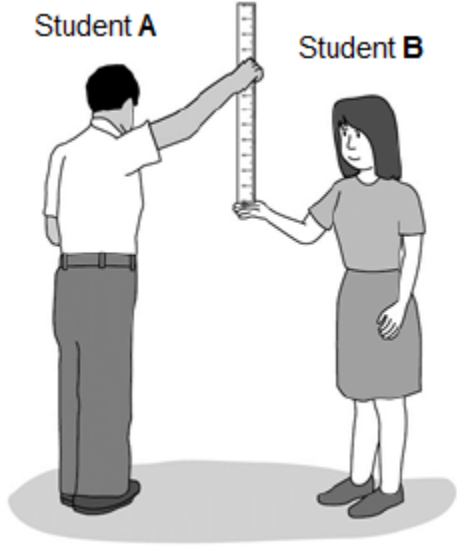


1

(a) The figure below shows two students investigating reaction time.



Student **A** lets the ruler go.

Student **B** closes her hand the moment she sees the ruler fall.

This investigation can be used to find out if listening to music changes the reaction times of a student.

Explain how.

.....

.....

.....

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.....

.....

(4)

- (b) A second group of students used a stop clock and computer simulation test to measure their reaction times.

The table below shows their results.

Student	Reaction time in seconds		
	Test 1	Test 2	Test 3
X	0.44	0.40	0.34
Y	0.28	0.24	0.22
Z	0.36	0.33	0.47

Give **one** conclusion that can be made from the results for student **X** and student **Y**.

.....
.....

(1)

- (c) Test **3** for student **Z** gave an anomalous result.

Suggest **two** possible reasons why this anomalous result occurred.

1

.....

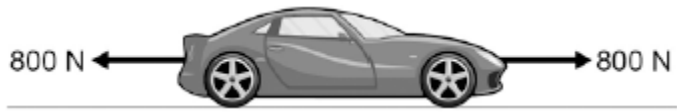
2

.....

(2)
(Total 7 marks)

2

The figure below shows the horizontal forces acting on a car.



(a) Which **one** of the statements describes the motion of the car?

Tick **one** box.

It will be slowing down.

It will be stationary.

It will have a constant speed.

It will be speeding up.

(1)

(b) During part of the journey the car is driven at a constant speed for five minutes.

Which one of the equations links distance travelled, speed and time?

Tick **one** box.

distance travelled = speed + time

distance travelled = speed × time

distance travelled = speed – time

distance travelled = speed ÷ time

(1)

(c) During a different part of the journey the car accelerates from 9m / s to 18m / s in 6 s.

Use the following equation to calculate the acceleration of the car.

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

.....

.....

acceleration = m / s²

(2)

(d) Which equation links acceleration, mass and resultant force?

Tick **one** box.

resultant force = mass + acceleration

resultant force = mass \times acceleration

resultant force = mass - acceleration

resultant force = mass \div acceleration

(1)

(e) The mass of the car is 1120 kg. The mass of the driver is 80 kg.

Calculate the resultant force acting on the car and driver while accelerating.

.....
.....

Resultant force = N

(2)

(f) Calculate the distance travelled while the car is accelerating.

Use the correct equation from the Physics Equation Sheet.

.....
.....
.....

Distance = m

(3)

(g) A car driver sees a fallen tree lying across the road ahead and makes an emergency stop.

The braking distance of the car depends on the speed of the car.

For the same braking force, explain what happens to the braking distance if the speed doubles.

You should refer to kinetic energy in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

(4)
(Total 14 marks)

3

When two objects interact, they exert forces on each other.

(a) Which statement about the forces is correct?

Tick (✓) **one** box.

	Tick (✓)
The forces are equal in size and act in the same direction.	
The forces are unequal in size and act in the same direction.	
The forces are equal in size and act in opposite directions.	
The forces are unequal in size and act in opposite directions.	

(1)

(b) A fisherman pulls a boat towards land.

The forces acting on the boat are shown in **Diagram 1**.

The fisherman exerts a force of 300 N on the boat.

The sea exerts a resistive force of 250 N on the boat.

Diagram 1



(i) Describe the motion of the boat.

.....
.....
.....
.....

(2)

(ii) When the boat reaches land, the resistive force increases to 300 N.
The fisherman continues to exert a force of 300 N.

Describe the motion of the boat.

Tick (✓) **one** box.

Accelerating to the right

Constant velocity to the right

Stationary

(1)

(iii) Explain your answer to part **(b)(ii)**.

.....
.....
.....
.....

(2)

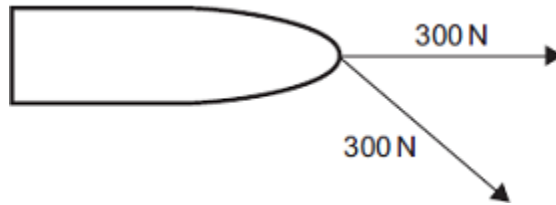
- (iv) Another fisherman comes to help pull the boat. Each fisherman pulls with a force of 300 N, as shown in **Diagram 2**.

Diagram 2 is drawn to scale.

Add to **Diagram 2** to show the single force that has the same effect as the two 300 N forces.

Determine the value of this resultant force.

Diagram 2



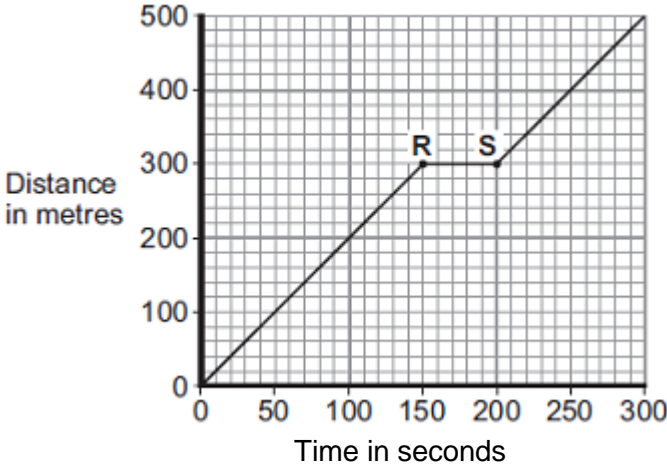
Resultant force = N

(4)
(Total 10 marks)

4

(a) **Figure 1** shows the distance–time graph for a person walking to a bus stop.

Figure 1



(i) Which **one** of the following statements describes the motion of the person between points **R** and **S** on the graph?

Tick (✓) **one** box.

Not moving

Moving at constant speed

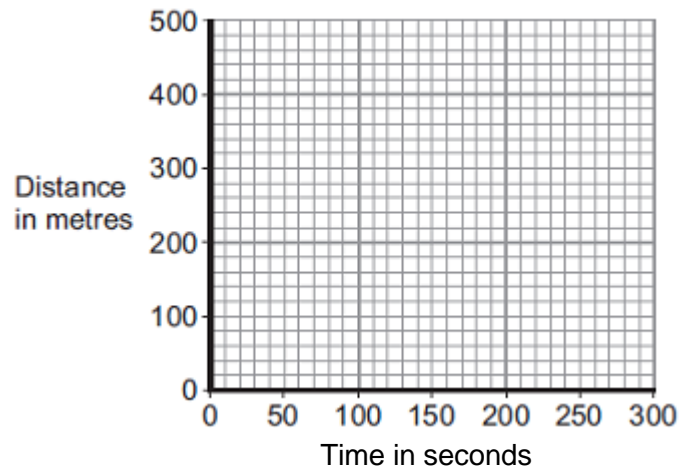
Moving with increasing speed

(1)

- (ii) Another person, walking at constant speed, travels the same distance to the bus stop in 200 seconds.

Complete **Figure 2** to show a distance–time graph for this person.

Figure 2



(1)

- (b) A bus accelerates away from the bus stop at 2.5 m/s^2 .

The total mass of the bus and passengers is 14 000 kg.

Calculate the resultant force needed to accelerate the bus and passengers.

.....

.....

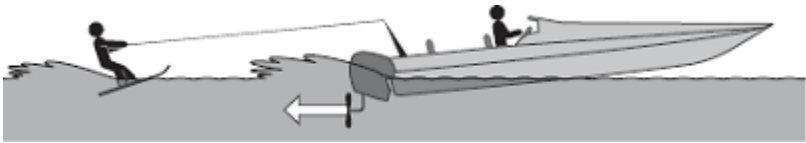
.....

Resultant force = N

(2)
(Total 4 marks)

5

The diagram shows a boat pulling a water skier.



- (a) The arrow represents the force on the water produced by the engine propeller. This force causes the boat to move.

Explain why.

.....
.....
.....
.....

(2)

- (b) The boat accelerates at a constant rate in a straight line. This causes the velocity of the water skier to increase from 4.0 m/s to 16.0 m/s in 8.0 seconds.

- (i) Calculate the acceleration of the water skier and give the unit.

.....
.....
.....

Acceleration =

(3)

(ii) The water skier has a mass of 68 kg.

Calculate the resultant force acting on the water skier while accelerating.

.....
.....
.....

Resultant force = N

(2)

(iii) Draw a ring around the correct answer to complete the sentence.

The force from the boat pulling the water skier forwards

will be

less than
the same as
greater than

 the answer to part (b)(ii).

Give the reason for your answer.

.....
.....

(2)
(Total 9 marks)

6

Some students designed and built an electric-powered go-kart.
The go-kart is shown below.



(a) Suggest **two** changes that could be made to the design of the go-kart to increase its top speed.

1

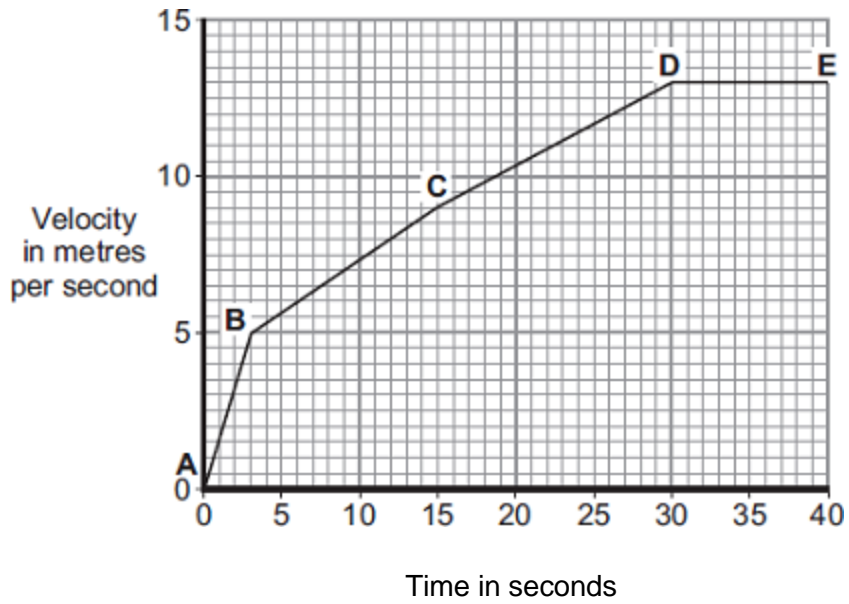
.....

2

.....

(2)

- (b) A go-kart with a new design is entered into a race. The velocity-time graph for the go-kart, during the first 40 seconds of the race, is shown below.



- (i) Between which **two** points did the go-kart have the greatest acceleration?

Tick (✓) **one** box.

A–B

B–C

C–D

Give a reason for your answer.

.....

.....

(2)

- (ii) The go-kart travels at a speed of 13 m/s between points **D** and **E**.
The total mass of the go-kart and driver is 140 kg.

Calculate the momentum of the go-kart and driver between points **D** and **E**.

.....
.....

Momentum = kg m/s

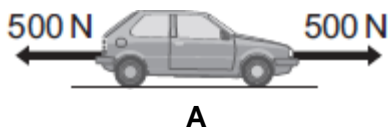
(2)
(Total 6 marks)

7

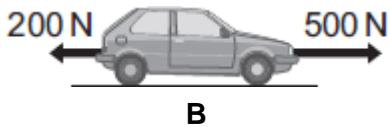
- (a) The diagrams, **A**, **B** and **C**, show the horizontal forces acting on a **moving** car.

Draw a line to link each diagram to the description of the car's motion at the moment when the forces act.

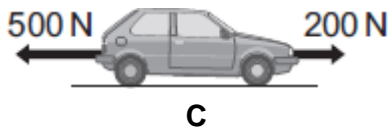
Draw only **three** lines.



stationary



constant speed

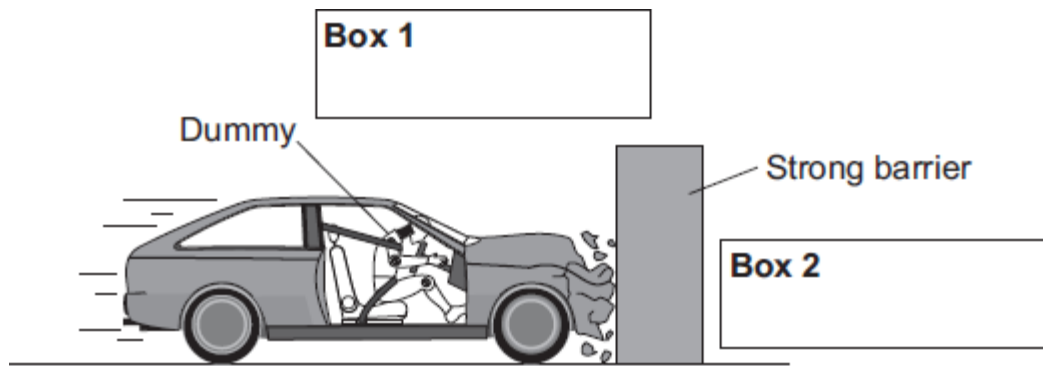


slowing down

accelerating forwards

(3)

- (b) The front crumple zone of a car is tested at a road traffic laboratory. This is done by using a remote control device to drive the car into a strong barrier. Electronic sensors are attached to a dummy inside the car.



- (i) Draw an arrow in **Box 1** to show the direction of the force that the car exerts on the barrier.

(1)

- (ii) Draw an arrow in **Box 2** to show the direction of the force that the barrier exerts on the car.

(1)

- (iii) Complete the following by drawing a ring around the correct line in the box.

The car exerts a force of 5000 N on the barrier. The barrier does not move. The force

exerted by the barrier on the car will be

more than
equal to
less than

5000 N.

(1)

- (iv) Which **one** of the following gives the most likely reason for attaching electronic sensors to the dummy?

Put a tick (✓) in the box next to your answer.

To measure the speed of the car just before the impact.

To measure the forces exerted on the dummy during the impact.

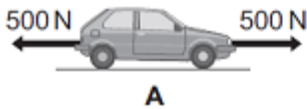
To measure the distance the car travels during the impact.

(1)
(Total 7 marks)

8

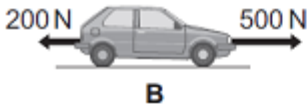
(a) A car is being driven along a straight road. The diagrams, **A**, **B** and **C**, show the horizontal forces acting on the moving car at three different points along the road.

Describe the motion of the car at each of the points, **A**, **B** and **C**.



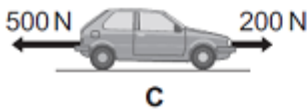
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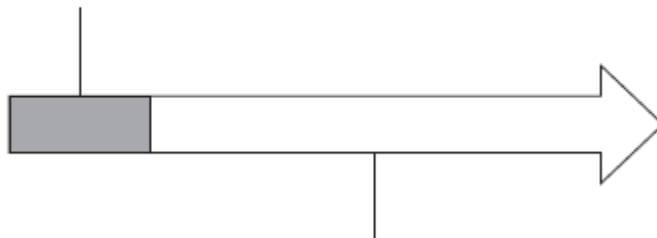
.....

(3)

(b) The diagram below shows the stopping distance for a family car, in good condition, driven at 22 m/s on a dry road. The stopping distance has two parts.

(i) Complete the diagram below by adding an appropriate label to the second part of the stopping distance.

The distance the car travels during the driver's reaction time



.....

.....

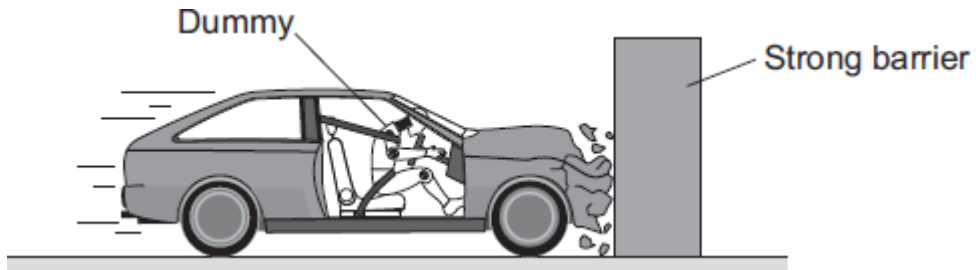
(1)

(ii) State **one** factor that changes both the first part **and** the second part of the stopping distance.

.....

(1)

- (c) The front crumple zone of a car is tested at a road traffic laboratory. This is done by using a remote control device to drive the car into a strong barrier. Electronic sensors are attached to the dummy inside the car.



- (i) At the point of collision, the car exerts a force of 5000 N on the barrier.

State the size and direction of the force exerted by the barrier on the car.

.....
.....

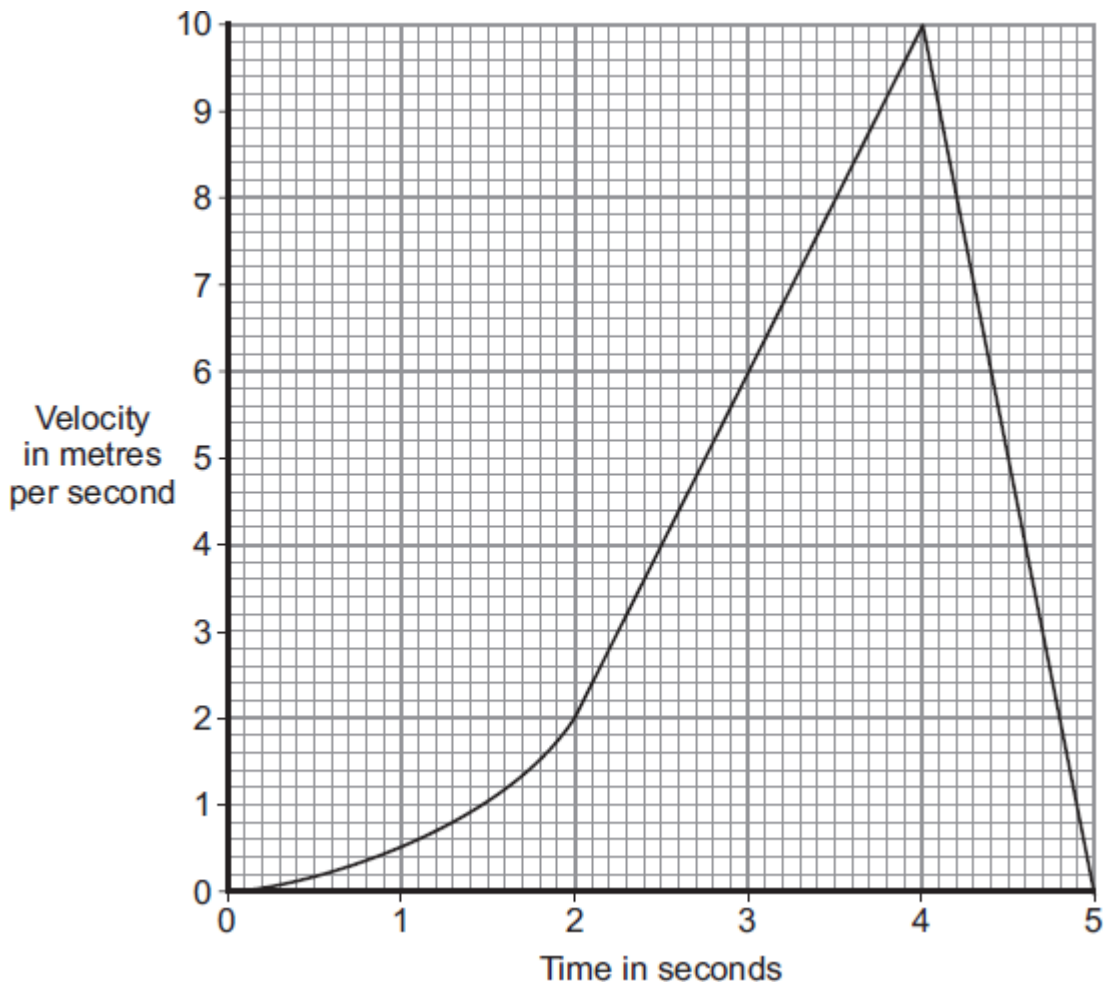
(1)

- (ii) Suggest why the dummy is fitted with electronic sensors.

.....
.....

(1)

(iii) The graph shows how the velocity of the car changes during the test.



Use the graph to calculate the acceleration of the car just before the collision with the barrier.

Show clearly how you work out your answer, including how you use the graph, and give the unit.

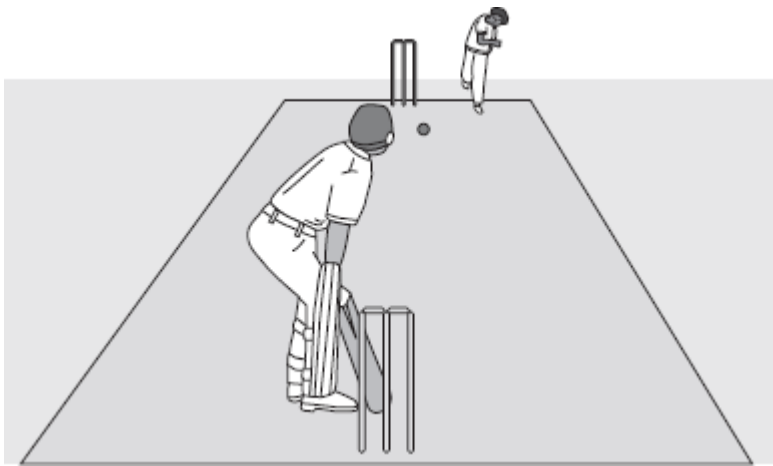
.....
.....
.....
.....

Acceleration =

(3)
(Total 10 marks)

9

The picture shows players in a cricket match.



(a) A fast bowler bowls the ball at 35 m/s. The ball has a mass of 0.16 kg.

Use the equation in the box to calculate the kinetic energy of the cricket ball as it leaves the bowler's hand.

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$$

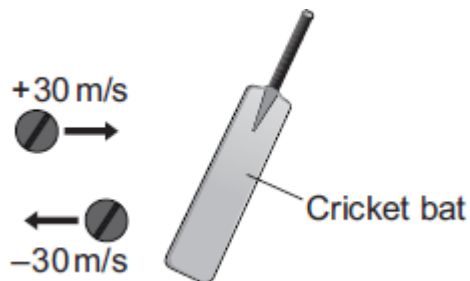
Show clearly how you work out your answer.

.....
.....
.....

Kinetic energy = J

(2)

- (b) When the ball reaches the batsman it is travelling at 30 m/s. The batsman strikes the ball which moves off at 30 m/s in the opposite direction.



- (i) Use the equation in the box to calculate the change in momentum of the ball.

$\text{momentum} = \text{mass} \times \text{velocity}$
--

Show clearly how you work out your answer.

.....

Change in momentum = kg m/s

(2)

- (ii) The ball is in contact with the bat for 0.001 s.

Use the equation in the box to calculate the force exerted by the bat on the ball.

$\text{force} = \frac{\text{change in momentum}}{\text{time taken for the change}}$

Show clearly how you work out your answer.

.....

Force = N

(1)

(c) A fielder, as he catches a cricket ball, pulls his hands backwards.

Explain why this action reduces the force on his hands.

.....

.....

.....

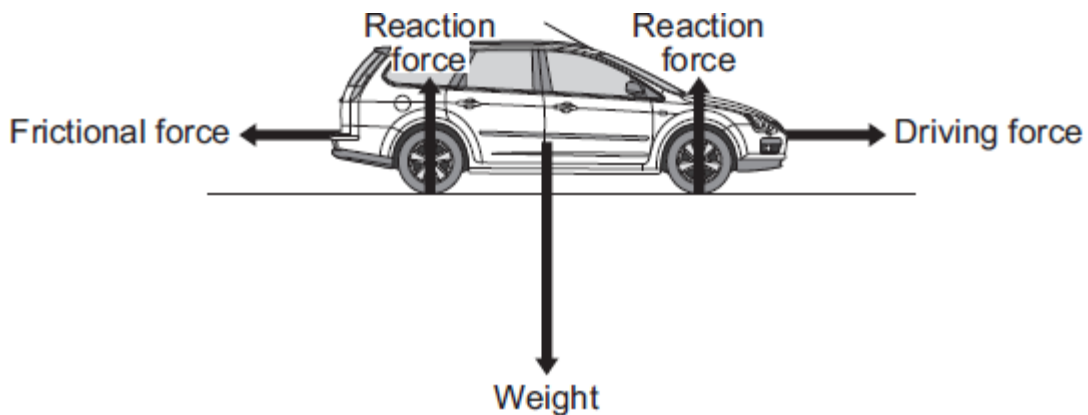
.....

.....

(2)
(Total 7 marks)

10

The diagram shows the forces acting on a car. The car is being driven along a straight, level road at a constant speed of 12 m/s.



(a) The driver then accelerates the car to 23 m/s in 4 seconds.

Use the equation in the box to calculate the acceleration of the car.

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken for change}}$$

Show clearly how you work out your answer and give the unit.

.....

.....

Acceleration =

(3)

(b) Describe how the horizontal forces acting on the car change during the first **two** seconds of the acceleration.

.....

.....

.....

.....

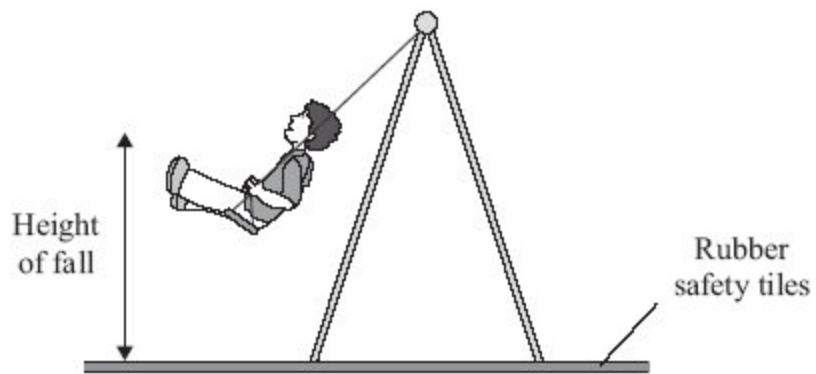
.....

.....

(3)
(Total 6 marks)

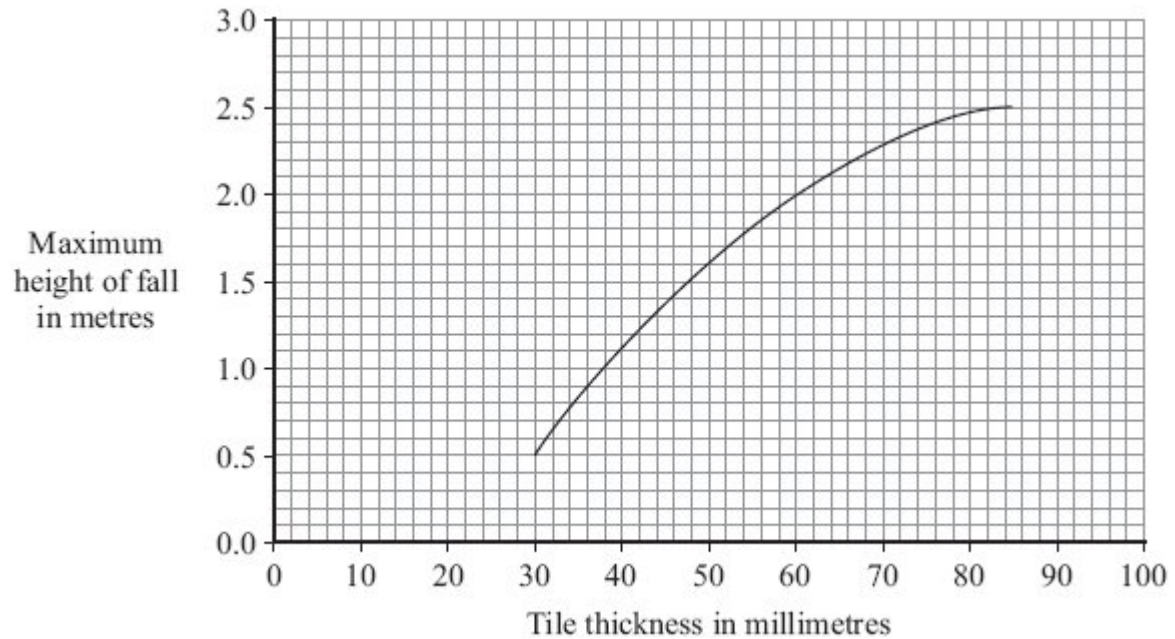
11

The diagram shows a child on a playground swing.



The playground surface is covered in rubber safety tiles. The tiles reduce the risk of serious injury to children who fall off the swing.

The graph gives the maximum height that a child can fall onto rubber safety tiles of different thicknesses and be unlikely to get a serious head injury.



(i) Describe how the maximum height of fall relates to the thickness of the rubber safety tile.

.....
.....

(1)

(ii) The maximum height of any of the playground rides is 2 metres.

What tile thickness should be used in the playground?

.....

Give a reason for your answer.

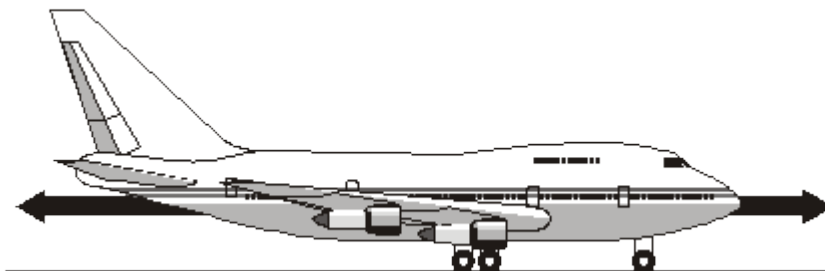
.....
.....

(2)

(Total 3 marks)

12

(a) The diagram shows an aircraft and the horizontal forces acting on it as it moves along a runway. The resultant force on the aircraft is zero.



(i) What is meant by the term *resultant force*?

.....
.....

(1)

(ii) Describe the movement of the aircraft when the resultant force is zero.

.....
.....

(1)

(b) The aircraft has a take-off mass of 320 000 kg. Each of the 4 engines can produce a maximum force of 240 kN.

Calculate the maximum acceleration of the aircraft.

Show clearly how you work out your answer and give the unit.

.....
.....
.....

Acceleration =

(3)

- (c) As the aircraft moves along the runway to take off, its acceleration decreases even though the force from the engines is constant.

Explain why.

.....

.....

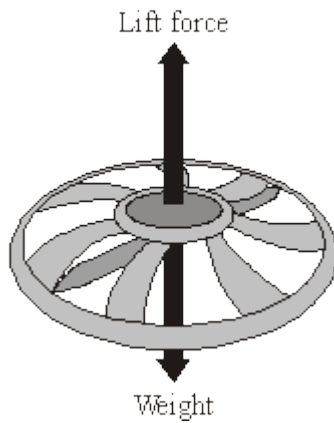
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.....

(2)
(Total 7 marks)

13

The diagram shows the forces on a small, radio-controlled, flying toy.



- (a) (i) The mass of the toy is 0.06 kg.
Gravitational field strength = 10 N/kg

Calculate the weight of the toy.

Show clearly how you work out your answer and give the unit.

.....

.....

Weight =

(3)

- (ii) Complete the following sentence by drawing a ring around the correct line in the box.

When the toy is hovering stationary in mid-air, the lift force is

bigger than
the same as
smaller than

the weight of the toy.

(1)

- (b) When the motor inside the toy is switched off, the toy starts to *accelerate* downwards.

- (i) What does the word *accelerate* mean?

.....

(1)

- (ii) What is the direction of the resultant force on the falling toy?

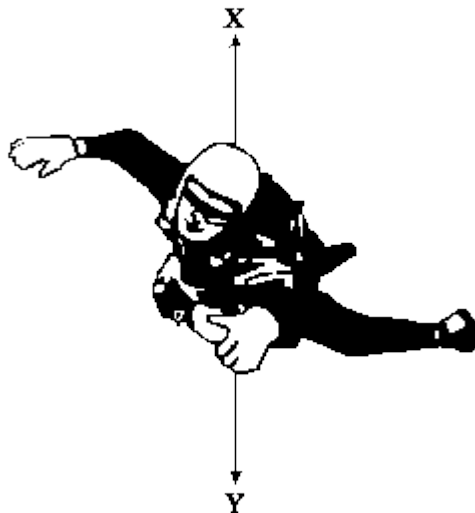
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(1)

(Total 6 marks)

14

The diagram shows a sky-diver in free fall. Two forces, **X** and **Y**, act on the sky-diver.



- (a) Complete these sentences by crossing out the **two** lines in each box that are wrong.

- (i) Force **X** is caused by

friction
gravity
weight

(1)

(ii) Force **Y** is caused by

air resistance
friction
gravity

 . (1)

(b) The size of force **X** changes as the sky-diver falls. Describe the motion of the sky-diver when:

(i) force **X** is smaller than force **Y**,

.....

(2)

(ii) force **X** is equal to force **Y**.

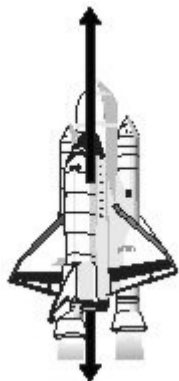
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(1)
(Total 5 marks)

15

(a) The arrows in the diagram represent the size and direction of the forces on a space shuttle, fuel tank and booster rockets one second after launch. The longer the arrow the bigger the force.

Thrust force



Weight of shuttle, fuel tanks and booster rockets plus air resistance

(i) Describe the upward motion of the space shuttle one second after launch.

.....

(1)

- (ii) By the time it moves out of the Earth's atmosphere, the total weight of the space shuttle, fuel tank and booster rockets has decreased and so has the air resistance.

How does this change the motion of the space shuttle? (Assume the thrust force does not change).

.....

(1)

- (b) The space shuttle takes 9 minutes to reach its orbital velocity of 8100 m/s.

- (i) Write down the equation that links acceleration, change in velocity and time taken.

.....

(1)

- (ii) Calculate, in m/s^2 , the average acceleration of the space shuttle during the first 9 minutes of its flight. Show clearly how you work out your answer.

.....

.....

average acceleration = m/s^2

(2)

- (iii) How is the velocity of an object different from the speed of an object?

.....

.....

(1)

(Total 6 marks)

16

(a) Two skydivers jump from a plane. Each holds a different position in the air.



A



B

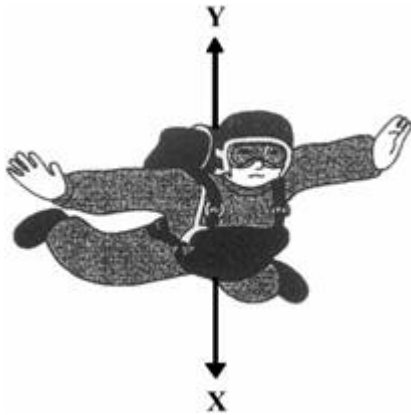
Adapted from Progress with Physics by Nick England, reproduced by permission of Hodder Arnold

Complete the following sentence.

Skydiver will fall faster because.....
.....
.....

(2)

The diagram shows the direction of the forces acting on one of the skydivers.



Adapted from Progress with Physics by Nick England, reproduced by permission of Hodder Arnold

(b) In the following sentences, cross out in each box the **two** lines that are wrong.

(i) Force X is caused by

air resistance
friction
gravity

(1)

(ii) Force Y is caused by

air resistance
gravity
weight

(1)

(iii) When force **X** is bigger than force **Y**, the speed of the

skydiver will

- go up
- stay the same
- go down

(1)

(iv) After the parachute opens, force **X**

- goes up
- stays the same
- goes down

(1)

(c) How does the area of an opened parachute affect the size of force **Y**?

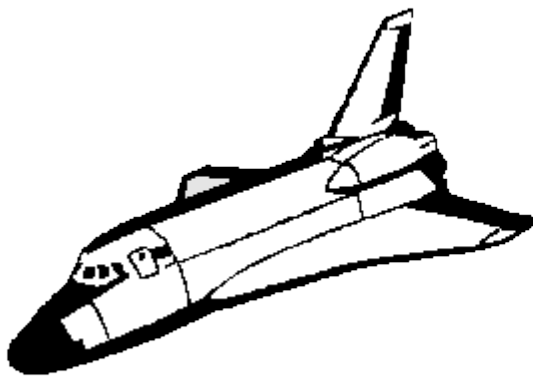
.....
.....

(1)

(Total 7 marks)

17

The diagram shows an orbiter, the reusable part of a space shuttle. The data refers to a typical flight.



Orbiter data	
Mass	78 000 kg
Orbital speed	7.5 km/s
Orbital altitude	200 km
Landing speed	100 m/s
Flight time	7 days

(a) (i) What name is given to the force which keeps the orbiter in orbit around the Earth?

.....

(1)

(ii) Use the following equation to calculate the kinetic energy, in joules, of the orbiter while it is in orbit.

$$\text{kinetic energy} = \frac{1}{2} mv^2$$

.....
.....

Kinetic energy = joules

(2)

(iii) What happens to most of this kinetic energy as the orbiter re-enters the Earth's atmosphere?

.....
.....

(1)

(b) After touchdown the orbiter decelerates uniformly coming to a halt in 50 s.

(i) Give the equation that links acceleration, time and velocity.

.....

(1)

(ii) Calculate the deceleration of the orbiter. Show clearly how you work out your answer and give the unit.

.....
.....

Deceleration =

(2)

(c) (i) Give the equation that links acceleration, force and mass.

.....

(1)

(ii) Calculate, in newtons, the force needed to bring the orbiter to a halt. Show clearly how you work out your answer.

.....
.....

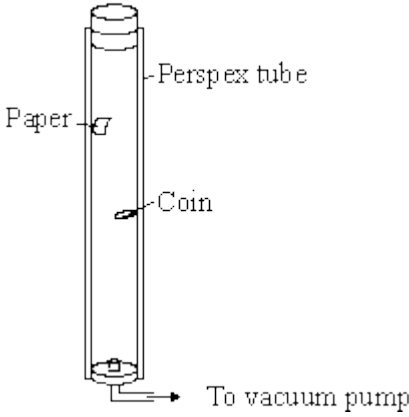
Force = newtons

(1)

(Total 9 marks)

18

The apparatus shown is used to compare the motion of a coin with the motion of a piece of paper as they both fall.



(a) When the tube is filled with air the coin falls faster than the piece of paper. Why?

.....
.....

(1)

(b) The air in the tube is removed by the vacuum pump. The tube is turned upside down. State **two** ways in which the motion of the coin and piece of paper will change compared to when there was air in the tube.

1
.....
.....
2
.....
.....

(2)
(Total 3 marks)

19

(a) A shopping trolley is being pushed at a constant speed. The arrows represent the horizontal forces on the trolley.

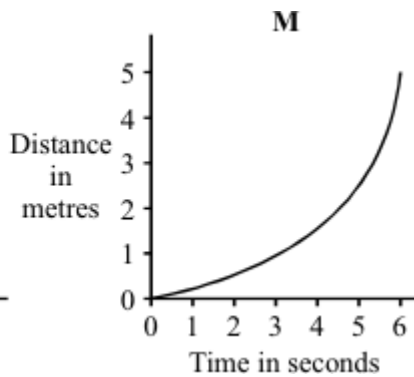
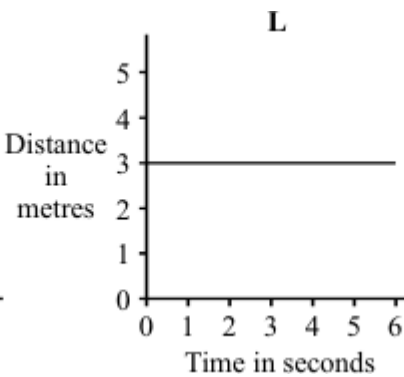
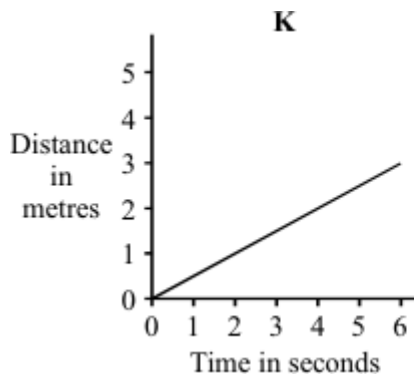


(i) How big is force **P** compared to force **F**?

.....

(1)

(ii) Which **one** of the distance-time graphs, **K**, **L** or **M**, shows the motion of the trolley? Draw a circle around your answer.



(1)

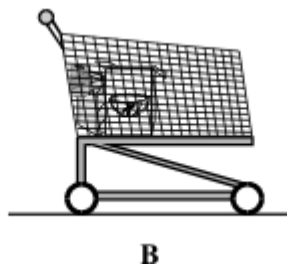
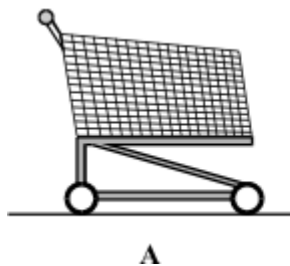
(b) Complete the sentence by crossing out the **two** words in the box that are wrong.

Acceleration is the rate of change of

energy.
speed.
velocity.

(1)

(c) Three trolleys, **A**, **B** and **C**, are pushed using the same size force. The force causes each trolley to accelerate.



Which trolley will have the smallest acceleration?

.....

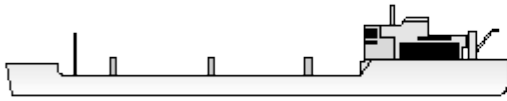
Give a reason for your answer.

.....

(2)
(Total 5 marks)

20

The table contains typical data for an oil tanker.

	Mass	56 000 000 kg
	Cruising speed	12 m/s
	Deceleration force	392 000 N
	Stopping distance	10 000 m

(i) Write down the equation which links acceleration, force and mass.

.....

(1)

(ii) Calculate the deceleration of the oil tanker. Show clearly how you work out your answer.

.....

.....

.....

Deceleration = m/s²

(2)
(Total 3 marks)

21

The manufacturer of a family car gave the following information.

Mass of car 950 kg

The car will accelerate from 0 to 33 m/s in 11 seconds.

(a) Calculate the acceleration of the car during the 11 seconds.

.....
.....
.....

(2)

(b) Calculate the force needed to produce this acceleration.

.....
.....
.....

(2)

(c) The manufacturer of the car claims a top speed of 110 miles per hour. Explain why there must be a top speed for any car.

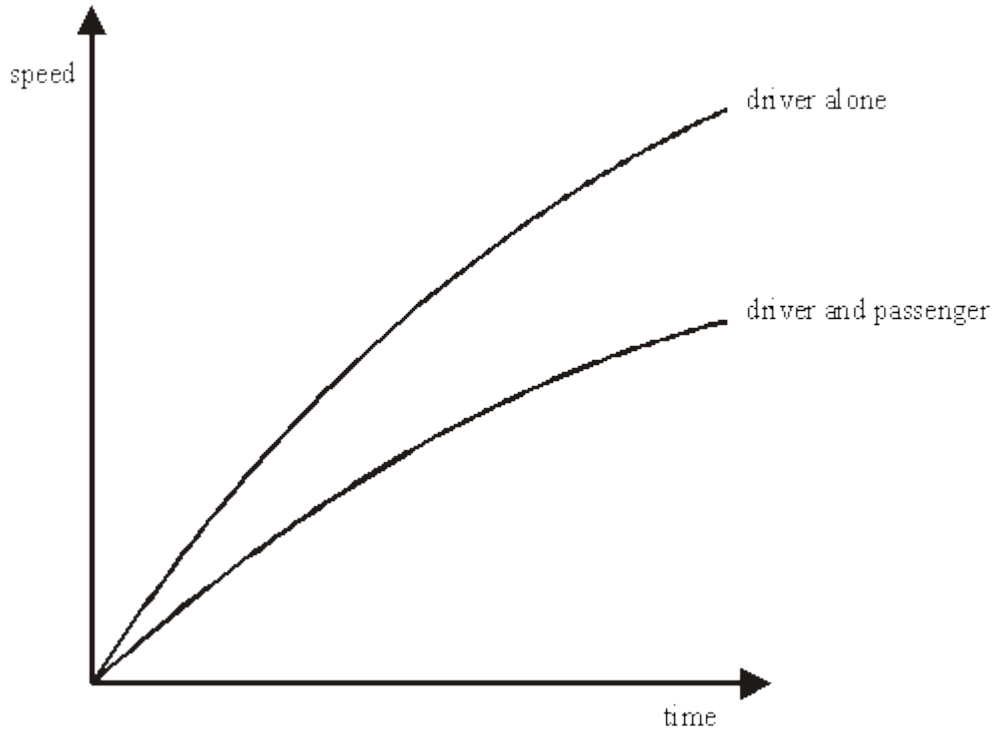
.....
.....
.....

(3)

(Total 7 marks)

22

(a) When a car is driven efficiently the engine gives a constant forward pull on the car as the car accelerates to its maximum speed. During this time frictional forces and air resistance oppose the forward motion of the car. The sketch graphs below show how the car's speed increases when only the driver is in the car, and when the driver has a passenger in the car.



(i) How does the acceleration of the car change with time?

.....
.....

(1)

(ii) What conclusion can be made about the resultant (net) forward force on the car as its speed increases?

.....
.....

(1)

(ii) On the graph, draw a line to show how you would expect the car's speed to vary if it carried three passengers.

(1)

(b) The manufacturer of a family car gave the following information.

Mass of car 950g

The car will accelerate from 0 to 33 m/s in 11 seconds.

- (i) Calculate the acceleration of the car during the 11 seconds.

.....
.....
.....

Answer

(2)

- (ii) Calculate the force needed to produce this acceleration.

.....
.....
.....

Answer N

(2)

- (iii) The manufacturer of the car claims a top speed of 110 miles per hour. Explain why there must be a top speed for any car.

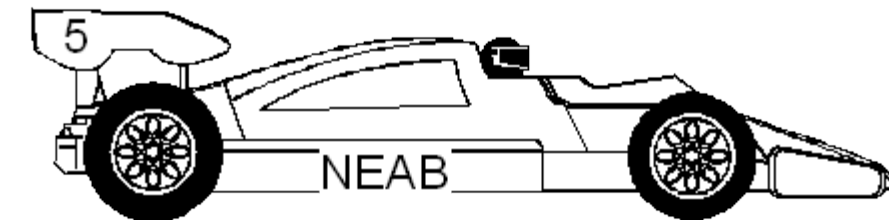
.....
.....

(2)

(Total 9 marks)

23

A racing driver is driving his car along a **straight** and **level** road as shown in the diagram below.



- (a) The driver pushes the accelerator pedal as far down as possible. The car does not accelerate above a certain maximum speed. Explain the reasons for this in terms of the forces acting on the car.

.....
.....
.....
.....
.....
.....

(4)

- (b) The racing car has a mass of 1250 kg. When the brake pedal is pushed down a constant braking force of 10 000 N is exerted on the car.

- (i) Calculate the acceleration of the car.

.....
.....
.....
.....
.....

- (ii) Calculate the kinetic energy of the car when it is travelling at a speed of 48 m/s.

.....
.....
.....
.....

- (iii) When the brakes are applied with a constant force of 10 000 N the car travels a distance of 144 m before it stops. Calculate the work done in stopping the car.

.....

.....

.....

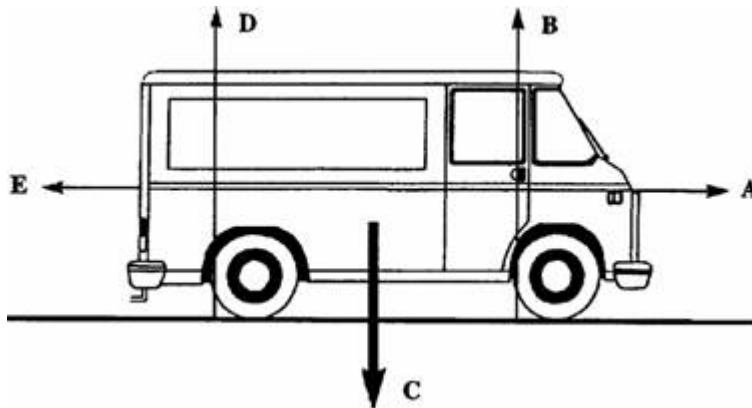
.....

.....

.....

(12)
(Total 16 marks)

24



Five forces, **A**, **B**, **C**, **D** and **E** act on the van.

- (a) Complete the following sentences by choosing the correct forces from **A** to **E**.

Force is the forward force from the engine.

Force is the force resisting the van's motion.

(1)

- (b) The size of forces **A** and **E** can change.
 Complete the table to show how big force **A** is compared to force **E** for each motion of the van.
 Do this by placing a tick in the correct box.
 The first one has been done for you.

MOTION OF VAN	FORCE A SMALLER THAN FORCE E	FORCE A EQUAL TO FORCE E	FORCE A BIGGER THAN FORCE E
Not moving	<input checked="" type="checkbox"/>		
Speeding up			
Constant speed			
Slowing down			

(3)

- (c) When is force **E** zero?

.....

(1)

- (d) The van has a fault and leaks one drop of oil every second.
 The diagram below shows the oil drops left on the road as the van moves from **W** to **Z**.



Describe the motion of the van as it moves from:

W to X

X to Y

Y to Z

(3)

(b) The van was driven for 20 seconds at a speed of 30m/s.

Calculate the distance travelled.

.....
.....
.....

Distance m

(2)

(c) The van was travelling at 30m/s. It slowed to a stop in 12 seconds.

Calculate the van's acceleration.

.....
.....
.....

Acceleration m/s²

(3)

(d) The driver and passenger wear seatbelts. Seatbelts reduce the risk of injury.

Explain how seatbelts reduce the risk of injury.

.....
.....
.....
.....
.....
.....
.....
.....
.....

(4)
(Total 12 marks)

26

A rollercoaster car stops above a vertical drop. Suddenly it falls under gravity.



The drop is 60 metres high and at the bottom of the drop the car travels at 125 km/h. The acceleration experienced by the people in the car is 10 m/s^2 . The mass of the car and its passengers is 1210 kg.

Calculate the force exerted on the car and its passengers. Show your working.

.....
.....
.....
.....
.....

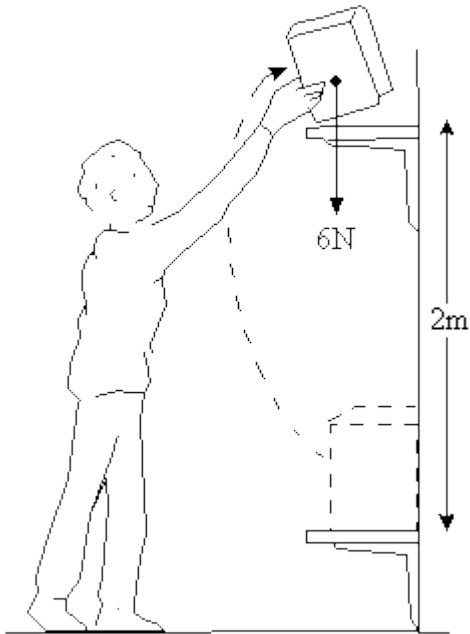
Force = N

(Total 3 marks)

27

A book weighs 6 newtons.

A librarian picks up the book from one shelf and puts it on a shelf 2 metres higher.



(a) Calculate the work done on the book. [Show your working].

.....
.....
.....

(3)

(b) The next person to take the book from the shelf accidentally drops it.

The book accelerates at 9.8m/s^2 .

Use this information to calculate the mass of the book. [Show your working].

.....
.....
.....

Answer kg.

(3)

- (c) If the book was dropped from an aeroplane high in the sky, it would accelerate to begin with. Eventually it would fall at a steady speed.

Explain, in as much detail as you can, why this happens.

.....

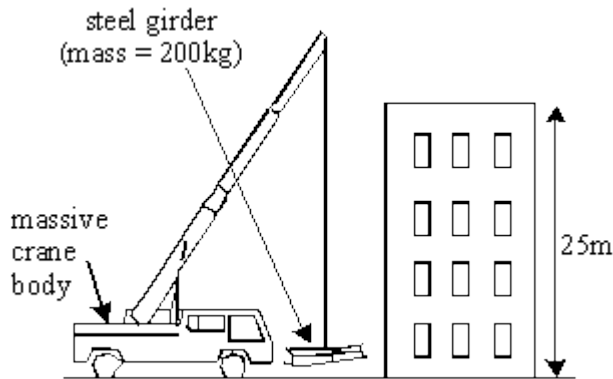
.....

.....

(3)
(Total 9 marks)

28

A crane is used to lift a steel girder to the top of a high building.



When it is lifted by the crane:

- the girder accelerates from rest to a speed of 0.6 m/s in the first 3 seconds;
- it then rises at a steady speed.

- (a) Calculate the **acceleration** of the girder.

(Show your working.)

.....

.....

.....

.....

(3)

- (b) (i) What is the **weight** of the steel girder?

Answer N

(1)

- (ii) Calculate the **power** of the crane motor as it lifts the girder at a steady speed of 0.6 m/s.

(Show your working. You can ignore the weight of the cable and hook which is small compared to the weight of the girder.)

.....
.....
.....

Answer W

(2)

- (c) A new motor is fitted to the crane. This motor accelerates the girder at 0.3 m/s^2 .

Calculate the **force** which the crane applies to the girder to produce this acceleration.

(Show your working.)

.....
.....
.....

Answer N

(3)

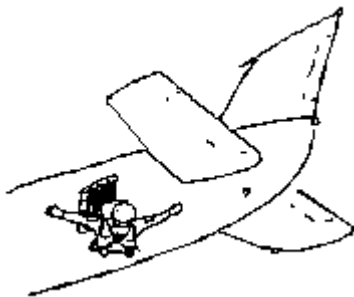
(Total 9 marks)

29

A sky-diver steps out of an aeroplane.

After 10 seconds she is falling at a steady speed of 50m/s.

She then opens her parachute.



After another 5 seconds she is once again falling at a steady speed.

This speed is now only 10m/s.

(a) Calculate the sky-diver's average acceleration during the time from when she opens her parachute until she reaches her slower steady speed. (Show your working.)

.....
.....
.....

(3)

(b) Explain, as fully as you can:

(i) why the sky-diver eventually reaches a steady speed (with or without her parachute).

.....
.....
.....
.....

(3)

(ii) why the sky-diver's steady speed is lower when her parachute is open.

.....

(1)

(c) The sky-diver and her equipment have a total mass of 75kg. Calculate the gravitational force acting on this mass. (Show your working.)

.....
.....

Answer N

(1)

(Total 8 marks)

Mark schemes

1

(a) **Level 2 (3–4 marks):**

A detailed and coherent description of a plan covering all the major steps is provided. The steps are set out in a logical manner that could be followed by another person to obtain valid results.

Level 1 (1–2 marks):

Simple statements relating to relevant apparatus or steps are made but they may not be in a logical order. The plan would not allow another person to obtain valid results.

0 marks:

No relevant content.

Indicative content

- measure the distance the ruler falls before being stopped
- the greater this distance the greater the reaction time
- repeat measurements and calculate a mean
- repeat several times with the student listening to music (through earphones). Calculate a mean.
- a (significant) difference between the two means would show that music affects reaction time.

4

(b) reaction time decreases with practice

allow Y has a shorter reaction time

1

allow Y has faster reaction times (than X)

(c) the stop clock was started before the computer test started

1

the student was distracted

1

[7]

2

(a) It will have a constant speed.

1

(b) distance travelled = speed × time

1

(c) $a = \frac{18 - 9}{6}$

6

1

$a = 1.5$

allow 1.5 with no working shown for 2 marks

1

(d) resultant force = mass × acceleration

1

(e) $F = (1120+80) \times 1.5$ 1

$F = 1800 \text{ (N)}$

allow 1800 with no working shown for 2 marks

1

accept their 10.3×1200 correctly calculated for 2 marks

(f) $18^2 - 9^2 = 2 \times 1.5 \times s$ 1

$s = 18^2 - 9^2 / 2 \times 1.5$ 1

$s = 81 \text{ (m)}$ 1

allow 81 (m) with no working shown for 3 marks

accept answer using their 10.3 (if not 1.5) correctly calculated for 3 marks

(g) **Level 2 (3–4 marks):**

A detailed and coherent explanation is provided. The response makes logical links between clearly identified, relevant points that include references to the numerical factor.

Level 1 (1–2 marks):

Simple statements are made. The response may fail to make logical links between the points raised.

0 marks:

No relevant content.

Indicative content

- doubling speed increase the kinetic energy
- kinetic energy increases by a factor of 4
- work done (by brakes) to stop the car increases
- work done increases by a factor of 4
- work done is force \times distance and braking force is constant
- so if work done increases by 4 then the braking distance must increase by 4

4

[14]

3

(a) the forces are equal in size and act in opposite directions 1

(b) (i) forwards / to the right / in the direction of the 300 N force
answers in either order 1

accelerating 1

(ii) constant velocity to the right 1

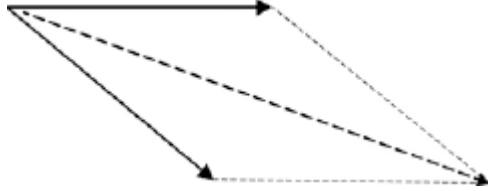
- (iii) resultant force is zero
accept forces are equal / balanced

1

so boat continues in the same direction at the same speed

1

- (iv) parallelogram or triangle is correctly drawn with resultant



3

value of resultant in the range 545 N – 595 N

parallelogram drawn without resultant gains 1 mark

If no triangle or parallelogram drawn:

*drawn resultant line is **between** the two 300 N forces gains 1 mark*

drawn resultant line is between and longer than the two 300 N forces gains 2 marks

1

[10]

4

- (a) (i) not moving

1

- (ii) straight line from origin to (200,500)
ignore a horizontal line after (200,500)

1

- (b) 35 000

allow 1 mark for correct substitution, ie $14\,000 \times 2.5$ provided no subsequent step

an answer of 87 500 indicates acceleration (2.5) has been squared and so scores zero

2

[4]

5

- (a) (produces) a force from water on the boat

1

in the forward direction

accept in the opposite direction

this must refer to the direction of the force not simply the boat moves forwards

an answer produces an (equal and) opposite force gains 1 mark

1

(b) (i) 1.5

allow 1 mark for correct substitution, ie $\frac{16-4}{8}$ or $\frac{12}{8}$

provided no subsequent step shown
ignore sign

2

m/s²

1

(ii) 102

or

their (b)(i) × 68 correctly calculated

allow 1 mark for correct substitution, ie 1.5 × 68

or their (b)(i) × 68

provided no subsequent step shown

2

(iii) greater than

reason only scores if greater than chosen

1

need to overcome resistance forces

accept named resistance force

accept resistance forces act (on the water skier)

do **not** accept gravity

1

[9]

6

(a) any **two** from:

- (make shape / body) more streamlined
accept a correct description
accept lower the seating position of the driver
- increase power of engine
faster engine is insufficient
- reduce mass / weight (of go-kart)
change wheel size is insufficient

2

(b) (i) A–B

reason only scores if A–B is chosen

1

steepest / steeper gradient / slope

1

(iii) 1820

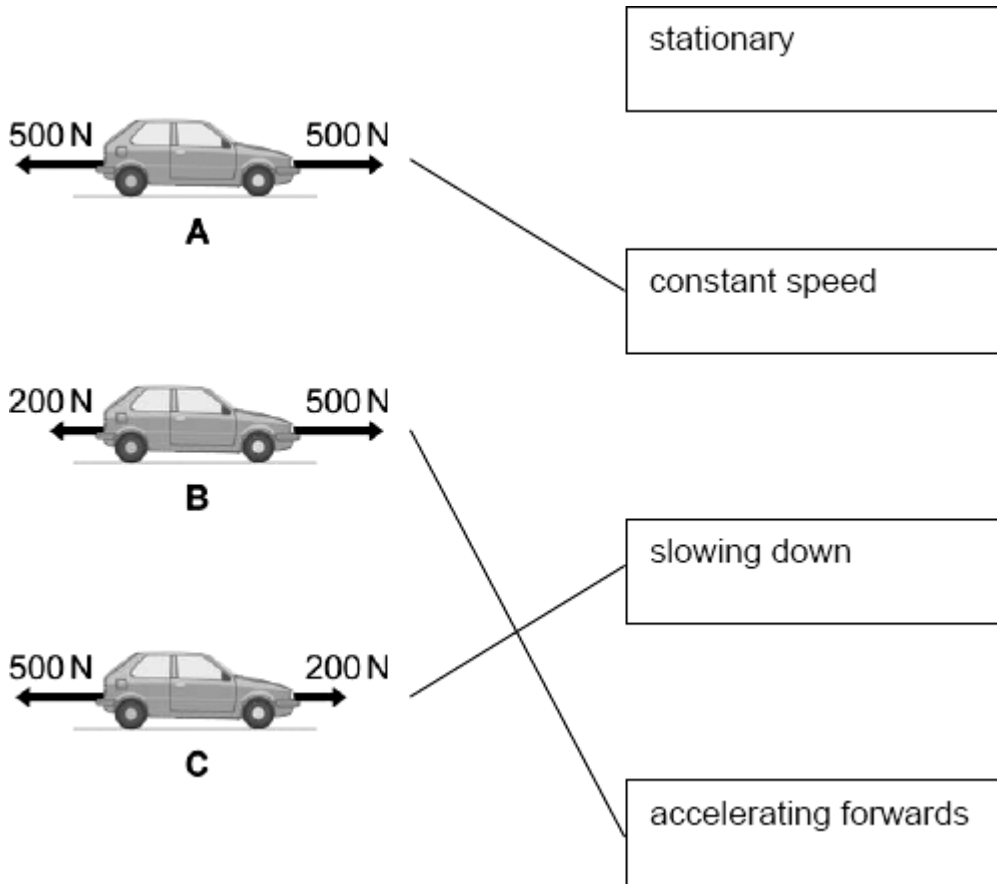
allow 1 mark for correct substitution, ie 140×13 provided no subsequent step shown

2

[6]

7

- (a) 3 lines drawn
all correct
allow 1 mark for each correct line
if two or more lines are drawn from any diagram then all these lines are incorrect



3

- (b) (i) horizontal arrow to the right
judge by eye
accept an arrow drawn outside the box if it is labelled correctly

1

- (ii) horizontal arrow to the left
judge by eye
accept an arrow drawn outside the box if it is labelled correctly

1

- (iii) equal to

1

(iv) to measure the forces exerted on the dummy during the impact

1

[7]

8

(a) **A** constant speed / velocity

accept steady pace

do not accept terminal velocity

do not accept stationary

1

B acceleration

accept speeding up

1

C deceleration

accept slowing down

accept accelerating backwards

accept accelerating in reverse

do not accept decelerating backwards

1

(b) (i) the distance the car travels under the braking force

accept braking distance

1

(ii) speed/velocity/momentum

1

(c) (i) 5000 (N) to the left

both required

accept 5000(N) with the direction indicated by an arrow drawn pointing to the left

accept 5000(N) in the opposite direction to the force of the car (on the barrier)

accept 5000(N) towards the car

1

(ii) to measure/detect forces exerted (on dummy / driver during the collision)

1

(iii) 4

allow 1 mark for showing a triangle drawn on the straight part of the graph

or correct use of two pairs of coordinates

2

m/s²

do **not** accept mps²

1

[10]

9

(a) 98

allow 1 mark for correct substitution

ie $\frac{1}{2} \times 0.16 \times 35 \times 35$ provided no subsequent step shown
an answer of 98 000 scores 0

2

(b) (i) 9.6

allow 1 mark for (change in velocity =) 60

ignore negative sign

2

(ii) 9600

ignore negative sign

or

their (b)(i) $\div 0.001$ correctly calculated, unless (b) (i) equals 0

1

(c) increases the time

1

to reduce/change momentum (to zero)

only scores if 1st mark scored

decreases rate of change of momentum scores both marks
provided there are no contradictions

accept decreased acceleration/deceleration

equations on their own are insufficient

1

[7]

10

(a) 2.75

allow 1 mark for correct substitution, ie $\frac{11}{4}$

or $\frac{23 - 12}{4}$

provided no subsequent step shown

2

m/s²

1

- (b) driving force increases 1
- frictional force increases 1
- accept air resistance / drag for frictional force*
- driving force > frictional force 1

[6]

- 11** (i) the thicker the tile, the greater the (fall) height 1
- accept the higher (the fall) the thicker the tile*
- accept there is a positive correlation*
- do **not** accept they are proportional*

- (ii) 60 (mm) 1
- accept any number or range between 60 and 85 inclusive*
- if units are given must match range*

- (minimum thickness) needed to reduce risk of injury 1
- reason must match thickness choice*
- do **not** accept to keep child safe*
- accept an answer in terms of – the thicker the tile, the less chance there is of a serious injury if the answer given is greater than 60*
- accept answers in terms of use of graph e.g. the graph shows that for a 2m fall a thickness of 60 mm is needed*
- minimum level answer' the graph shows that's what's needed'*
- accept only if 60 is the answer*

[3]

- 12** (a) (i) a single force that has the same effect as all the forces combined 1
- accept all the forces added / the sum of the forces / overall force*
- (ii) constant speed (in a straight line) 1
- do **not** accept stationary*
- or** constant velocity 1

(b) 3

allow 1 mark for correct substitution into transformed equation
accept answer 0.003 gains 1 mark
answer = 0.75 gains 1 mark

2

m/s²

1

(c) as speed increases air resistance increases

accept drag / friction for air resistance

1

reducing the resultant force

1

[7]

13

(a) (i) 0.6

allow 1 mark for correct substitution

2

newtons

accept N

*do **not** accept n*

accept Newtons

1

(ii) the same as

1

(b) (i) changed velocity

accept increased/ decreased for change

accept speed for velocity

accept change direction

accept getting faster/ slower

accept start/ stop moving

accept correct equation in terms of change in speed or change in velocity

1

(ii) down(wards)

accept towards the ground

accept ↓

*do **not** accept south*

1

[6]

14

- (a) (i) friction
accept any way of indicating the correct answer 1
- (ii) gravity
accept any way of indicating the correct answer 1
- (b) (i) accelerates **or** speed / velocity increases
accept faster and faster (1 mark)
*do **not** accept faster pace / falls faster*
or suggestions of a greater but constant speed 1
- downwards / falls
accept towards the Earth / ground
this may score in part (b)(ii) if it does not score here and there is no contradiction between the two parts 1
- (ii) constant speed / velocity **or** terminal velocity / speed or zero acceleration
stays in the same place negates credit 1

[5]

15

- (a) (i) accelerating
accept getting faster
accept speed / velocity increasing 1
- (ii) acceleration increases
accept velocity / speed increases more rapidly
*do **not** accept velocity / speed increases* 1

(b) (i) acceleration = $\frac{\text{change in velocity}}{\text{time (taken)}}$

accept $a = \frac{V - U}{t}$ **or** $a = \frac{V_1 - V_2}{t}$

do **not** accept velocity for change in velocity

do **not** accept change in speed

do **not** accept $a = \frac{V}{t}$

1

(ii) 15

allow **1** mark for an answer of 900 **or** for correct use of 540 seconds

2

(iii) velocity includes direction

accept velocity is a vector (quantity)

accept converse answer

1

[6]

16

(a) B

more aerodynamic **or** most streamlined shape **or**
smaller (surface) area

accept less air/wind resistance **or** less drag **or** less friction clothing
traps less air **or** rolled up into ball **or** arms, legs drawn in
accept converse

2

(b) (i) gravity

1

(ii) air resistance

1

(iii) go up

1

(iv) stays the same

1

- (c) bigger the area, the bigger force Y
accept the converse
- or** bigger the area more drag
accept when the parachute opens then force Y bigger
- or** bigger the area more air resistance
need the relation of area to force

1

[7]

17

- (a) (i) gravity/weight

1

- (ii) 2193750000000 or 2.19×10^{12}

not 2.19^{12}

allow 1 mark for the correct conversion to 7500 (m/s)

allow one mark for answer 2193750(J)

2

transferred to heat

ignore extras of sound and light

accept changed to heat

accept lost due to friction

1

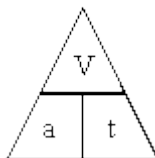
- (b) (i) acceleration = $\frac{\text{change in velocity}}{\text{time (taken)}}$

accept word speed instead of velocity

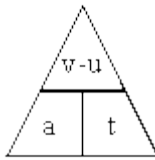
accept $a = \frac{V - U}{t}$

or correct rearrangement

do not accept



even if subsequent calculation correct



can gain credit if subsequent calculation correct

1

(ii) 2

ignore + or – signs

m/s^2 1

accept m/s/s or ms^{-2}

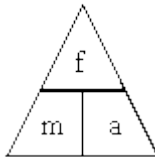
2

(c) (i) force = mass \times acceleration

accept correct rearrangement

accept $F = m \times a$

do not accept



unless subsequent calculation correct

1

(ii) 156 000

accept 78 000 \times their (b)(ii)(only if (b)(i) correct)

1

[9]

18

(a) air(resistance) has greatest effect on paper

1

(b) paper **or** both fall faster

1

(both) fall together

accept same speed **or** rate

1

[3]

19

(a) (i) same size

1

(ii) K

1

(b) velocity

1

(c) C

1

greatest mass **or** because it's heavier
accept biggest load
*accept heaviest **or** more weight*
*do **not** accept fuller*
*do **not** accept more items*
*do **not** accept it's loaded*
*do **not** accept loaded most*
ignore references to time as neutral

1

[5]

20

(i) force = mass × acceleration

accept $F = m \times a$
*accept upper **or** lower case letters*
accept equation using correct units
accept



if subsequent method correct

1

(ii) 0.007

allow 1 mark for correct transformation or substitution

2

[3]

21

- (a) 3
gains 1 mark
- m/s²
gains 1 mark
- else working *gains 1 mark* 2
- (b) 2850 ecf
gains 1 mark
- N
gains 1 mark
- else working
gains 1 mark 2
- (c) friction/air resistance increases with speed;
till frictional = max forward force;
then force/acceleration is zero
for 1 mark each
- alternative limitation for safety
gains 1 mark only 3

[7]

22

- (a) (i) decreases
for 1 mark 1
- (ii) decreases
for 1 mark 1
- (iii) lower speed everywhere
for 1 mark 1

(b) (i) $3a = \frac{s}{t}$ or $a = \frac{33}{11}$

gains 1 mark

1

ms^{-2}

gains 1 mark

1

(ii) 2850 ecf

gains 2 marks

else working

gains 1 mark

2

(iii) air resistance/frictional forces increase with speed;
till frictional force = max forward engine force;
when acceleration is zero

(incorrect statement – 1 mark)

or (limitation on maximum speed for safety-1 mark)

any two for 1 mark each

2

[9]

23

(a) there is a (maximum) forward force
drag/friction/resistance (**opposes** motion) (**not** pressure)
increases with speed
till forward and backward forces equal
so no net force/acceleration

any 4 for 1 mark each

4

(b) (i) $F = ma$
 $10\,000 = 1250a$
 $a = 8$
 m/s^2

for 1 mark each

4

(ii) $ke = \frac{1}{2} mv^2$
 $ke = \frac{1}{2} 1250.48^2$
 $ke = 1\,440\,000$
 J
for 1 mark each

4

(iii) $W = Fd$
 $W = 10\,000 \cdot 144$
 $W = 1\,440\,000$
 J
for 1 mark each

4

[16]

24

(a) A then E
for one mark

1

(b) $A > E$
 $A = E$
 $A < E$
in this order for 1 mark each

3

(c) when van stops / is stationary / is parked
for one mark

1

(d) WX – slowing down (owtte)
 XY – constant speed (owtte)
 YZ – speeding up (owtte)
for 1 mark each

3

(e) force forwards backward
for 1 mark each

3

[11]

25

(a) WX deceleration / speed decreasing / slowing down / negative acceleration

XY constant speed / steady speed *not* constant motion / slow speed

YZ acceleration / speed increasing / speeding up

for 1 mark each

3

(b) distance = $v \times t$ **or** distance = 30×20

gains 1 mark

but

distance = 600(m)

gains 2 marks

2

(c) acceleration = v / t **or** acceleration = $30 / 12$

gains 1 mark

(if $-30 / 12$, allow negative sign here if not in the answer)

3

but

acceleration = 2.5 (m/s²)

gains 2 marks

but

acceleration = -2.5 (m/s²)

gains 3 marks

(d) in a crash / during hard braking car body stops / slows rapidly driver / passengers continue to move forward *not* thrown forward seatbelts provide backward force / keep them in their seats / restrain them to stop them hitting the windscreen / dashboard

(an alternative argument involving momentum is acceptable)

for 1 mark each

4

[12]

26

12 100

correct answer with no working = 3

if answer incorrect, allow 1 mark for force = mass \times acceleration

1210 \times 10 = 2 force / weight = mass \times gravity is neutral

N.B. no marks for correct answers with incorrectly recalled relationship

[3]

27

- (a) $WD = \text{force} \times \text{distance}$ **or** 6×2
gains 1 mark

but 12 *gains 2 marks*
units J/joules [credit Nn]
for 1 mark

3

- (b) 0.6 (i.e. using the **recalled** 10N/kg)
gains 1 mark

but evidence of force = mass \times acceleration
or of correct substitution e.g. 6/9.8
gains 2 marks

but 0.61 (2...)
gains 3 marks

3

- (c) *any reference to*
initial acceleration due to gravity
(force due to) friction/air resistance
each for 1 mark

ideas that
this increases as speed increases
forces eventually balance
each for 1 further mark

9

[9]

28

(a) *evidence of acceleration = $\frac{\text{change in speed}}{\text{time}}$ or $\frac{0.6}{3}$
gains 1 mark

but 0.2

gains 2 marks

units m/s^2

for 1 mark

3

(b) (i) 2000 or 1960
for 1 mark

1

(ii) evidence of power = $\frac{\text{work done}}{\text{time taken}}$ or weight \times speed (credit figures) $\frac{25}{0.6}$

(iii) $\frac{25}{0.6}$
gains 1 mark

but 1200/1176 or figure consistent with (b)(i)
gains 2 marks

2

(c) evidence of force = mass \times acceleration or 200×0.3
gains 1 mark

but 60

gains 2 marks

but 60 + weight of girder (2060/2020*) (or figure consistent with (b)(i))
gains 3 marks

3

[9]

29

- (a) evidence of $\frac{\text{change in speed}}{\text{time taken}}$ or $\frac{40}{5}$

gains 1 mark

(credit 50/10 or 5 with 1 mark) NOT 40/10 or 50/5

but 8 [N.B. negative not required]

gains 2 marks

units metres per second per second or (metres per second squared or m/s²)

for 1 mark

3

- (b) (i) *idea that*
accelerates at first due to gravity
air/wind resistance
friction/resistance/drag with air increases with speed
eventually gravity and friction cancel balance
or (no net/accelerating force) [NOT terminal velocity]

each for 1 mark

3

- (ii) *idea*
a bigger resistance/friction/drag at any given speed (credit a bigger drag (factor))

for 1 mark

1

- (c) evidence of $\times 10$ / $\times 9.8$ / $\times 9.81$ or 750/735(75)

for 1 mark

1

[8]