

PHYSICS



EXAM QUESTION PACK

P2.2 NEWTON'S LAWS

SCORE

/213

PERCENTAGE

%

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Gateway Physics A (9-1)

Newton's laws

Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

OCR supplied materials:

Additional resources may be supplied with this paper.

Other materials required:

- Pencil
- Ruler (cm/mm)

Duration: Not set

Candidate
forename

Candidate
surname

Centre number

Candidate number

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **213**.
- The total number of marks may take into account some 'either/or' question choices.

1 Which sentence is the definition of the power of a machine?

- A The amount of work done by the machine.
- B The efficiency of the machine.
- C The number of joules of energy the machine requires to work.
- D The rate at which energy is transferred by the machine.

Your answer

[1]

2 A firework rocket has a resultant force of 2 N acting on it.

It has a mass of 0.1 kg.

What is the acceleration of the firework rocket?

- A 0.2 m/s^2
- B 0.5 m/s^2
- C 20 m/s^2
- D 200 m/s^2

Your answer

[1]

3(a) Four students investigate the idea of work done.

$\text{work done} = \text{force} \times \text{distance}$

Look at their results.

Student	Force (N)	Distance travelled (m)
A	100	5
B	50	10
C	120	12
D	40	4

Use calculations to show which student does the most work.

-----[2]

(b) Which **two** students do the same amount of work?

-----[1]

(c) State **two** reasons why it is important to repeat measurements in any experiment.

-----[2]

(d) Student C takes 0.5 minutes to push the trolley.

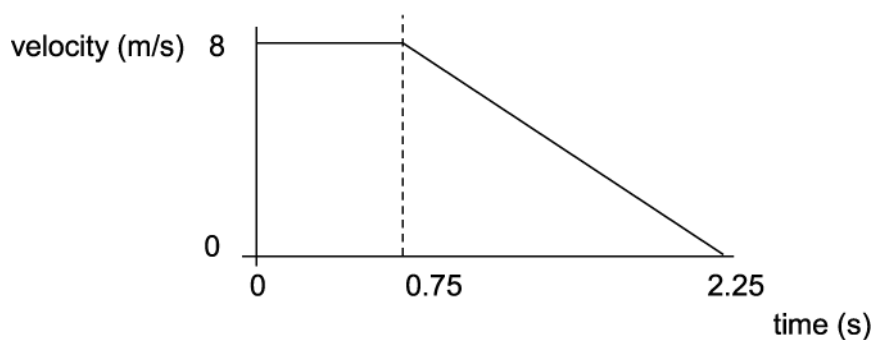
How much power do they use?

Show your working.

answer: ----- W [4]

- 4 A car takes 6 m to brake when moving at 8 m/s.

Look at the graph of a car travelling at 8 m/s, starting to brake and then stopping.



- (i) Calculate the acceleration of the car during braking.

Show your working and state the unit.

answer: ----- unit ----- [4]

- (ii) The car has a braking force of 5000 N.

Calculate the work done by the brakes on the car.

answer: ----- J [2]

5 A car on a roller coaster is stationary at the top of a slope.

It has a weight of 6 500 N and a potential energy of 217 000 J.

Calculate how high above the ground it is.

answer: ----- m

[2]

6 A car on a roller coaster is stationary at the top of a slope.

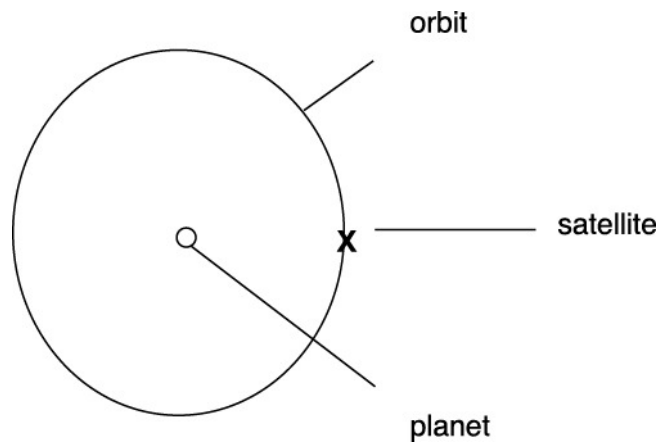
It has a weight of 6 500 N and a potential energy of 217 000 J.

Calculate how high above the ground it is.

answer: ----- m

[2]

- 7 An artificial satellite (X) is kept in a stable circular orbit around a planet by a centripetal force caused by gravity.



- (i) Explain how the velocity of a satellite is constantly changing whilst its speed remains the same when it is in orbit.

----- [2]

- (ii) The satellite is remotely controlled from Earth.

The scientists want the satellite to move slower.

What effect will this change in speed have on the height of its orbit?

Explain your answer.

----- [2]

8 Cars and lorries have different brakes.

Brakes absorb the energy of the vehicle before it comes to rest.

The brakes on lorries have larger brake discs and brake pads than cars.

Brakes are designed for increased air flow.

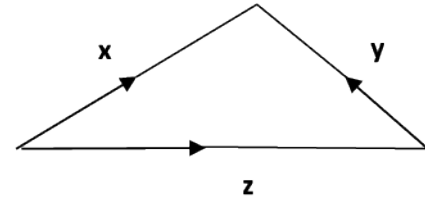
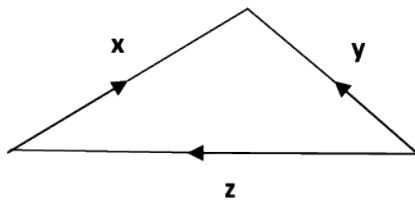
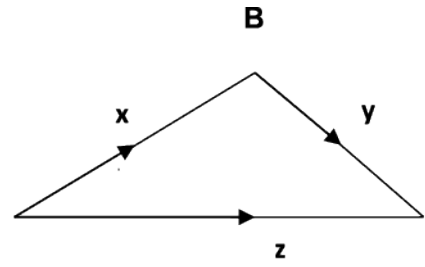
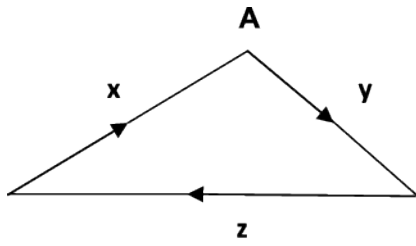
Explain why this is more important for lorries than cars.

[4]

9 A body has three forces, x , y and z acting on it.

The body is in **equilibrium**.

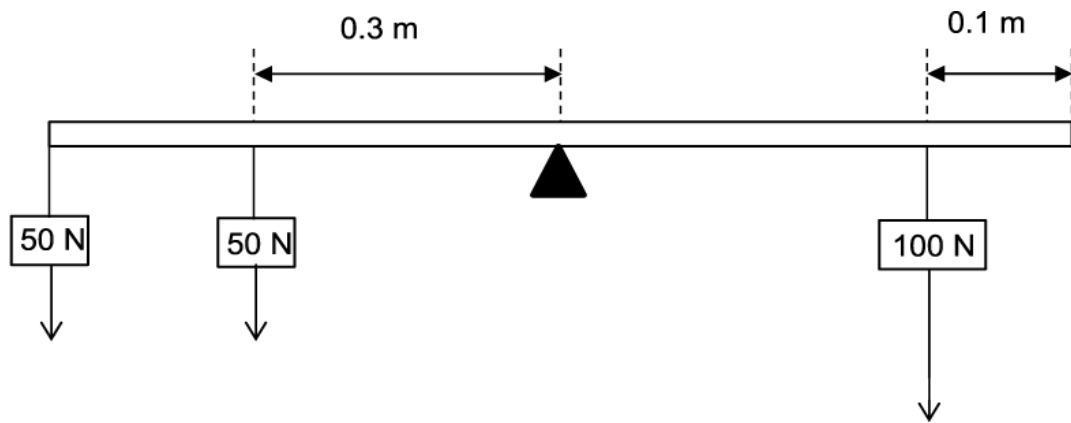
Which vector diagram represents this situation?



Your answer

[1]

10 A uniform 1.0 m rod is pivoted at its centre.



The rod is in equilibrium.

What is the value of the anti-clockwise moment about the pivot?

- A 10 Nm
- B 15 Nm
- C 40 Nm
- D 100 Nm

Your answer

[1]

11 A car and driver with a total mass of 1000 kg is travelling at 20 m/s.

The driver applies the brake and the car comes to a stop in 4 seconds.

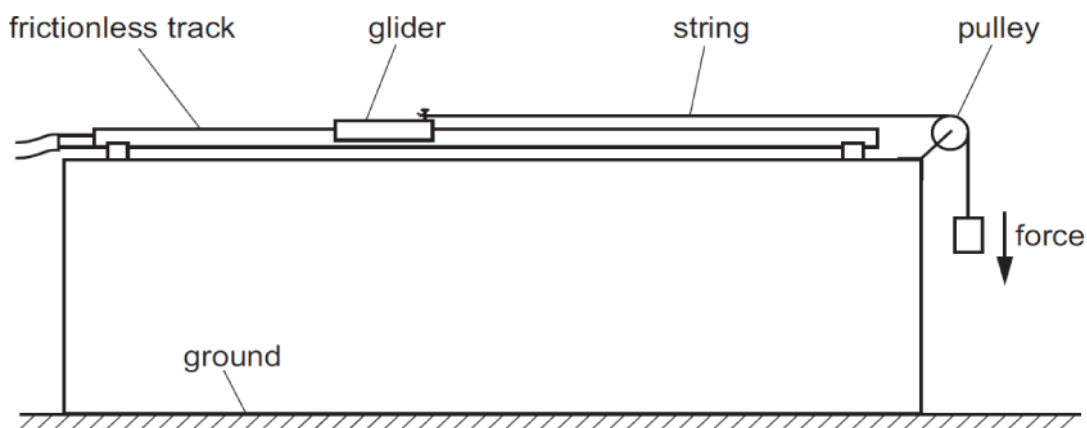
What is the mean force on the car?

- A 80 000 N
- B 5 000 N
- C 200 N
- D 12.5 N

Your answer

[1]

12(a) A student investigates the motion of a glider on a frictionless air track using the apparatus shown in the picture.



(i) Explain how the student can use this apparatus to demonstrate Newton's Second Law.

Include details of any additional equipment required.

[3]

(ii) A 0.25 kg glider is pulled by a 1.0 N force.

Calculate the acceleration of the glider using the formula:

$$\text{force} = \text{mass} \times \text{acceleration}$$

answer: _____ m/s²

[1]

(iii) Suggest reasons why the recorded value was less than your calculated value.

----- [2]

(b) The student carries out the experiment for 5 forces

Force (N)	Acceleration (m/s ²)			
	Attempt 1	Attempt 2	Attempt 3	Mean
1.0	3.8	3.9	3.7	3.8
2.0	7.8	7.7	7.7	7.7
3.0	11.2	11.4	11.6	11.4
4.0	12.0	14.9	15.1	13.8
5.0	19.0	18.9	19.1	19.0

There is an anomaly in the results.

Identify the anomaly and explain how the student could have dealt with it.

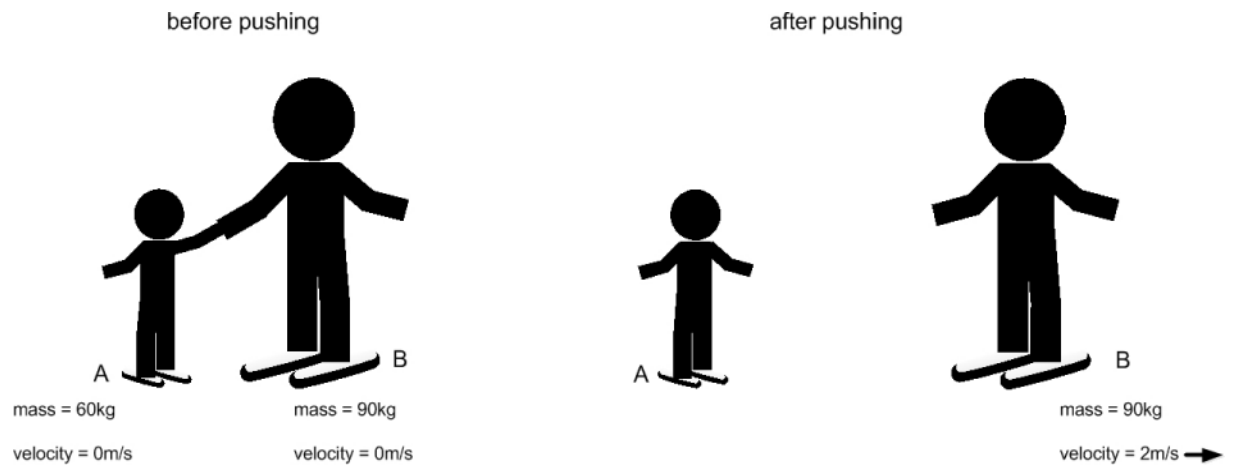
----- [2]

(c) Explain what is meant by a reproducible experiment.

----- [1]

13(a) Two ice skaters A and B, at rest, start together on the ice.

The ice skaters push apart and they move off in opposite directions.



State the law of conservation of momentum.

----- [1]

(b) Use the data and your knowledge of momentum to calculate the velocity of skater A after pushing.

----- [2]

- 14 A student researches potential and kinetic energy. She looks at some data from experiments with motion trolleys and energy.

The trolleys are stationary at the top of the ramp and have a gravitational potential energy of 8 J.

Each trolley has a mass of 1 kg.

Look at the research data on the trolleys.

Trolley	Velocity at the bottom of the ramp (m/s)
W	3
X	4
Y	5
Z	6

The student thinks the data is wrong.

Use the data and your understanding of energy transfer to justify why trolley W has the most likely velocity and why X, Y and Z do not.

[4]

15 A car runs out of fuel 80 m from a garage.

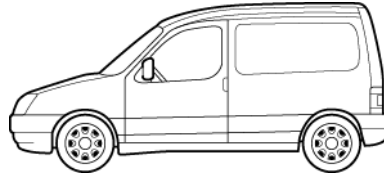
A passenger pushes the car to the garage with a constant force of 220 N.

Calculate the work done in pushing the car to the garage.

answer ----- J

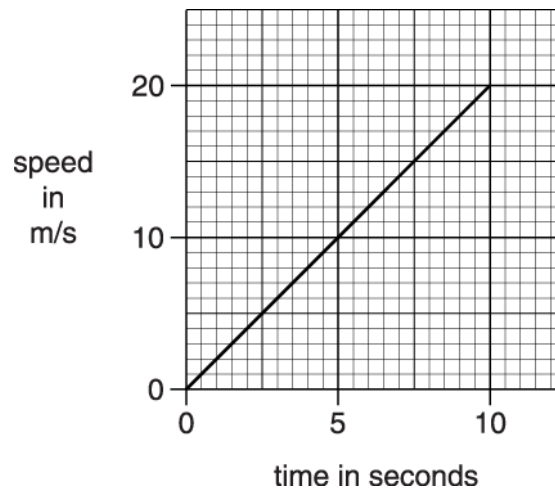
[2]

16(a) Emily has a van.



The van has a mass of 1400 kg.

Look at the speed–time graph for the first 10 seconds of her journey in the van.



Calculate the acceleration of the van in the first 10 seconds.

Choose your answer from:

0.5 m/s²

2 m/s²

10 m/s²

100 m/s²

200 m/s²

answer _____ m/s²

[1]

(b) The accelerating force on the van is 2800 N.

Use this force and information from the graph to calculate the work done to accelerate the van in the first 10 seconds.

answer ----- J

[3]

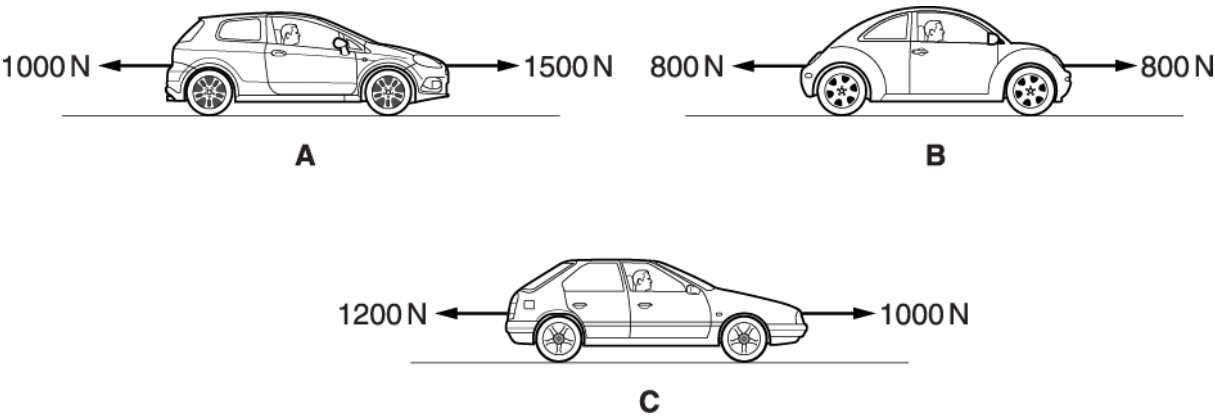
(c) The van now travels at a steady speed of 20 m/s.

Use the force given in (b) to calculate the power developed by the engine when travelling at this speed.

answer ----- W

[2]

17(a) Look at the drawings showing forces acting on cars A, B and C travelling from left to right.



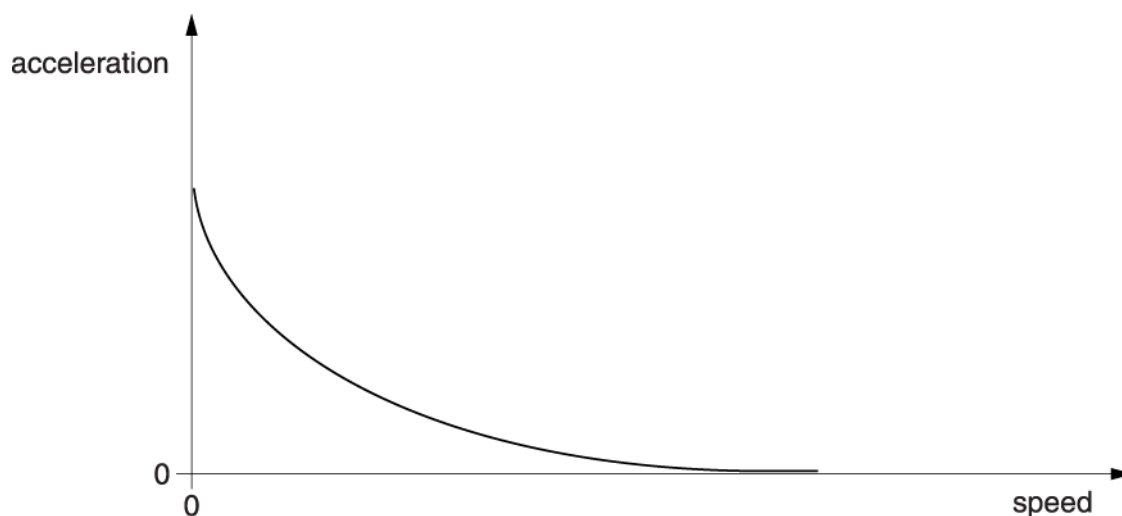
Put a tick (✓) in the correct box in the table below to show if each car is moving at a steady speed, increasing speed or decreasing speed.

	steady speed	increasing speed	decreasing speed
A			
B			
C			

[2]

- (b) Amy accelerates her remote controlled car on a flat, straight test track with a constant driving force.

Look at the acceleration–speed graph for the car.



The acceleration changes as the speed changes.

- (i) Describe how the acceleration changes as the speed increases.

----- [1]

- (ii) Explain how the forces on the car cause the acceleration to change in this way.

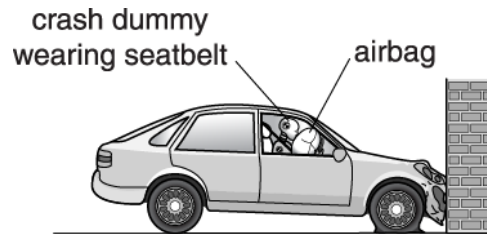
----- [2]

18 Scientists check the safety of cars by doing crash tests with crash dummies.

They use sensors to make measurements.

They put the sensors in the car and on the crash dummy.

Look at the diagram of a car crashing into a wall.



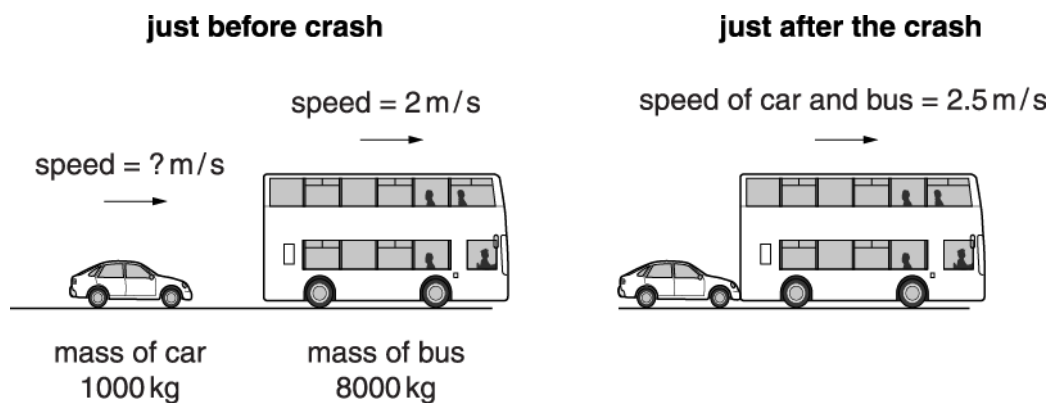
A minor accident happens outside school. The police investigate the accident.

Here are the facts:

- the speed limit outside school is 9 m/s (20 miles per hour)
- a car runs into the back of a bus
- the car and the bus move together at the same speed after the collision.

The police need to find out if the car was breaking the speed limit.

Look at the information in the diagrams.



Use a calculation to find the speed of the car just before the accident.

Car's speed before crash = _____ m/s

Did the car break the speed limit? _____.

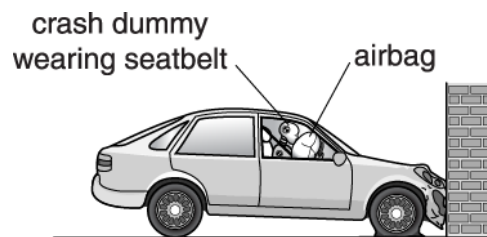
[3]

19(a) Scientists check the safety of cars by doing crash tests with crash dummies.

They use sensors to make measurements.

They put the sensors in the car and on the crash dummy.

Look at the diagram of a car crashing into a wall.



The crash dummy wears a seatbelt.

Just after the crash the dummy moves forward. A force then acts on the dummy.

What produces this force and what does the force do to the dummy's motion?

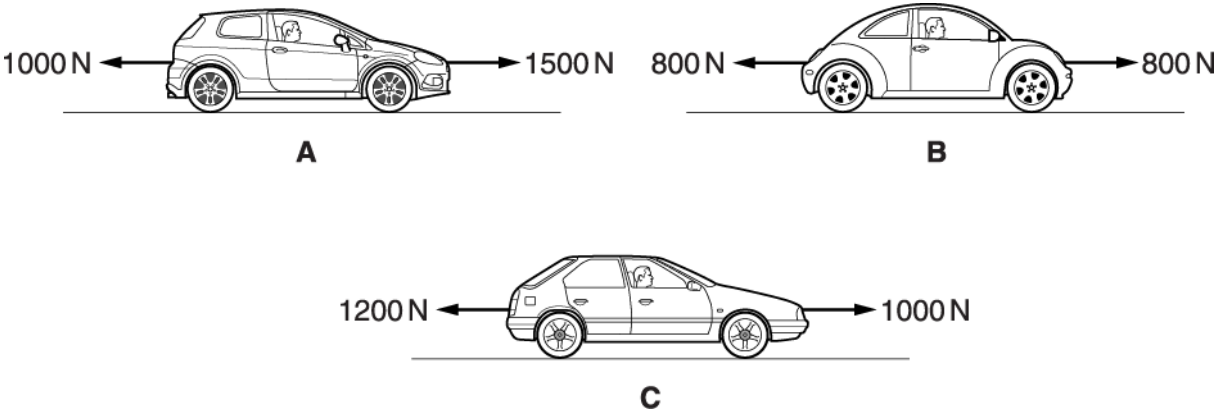
[1]

(b) On impact the airbag quickly inflates with gas.

Explain how the gas particles produce a pressure to inflate the airbag.

----- [2]

20 Look at the drawings showing forces acting on cars A, B and C travelling from left to right.



Put a tick (✓) in the correct box in the table below to show if each car is moving at a steady speed, increasing speed or decreasing speed.

	steady speed	increasing speed	decreasing speed
A			
B			
C			

[2]

21 Air resistance reduces the speed of cars.

Suggest ways of reducing air resistance.

[2]

22(a) Adrian runs a 100 m race.

It takes him 12 seconds to run the race.

Calculate his average speed.

Give your answer to two significant figures.

answer _____ m/s

[2]

(b) At the start of the race it takes him 4 seconds to increase his speed by 10 m/s.

(i) Calculate his average acceleration.

answer ----- units -----

[3]

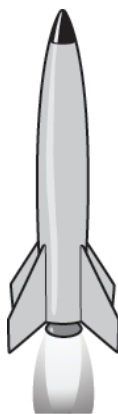
(ii) Adrian has a mass of 60 kg.

Calculate the average force needed at the start of the race to cause this acceleration.

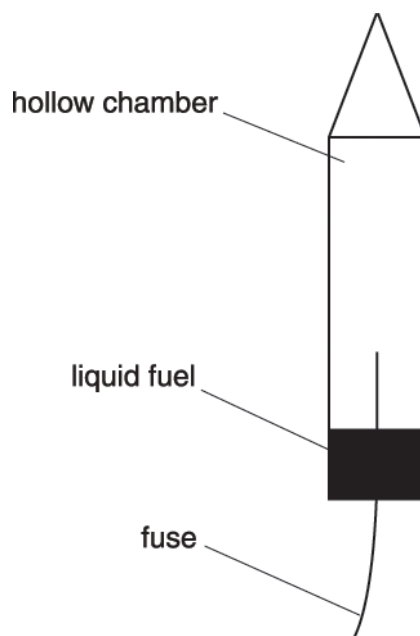
answer ----- N

[2]

23(a) Rockets use hot gases to make them move.



Look at the diagram of a simple rocket.



Denise lights the fuse of the rocket. The fuel in the rocket ignites.

A very fast chemical reaction takes place which creates a large amount of hot gas.

Explain what happens to the hot gas and how this makes the rocket move.

[2]

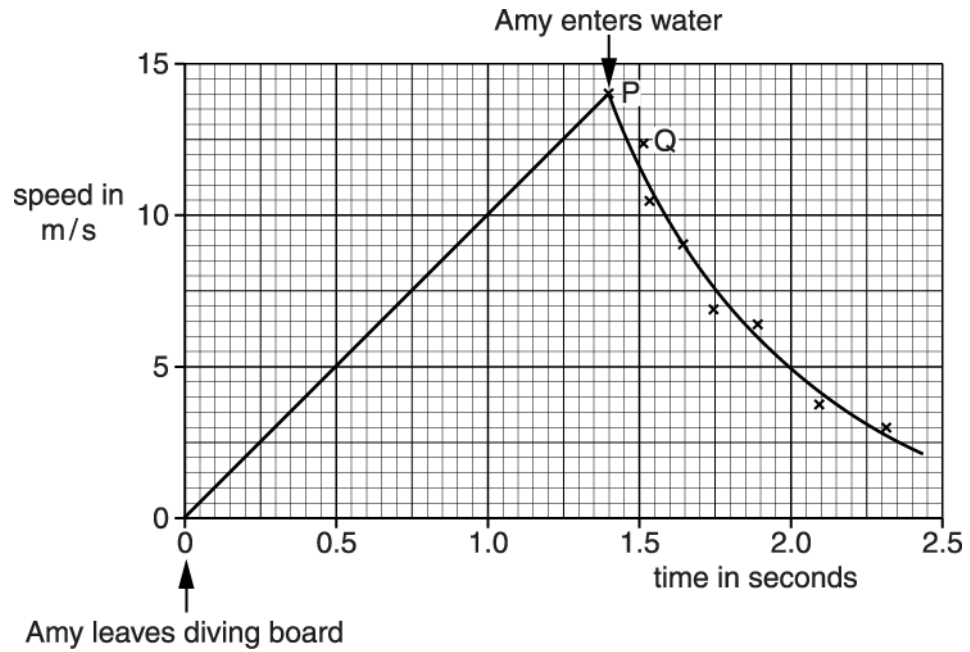
(b) Denise re-uses the rocket. This time she puts in more fuel than before.

Suggest what happens to the acceleration of the rocket.

Explain your answer.

[2]

- 24 Amy dives from the high diving board at a swimming pool.
Look at the graph of her motion.



- (i) John thinks that he can find Amy's deceleration just after she enters the water by using points P and Q on the graph.
Elaine thinks it is better to find Amy's deceleration just after she enters the water by using the gradient of the graph at point P.
Explain why Elaine's method is better than John's to find the deceleration.

[2]

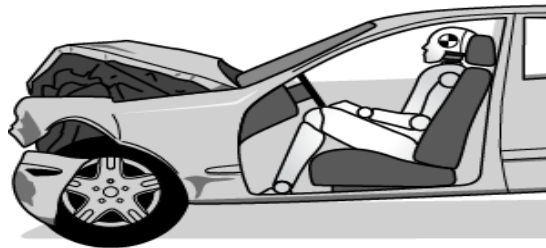
- (ii) Amy has a mass of 60 kg.
Amy's deceleration as she enters the water is 20 m/s^2 .
Calculate the decelerating force on Amy just as she enters the water.

25 Scientists investigate the safety of seat belts.

They use two cars. Each car has an identical dummy in the driver's seat.

Both cars are crashed, at the same speed, into identical barriers.

In one car, the dummy is wearing a seat belt. In the other car, the dummy is not wearing a seat belt and hits the windscreen in the collision.



Look at the results.

	Crash with seat belt	Crash without seat belt
Mass of dummy	60 kg	60 kg
Distance travelled by dummy whilst stopping	60 cm after seat belt locked	20 cm after hitting windscreen
Time taken for dummy to stop moving	0.08 sec	0.03 sec
Deceleration	175 m / s^2	467 m / s^2
Stopping force	10500 N	

Calculate the missing data and use the information in the table to explain how seat belts reduce injury in a crash.



The quality of written communication will be assessed in your answer to this question.

[6]

26 Modern cars have many safety features.

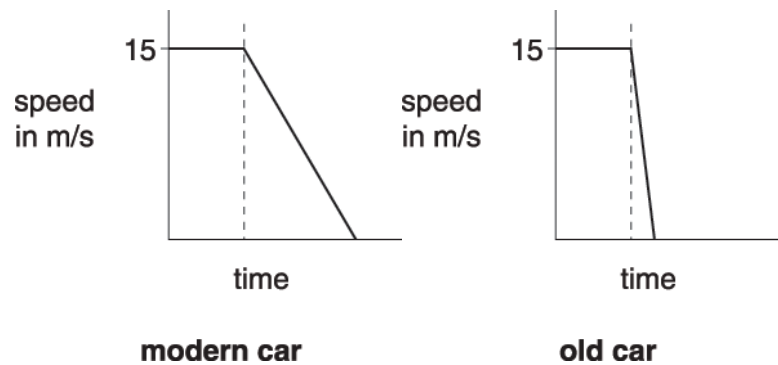
Some features protect people in a crash.

Scientists use crash dummies inside real cars to determine their safety ratings.

Look at the data from two crash tests at 15 m/s.

One is for a **modern** car.

The other is for an **old** car.



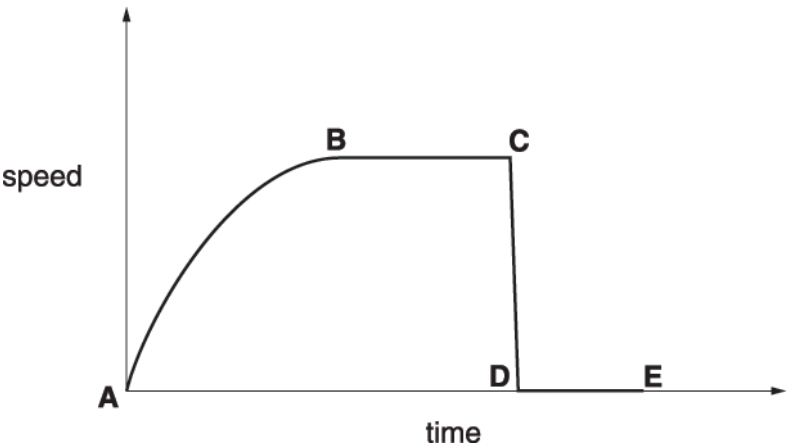
The forces on the crash dummies in the old car are much higher.

Old cars do not have crumple zones.

Use the information in the graphs to explain why crumple zones in modern cars reduce forces on crash dummies.

[3]

27(a) Look at the graph. It shows the speed of a football dropped from a high cliff.



Write down the name of the force causing the football to accelerate in part **AB** of the graph.

----- [1]

(b) Write down the name of the force acting against the movement of the football in part **AB** of the graph.

----- [1]

(c)

(i) Which part of the graph shows the football **moving** at terminal speed?

Choose from

AB BC CD DE

answer -----

[1]

(ii) Why does the football reach a terminal speed?

----- [1]

- (i) When a lift is moving upwards work is done by the lift motors.

There are 8 people in the lift. The **average** weight of each person is 600 N.

They travel a distance of 30 m upwards from the first floor.

Calculate the work done in lifting the 8 people.

----- J

[2]

- (ii) The lift now travels upwards a further 40 m with the 8 people inside.

Put a tick (✓) in the box which correctly completes the sentence about this second journey.

Compared with the first journey ...

... more work is done in the second journey.

☐

... the same amount of work is done in the second journey.

☐

... less work is done in the second journey.

☐

[1]

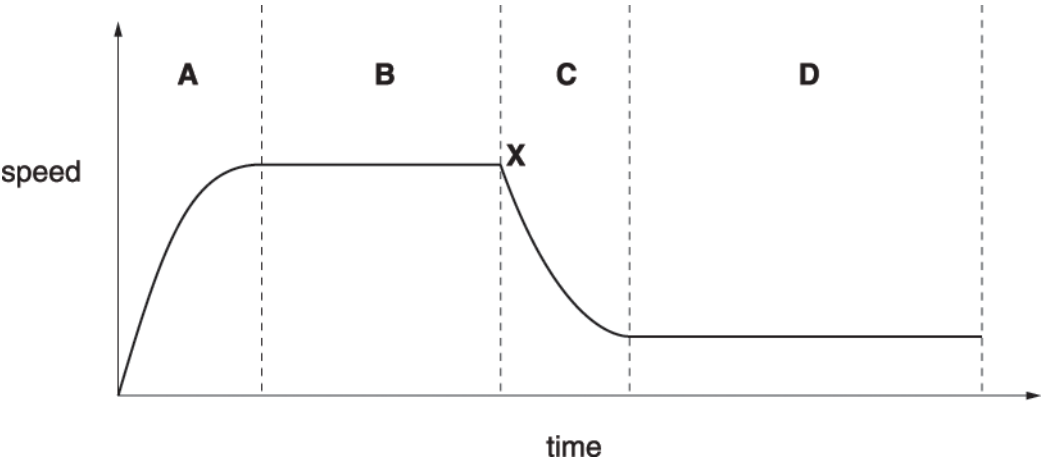
29(a) Susie is a skydiver.

Look at the graph.

It shows her speed after she has jumped from an aeroplane.

There are four sections of the graph, labelled A, B, C and D.

Susie opened her parachute at point X shown on the graph.



Write about the forces acting on Susie during her descent to explain the different speeds she travels at.

[4]

(b) Susie practises her landings by jumping from a low platform.

She is attached to straps which act like a parachute.

platform



ground



A Susie **standing still**
on platform.

B Susie is **exactly**
half way down.

C Susie is **on** the
ground.

Look at the statements about Susie's energy as she does her practice fall.

Put a tick (✓) in the box beside any correct statement and a cross (✗) beside any incorrect statement.

The first one has been done for you.

At A all of Susie's energy is GPE.

☒

Between A and B Susie gains **both** GPE and KE.

☐

Between A and B Susie gains **only** KE.

☐

At B her KE is **exactly** half her GPE at A.

☐

Just before touching the ground at C Susie has her maximum KE.

☐

On the ground at C Susie has zero KE.

☐

On the ground at C Susie has her maximum GPE.

☐

[3]

30 Scientists investigate the safety of seat belts.

They use two cars. Each car has an identical dummy in the driver's seat.

Both cars are crashed, at the same speed, into identical barriers.

In one car, the dummy is wearing a seat belt. In the other car, the dummy is not wearing a seat belt and hits the windscreen in the collision.



Look at the results.

	Crash with seat belt	Crash without seat belt
--	----------------------	-------------------------

Mass of dummy	60 kg	60 kg
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Deceleration	175 m / s^2	467 m / s^2
Stopping force	10500 N	

Calculate the missing data and use the information in the table to explain how seat belts reduce injury in a crash.



The quality of written communication will be assessed in your answer to this question.

[6]

31 Alice drops a pebble from the top of a high cliff.

(i) The mass of the pebble is 0.30 kg.

Calculate the momentum of the pebble when it is falling at a speed of 4.0 m / s.

answer ----- kg m / s

[2]

(ii) It reaches a terminal speed before it hits the ground.

Explain why it travels at a terminal speed.

[2]

(iii) An astronaut does the same experiment as Alice, on the Moon.

In this experiment, the pebble falls, but does not reach a terminal speed.

Suggest why.

[1]

32(a) Haroon completes a project about work done.

Look at his project.

Work Done

Work is done when you lift weights, climb stairs, pull a sledge or lean against a wall.

Work done depends on the distance moved and the time it takes to move the object.

The unit for work done is the joule.

Energy is never transferred when work is done.

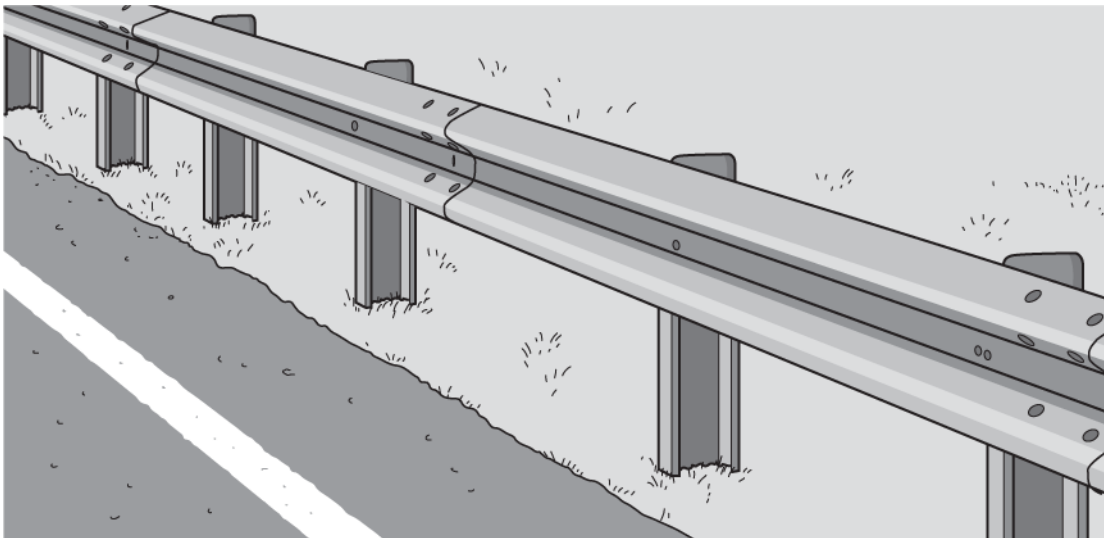
There are three mistakes in Haroon’s homework.

Write down the **three** mistakes.

[3]

(b) Choose **one** of the mistakes and write down the correct information.

[1]



Explain how a crash barrier can reduce the force on the passengers in a car when the car crashes.

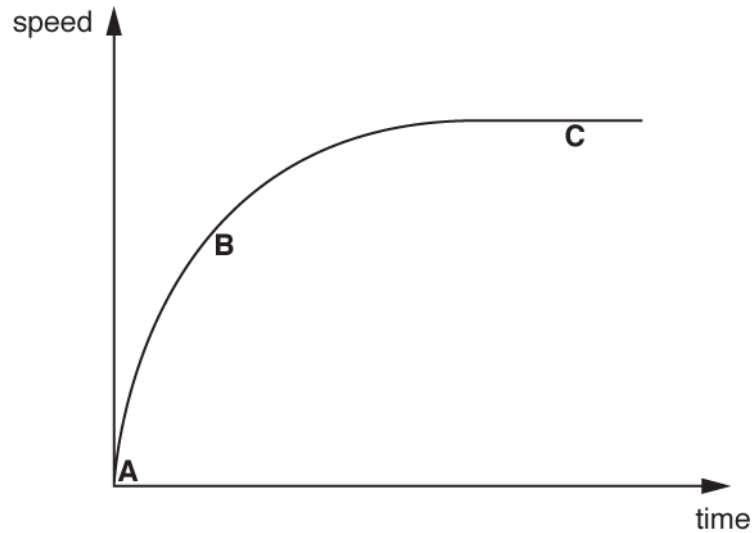
[3]

34 Mia investigates terminal velocity.

She drops an object and looks at its motion as it falls through the air.

Mia plots a graph of the speed of the object against time as it falls through the air.

Look at the graph.



Describe the motion of the object from being dropped until it reaches terminal velocity.

Include ideas about forces and acceleration in your answer.



The quality of written communication will be assessed in your answer to this question.

[6]

35 The car stops accelerating when it reaches the final velocity of 11 m / s.



The car crashes into a tree.

(i) Describe what happens to the motion of the car **and** the tree during the collision.

----- [1]

(ii) What type of forces act on the car and the tree during the collision?

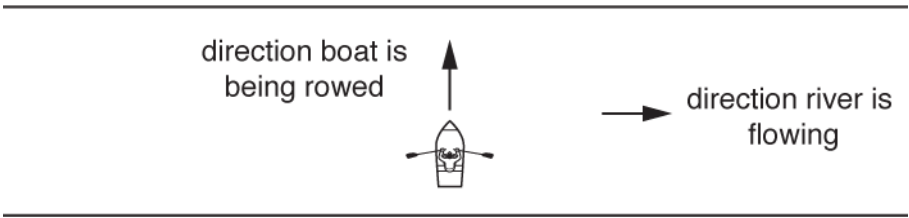
Choose from

- forces are equal and in the same direction
- forces are equal and in opposite directions
- forces are unequal and in the same direction
- forces are unequal and in opposite directions

answer ----- [1]

36 A boat is rowed across a river at 4 m/s.

The river flows at 3 m/s.



The velocities are at right angles to each other.

Use a scale diagram to find the **size and direction** of the resultant velocity.

[3]

37 The maker of a car wants to increase the acceleration of the car.

Suggest **one** factor they could change to **increase** the acceleration of the car.

[1]

38 An object moved 20 cm with a force of 20 N.

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

Which is the correct calculation of work done?

A 0.4 J

B 4.0 J

C 40 J

D 400 J

Your answer

[1]

39(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 ÷ Time taken

Answer = ... m/s² [3]

40 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

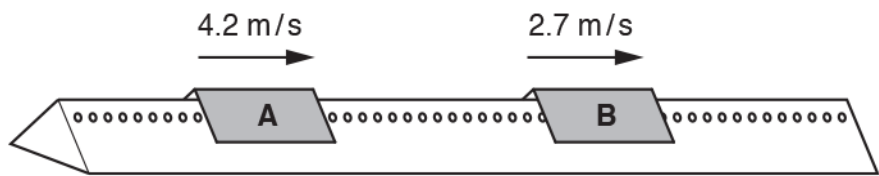
[1]

41(a) A student investigates collisions of trolleys on a horizontal airtrack.

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

[2]

(b) Trolley A has a mass of 2 kg. Trolley B has a mass of 2.5 kg.



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

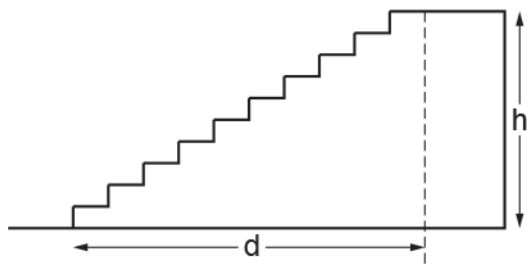
Trolley A = ... kg m/s
Trolley B = ... kg m/s
[3]

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

Record your answer to 2 significant figures.

Answer = ... m/s [3]

42 A student of weight W runs up a flight of stairs.



She moves a distance d metres horizontally and h metres vertically.

What is the work done against gravity running up the stairs?

- A $W \times d$
- B $W \times h$
- C $(W \times d) + (W \times h)$
- D $W \times \frac{h}{d}$

Your answer

[1]

43 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.

Describe the motion of the stone as it falls.

Assume it does not reach terminal velocity.

Use a free body diagram to help you.

[4]

44 Look at the information about different electric motors.

Electric motor	Energy input per hour (J)	Useful energy output per hour (J)	Energy 'wasted' per hour (J)
A	72 000	60 000	
B	54 000	36 000	
C	18 000		3 000
D		48 000	12 000
E	54 000	48 000	

(i) Calculate the energy input per hour in J for electric motor D.

Answer = ----- J [2]

(ii) Which electric motor has the **lowest** 'wasted' energy in one hour?

----- [1]

(iii) Which electric motor has the **highest** 'wasted' energy in one hour?

----- [1]

(iv) Describe how energy is 'wasted' in an electric motor.

----- [1]

(v) Suggest how this 'wasted' energy can be reduced in an electric motor.

----- [1]

45 This question is about force, mass and acceleration.

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 [2]

46 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

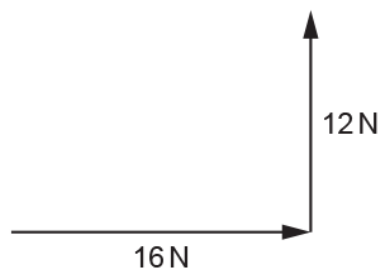
C 42 kg m / s

D 80 kg m / s

Your answer

[1]

47 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

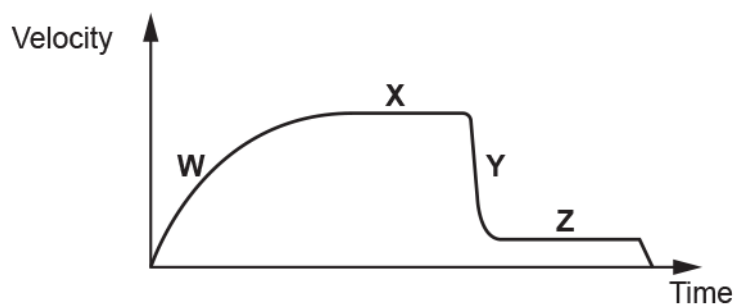
D 24 N

Your answer

[1]

48 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]

49 A student puts a small load on a spring. It is in equilibrium.

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

[3]

50 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

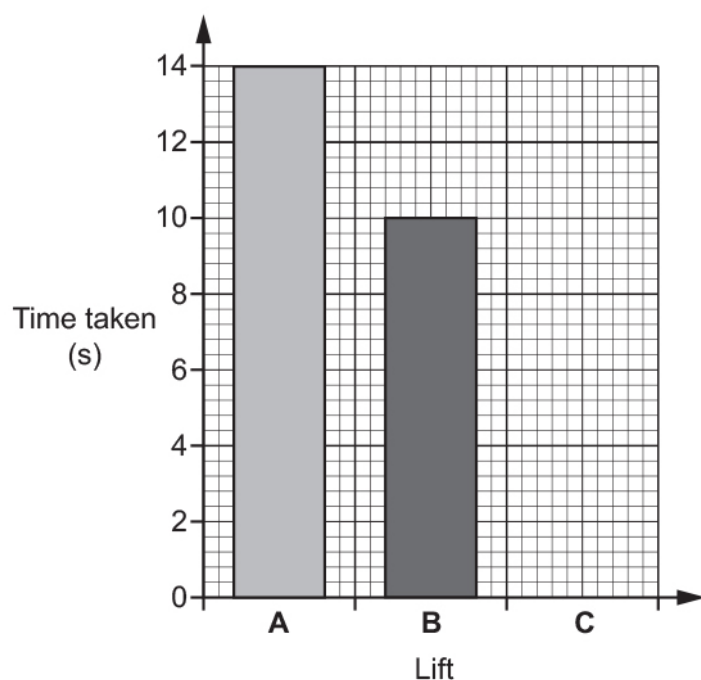
[1]

51(a) A tall building needs a lift to move people from one floor to another.

The builder has a choice of three different lifts.

Each lift takes a different amount of time to move between the two floors.

Look at a bar chart of the time taken for each lift.



(i) Lift C takes 12 s to move between the two floors.

Draw a bar for lift C on the bar chart.

[1]

(ii) Calculate the **mean** time of the three lift journeys.

Mean = ... s [2]

(iii) Explain which lift uses the most power.

----- [2]

(b)

- (i) One lift uses 50 000 J for a 12 s journey.

Calculate the power of the lift.

Give your answer to 1 decimal place.

Power = ... W [4]

- (ii) When the lift is broken the stairs are used.

Calculate the work done when a 750 N person climbs a distance of 4 m.

Work done = ... J [3]

52 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]

53 A runner has a mass of 80 kg and moves at a speed of 5 m / s.

Calculate the kinetic energy of the runner.

Use the equation: kinetic energy = $0.5 \times \text{mass} \times (\text{speed})^2$

- A 200 J
- B 1000 J
- C 2000 J
- D 40 000 J

Your answer

[1]

54 A student uses 2250 J of energy climbing up steps. It takes the student 15 seconds to climb the steps.

Calculate the power of the student.

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

- A 15 W
- B 150 W
- C 9000 W
- D 33750 W

Your answer

[1]

55 Which of the pairs are contact forces?

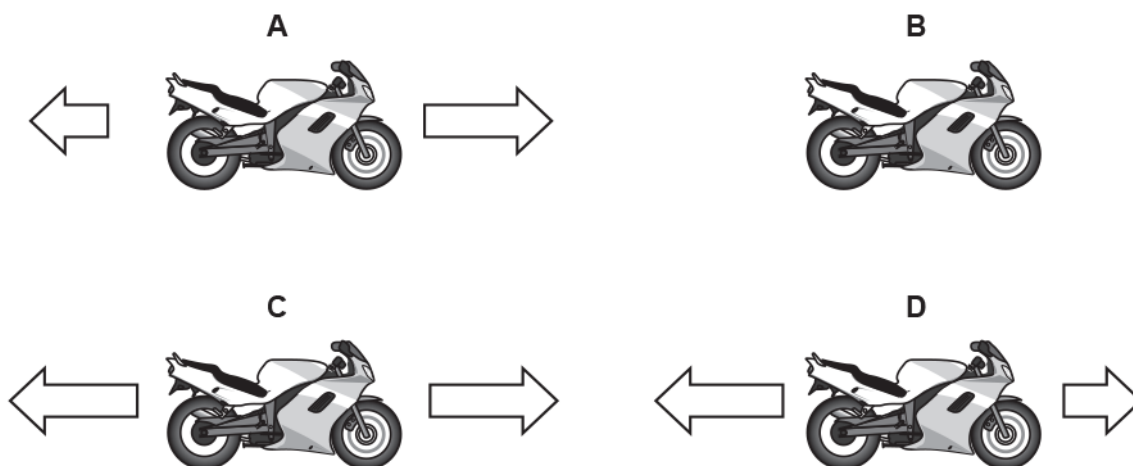
- A Air resistance and gravity
- B Friction and gravity
- C Magnetism and normal contact force
- D Normal contact force and air resistance

Your answer

[1]

56 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]

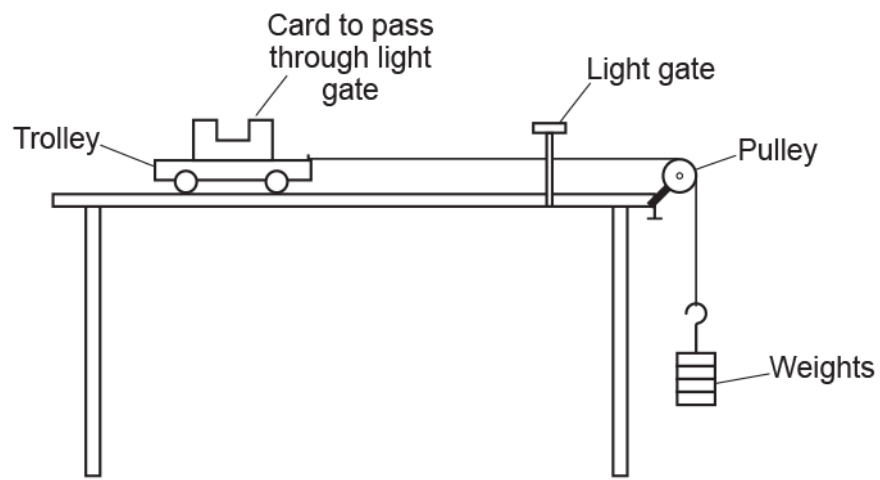
57 Which statement is an example of Newton's third law?

- 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]

58 A student investigates the acceleration of a trolley.



The trolley is released from a fixed position and accelerates.

- (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]

59 Four cars of the same mass are shown here.

A



B



C



D



Which car will accelerate?

Your answer

[1]

60(a) The mass of a toy car is 5 kg and it has an acceleration of 4 m / s².

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

Use the equation: force = mass × acceleration

Force = ... N [2]

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

[1]

(b)

- (i) A 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 (i).

Power = ... W [3]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1			D	1	
			Total	1	
2			C	1	
			Total	1	
3	a		C (1) The product of force $\times$ distance is the most / AW (1)	2	
	b		A and B (1)	1	Both needed for this mark Any order
	c		Reduce random errors / identify anomalies / AW (1) Allows a mean / average to be calculated (1)	2	
	d		Power = energy / time (1) Conversion of time into seconds (1) $(120 \times 12)/30$ (1) 48 (W) (1)	4	ALLOW ECF from (a)
			Total	9	
4		i	Use of graph to calculate time / $t = 2.25 - 0.75$ / $t = 1.5$ (1) Substitution into acceleration formula: $8 / 1.5$ (1) $(-)$ 5.3 (1) m/s^2 (1)	4	
		ii	$5\,000 \times 6$ (1) 30 000 (J)	2	
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
5			Re-arrange and substitute into $WD = F \times D$: 217 000 / 6 500 (1) 33 (m) (1)	2	ALLOW 33.4 (m)
			Total	2	
6			Re-arrange and substitute into $WD = F \times D$: 217 000 / 6 500 (1) 33.4 (m) (1)	2	
			Total	2	
7		i	Velocity is speed in a given / known direction / straight line (1) Direction continuously changing (1)	2	ALLOW higher level answers e.g. changing velocity denotes acceleration (1) Always accelerating to the centre (1)
		ii	Higher orbit (1) Less (force of) gravity / acceleration (1)	2	
			Total	4	
8			Lorry has more KE than a car at the same velocity (1) More absorption of energy by larger brake discs (1) Higher rate of dissipation of energy to surrounding air (1) Brakes less likely to overheat (1)	4	
			Total	4	
9			A	1	
			Total	1	
10			C	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
11			B	1	
			Total	1	
12	a	i	Change mass / Force applied (1) Release glider and idea of measuring acceleration with appropriate apparatus to do this stated (e.g. Light gates / datalogger) (1) Check results / plot graph to see if it matches $F = ma$ formula (1)	3	e.g. $F \propto a$ or $m \propto 1/a$
		ii	4 m/s^2 (1)	1	
		iii	Any 2 from: The track is not perfectly frictionless / AW (1) Friction of the pulley (1) (Idea of) light gates incorrectly set up (1)	2	
	b		Attempt 1 at 4 newtons / 12.0 (1) Don't include it in the mean / repeat readings / repeat this reading during the experiment (1)	2	
	c		Another person / group gets similar results / AW (1)	1	
			Total	9	
13	a		The momentum at the start and at the end will be equal as long as no external forces act / AW (1)	1	
	b		$(90 \times 2) + (60 \times \text{velocity}) = 0$ (1) Velocity = (-3 m/s) (1)	2	
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
14			Idea that the KE at bottom must be equal to or less than GPE at the top (1) W: KE = 4.5J and so is possible as it is likely that some energy will be lost / AW (1) X: KE = 8J and so is possible but it will not be 100% efficient/X is unlikely as it implies no energy is lost / AW (1) Y: KE = 12.5J and Z: KE = 18J and so not possible (1)	4	
			Total	4	
15			17600 J (2) but If incorrect 220 × 80 (1)	2	<u>Examiner's Comments</u> Candidates correctly calculated the work done as 17600J.
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
16	a		$2 \text{ (m/s}^2\text{)}$ [1]	1	NOT 2m/s Examiner's Comments This motion, acceleration and power question gave the opportunity for candidates to give some good answers. Most correctly calculated the acceleration from the graph.
	b		280000 (J) [3] but if incorrect 2800×100 [2] but if incorrect distance = 100(m) OR $2800 \times \text{distance}$ OR evidence of using work done = force x distance [1]	3	Eg 2800×200 or 560000 [1] Examiner's Comments This was generally poorly done as many did not obtain the correct distance from graph and simply read off a speed. Most candidates identified the correct formula (work done = force x distance) to use but were unable to calculate an appropriate distance to gain one mark for a reasonable substitution into the correct formula.
	c		56000 (W) [2] but if answer incorrect 2800×20 [1]	2	The power was correctly calculated by many.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance												
17	a		<table><tr><td>A</td><td></td><td>✓</td><td></td></tr><tr><td>B</td><td>✓</td><td></td><td></td></tr><tr><td>C</td><td></td><td></td><td>✓</td></tr></table> [2]	A		✓		B	✓			C			✓	2	all correct [2] any 1 correct [1] ignore any line with more than one tick Examiner's Comments This question from module P3 was about speed and force. This part of the question was common with the foundation paper (B751-01). Most scored 2 marks with a correct table.
A		✓															
B	✓																
C			✓														
	b	i	acceleration decreases (as speed increases) / non uniform change in acceleration / acceleration drops more quickly at the start [1]	1	Examiner's Comments They generally could describe the relationship but often expressed it unclearly e.g. As acceleration increases the speed decreases.												
		ii	resistive force / friction / air resistance / drag increases (as speed increases) [1]	2	Allow forces balance [1] Examiner's Comments Many did not realise that drag or air resistance was involved. Better answers stated that the drag increased with speed and the (driving) force and drag force would balance. It was unusual however, for answers to get full marks here.												
		ii	idea that resultant force decreases / the driving force equals the resistive force [1]														
			Total	5													

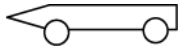
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
18			EITHER 6.5 (m/s) AND this is less than 9m/s OR 6.5 (m/s) AND no [3] OR it is 2.5 (m/s) below the speed limit [3] But if incorrect or incomplete then: $1000 \times V + 8000 \times 2 = 9000 \times 2.5$ scores [2] But if incorrect or incomplete then: EITHER (momentum after): 9000×2.5 or 22500 [1] OR (momentum before): $1000 \times V + 8000 \times 2$ [1]	3	Speed limit mark is only available with a correct value Allow 6.5 and yes / breaks speed limit scores [2] Allow 6.5 and no comment given [2] qualitative idea the momentum is conserved e.g. no momentum is lost or gained / momentum before = momentum after [1] Examiner's Comments About a third of candidates got the full calculation correct – '6.5 m/s and no'. A few got the idea that momentum was conserved (often by stating the equation). Others misused the equations of motion to gain various answers. Sometimes the equation would be populated with the correct substitution ($1000 \times V + 8000 \times 2 = 9000 \times 2.5$) without the final calculation of V. This scored [2] marks.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance												
19	a		idea that the force is caused by the seat belt slowing the dummy down [1]	1	allow air bag or steering wheel or dash board or windscreen stops slows down the dummy [1] Examiner's Comments This about the action of safety features in a car was not well answered across the ability range Very few recognised that the force applied by the seat belt or air bag slowed he passenger down. Many answers were poorly described in terms of the dummy jolting forwards.												
	b		particles move/ AW or spread out [1] particles hit inside (surface) of airbag / AW [1]	2	allow moving particles push the bag outwards [2] Examiner's Comments This about the action of safety features in a car was not well answered across the ability range Most candidates had little idea about the kinetic theory of gases when applied to an air bag. This area was very unfamiliar to almost all candidates.												
			Total	3													
20			<table><tr><td>A</td><td></td><td>✓</td><td></td></tr><tr><td>B</td><td>✓</td><td></td><td></td></tr><tr><td>C</td><td></td><td></td><td>✓</td></tr></table> [2]	A		✓		B	✓			C			✓	2	all correct [2] any 1 correct [1] ignore any line with more than one tick Examiner's Comments Most candidates completed the table correctly.
A		✓															
B	✓																
C			✓														
			Total	2													

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
21			decrease speed / travel at a lower speed [1] make the car (more) streamlined /aerodynamic [1]	2	allow diagram streamlining e.g  [1] Allow examples eg close the windows /remove roof-rack (1) <u>Examiner's Comments</u> Candidates were asked to suggest how air resistance could be reduced for cars. The majority of candidates gave an answer of streamlining (or a description) for one mark, but hardly any candidates stated that reducing the speed reduced air resistance.
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
22	a		8.3 (m/s) [2] but if incorrect $\frac{100}{12} \text{ [1]}$	2	allow 8.333 (m/s) [1] <u>Examiner's Comments</u> Most candidate calculated average speed correctly to two significant figures. Very few candidates did not follow the instruction and used more than two figures.
	b	i	2.5 [2] but if incorrect $\frac{10}{4} \text{ [1]}$ m/s² [1]	3	allow m/s/s [1] <u>Examiner's Comments</u> Whilst the majority of candidates correctly calculated the acceleration as 2.5 few gave the correct units of ms⁻².
		ii	150 (N) [2] but if incorrect 60 x 2.5 [1]	2	allow ecf answer to b x 60 correctly calculated [2] allow ecf answer to b x 60 uncalculated [1] <u>Examiner's Comments</u> Candidates had no problem with calculating the force as 150N.
			Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
23	a		(some hot) gas escapes backwards / downwards / AW (1) (hot other gas) pushes or forces the rocket forwards / hot gas creates thrust or lift / AW (1)	2	second marking point must give an indication of a force or reaction (on the rocket) allow gas released out of the bottom of the rocket / gas leaves the bottom of the rocket ignore just gases are released allow descriptions e.g. force pushing gas particles backwards equals force pushing rocket forwards (2) allow idea of equal and opposite reactions (2) Examiner's Comments About half of candidates scored on this question. Many candidates described the buildup of pressure inside the rocket and about collisions between energetic particles and the walls of the rocket. Candidates often scored from the description of the force acting on the rocket. One unexpected misconception from a significant minority was that the rocket was lifted due to the reduced density of the gas inside - as a hot air balloon.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b		idea of more acceleration (no mark) and any 2 from more gas (or fuel) (1) (so) higher temperature / AW (1) (so) more pressure / AW (1) (so) more force (1) or idea of less acceleration (no mark) more fuel (to move) (1) BUT more (gas or) fuel so more mass or inertia (to move) (2)	2	ignore references to speed increasing or top speed being higher ignore more heat allow greater mass per second / gas escapes faster allow as additional marking points higher level explanations in terms of kinetic / particulate theory allow heavier or more mass (so less acceleration) allow acceleration increases as mass is lost (2) if no marks awarded allow rocket travels for longer or travels further (1) Examiner's Comments Most candidates scored on this question and focused on increased acceleration due to the increased pressure of hot gases but few went on to link this to an acceptable consequence e.g. more force. A significant number realised that the rocket would be heavier and therefore acceleration would be less. When candidates did not achieve any marks it was often due to disregarding the question and writing about the speed of the rocket.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
24		i	instantaneous deceleration at point P is (more representative of) when diver enters water [1] idea of ignoring anomalous results / point Q is not on the line / (1) Elaine's method covers more data / more appropriate data / AW [1] (gradient gives a more) accurate result (1)	2	allow Q is (some time) after diver enters water [1] allow deceleration / acceleration changes (after P) [1] eg point Q is anomalous [1] <u>Examiner's Comments</u> This question was set in the context of diving into water from a diving board. In part (i), there were a few good answers described in terms of Elaine and these discriminated well. Usually the idea of more data or gradient showing the real or more accurate deceleration gave candidates a route into successful answers. It was a challenging question, which gave a good range of responses.
		ii	1200 (N) (1)	1	Allow ? 1200 (N) [1] <u>Examiner's Comments</u> This question was set in the context of diving into water from a diving board. In part (ii), most gave 1200N as the correctly calculated answer.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
25			(Level 3) calculates the force AND Gives a detailed linked answer in terms of forces or acceleration Quality of written communication does not impede communication of the science at this level (5 – 6 marks) (Level 2) calculates the force AND Gives a simplistic answer in terms of forces or acceleration Quality of written communication partly impedes communication of the science at this level (3 – 4 marks) (Level 1) calculates the force OR Gives a simplistic answer in terms of forces or acceleration Quality of written communication impedes communication of the science at this level (1 – 2 marks) (Level 0) Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted up to grade C Indicative scientific points at level 3 may include: The calculation from level 1 and 2 and a link between change in distance or stopping time to acceleration or force. • increases distance travelled by dummy so this reduces force / acceleration of dummy • increase stopping time of dummy so this reduces force / acceleration of dummy • reduced acceleration so reduced force • reduces the rate of change of momentum Indicative scientific points at level 1 and 2 may include: • force = 28020 or 28000 N seatbelts • hold dummy in seat / stop dummy hitting windscreen • stretches • reduce forces on dummy • increase stopping time of dummy • decrease acceleration of dummy Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This six mark extended prose level of response question was about seatbelts. Most calculated the force correctly (level 1 – [2] marks) and described the simple action of the seatbelt (eg. 'stops driver hitting windscreen). Better answers at level 3 needed to link the longer (stopping) distance or (stopping) time to the lower acceleration or forces.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
26			maximum of three marks from: more collision time (1) more collision distance (1) less acceleration (1) same quantity of energy absorbed / same change of momentum for each car (1)	3	allow ora for an old car longer collision (1) allow areas under graph correctly compared (1) allow higher level answers in terms of force = change in momentum / time: Eg. force = $\frac{\text{change in momentum}}{\text{time}}$ (1) but stating and using the equation can score (3): Eg. force = $\frac{\text{change in momentum}}{\text{time}}$ (1) so a longer collision time (1) means a smaller rate of change of momentum (1) Examiner's Comments Most got the idea that the collision took a longer time [1]. Rather fewer realised the acceleration was reduced. Some good answers used the equation 'force = change in momentum/time' [1], referred to a longer time [1] and even mentioned that the momentum change was the same [1]. Many answers focussed on some lower demand points: crumple zones absorb the kinetic energy (or just the energy). A common misconception was that crumple zones absorb the force or impact of the collision.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
27	a		weight / gravity (1)	1	allow gravitational force but not gravitational potential force Examiner's Comments In the region of half of the entry were able to decide what was happening to the ball's speed from the graph. Those that did could therefore identify the forces required in part AB of the graph. Some candidates, on the right lines, reversed the correct forces in their answers. Poor answers gave energy (kinetic / potential) for forces.
	b		drag / friction / air resistance (1)	1	ignore upthrust / resistance on its own / wind
	c	i	BC (1)	1	if answer line is blank allow correct answer ticked circled or underlined Examiner's Comments BC was usually correctly chosen, with CD being the frequent incorrect selection. AB and DE were offered as answers less often.
		ii	forces are / become balanced (1)	1	allow higher level answers eg weight and drag are equal eg gravity and air resistance are equal or balanced eg drag increases to the same level as weight Examiner's Comments The concept of balanced forces (or named forces being equal) is difficult at Foundation level. Often answers restated the idea of constant speed or that the football could not travel any faster; others contained descriptions about gravity and energy 'balancing out'. Very few correct answers were given.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance						
28		i	144000 (2) but if answer is incorrect $600 \times 8 \times 30$ (1)	2	 allow $600 \times 30 = 18000$ or force $\times$ distance =18000 Examiner's Comments Approximately 80% of candidates gained credit in the calculation, although a significant number failed to appreciate the importance of '8 people' and gained only one mark for correctly computing $600 \times 30 = 18000$.						
		ii	<table border="1"><tr><td>more work is done in the second journey</td><td>✓</td></tr><tr><td>the same amount of work is done in the second journey</td><td></td></tr><tr><td>less work is done in the second journey</td><td></td></tr></table> (1)	more work is done in the second journey	✓	the same amount of work is done in the second journey		less work is done in the second journey		1	 Examiner's Comments A sizeable majority correctly identified that more work would be done in the second journey.
more work is done in the second journey	✓										
the same amount of work is done in the second journey											
less work is done in the second journey											
			Total	3							

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
29	a		A – (acceleration section) acceleration because weight is greater than drag (1) OR acceleration reduces because drag increases (1) B – (terminal speed section) terminal speed because weight = drag (1) OR forces are equal and opposite/balanced (1) C – (deceleration section) decelerating as drag increases (greatly) (1) OR decelerating as drag now greater than weight (1) D – ((lower) terminal speed section) drag = weight (1) OR forces are equal and opposite/balanced (1)	4	for max marks (4) the links must be there on all four points e.g. part A – acceleration because weight is greater than drag (1) without links max (2) for correctly describing the motion OR the forces in the 4 sections without links max (1) for correctly describing the motion OR the forces in 2 or 3 sections ignore gravity (rather than weight) ignore upthrust ignore GPE and KE allow air resistance / friction (rather than drag) allow for terminal speed – steady / constant speed allow for acceleration – increasing speed allow for deceleration – decreasing speed allow negative acceleration (for deceleration) Three links plus one description scores 3 Two links and two descriptions scores 3 Two links and one description scores 2 One link and two or three descriptions scores 2 One link and one description scores 1 The links and the descriptions must be from different sections. Examiner's Comments This part effectively asked candidates to describe and explain the parts of the fall. For full marks each section needed to be described correctly and explained, e.g. part A shows acceleration and the weight is greater than the drag [1]. Some only referred to the descriptions, e.g. A is accelerating and B is terminal velocity [1]. Many answers fell short in their

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Question			Answer/Indicative content	Marks	Guidance														
					descriptions by using vague terms such as 'gravity' for weight or 'upthrust' for drag.														
	b		<table><tr><td>At A all of Susie's energy is GPE.</td><td>(✓)</td></tr><tr><td>Between A and B Susie gains both GPE and KE.</td><td>✗</td></tr><tr><td>Between A and B Susie gains only KE.</td><td>✓</td></tr><tr><td>At B her KE is exactly half her GPE at A.</td><td>✗</td></tr><tr><td>Just before touching the ground at C Susie has her maximum KE.</td><td>✓</td></tr><tr><td>On the ground at C Susie has zero KE.</td><td>✓</td></tr><tr><td>On the ground at C Susie has her maximum GPE.</td><td>✗</td></tr></table>	At A all of Susie's energy is GPE.	(✓)	Between A and B Susie gains both GPE and KE.	✗	Between A and B Susie gains only KE.	✓	At B her KE is exactly half her GPE at A .	✗	Just before touching the ground at C Susie has her maximum KE.	✓	On the ground at C Susie has zero KE.	✓	On the ground at C Susie has her maximum GPE.	✗	3	Use marking tool on scoris to identify the crosses all 6 correct (3) 4 or 5 correct (2) 2 or 3 correct (1) only 1 correct (0) ignore blank boxes Examiner's Comments Although this was an objective question it remained high demand. 10% gained all marks here. Some candidates ticked but did not cross in the boxes. Blank boxes were ignored by examiners. Most candidates gained [1] or [2] marks here.
At A all of Susie's energy is GPE.	(✓)																		
Between A and B Susie gains both GPE and KE.	✗																		
Between A and B Susie gains only KE.	✓																		
At B her KE is exactly half her GPE at A .	✗																		
Just before touching the ground at C Susie has her maximum KE.	✓																		
On the ground at C Susie has zero KE.	✓																		
On the ground at C Susie has her maximum GPE.	✗																		
			Total	7															

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
30		[Level 3] calculates the force AND Gives a detailed linked answer in terms of forces or acceleration Quality of written communication does not impede communication of the science at this level (5 – 6 marks) [Level 2] calculates the force AND Gives a simplistic answer in terms of forces or acceleration Quality of written communication partly impedes communication of the science at this level (3 – 4 marks) [Level 1] calculates the force OR Gives a simplistic answer in terms of forces or acceleration Quality of written communication impedes communication of the science at this level (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted up to grade C Indicative scientific points at level 3 may include: The calculation from level 1 and 2 and a link between change in distance or stopping time to acceleration or force. • increases distance travelled by dummy so this reduces force / acceleration of dummy • increase stopping time of dummy so this reduces force / acceleration of dummy • reduced acceleration so reduced force • reduces the rate of change of momentum Indicative scientific points at level 1 and 2 may include: • force = 28020 or 28000 N seatbelts • hold dummy in seat / stop dummy hitting windscreen • stretches • reduce forces on dummy • increase stopping time of dummy • decrease acceleration of dummy Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This six mark extended prose level of response question was targeted up to grade C. It was about seatbelts and most candidates were willing to answer. Most calculated the force correctly (level 1 – [2] marks) and described the simple action of the seatbelt (eg. 'stops driver hitting windscreen'). Both these qualified for level 2 and [4] marks. Better answers at level 3

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					needed to link the longer (stopping) distance or (stopping) time to the lower acceleration or forces. This discriminated well with only strong grade C candidates gaining [5] or [6] marks.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
31		i	1.2 (kg m/s) (2) but if answer incorrect 4×0.3 (1)	2	Examiner's Comments The momentum calculation was usually correct [2].
		ii	any two from (correct use of) drag / air resistance / weight (1) forces are balanced (1) not accelerating (1)	2	e.g. weight / (force of) gravity pulls downwards [1] e.g. air resistance pushes upwards [1] ignore wind resistance (1) allow gravity = drag (1) allow higher level answer e.g. weight = drag or air resistance (2) not merely steady speed allow drag stops it accelerating (2) Examiner's Comments This question on terminal speed saw candidates struggling to communicate their ideas clearly. Good concise answers such as 'it is when drag = weight scored [2]. Gravity = air resistance was common [1] as was gravity = upthrust [0]. Some also realised that terminal velocity meant zero acceleration [1].
		iii	(Moon has) no atmosphere / no drag (1)	1	allow less / no drag or less / no air resistance / no upward force (1) ignore less / no gravity Examiner's Comments A common misapprehension here was highlighted by the many answers describing the moon as having no gravity. Better answers referred to the lack of atmosphere or air resistance [1].
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
32	a		(work is done) when you lean against a wall (1) (work done depends on) the time it takes (1) (energy is) never transferred when work is done (1)	3	Look at parts (a) and (b) together. Eg. If work depends on distance and time in part (a) and part (b) corrects it to work depends on distance and force give credit in both parts. If part (a) has work depends on distance and time but this is not corrected in part (b) then the answer in (a) should be marked incorrect in line with the guidance below. If full statement or any correct part of statement is included in the answer to (a) then the answer is incorrect unless fully corrected in (b). Give marks for each statement if clear which parts were wrong even if written in correct form in this section.
	b		any one from: no work is done when you lean against a wall / AW (1) work done depends on the distance and the force / AW (1) energy is transferred when work is done / AW (1)	1	
			Total	4	

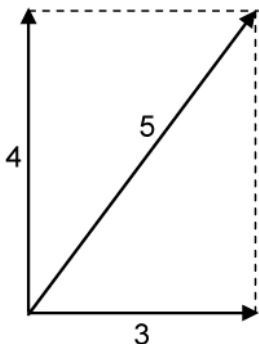
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
33			Maximum of TWO marks from: • increase stopping / collision time (1) • decrease acceleration (1) • reduces the rate of change of momentum / AW scores (2) and ONE mark for: • increase stopping / collision distance (1)	3	ignore references to energy / changing shape assume 'longer' refers to time unless indicated otherwise Not merely 'Slows it down more gradually' / 'less suddenly' NOT merely 'slower acceleration' or 'rate of acceleration' Look for use of the equation rather than simply stating it.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
34			Level 3: 5–6 marks Forces discussed and linked to acceleration at three points AND drag linked to acceleration / velocity / speed. Quality of written communication does not impede communication of science at this level. Level 2: 3–4 marks Forces discussed and linked to acceleration at two points. Quality of written communication partly impedes communication of science at this level. Level 1: 1–2 marks Forces discussed and linked to acceleration at one point OR forces discussed at two points OR acceleration described at two points Quality of written communication impedes the communication of science at this level Level 0: 0 marks Insufficient or irrelevant science. Not worthy of credit.	6	This question is targeted up to grade A Ignore references to energy Drag is equivalent to air resistance or friction Indicative scientific points may include (but are not limited to) the following: At point A • drag is zero / minimal • weight is greater than drag • there is a resultant force • object accelerates (maximum acceleration) At point B • as speed / velocity increases, drag increases • increasing drag means a smaller resultant force • acceleration is reduced, but still positive • object has lower acceleration At point C • drag equals weight so no acceleration / terminal velocity • no resultant force so no acceleration / terminal velocity
			Total	6	
35		i	Any one from the following pairs Car slows down and tree moves right (1) Car stops and tree remains stationary (1) Car carries on moving and tree is knocked down (1) Car recoils and tree remains stationary (1) Car recoils and tree moves right (a little) (1)	1	
		ii	forces are equal and in opposite directions (1)	1	more than one answer = 0 marks if answer line blank allow correct answer indicated in list
			Total	2	

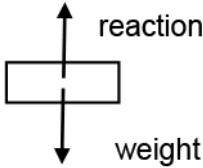
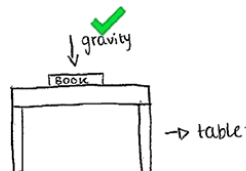
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
36			Vectors / lines labelled 4 and 3 OR drawn to scale (by eye) at right angles to each other (1) BUT vectors / lines labelled 4 and 3 AND drawn to scale (by eye) at right angles to each other (2) Correct resultant drawn (north east) from scale diagram indicating magnitude of 5 (allow 4.8 to 5.2) (1) Calculation route (maximum 2 marks): size of resultant velocity calculated at 5 (m / s) (1) angle calculated as $37^\circ / 53^\circ$ (1)	3	If diagram and calculation routes are both shown do not combine marks but award highest mark. 
			Total	3	
37			any one from: make it lighter / AW (1) make it more streamlined / AW (1) increase traction / AW (1)	1	
			Total	1	
38			B ✓	1 (AO2.1)	<u>Examiner's Comments</u> This was the hardest multiple-choice question, with one in six candidates getting it right. Most candidates did not convert cm into m.
			Total	1	

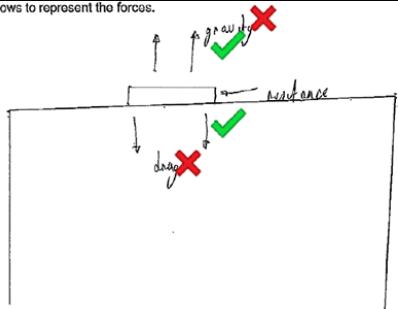
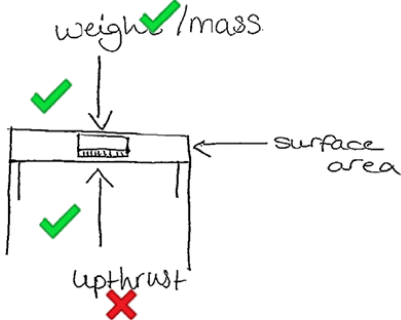
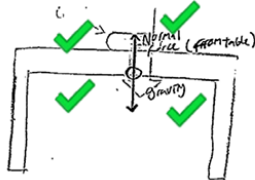
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
39	a		Any one from: electrostatics ✓ gravity/weight ✓ magnetism ✓ (normal) contact force ✓ friction ✓	1 (AO1.1)	Allow 'static electricity' but not just 'static' ALLOW reaction force ALLOW drag/air resistance <u>Examiner's Comments</u> Most candidates were able to name an appropriate force. The most common misconception was to name kinetic energy as a type of force.

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
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 (AO4 × 2.1)	e.g.  Examiner's Comments The best answers were offered by candidates who drew diagrammatic side view of a book on a table with opposing vertical forces shown by arrows pointing outwards from the centre of the book (see exemplar 11 below). Many candidates had drawn vertical arrows of equal length with the downward force labelled 'gravity' (see exemplars 8 and 9), the use of the correct force "weight" was rare (see exemplars 10 and 11). Fewer candidates labelled the counter-force 'reaction' or 'contact force'. The position of the arrows emanating from a point/box representing the centre of mass of the book was not an enforced marking point. Exemplar 8 Use arrows to represent the forces.  Exemplar 9 [4]

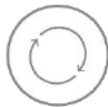
Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
			Use arrows to represent the forces.  [4] Exemplar 10  [4] Exemplar 11  [4]

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	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 (AO2 × 1.2)	Examiner's Comments Many candidates did not seem to know what an air-track glider was and as a result there answers showed limited understanding of the practical activity. Other candidates had seen an air-track glider and discussed the (relatively) unhindered movement of the glider and the action of air resistance. The most able candidates gained credit for discussing the motion of the glider during the initial push given by the teacher.
	d	i	$F = ma$ / force equals mass times acceleration ✓ so reducing mass means the same engine force will cause greater acceleration ✓	2 (AO1.2) (AO2.2)	Must start with Newton II NOT less force for same acceleration Examiner's Comments Few candidates identified that this question was about the implications of the equation $F = ma$. Candidates did not recognise that the force would be the same for both the heavier and the lighter model of car. Most candidates discussed the effects of friction on the car. For the order of magnitude for changes in mass between different models of a car frictional forces would have no measurable effect on acceleration. Exemplar 12 (i) Explain why the presenter is correct. ...if the car is heavier the weight on the wheels ...can affect the acceleration as the mass is less ...there will be less weight on the wheels so the acceleration will be less This answer only considers the marginal changes in friction caused by a very small increase in the contact area of the tyres but ignores the more significant effect that the same force applied to a smaller mass will have on acceleration. Exemplar 13 (i) Explain why the presenter is correct. As force = mass × acceleration and force ÷ mass = acceleration ...so a smaller mass will mean faster acceleration ...as there is less mass to move [2]

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					This candidate's answer shows very clearly why using a more mathematical approach in physics saves time and increases understanding. They have identified the appropriate equation ($F=ma$), changed the subject to acceleration and then drawn the correct conclusion. Using this approach their answer was shorter, clearer and more relevant than exemplar 12.  AfL As a starter exercise show students the question and ask them to select the equation that will answer the question. Helping students to be more comfortable using equations will help them overcome their reluctance to answer physics questions using maths.
		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 = $20 \div 4$ (m/s²) ✓ = 5 (m/s²) ✓	3 (AO2.1) (AO2.1) (AO2.1)	e.c.f. incorrect change in speed if subtraction attempted <u>Examiner's Comments</u> This calculation was well done with most candidates being credited with all three marks.
			Total	12	
40			B ✓	1 (AO1.1)	<u>Examiner's Comments</u> This question about $F = ma$ was answered well with about 80% of candidates getting it correct with the answer B. All other responses were seen with A being the most common incorrect answer given.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
41	a		momentum ✓ kinetic energy or KE ✓	2 (AO 2 × 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 ✓ <u>Examiner's Comments</u> Kinetic energy and momentum were the answers here. Full marks (in 10% of cases) were attained by more able candidates only. Just less than a half gained 1 mark only. 'Energy' or 'potential energy' (rather than kinetic energy) was often seen along with mass, velocity.
	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 × 4.2 2.5 × 2.7 ✓ A: 8.4 (kgm/s) ✓ B: 6.75/6.8 (kgm/s) ✓	3 (AO 1.2) (AO 2.2) (AO 2.2)	8.4 and 6.7 scores ✓✓ (incorrect rounding of one of the values) <u>Examiner's Comments</u> The great majority calculated both values of momentum correctly and gained 3 marks.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 3.4 (m/s) award 3 marks $(8.4 + 6.75) \times 4.5 \checkmark$ $3.37 / 3.366666667 \text{ (m)} \checkmark$ 3.4 (rounding to 2 sf) $\checkmark$	3 (AO 2.2) (AO 2.2) (AO 1.2)	ECF for momentum values eg. $(A + B) \div 4.5$ Wrong answer but evidence of correct rounding $\checkmark$ Eg. 6.75 to 6.8 $\checkmark$ <u>Examiner's Comments</u> Just under a half of candidates calculated this correctly to two significant figures. About a third did gain any credit at all and gave attempts of calculations that were incorrect or difficult to follow.
			Total	8	
42			B $\checkmark$	1 (AO1.1)	<u>Examiner's Comments</u> Only about a third of candidates gave the correct answer 'B'. A common incorrect response was 'A' although the other distractors were also seen on occasions.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
43			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 (AO 2.1) (AO 1.1) (AO 2.1) (AO 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 Drag / air resistance  (3 marks) Weight or force of gravity <u>Examiner's Comments</u> There were some good answers here. A common error was to state 'gravity' rather than weight or force of gravity. The relative sizes of the arrows were often correct. Upthrust was often unsuccessfully substituted for air resistance. The question discriminated well with about a third gaining full marks.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
44		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 60 000 (J) award 2 marks 48 000 + 12 000 ✓ = 60 000 (J) ✓	2 (AO 2.2) (AO 2.2)	Check table <u>Examiner's Comments</u> Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.
		ii	C ✓	1 (AO 3.2b)	<u>Examiner's Comments</u> Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.
		iii	B ✓	1 (AO 3.2b)	<u>Examiner's Comments</u> Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iv	Heat / sound / KE of particles passed to other particles / AW ✓	1 (AO 1.1)	ALLOW (energy) transferred to surroundings / by friction <u>Examiner's Comments</u> A large number of candidates correctly stated that the motor would produce heat and/or sound or indicated that the energy was 'wasted' through friction. Some candidates wrote out all the energy transfers in an electric motor (e.g. "heat, sound and kinetic energy") which could not gain credit as it did not describe how energy is 'wasted'. Credit was given when it was clear that the 'waste' resulted from the transfer of the kinetic energy store of particles passed on to other particles or to the surroundings but not a vague transfer of 'kinetic energy to the atmosphere'.
		v	Lubrication / oil ✓	1 (AO 2.1)	ALLOW reduce friction <u>Examiner's Comments</u> Candidates found this question extremely challenging. There were very few suggestions of specific improvements to the electric motor such as lubricating it or applying oil to the moving parts. Many candidates suggested general energy efficiency tips such as switching it off when it not in use, running the motor at a slower speed or putting insulation around the motor.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
45			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 (AO 1.2) (AO 2.1) (AO 2.1)	ALLOW 0.8 for two marks Examiner's Comments Some candidates divided their calculated answer by 1000 so that their answer was actually in tonnes rather than kilograms. Because the equation uses force in N and acceleration in m/s^2 the computed mass will be kilograms. Other candidates divided 4000 by 5^2 perhaps thinking that 5 m/s^2 implied it needed to be squared.
			Total	3	
46			D ✓	1 (AO2.1)	Examiner's Comments This was a straightforward question to begin section A. Almost all the candidates correctly substituted the numbers into the given equation. Some candidates wrote their working in the space around the question. The advantages of this method are that there is a smaller chance of making a mistake by using the wrong numbers and it is easier to check the answer later.
			Total	1	
47			B ✓	1 (AO1.1)	Examiner's Comments This question was generally well answered. Candidates should be encouraged to use the space around the question for their working.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
48			C ✓	1 (AO2.1)	<u>Examiner's Comments</u> This question was well answered. Candidates should be encouraged to consider each letter of the diagram, adding a small cross to the ones that are eliminated.
			Total	1	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
49	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 (AO3x 2.2)	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 <u>Examiner's Comments</u> A small majority of candidates gained at least two marks for this question. Most of these candidates drew two arrows of equal length and labelled correctly the weight or gravitational force. Few candidates labelled the upwards arrow "tension" or "force from spring". A common misconception was the use of the term "upthrust". When representing vectors by straight lines, candidates should be encouraged to use a ruler with a millimetre scale. Ideally candidates should refer to the gravitational force as "weight" or "force due to gravity" rather than "gravity". A few candidates did not understand a "free body force diagram" and drew the apparatus and labelled the apparatus. Other errors were the drawing of many arrows on the diagram in varying directions. Exemplar 3  This candidate has drawn a "free body force diagram" with two arrows of the same length – the candidate confirms that the arrows are the same length. Force of load was allowed for one of the label marks.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	3	
50			A ✓	1 (AO1.1)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
51	a	i	Bar C drawn to the correct height of 12s ✓	1 (AO1.2)	<u>Examiner's Comments</u> Most candidates drew the correct bar in (a)(i) and then went on to carry out an accurate calculation of the mean time.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 12 (s) award 2 marks $14 + 10 + 12 = 36 / (14 + 10 + 12)/3$ without the 36 ✓ $36 \div 3 = 12$ (s) ✓	2 (AO3.1a) (AO1.2)	ECF from (a)(i) ECF from mp1 above <u>Examiner's Comments</u> Most candidates drew the correct bar in (a)(i) and then went on to carry out an accurate calculation of the mean time.
		iii	Lift B ✓ Takes the least time (power is work done ÷ time taken)/AW ✓	2 (AO3.1b) (AO1.2)	If A chosen and correct explanation (for B) given, award mp2 but not mp1 <u>Examiner's Comments</u> Many candidates identified lift B uses the most power correctly but did not provide an explanation of why it use the most power for the second mark. Some candidates clearly thought the highest bar in the bar chart indicated a greater height reached by the lift and so chose lift A.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4166.7 (W) award 4 marks $P = E \div t$ / power = work done $\div$ time taken ✓ $P = 50000 \div 12$ ✓ $P = 4166.666667$ (W) ✓ $P = 4166.7$ (W) (1dp)✓	4 (AO1.2) (AO2.1) (AO2.1) (AO1.2)	ALLOW energy (transferred) $\div$ time taken ALLOW 4166.7 for 2 marks if more dp not given ECF own calculated power to 1 dp <u>Examiner's Comments</u> Part (i): required candidates to round their answer to one decimal place. Many candidates did the calculation well and gained 4/4, or 3/4 with incorrect rounding. Any calculation error in finding the power of the lift could still earn the candidate the last mark if their result was rounded correctly. Part (ii) was done correctly by the majority of candidates. The stem of the question contained some data that they did not need to complete the calculation, which made this a more challenging task than it may appear to be.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 3000 (J) award 3 marks ✓ Work done = force $\times$ distance ✓ $W = 750 \times 4$ ✓ $W = 3000$ (J) ✓	3 (AO1.2) (AO2.1) (AO2.1)	
			Total	12	
52			C ✓	1 (AO2.1)	<u>Examiner's Comments</u> This question was answered well with candidates being able to recall the equation relating acceleration, force and mass.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
53			B ✓	1 (AO2.1)	<u>Examiner's Comments</u> This question was very well answered. Candidates correctly squared the speed. Again, higher ability candidates used the space around the question for their working.
			Total	1	
54			B	1 (AO2.1)	
			Total	1	
55			D	1 (AO1.1)	
			Total	1	
56			C	1 (AO2.1)	
			Total	1	
57			D	1 (AO2.1)	
			Total	1	
58		i	Gravitational (potential energy store) to kinetic (energy store) ✓	1 (AO2.1)	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 (AO1.2) (AO2.1) (AO2.1) (AO1.2)	ALLOW ecf for missing or incorrect unit conversion e.g. 260 (J) for 3 marks, 258 (J) for 2 marks
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
59			B	1 (AO2.1)	
			Total	1	
60	a	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 20 (N) award 2 marks $5 \times 4 \checkmark$ $= 20 \text{ (N)} \checkmark$	2 (AO2.1) (AO2.1)	
		ii	Any one from: Not all energy is transferred to motion $\checkmark$ (Air) resistance $\checkmark$ Drag $\checkmark$ Friction $\checkmark$	1 (AO3.2a)	ALLOW Energy losses
	b	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1500 (J) award 2 marks $30 \times 50 \checkmark$ $= 1500 \text{ (J)} \checkmark$	2 (AO2.1) (AO2.1)	
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 20 (W) award 3 marks work done $\div$ time $\checkmark$ $1500 \div 75 \checkmark$ $= 20 \text{ (W)} \checkmark$	3 (AO1.2) (AO2.1) (AO2.1)	ALLOW ecf from (i) ALLOW $P = WD \div t$
			Total	8	