

Use the equation: power = $\frac{\text{work done}}{\text{time}}$

Include the correct unit.

Power = ... Unit [3]

(c) A student writes a summary about gravitational fields.

The student has made **two** mistakes in their summary.Gravitational Fields

All matter has a gravitational field.

Gravitational fields cause repulsion.

More massive objects have a smaller gravitational field strength.

Identify the **two** mistakes and write down the correct word for each mistake.

Mistake 1:

Correct word 1:

Mistake 2:

Correct word 2:

[4]



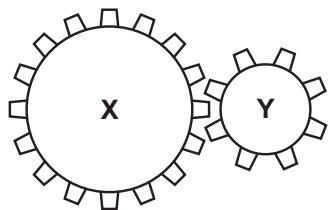
SUB-TOPIC P2.3

FORCES IN ACTION

24 questions in this sub-topic · 108 marks · lowest tariff first



- 3 Cog **X** has 16 teeth and cog **Y** has 8 teeth.



Cog **X** is turned around **two** times.

How many times does cog **Y** turn around?

- A 1
- B 2
- C 4
- D 8

Your answer

[1]

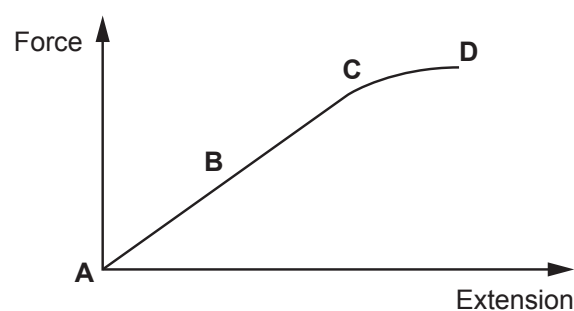
4 What is the **smallest** number of forces needed to bend an object?

- A 1
- B 2
- C 3
- D 4

Your answer

[1]

- 5 The diagram shows the relationship between force and extension for a spring.



Which letter on the graph shows the **elastic limit** of the spring being stretched?

Your answer

[1]

10 In which situation does the force cause a rotation?

- A** Bouncing on a trampoline
- B** Hitting a nail with a hammer
- C** Pushing a friend on a swing
- D** Sitting on a chair

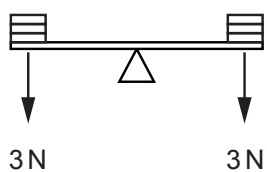
Your answer

[1]

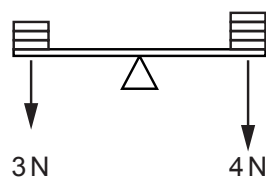


2 A student puts different weights on four balances.

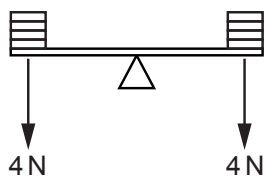
A



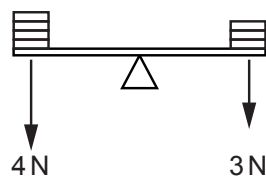
B



C



D



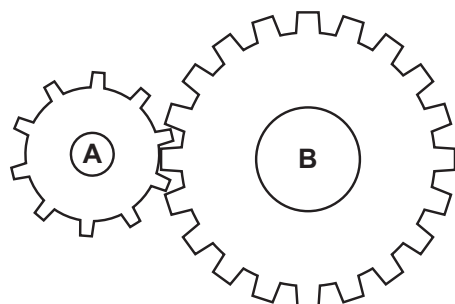
Which balance will give a **clockwise** moment?

Your answer

[1]

11 A student sets up two cogs.

Cog **A** has 10 teeth and cog **B** has 20 teeth.



Cog **A** is turned **2** times.

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

- A** 0.5 times
- B** 1 time
- C** 2 times
- D** 20 times

Your answer

[1]

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

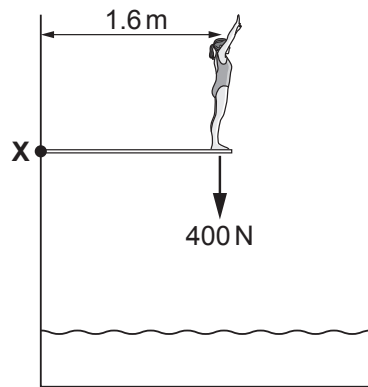
- A** Lowering a book vertically from a shelf
- B** Opening a door
- C** Lifting a book vertically onto a shelf
- D** Sitting in the centre of a see-saw

Your answer

[1]



10 A girl, of weight 400 N, is standing on the end of a horizontal diving board.



Calculate the moment of the girl's weight about point X.

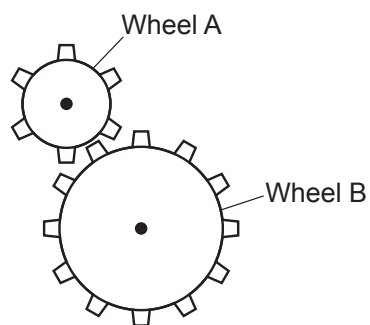
Use the equation: moment of a force = force $\times$ distance

- A** 250 Nm anti-clockwise
- B** 250 Nm clockwise
- C** 640 Nm anti-clockwise
- D** 640 Nm clockwise

Your answer

[1]

11 Gears can be used to transmit forces.



Wheel A is turned clockwise.

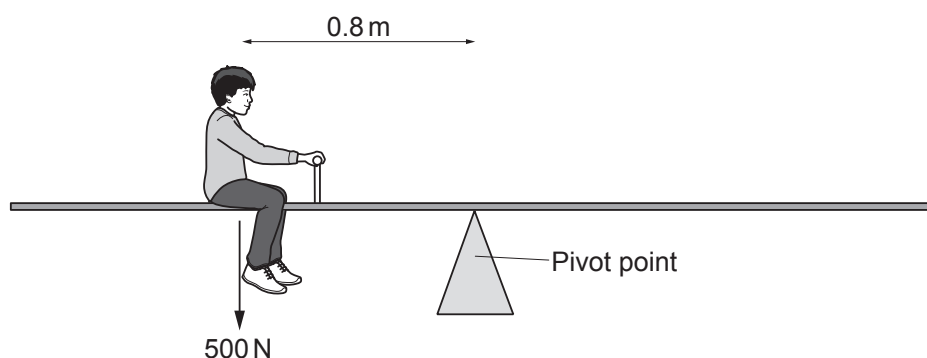
Which statement explains how these gears transmit forces?

- A Wheel B has a bigger rotational effect and turns more quickly than wheel A.
- B Wheel B has a bigger rotational effect and turns more slowly than wheel A.
- C Wheel B has a smaller rotational effect and turns more quickly than wheel A.
- D Wheel B has a smaller rotational effect and turns more slowly than wheel A.

Your answer

[1]

- 12 A student with a weight of 500 N sits on the left-hand side of a see-saw, 0.8 m from the pivot point. Another student then sits on the right-hand side of the pivot point.



Which student will balance the see-saw when they sit on the right-hand side of the pivot point?

Use the equation: moment of a force = force $\times$ distance (normal to direction of the force)

	Moment of the student's weight (N)
A	40
B	62.5
C	400
D	625

Your answer

[1]

13 A student investigates the gears on their bicycle.

The larger cog has 60 teeth and the smaller cog has 20 teeth.

If the larger cog rotates once, how many times does the smaller cog rotate?

- A** 1
- B** 3
- C** 40
- D** 80

Your answer

[1]

9 A spring is stretched by a load but does **not** return to its original length when the load is removed.

Which statement correctly describes the spring?

- A** The force-extension graph for the spring is linear.
- B** The spring has plastic deformation.
- C** The spring is elastic.
- D** The spring obeys Hooke's Law.

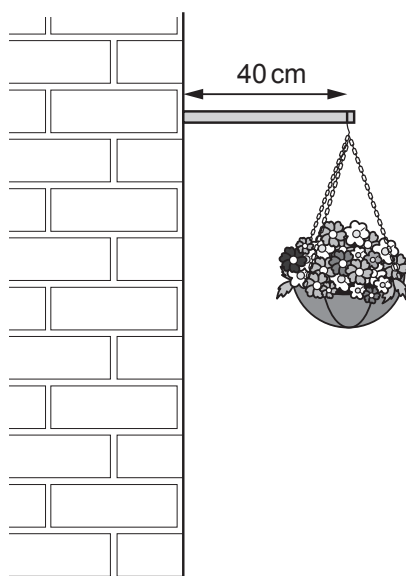
Your answer

[1]



11 A basket of flowers hangs at the end of a horizontal pole attached to a vertical wall.

The basket weighs 8 N and hangs from a point on the pole 40 cm away from the wall.



What is the moment of the basket about the point where the pole is attached to the wall?

Use the equation: moment of a force = force $\times$ distance

- A** 3.2 N m anti-clockwise
- B** 3.2 N m clockwise
- C** 320 N m anti-clockwise
- D** 320 N m clockwise

Your answer

[1]

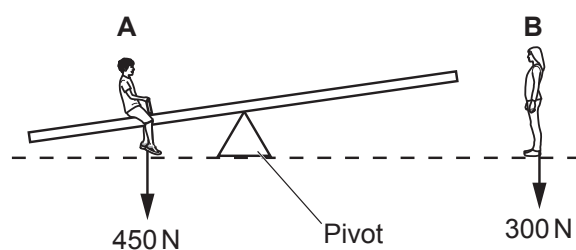
3 Which row shows the minimum number of forces needed to stretch an object and the minimum number of forces needed to bend an object?

	Minimum number of forces needed to stretch an object	Minimum number of forces needed to bend an object
A	1	1
B	1	2
C	2	1
D	2	2

Your answer

[1]

13 Two children want to play on a seesaw.



Child **A** sits 3.0 m from the pivot.

What distance from the pivot will child **B** need to sit to balance the seesaw?

Use the equation: moment of a force = force $\times$ distance (normal to direction of the force)

A 1.5 m

B 2.0 m

C 3.0 m

D 4.5 m

Your answer

[1]

18 A student has a spring, a ruler and a 2.0 N weight.

- (a) Describe how the student can use this equipment to determine the **spring constant** of the spring.

.....

.....

.....

.....

.....

..... [3]

- (b) The 2.0 N weight has a surface area of 0.005 m^2 .

Calculate the **pressure** when it is placed on a surface.

Use the equation: pressure = force normal to a surface $\div$ area of that surface

Pressure = ... Pa [2]

- (c) Describe how to change the shape of an object.

Use the idea of forces in your answer.

.....

.....

.....

..... [2]

- (d) Describe the differences between elastic and plastic deformation.

.....

.....

.....

..... [2]

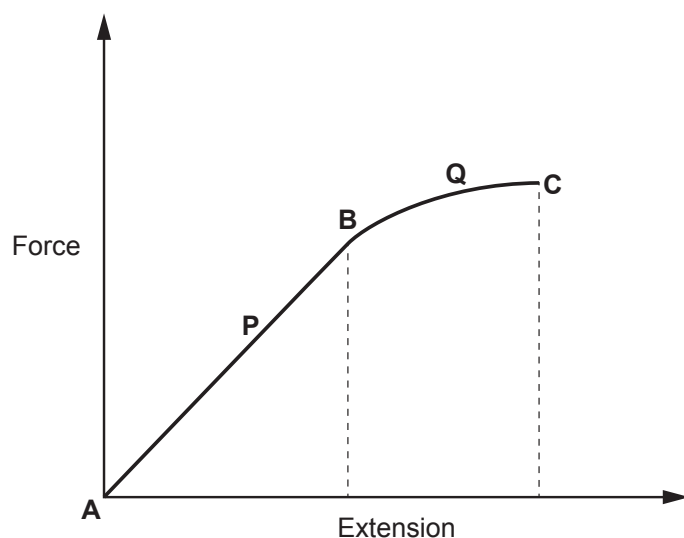


- 19 A student applies different forces to a spring and measures the extension of the spring each time. The force–extension graph shows their results.

A, **B** and **C** are points on the graph.

P is the region on the graph between points **A** and **B**.

Q is the region on the graph between points **B** and **C** where the spring is permanently deformed.



- (a) Use the letters **A**, **B**, **C**, **P** and **Q** to answer the following questions about the graph.

- (i) Which letter represents where the spring has elastic deformation?

..... [1]

- (ii) Which letter represents where the spring obeys Hooke's Law?

..... [1]

- (iii) Which letter represents the elastic limit of the spring?

..... [1]

- (iv) Which letter represents where the graph is non-linear?

..... [1]

- (b) State the **minimum** number of forces that need to be applied to the spring in order to stretch it.

..... [1]



(c) The spring constant of the spring is 28 N/m .

(i) Calculate the force exerted by the spring when it is extended by 0.15 m .

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

Force = ... N [2]

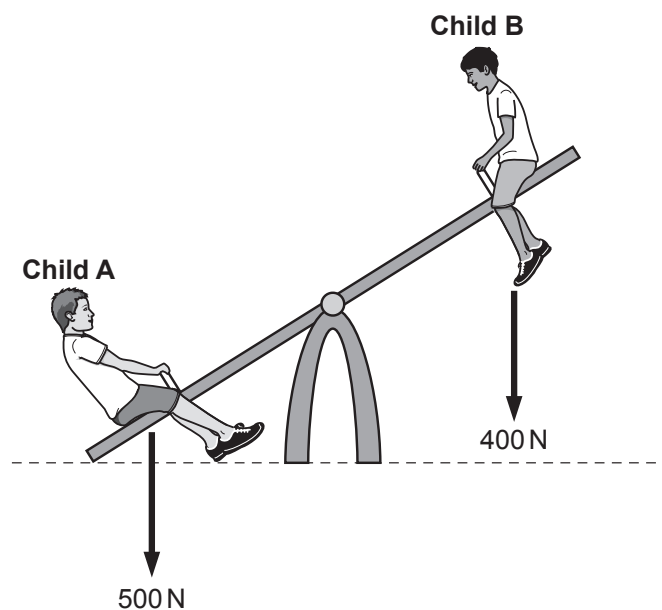
(ii) Calculate the energy transferred when the spring is extended by 0.15 m .

Use the Equation Sheet.

Energy transferred when stretching = ... J [2]



21 Two children play on a seesaw.



Both children sit **2 m** from the pivot.

- (a) (i) Calculate the clockwise and anti-clockwise moments around the pivot when the seesaw is horizontal.

Clockwise moment = ... Nm

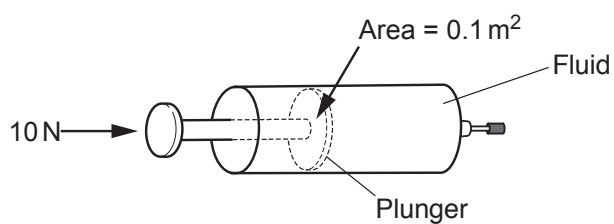
Anti-clockwise moment = ... Nm
[3]

- (ii) Calculate where **Child A** should sit to balance the seesaw.

Answer = ... [3]



- (b) A student tries to compress the fluid in a sealed syringe with a force of 10 N.



The area of the end of the syringe is 0.1 m^2 .

- (i) Calculate the pressure in the fluid.

Answer = ... Pa [3]

- (ii) Write down the direction of the force produced by the fluid on the plunger.

..... [1]

21 A student investigates how a spring stretches.

She measures the original length of the spring, adds a 2.0 N weight, and then measures the extended length of the spring.

Look at her data in the table.

Force used	2.0 N
Original length	3.0 cm
Extended length	7.0 cm
Extension	4.0 cm

(a) (i) Calculate the spring constant for the spring.

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

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

(ii) Suggest **two** ways that the student could improve and develop their method to find the spring constant.

.....

 **[2]**

(b) The spring constant of a different spring is 40 N/m.

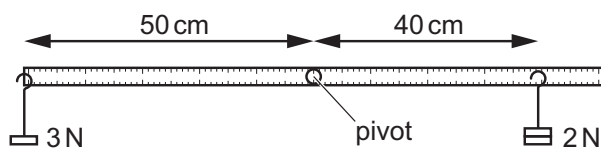
Calculate the energy stored in the spring when it is stretched 0.20 m.

Use an equation from the data sheet to help you.

Energy stored = ... J **[2]**



(c) The diagram shows an experiment a student set up to study moments.



The student:

- holds the metre rule so that it is horizontal
- adds weights to the metre rule at different distances from the pivot.

(i) Calculate the moments of the 2 N weight and the 3 N weight about the pivot.

Use the equation: $\text{moment} = \text{force} \times \text{distance from pivot}$

Moment of 2 N weight = ... Ncm

Moment of 3 N weight = ... Ncm
[2]

(ii) Which way will the metre rule rotate when it is released by the student?

..... [1]

24 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)

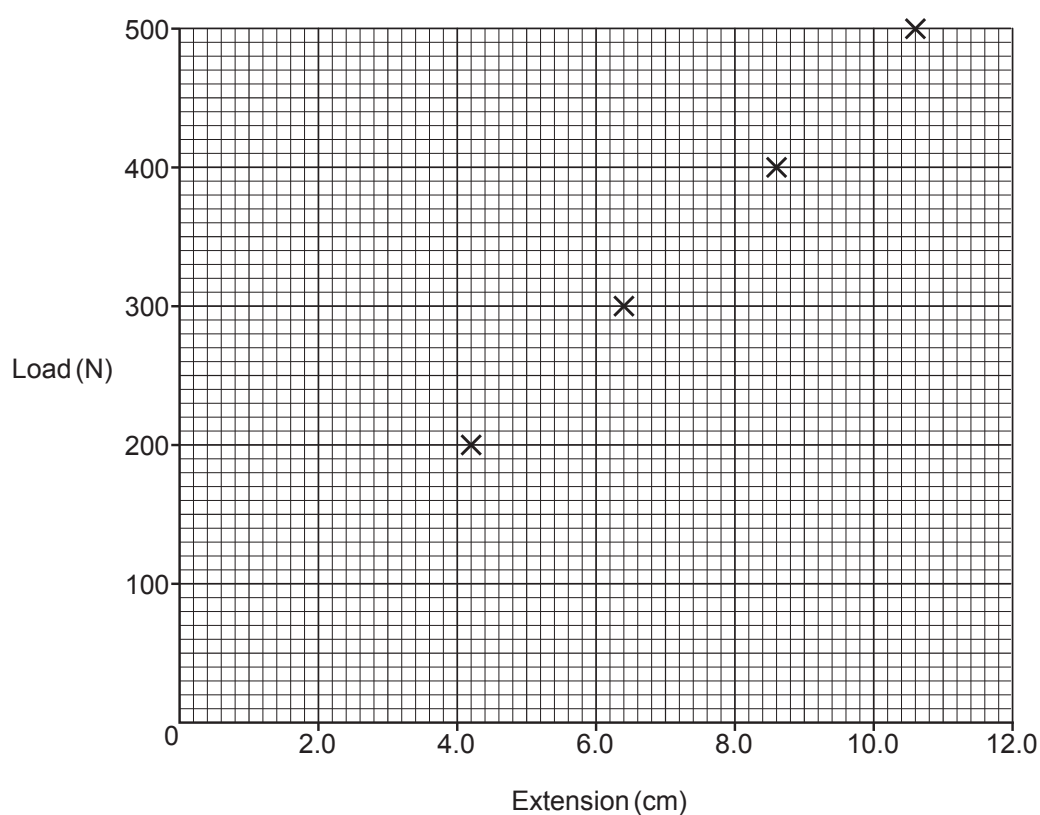
- (i)** Calculate the missing value of the mean extension for a load of 100 N to a suitable degree of accuracy.

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]



- 22** A climber investigates how a rope stretches with different forces. The climber's results are shown in the table.

Force (N)	Extension (m)
0	0.00
10	0.15
20	0.3
30	0.45
40	0.60

- (a)** The climber has made a mistake when recording their results.

Identify the mistake and suggest how it could be corrected.

Mistake:

Correction:

[2]

- (b) (i)** Calculate the spring constant for the rope.

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

Use the equation: $\text{force} = \text{extension} \times \text{spring constant}$

Spring constant = ... N/m **[4]**

- (ii)** Calculate the energy transferred when the rope is stretched with a force of 40 N.

Use the Data Sheet.

Energy transferred in stretching = ... J **[2]**



(iii) A 200 N force is attached to the rope.

Suggest what extension the rope would have if it does not exceed its elastic limit.

..... [1]

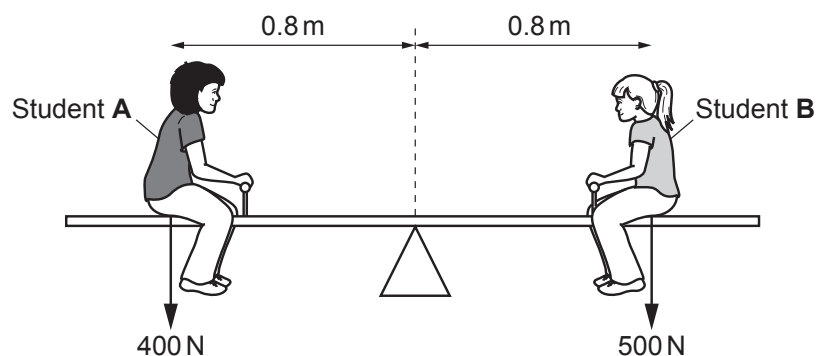
(c) When a force of 500 N is applied, the rope exceeds its elastic limit.

Explain what this means.

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



21 The diagram shows two students sitting on a seesaw.



(a) (i) Explain what happens to the seesaw when both students lift their feet off the ground.

.....

 [2]

(ii) Calculate the distance from the pivot that student B sits to balance the seesaw when student A sits 0.6 m from the pivot.

Use the equation: moment of a force = force $\times$ distance

Distance = ... m [3]

(b) Student A has a weight of 400 N.

(i) Calculate the mass of student A.

Use the equation: gravitational force = mass $\times$ gravitational field strength

Mass = ... kg [3]

(ii) Student A stands on one foot when they leave the seesaw.

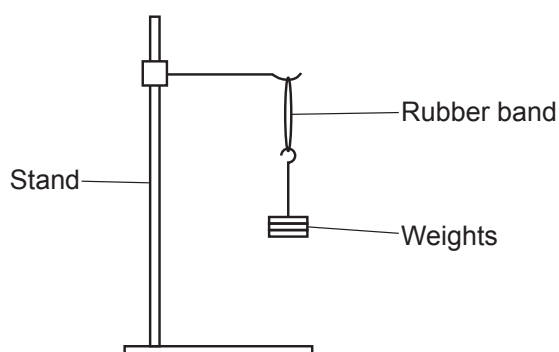
The area of their foot in contact with the ground is $2.5 \times 10^{-2} \text{ m}^2$.

Calculate the pressure student A exerts on the ground.

Use the Equation Sheet.

Pressure = ... Pa [3]

20 A student investigates how a rubber band stretches.



This is their method:

- Measure the original length of the rubber band using a ruler.
- Add 1.0 N weights, one at a time.
- Measure the new length of the rubber band after each weight is added.

(a) Suggest **one** risk for this investigation and how the risk can be reduced.

Risk:

How the risk can be reduced:

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

(b) The student records this data when adding a weight:

Original length of the rubber band = 5.0 cm

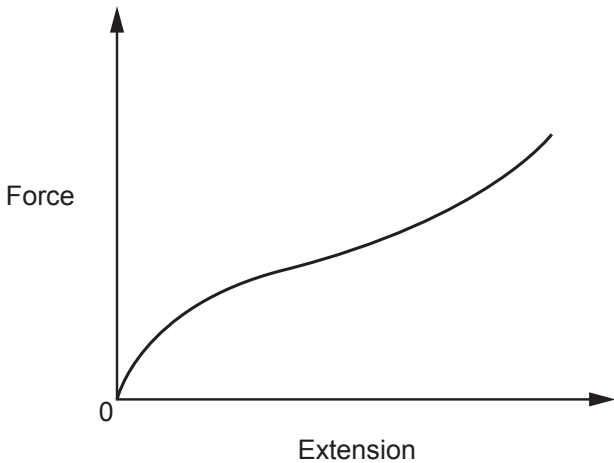
New length of the rubber band after the weight is added = 14.0 cm

What is the extension of the rubber band?

Extension = ... cm **[1]**



(c) The student sketches a graph of the results of the investigation.



The student removes the weights from the rubber band. The rubber band returns to its original length.

Which statements about this investigation are **true**, and which are **false**?

Tick (✓) **one** box in each row.

Conclusion	True	False
The relationship between force and extension is linear.		
The rubber band obeys Hooke’s Law.		
The deformation is only elastic.		

[2]

(d) The student also stretches two springs.

(i) The first spring has a spring constant of 50 N/m.

Calculate the energy transferred in stretching when this spring is extended by 0.18 m.

Use the equation: energy transferred in stretching = $\frac{1}{2} \times \text{spring constant} \times (\text{extension})^2$

Energy transferred = ... J [2]

(ii) The second spring has a spring constant of 48 N/m.

Calculate the force needed to stretch this spring by 0.18 m.

Use the Equation Sheet.

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

Force = ... N [4]

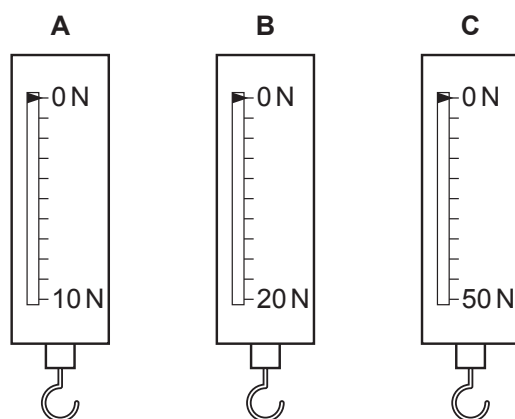


19 Newton-meters are used for measuring forces. Each newton-meter contains a spring.

(a) What is the minimum number of forces needed to stretch a spring?

..... [1]

(b) A student has three different newton-meters.



(i) Which newton-meter would be best to use to measure a force of about 11 N?

.....

Explain your answer.

..... [2]

(ii) Explain what could happen if a 50 N weight was put on newton-meter A.

..... [2]

(iii) Which newton-meter has the **largest** spring constant?

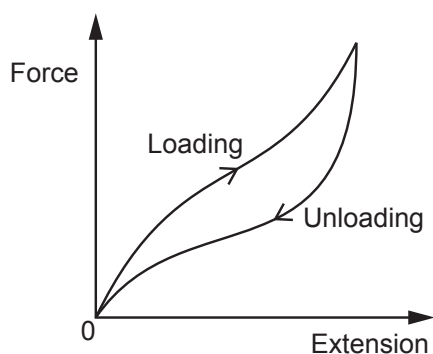
.....

Explain your answer.

..... [2]

- (c) Another student suggests that an elastic band could be used instead of a spring in a newton-meter.

Look at the force-extension graph for an elastic band.



Explain why the elastic band would **not** make a good replacement for a spring.

.....

.....

.....

..... [2]

- (d) A spring has a spring constant of 30 N/m .

Calculate the energy transferred when the spring is extended by 4.0 cm .

Use an equation from the data sheet to help you.

Energy transferred = ... J [3]

MARK SCHEMES

official Pearson Edexcel mark schemes



Question				Answer		Marks	AO element	Guidance	
8				B ✓		1	2.1		



Question				Answer	Marks	AO element	Guidance
11				D ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
4				B ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
5				C ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
8			B ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
12				B ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
3				B	1	2.1	



Question				Answer	Marks	AO element	Guidance
8			A		1	2.1	



Question				Answer	Marks	AO element	Guidance
9			A		1	1.1	



Question				Answer	Marks	AO element	Guidance
7				D ✓	1	1.2	



Question			Answer	Marks	AO element	Guidance
9			C ✓	1	1.2	



Question				Answer		Marks	AO element	Guidance	
4				D	✓	1	1.1		



Question			Answer	Marks	AO element	Guidance
9			A ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
5	D ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
7				C ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
6	B	1	1.2	



Question	Answer	Marks	AO element	Guidance
8	A	1	1.2	



Question	Answer	Marks	AO element	Guidance
3	D	1	1.2	



Question	Answer	Marks	AO element	Guidance
10	B	1	2.1	ALLOW 80



Question	Answer	Marks	AO element	Guidance
13	A	1	1.1	



Question	Answer	Marks	AO element	Guidance
14	B	1	2.1	



Question	Answer	Marks	AO element	Guidance
6	D	1	1.1	



10	A	1	2.2	A: $28 \div 4$ B: $30 \div 4$ C: $4 \times 28 \div 2$ D: 4×28
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Question	Answer	Marks	AO element	Guidance
10	D	1	2.2	



Question	Answer	Marks	AO element	Guidance
13	C	1	1.2	



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 description and comparison of the motion of all four students in terms of distance and time relating speed to distance run AND Calculates the speed of all four students. <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) Description and comparison of the motion of three students of distance and time OR Calculates the speed of at least three students. <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) Brief description of the motion of at least three students. OR Calculates the speed of at least one student. <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>	6	2 x 1.1 2 x 2.2 1 x 3.1a 1 x 3.2b	AO1.1 Demonstrate knowledge and understanding of the correct formulae • speed = distance ÷ time • $v = s \div t$ • evidence of calculation AO2.2 Apply knowledge and understanding of the motion of the four students • Race B is a longer distance than race A • Race B and C are the same distance • Students B & C take different amounts of time • Student D takes the longest time • Race D is the longest distance • Race A is the shortest distance • Student A speed = $15 \div 6 = 8.3\text{m/s}$ • Student B speed = $100 \div 15 = 6.7\text{m/s}$ • Student C speed = $100 \div 14 = 7.1\text{m/s}$ • Student D speed = $200 \div 31 = 6.5\text{m/s}$ AO3.1a & AO3.2b Analyse information to interpret and draw conclusions about the motion of the four students • Race B is twice the length of race A, but time is more than twice that of race A • C is faster than B as the time is shorter (for the same distance) • As race length increases, average speed decreases
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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) Detailed description AND analysis of the journey (including suitable correct calculations) <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 journey (including calculations) <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 journey (including an attempt at a calculation) <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	A2.1: Description of the journey. For example - as the time increases the distance increases - the distance increases (steadily) at first - the distance remains the same in the middle section - there is no change in distance in the middle section - the distance increases (steadily) in the final section AO3.1a: Analysis of the journey. For example - The student has a constant speed/velocity for the first 40 seconds - The student moves 200m in the first 40 seconds - The student remains stationary/does not move for the next 60 seconds (between 40 and 100 seconds) - The student has a constant speed/velocity for the final 40 seconds (between 100 and 140 seconds) - The student moves 200m in the first 40 seconds - The speed/velocity in the first 40 seconds is the same as the speed/velocity in the final 40 seconds - The overall distance travelled is 400m - The first and last sections were the same speed AO 2.2: Calculations
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Question	Answer	Marks	AO element	Guidance
				For example - The speed/velocity of the student in the first 40 seconds is 5 m/s - The speed/velocity of the student between 40 and 100 seconds is 0 m/s - The speed velocity of the student in the final 40 seconds (between 100 and 140 seconds) is 5 m/s - The average speed of the journey is 2.9 m/s

23	(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 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 / light gates / A/W ✓ OR Error: Not dropping ball from exact height / AW Improvement: Indication of marking the point from where it should be dropped / A/W	2	3.3b 3.3a	Marks can be awarded for errors/improvements in either section IGNORE difficulty in timing without reason IGNORE human error unless qualified ALLOW use larger distances (so that % error in time is reduced)

16	(a)	(i)	Ruler / metre rule / tape measure ✓	1	1.2	ALLOW metre stick / rule
		(ii)	Stop clock / stopwatch / (mobile phone) timer ✓	1	1.2	ALLOW light gates
	(b)	(i)	1 (s) ✓	1	2.2	
		(ii)	4.5 (s) ✓	1	2.2	
		(iii)	Increase ✓	1	3.1a	ALLOW (accelerate) quicker/faster / more/higher (acceleration)
		(iv)	Line drawn with increased slope ✓	1	3.2b	IGNORE any lines on the graph after the increased gradient ALLOW line starting from anywhere on the x-axis
	(c)		Magnitude ✓ Direction ✓	2	2 x 1.1	Answers can be in either order

16	(a)	(i)	50 (m) ✓	1	2.2	
		(ii)	60 (s) ✓	1	2.2	
		(iii)	Any one from: Tape measure/ Measuring tape ✓ Trundle wheel ✓	1	1.1	ALLOW Metre ruler / metre stick / metre wheel / surveyors' wheel DO NOT ALLOW ruler ALLOW Fitbit/smartphone app
	(b)	(i)	C ✓ It has the steepest line/gradient/slope / greatest change in distance per second / AW ✓	2	2.2 1.1	ALLOW calculation of all 4 speeds NOT 'highest distance change in shortest amount of time'
		(ii)	B ✓ The line is horizontal/flat /distance does not change/AW ✓	2	2.2 1.1	
	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (m/s ²) award 2 marks $v = 20 \div 40$ ✓ $v = 0.5$ (m/s ²) ✓	2	2.1 2.1	Mp2 dependent on correct substitution for mp1

23	(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 ALLOW any sensible answer related to stopping
		(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

21	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer is 6.6 (s) award 2 marks Mean = $(6.7 + 6.3 + 6.7 + 6.6) \div 4$ ✓ (Mean =) 6.6 (ms) ✓	2	2 × 1.2	ALLOW one mark for 6.575 (ms) ALLOW candidate's average roundly correctly to 2 s.f. for one mark
	(b)	Any one from: The timer would start and stop at (roughly) the same time ✓ The time would not be the time for the sound to travel from mic 1 to mic 2 ✓	1	2.2	ALLOW the time measurement would be incorrect
	(c) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer is 320 (m / s) award 4 marks 7.5 ms = 0.0075 s ✓ Rearrangement: speed = distance ÷ time ✓ (Speed =) $2.4 \div 0.0075$ ✓ (Speed =) 320 (m / s) ✓	4	1.2 1.2 2 × 2.1	
	(ii)	With a tape measure / (several) metre-rule(s) ✓	1	1.2	DO NOT ALLOW with a ruler
	(iii)	Any one from: Errors / Uncertainty in measuring time ✓ Errors / Uncertainty in measuring distance ✓ Value on the website might be for different conditions (air temperature etc) ✓	1	3.2a	DO NOT ALLOW the value on the website could be incorrect.

23	(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 ✓ $2.0 / 25$ ✓ $0.08 \text{ (m/s}^2\text{)}$ ✓	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

21	(a)	*	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) States that there is no clear trend. AND Detailed identification of at least two problems with the experiment with suggestions of detailed improvements. <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) Recognises that the average speeds are similar. AND Identifies at least one problem with the experiment with a suggested improvement. <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) Refers to data from the table. AND Suggests an improvement to the experiment or identifies one problem with the experiment. <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 No response or no response worthy of credit.	6	2×3.1a 2×3.2a 2×3.3b AO3.1a Analyse information and ideas to describe trend in results For example: - No obvious/discernible trend - As loads increased time $\approx$ the same - As loads increased speeds $\approx$ the same 20N and 60N mean speeds the same 20N and 60N times the same 40N and 80N mean speeds the same 40N and 80N times the same AO3.2a Analyse information and ideas to make judgements and identify problems with the experiment For example: - Only 4 loads tested - Ramp distance too short - No repeated readings - Mass/weight of trolley ignored - Reaction times an issue for short times AO3.3b Analyse information and ideas to improve experimental procedures For example: - Test more loads - Include mass/weight of the trolley - Use a longer ramp - Have a smaller angle of ramp - Start higher up the ramp - Electronic timing method - Repeat readings and take a mean
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Question	Answer	Marks	AO element	Guidance
(b)	EITHER $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 2^2 \div (2 \times 2.0)$ ✓ $a = 1.0/1$ (m/s²) ✓ OR mean $v = \frac{1}{2} (0 + 2 \text{ m/s}) = 1 \text{ m/s}$ ✓ $t = s/\text{mean } v = 2 \text{ m} / 1 \text{ m/s} = 2 \text{ s}$ ✓ $a = \Delta v/t$ ✓ $= (2 \text{ m/s} - 0)/2 \text{ s} = 1 \text{ (m/s}^2\text{)} \checkmark$	4	2.1 2.1 2.1 2.1	If no working shown and answer = 1 (m/s²), award all 4 marks. If wrong physics used, then award marks as appropriate for either approach.



19	(a)	(i)	Any two from: First student drops the ruler and second student catches as quick as possible ✓ Measure the distance on the ruler where it was caught ✓ Use look-up table/equation to find time to travel this distance ✓	2	2 × 1.2	1
		(ii)	Any one from: To check the precision or repeatability of the readings ✓ to find the uncertainty in the measurement ✓ to find an average or mean ✓	1	3.3a	
		(iii)	Student B's reaction times will be longer / increases ✓	1	3.2a	ALLOW B will be slower
	(b)	(i)	(9 + 14) = 23 (m) ✓	1	2.2	
		(ii)	Stopping distance at 50 mph = 53 m ✓ Stopping distance is greater than 40 m / Car hits the barrier ✓	2	3.1a 3.2a	ALLOW 52-54m

Question	Answer	Marks	AO element	Guidance
19 (b) (iii)	Factor: larger mass (of car) ✓ Reason: Braking distance is increased ✓ because deceleration is less / larger KE to dissipate ✓ OR Factor: Poor quality brakes / tyres ✓ Reason: Braking distance is increased ✓ Less friction / smaller deceleration ✓ OR Factor: Icy / wet / slippery road ✓ Reason: Braking distance is increased ✓ Less friction / smaller deceleration ✓ OR Factor: Going uphill ✓ Reason: Braking distance is decreased ✓ Weight of car increases deceleration ✓ OR Factor: Going downhill ✓ Reason: Braking distance is decreased ✓ Weight of car decreases deceleration ✓	3	1.1 2 × 2.1 1.1 2 × 2.1 1.1 2 × 2.1 1.1 2 × 2.1	DO NOT ALLOW distance for braking/thinking distance DO NOT ALLOW stopping distance

Question	Answer	Marks	AO element	Guidance
19 (c) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 3.25/3.3 (m/s²) award 2 marks 13 ÷ 4 ✓ = 3.3 (m/s ²) ✓	2	2 × 2.1	ALLOW 3.25 (m/s ²)
	(ii) Any two from: Yes / No (no mark) (agree with driver) stopping distance is shorter ✓ Less likely to hit obstacles / safer ✓ Attempt to quantify, e.g. 4 s / 0.4 s = 10 ✓ OR (disagree with driver) ($F = ma$ / so) the force (acting on the people in the car) is 10x greater ✓ This can lead to injury / 10× more dangerous ✓ Other factors involved (so cannot quantify) ✓	2	2.1 2 × 3.1b 2.1 2 × 3.1b	1
	(iii) Seat belt / airbag / crumple zone ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
1				A ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
9				A ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
10				C ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
11	C ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
2			D		1	1.1	



Question				Answer	Marks	AO element	Guidance
6				B	1	2.1	



Question				Answer	Marks	AO element	Guidance
11				B	1	2.1	



Question			Answer	Marks	AO element	Guidance
3			B ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
8				C ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
2	D ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
3	B ✓	1	1.1	



Question	Answer	Marks	AO element	Guidance
2	C	1	1.1	



Question	Answer	Marks	AO element	Guidance
4	C	1	1.1	



Question	Answer	Marks	AO element	Guidance
5	D	1	1.1	



Question	Answer	Marks	AO element	Guidance
12	B	1	2.1	



Question	Answer	Marks	AO element	Guidance
12	A	1	2.1	



22	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 12 (m/s) award 2 marks Rearrange formula - 4×3 ✓ 12 (m/s) ✓	2	2.1 2.1	
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 800 (kg) award 3 marks Recall: force = mass $\times$ acceleration ✓ $4000 \div 5$ ✓ 800 (kg) ✓	3	1.2 2.1 2.1	 ALLOW 0.8 for two marks

22		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 description of the trend shown AND detailed suggestions to obtain more accurate or precise results. <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 of the trend shown and clear suggestions to obtain more accurate or precise results OR Detailed description of the trend shown and simple suggestions to obtain more accurate or precise results. OR Basic description of the trend shown and detailed suggestions to obtain more accurate or precise results <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. OR	6	3.1a x 3 3.3b x 3 AO3.1a Analyses the results to interpret the trend shown by the graph. For example - as the load increases, acceleration increases / as the load decreases, acceleration decreases - double the force you double the acceleration - Spots anomaly (3.12 vs 3.0) 4x force gives 4x acceleration - the relationship is (approximately) linear / (directly) proportional (e.g., approx. 1.5m/s² increase per 2kg, 0.75m/s² per kg) - use of $m = F/a$ / Newton's second law AO3.3b Analyses the information to improve experimental procedures. For example - Repeat readings (take a mean) - Take more readings (3 readings is not enough)/extend range / more (different) loads - Record acceleration data to a consistent number of decimal places/significant figures - Adjust the ramp height to eliminate friction - Use the full length of the ramp - Use a shorter piece of string/raise the table height/move ramp to the left to stop the load hitting the floor - Ensure the total of the trolley mass and mass of the load are the same throughout. - Weighing the load each time
		Simple suggestions to obtain more accurate or precise results. <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>		- Make sure start at exactly same point - Closer intervals between loads

21	(a)	(i)	Steady/uniform/constant speed/velocity ✓	1	2.1	ALLOW no acceleration/deceleration
		(ii)	Accelerates / increases in speed ✓ because forces are unbalanced / forwards force > resistive force ✓	2	2 x 2.1	ECF (a)(i) ALLOW until resistive force reaches new forward force
	(b)	(i)	P ✓	1	2.2	
		(ii)	Y ✓	1	2.2	
	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 750 (N) award 3 marks			ALLOW 735 (N) as $g = 9.8$ has been used
			Gravitational field strength / $g = 10$ (N/kg) ✓ 75 x 10 ✓ 750 (N) ✓	3	1.1 2.1 2.1	ALLOW $g = 9.8$ (N/kg) or 9.81 (N/kg) ALLOW ECF for maximum of 2 marks if incorrect value for g used

21	(a)	(i)	Earth ✓ g is largest ($W = mg$ and m is fixed) ✓	2	3.2a 1.1	
		(ii)	Mass ✓	1	1.1	ALLOW distance from another object
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2000 (N/m²) award 3 marks pressure = force / area ✓ 600 / 0.3 ✓ 2000 (N/m ²) ✓	3	1.2 2.1 2.1	
		(ii)	Upwards arrow labelled as normal contact force ✓ Downwards arrow labelled as weight ✓ Arrows are equal length (by eye) ✓	3	3 x 1.1	ALLOW force exerted by ground ALLOW two upwards arrows, one per foot ALLOW force exerted by Earth If two upwards arrows, each should be half the weight

20	(a)	(i)	3 m/s ² ✓	1	1.2	
		(ii)	First check the answer on the answer line If answer = 5 400 (N) award 2 marks (F =) 1800 × (a)(i) ✓ (F =) 5400 (N) ✓	2	2 × 2.1	ECF from (a)(i) If a = 50 (m/s ²), F = 90 000 (N) ✓ If a = 100 (m/s ²), F = 180 000 (N) ✓
	(b)		First check the answer on the answer line If answer = 120 (m/s²) award 2 marks (deceleration =) 18 ÷ 0.15 ✓ (deceleration =) 120 (m/s ²) ✓	2	2 × 2.1	IGNORE “–”
	(c)	(i)	Any three from: Probability increases (as change in velocity increases) / ORA ✓ Changes from 0.1 to 0.9 or change by 0.8 or 9 times greater ✓ Probability changes more rapidly at low change in velocity / ORA ✓ Relationship is non-linear / not proportional ✓	3	3 × 3.1b	ALLOW an alternative for the first two marking points probability increases from 0.1 to 0.9 or increases by 0.8 for two marks ✓✓
		(ii)	26(.0) to 27.5 m/s ✓	1	2.2	

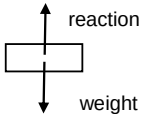


19	(a)	Any two from: Speed is a scalar ✓ Velocity is a vector ✓ Speed does not take direction into account / AW ✓ Velocity does take direction into account / AW ✓ Speed is calculated using distance ✓ Velocity is calculated using displacement ✓ Displacement depends on direction from start point / displacement takes into account direction ✓ Distance does not depend on direction from start point / distance does not take into account direction ✓	2	1.1 x 2	
	(b) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 20 (N) award 2 marks 5×4 ✓ $= 20$ (N) ✓	2	2.1 2.1	
	(ii)	Any one from: Not all energy is transferred to motion ✓ (Air) resistance ✓ Drag ✓ Friction ✓	1	3.2a	ALLOW Energy losses

Question			Answer	Marks	AO element	Guidance
19	(c) (i)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1500 (J) award 2 marks 30×50 ✓ $= 1500$ (J) ✓	2	2.1 2.1	
	(ii)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 20 (W) award 3 marks work done ÷ time ✓ $1500 \div 75$ ✓ $= 20$ (W) ✓	3	1.2 2.1 2.1	ALLOW ecf from (c)(i) ALLOW $P = WD \div t$

22	(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 ✓	3	1.2 2.1	

Question	Answer	Marks	AO element	Guidance
	90 000 (N) ✓		2.1	ALLOW 90 kN
Question	Answer	Marks	AO element	Guidance

20	(a)	Any one from: electrostatics ✓ gravity/weight ✓ magnetism ✓ (normal) contact force ✓ friction ✓	1	1.1	Allow 'static electricity' but not just 'static' ALLOW reaction force ALLOW drag/air resistance
	(b)	Two arrows drawn of equal length ✓ One up and one down ✓ The downwards arrow labelled weight/gravity ✓ The upwards arrow labelled contact/reaction force ✓	4	4 x 2.1	e.g. 
	(c)	Any two from: (glider) accelerates during the push ✓ (then has) constant/steady/uniform speed/velocity ✓ (because) there are no other/horizontal/external (unbalanced) forces acting on it / AW ✓ there is (slight) deceleration due to air resistance ✓	2	2 x 1.2	
	(d) (i)	$F = ma$ / force equals mass times acceleration ✓ so reducing mass means the same engine force will cause greater acceleration ✓	2	1.2 2.2	Must start with Newton II NOT less force for same acceleration
	(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 5 (m/s²) award 3 marks change in speed = 25-5 = 20 (m/s) ✓ acceleration = 20 ÷ 4 (m/s ²) ✓ = 5 (m/s ²) ✓	3	2.1 2.1 2.1	e.c.f. incorrect change in speed if subtraction attempted

19	(a)	(i)	Upwards force = normal contact force ✓ Downwards force = weight ✓	2	1.1 x2	
		(ii)	Any two from: The water pushes on the rocket and the rocket pushes on the water ✓ The forces act in opposite directions ✓ The forces are the same size (and type) ✓ Each force acts on a different object ✓	2	2.1 x2	ALLOW 2 marks for Forces are equal and opposite ALLOW Upwards and downwards forces ALLOW Forces are equal ALLOW 1 mark for stating 'For every action there is an equal and opposite reaction' if no other mark has been awarded
		(iii)	The upwards force needs to be greater/stronger than the downwards force / AW / ORA ✓	1	2.1	ALLOW the thrust needs to be greater/stronger than the weight/force due to gravity IGNORE pressure
	(b)	(i)	First check the answer on the answer line If answer = 2250 (J) award 2 marks E = 5x10x45 ✓ E = 2250 (J) ✓	2	2.1 2.1	
		(ii)	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 2500 W award 3 marks (P = E / t) P = 12500 / 5 ✓ P = 2500 ✓ W or watts ✓	3	2.1 2.1 1.2	Unit mark is an independent mark ALLOW J/s

Question	Answer	Marks	AO element	Guidance
(c)	Mistake 1: (gravitational fields cause) repulsion ✓ Correct word 1: (gravitational fields cause) attraction ✓ Mistake 2: (More massive objects have a) smaller (gravitational field strength) ✓ Correct word 2: (More massive objects have a) greater (gravitational field strength) / AW ✓ OR Mistake 2: More (massive objects have a) smaller gravitational field strength ✓ Correct word 2: Less (massive objects have a) smaller gravitational field strength ✓	4	3.2a 1.1 3.2a 1.1	Mistakes can be listed in any order ALLOW smaller = less massive

Question				Answer	Marks	AO element	Guidance
3				C ✓	1	2.2	



Question				Answer	Marks	AO element	Guidance
4				B ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
5				C ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
10				C ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
2				B ✓	1	2.2	



Question				Answer	Marks	AO element	Guidance
11				B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
15			B ✓	1	1.1	

For Section B, grey shading in the left-hand column indicates an overlap question: 22 & 23 here are identical to 16 & 17 in J249/03



Question			Answer	Marks	AO element	Guidance
10			D ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
11			B ✓	1	1.2	



Question	Answer	Marks	AO element	Guidance
12	C ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
13	B	1	2.1	ALLOW 3



Question	Answer	Marks	AO element	Guidance
9	B	1	1.1	



Question	Answer	Marks	AO element	Guidance
11	B	1	2.1	



Question	Answer	Marks	AO element	Guidance
3	D	1	1.1	



13	D	1	2.2	A: $450+300$ B: $300\times3.0+450$ C: same distance as Child A D: $450\times3.0+300$
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18	(a)	Any three from: Measure original length (using the ruler) ✓ Add the 2N weight ✓ Measure the extended length and use Extension = extended length – original length ✓ Use $k = F \div x$ to determine k ✓	3	1.2 x3	ALLOW measure the extension/how far it stretched
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 400 (Pa) award 2 marks $P = 2 \div 0.005$ ✓ $P = 400$ (Pa) ✓	2	2.1 2.1	
	(c)	Two (or more) forces (are needed) ✓ Acting in different directions ✓	2	1.1 1.1	Multiple forces are implied by the use of certain verbs e.g. squash, twist, squeeze ALLOW the marking points shown on a diagram Idea of second force can be implied by fixing one end/part of the material ALLOW clear use of tension or compression for both marks
	(d)	Plastic – stays deformed (when force is removed) ✓ Elastic – returns to original shape (when force removed) ✓	2	1.1 1.1	ALLOW permanently changed

19	(a)	(i)	P ✓	1	1.2	ALLOW A to B
		(ii)	P ✓	1	1.2	ALLOW A to B
		(iii)	B ✓	1	1.2	
		(iv)	Q ✓	1	1.2	ALLOW B to C
	(b)		2 ✓	1	1.1	
	(c)	(i)	First check the answer on answer line If answer = 4.2 (N) award 2 marks (F ⇒) 28×0.15 ✓ (F ⇒) 4.2 (N) ✓	2	2.1 2.1	
		(ii)	First check the answer on answer line If answer = 0.315 (J) award 2 marks (E ⇒) $0.5 \times 28 \times 0.15^2$ ✓ (E ⇒) 0.315 (J) ✓	2	2.1 2.1	ALLOW 0.32 (J)

21	(a)	(i)	moment = force x distance ✓ clockwise moment = 800 (Nm) ✓ anti-clockwise moment = 1000 (Nm) ✓	3	1.2 2.1 2.1	ALLOW 2 marks (total) if clockwise and anti-clockwise moments are reversed Correct calculation of either moment implies correct equation so gets m.p.1 also
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.6 (m) award 3 marks (anti-clockwise moment) 500 (N) × distance = 800 (N m) ✓ distance = 800 ÷ 500 ✓ = 1.6 (m) ✓	3	1.2 2.2 2.2	E.c.f. clockwise moment from (a)(i) for 800 (N m) If child B chosen, giving 1000 ÷ 400 = 2.5 (m), award 2 marks (loses m.p.1)
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 100 (Pa) award 3 marks pressure = force ÷ area ✓ = 10 ÷ 0.1 ✓ = 100 (Pa) ✓	3	1.2 2.1 2.1	
		(ii)	at right angles/perpendicular/90° (to the plunger)	1	1.1	ALLOW to the left opposite to the force from the plunger

21	(a)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (N/cm) award 3 marks (Spring constant =) force ÷ extension ✓ $2.0 \div 4.0$ ✓ $= 0.5 \text{ (N/cm)}$ ✓	3		ALLOW 3 marks for 50 N/m 1.2 Needs algebraic or arithmetic rearrangement for this m.p. 2.1 Choice of F , ext for wrong data point loses mp2 but can get mp3 for evaluation ecf. 2.1
		(ii)	Any two from: Repeat readings and calculate a mean/average ✓ Use more forces ✓ Plot data on a graph (and use a line of best fit) ✓ Use equipment with a higher resolution ✓ Repeat experiment with different equipment (and compare results) ✓	2	3.3b x 2	
	(b)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.8 (J) award 2 marks $\frac{1}{2} \times 40 \times 0.2^2$ ✓ $= 0.8 \text{ (J)}$ ✓	2		ALLOW 3.8 (J) 2.1 2.1
	(c)	(i)	(moment of 2N weight) = 80 (N cm) ✓ (moment of 3N weight) = 150 (N cm) ✓	2		2.1 ALLOW 1 mark if answers are reversed 2.1
		(ii)	Anti-clockwise (as anti-clockwise moment is larger than the clockwise moment) / left hand side goes down / AW✓	1	3.1b	ALLOW indication of rotation by an arrow on the diagram

24	(a)	(i)	2.2 ✓	1	1.2	ALLOW 2.17 IGNORE 2.16666666, $\frac{13}{6}$, 2.16̇, 2.17̇
		(ii)	Point correctly plotted (within ½ 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"

22	(a)	Mistake: Extension for 20 N recorded to different number of / only one significant figures ✓ Correction: Record all data to the same number of significant figures/decimal places ✓	2	3.1a 3.3b	ALLOW different number of decimal places ALLOW specific corrections, e.g. 0.30 for both marking points ALLOW also any 2 s.f. measurement which rounds to 0.3
	(b) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 67 (N/m) award 4 marks (Spring constant =) force / extension ✓ 40 / 0.6 ✓ 66.7 (N/m) ✓ 67 (N/m) ✓	4	1.2 2.1 2.1 1.2	ALLOW F / e ALLOW Any two values correctly used from the table, e.g. $30 \div 0.45$ / $20 \div 0.30$ / $10 \div 0.15$ IGNORE evaluation resulting from incorrect equation or incorrect substitution ALLOW 66.6/66.67/66.6 recurring for 3 marks ALLOW any previously calculated answer correctly rounded to 2 s.f.
	(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 12 (J) award 2 marks $0.5 \times 67 \times (0.60)^2$ ✓ 12.(06) (J) ✓	2	2.1 2.1	ALLOW ECF from 22(b)(i) No evaluation mark unless substitution is correct
	(iii)	3 (.0) (m)	1	3.1a	ECF from (b)(i) value of k ALLOW extra precision e.g. 2.99 (m)
	(c)	Any two from: Plastic deformation occurs ✓ Rope will not return to its original length/shape (when force is removed) ✓ Energy used/work done in making permanent changes to the rope ✓	2	2 x 1.1	ALLOW Force and extension relationship is non-linear / no longer linear

21	(a)	(i)	Moves clockwise / student B goes down / student A goes up ✓ More turning force/moment on the right-hand side / student B provides more turning force/moment ✓	2	1.2 2.2	ALLOW down on the right / up on the left ALLOW heavier (student) goes down / lighter student goes up ALLOW student A is heavier than student B AND is sitting the same distance from the pivot.
		(ii)	First check the answer on answer line If answer = 0.48 (m) award 3 marks (LHS/anticlockwise moment = $400 \times 0.6 \Rightarrow 240$ (Nm) / (RHS/clockwise moment =) $500 \times d$ ✓ LHS moment = RHS moment / $240 = 500d$ ✓ ($d =$) 0.48 (m) ✓	3	2.1 2.1 2.1	ALLOW $240 \div 500 = d$ ✓
	(b)	(i)	First check the answer on answer line If answer = 40 (kg) award 3 marks ($W = mg$) $g = 10$ (N/kg) ✓ ($m =$) $W \div g$ / $400 \div 10$ ✓ ($m =$) 40 (kg) ✓	3	1.1 2.1 2.1	ALLOW 9.8 / 9.81 (N/kg) ALLOW ($m =$) $400 \div 9.8$ / 9.81 ALLOW 40 to 40.82 (kg)
		(ii)	First check the answer on answer line If answer = 16 000 (Pa) award 3 marks ($P =$) $F \div A$ ✓ ($P =$) $400 \div (2.5 \times 10^{-2})$ ✓ ($P =$) 16 000 ✓ (Pa)	3	1.2 2.1 2.1	ALLOW equation in any form

20	(a)	Rubber band may snap/fly off (and hit someone on the face/eyes) ✓ Wear safety goggles/glasses / don't add too many weights ✓ OR Weights may fall and damage feet ✓ Suspend above the desk / keep feet away from area / wear (robust) shoes ✓	2	2 × 3.3a	ALLOW fail/break/split etc. for snap ALLOW wear eye protection ALLOW suitable method for stopping elastic band flying off e.g. clamp it. / AW IGNORE thicker elastic band ALLOW something to catch the weights / AW
	(b)	9.0 (cm) ✓	1	2.1	ALLOW 9 (cm)
	(c)	False False True ✓✓	2	2 × 3.2a	2 correct award one mark 3 correct award two marks
	(d)	(i) First check the answer on the answer line If answer = 0.81 (J) award 2 marks (E = $\frac{1}{2} ke^2$) E = $\frac{1}{2} \times 50 \times 0.18^2$ ✓ E = 0.81(J) ✓	2	2.1 2.1	

Question	Answer	Marks	AO element	Guidance
	(ii) First check the answer on the answer line If answer = 8.6 (N) award 4 marks F = ke ✓ F = 48 × 0.18 ✓ E = 8.64 (N) ✓ E = 8.6 (N) ✓	4	1.1 2.1 2.1 1.1	ALLOW force = spring constant × extension ALLOW clear evidence of correct rounding of incorrect answer to 2sf

19	(a)		2 ✓	1	1.1	
	(b)	(i)	B ✓ Any one from: A only goes up to 10 ✓ B has the best resolution (for 11N reading) ✓ Reading on B will be in the middle of the scale ✓ C goes up in 5N (increments)/ scale is too coarse ✓	2	3.2a 2.2	
		(ii)	Elastic limit exceeded / spring no longer returns to original length ✓ Plastic deformation / spring permanently stretched ✓	2	2 x 2.2	ALLOW Newton-meter is broken / no longer works.
		(iii)	C ✓ Least extension (for same force) / AW ✓	2	3.2b 2.2	ALLOW spring is stiffer
	(c)		Any two from: It is not linear ✓ The extension is different when loading and unloading ✓ Force and extension are not proportional ✓ It does not obey/follow Hooke's law ✓	2	2 x 1.2	ALLOW It does not go up (or down) evenly
	(d)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.024 (J) award 3 marks 4 cm = 0.04 m ✓ $\frac{1}{2} \times 30 \times 0.04^2$ ✓ 0.024 (J) ✓	3	1.2 2.1 2.1	