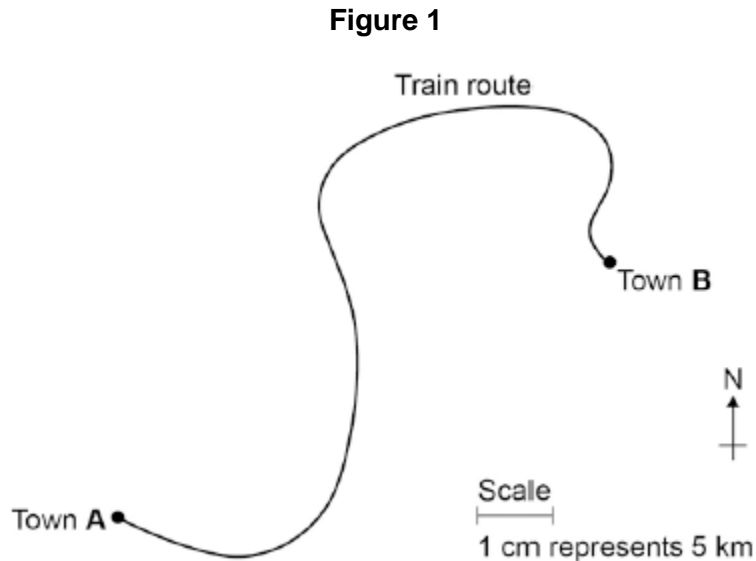


1

A train travels from town **A** to town **B**.

**Figure 1** shows the route taken by the train.

**Figure 1** has been drawn to scale.



- (a) The distance the train travels between **A** and **B** is not the same as the displacement of the train.

What is the difference between distance and displacement?

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

(1)

- (b) Use **Figure 1** to determine the displacement of the train in travelling from **A** to **B**.

Show how you obtain your answer.

.....  
.....

Displacement = ..... km

Direction = .....

(2)

(c) There are places on the journey where the train accelerates without changing speed.

Explain how this can happen.

.....

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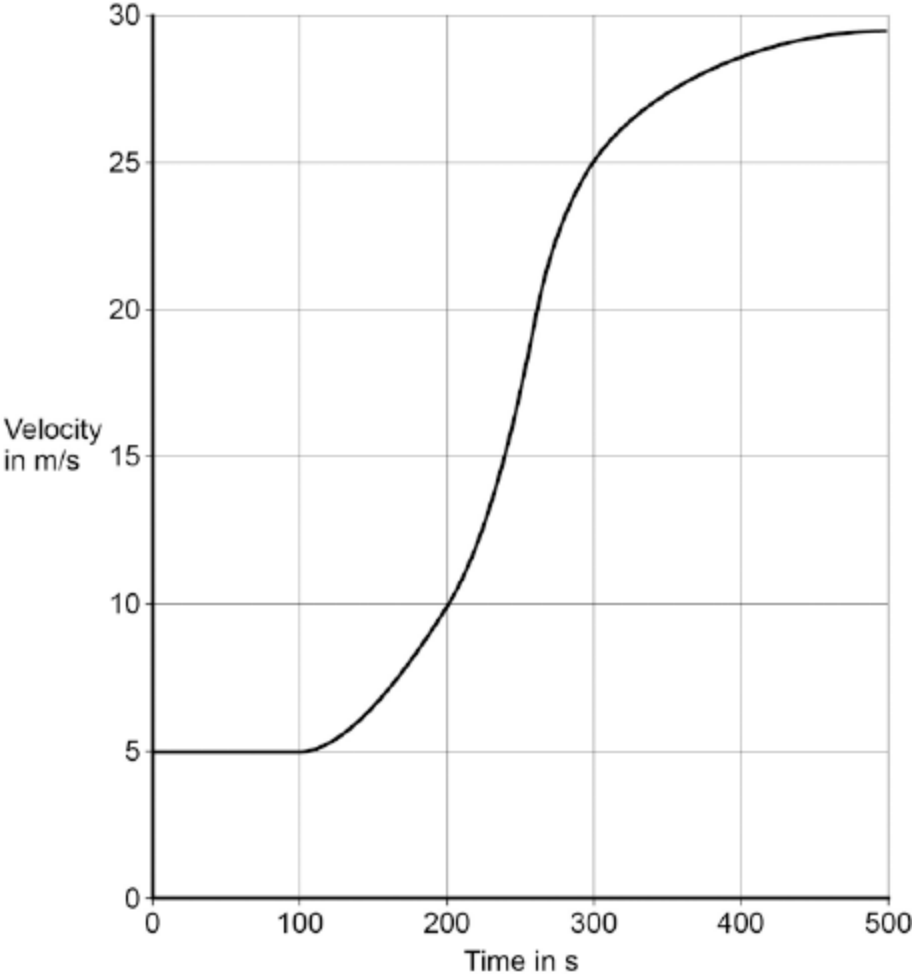
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**(2)**

(d) **Figure 2** shows how the velocity of the train changes with time as the train travels along a straight section of the journey.

**Figure 2**



Estimate the distance travelled by the train along the section of the journey shown in **Figure 2**.

To gain full marks you must show how you worked out your answer.

.....

.....

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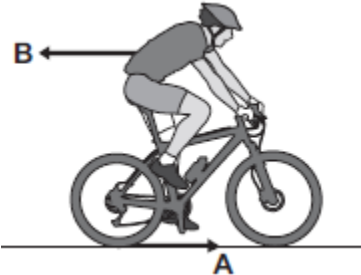
Distance = ..... m

**(3)**  
**(Total 8 marks)**

2

(a) **Figure 1** shows the horizontal forces acting on a moving bicycle and cyclist.

**Figure 1**



(i) What causes force **A**?

Draw a ring around the correct answer.

- friction          gravity          weight**

(1)

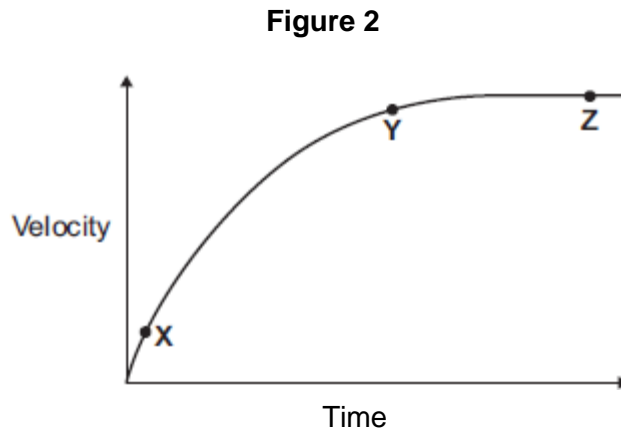
(ii) What causes force **B**?

.....

(1)

(iii) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

**Figure 2** shows how the velocity of the cyclist changes during the first part of a journey along a straight and level road. During this part of the journey the force applied by the cyclist to the bicycle pedals is constant.



Describe how **and** explain, in terms of the forces **A** and **B**, why the velocity of the cyclist changes:

- between the points **X** and **Y**
- and between the points **Y** and **Z**, marked on the graph in **Figure 2**.

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Extra space .....

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**(6)**

(b) (i) The cyclist used the brakes to slow down and stop the bicycle.

A constant braking force of 140 N stopped the bicycle in a distance of 24 m.

Calculate the work done by the braking force to stop the bicycle. Give the unit.

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

Work done = .....

**(3)**

(ii) Complete the following sentences.

When the brakes are used, the bicycle slows down. The kinetic energy of the bicycle .....

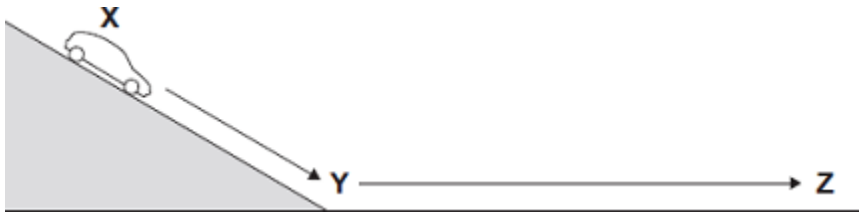
At the same time, the ..... of the brakes increases.

**(2)**

**(Total 13 marks)**

3

(a) The diagram shows a car at position **X**.



The handbrake is released and the car rolls down the slope to **Y**.  
The car continues to roll along a horizontal surface before stopping at **Z**.  
The brakes have **not** been used during this time.

(i) What type of energy does the car have at **X**?

.....

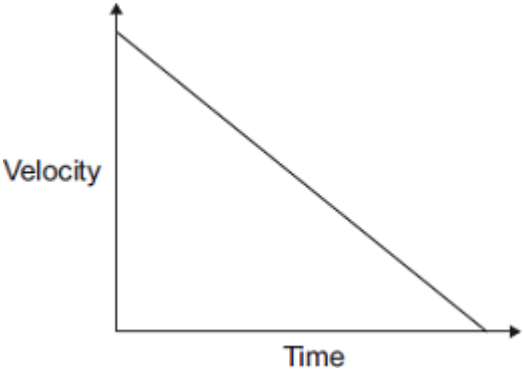
(1)

(ii) What type of energy does the car have at **Y**?

.....

(1)

(b) The graph shows how the velocity of the car changes with time between **Y** and **Z**.



(i) Which feature of the graph represents the negative acceleration between **Y** and **Z**?

.....

(1)

(ii) Which feature of the graph represents the distance travelled between **Y** and **Z**?

.....

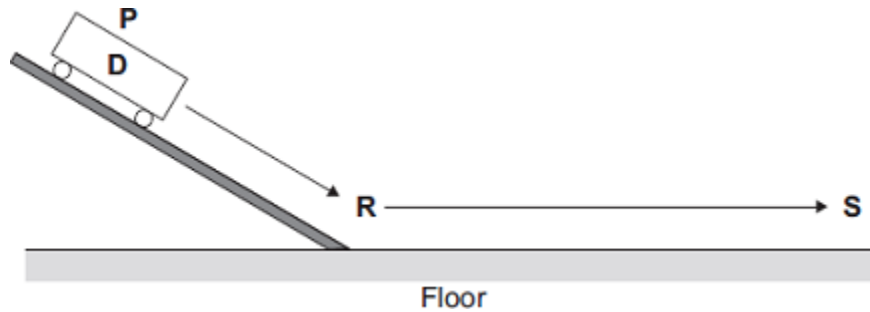
(1)

- (iii) The car starts again at position **X** and rolls down the slope as before. This time the brakes are applied lightly at **Y** until the car stops.

Draw on the graph another straight line to show the motion of the car between **Y** and **Z**.

(2)

- (c) Three students carry out an investigation. The students put trolley **D** at position **P** on a slope. They release the trolley. The trolley rolls down the slope and along the floor as shown in the diagram.



The students measure the distance from **R** at the bottom of the slope to **S** where the trolley stops. They also measure the time taken for the trolley to travel the distance **RS**. They repeat the investigation with another trolley, **E**.

Their results are shown in the table.

Trolley	Distance RS in centimetres	Time taken in seconds	Average velocity in centimetres per second
<b>D</b>	65	2.1	
<b>E</b>	80	2.6	

- (i) Calculate the average velocity, in centimetres per second, between **R** and **S** for trolleys **D** and **E**. Write your answers in the table.

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

(3)



(ii) Before the investigation, each student made a prediction.

- Student 1 predicted that the two trolleys would travel the same distance.
- Student 2 predicted that the average velocity of the two trolleys would be the same.
- Student 3 predicted that the negative acceleration of the two trolleys would be the same.

Is each prediction correct?

Justify your answers.

.....

.....

.....

.....

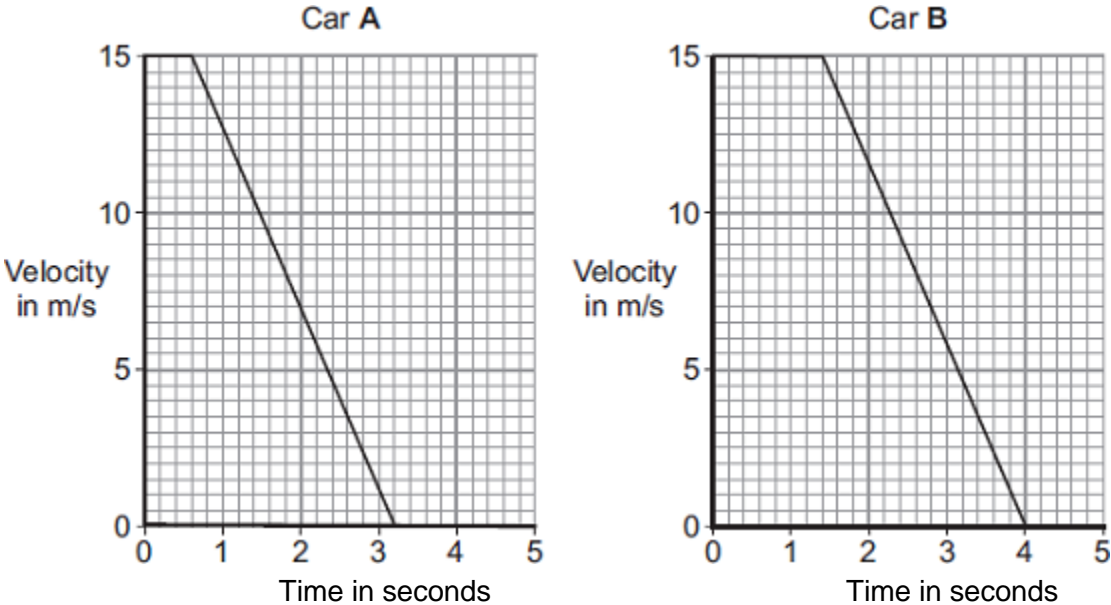
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**(3)**  
**(Total 12 marks)**

4

(a) The graphs show how the velocity of two cars, **A** and **B**, change from the moment the car drivers see an obstacle blocking the road.



One of the car drivers has been drinking alcohol. The other driver is wide awake and alert.

(i) How does a comparison of the two graphs suggest that the driver of car **B** is the one who has been drinking alcohol?

.....  
.....

(1)

(ii) How do the graphs show that the two cars have the same deceleration?

.....  
.....

(1)

(iii) Use the graphs to calculate how much further car **B** travels before stopping compared to car **A**.

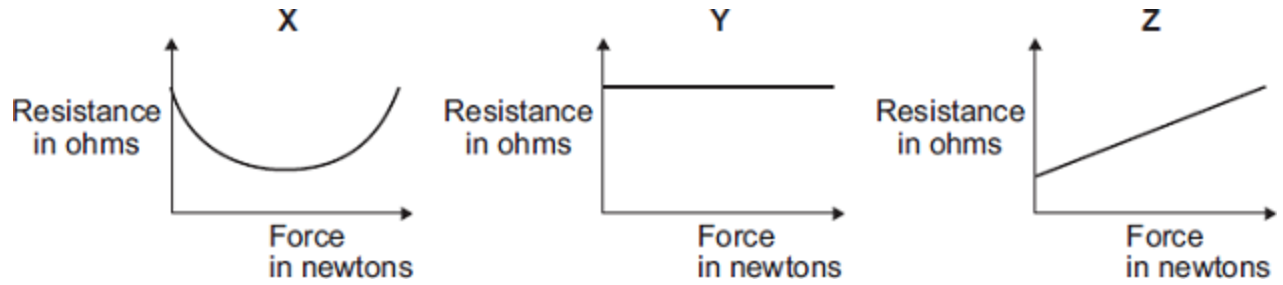
Show clearly how you work out your answer.

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

Additional stopping distance = ..... m

(3)

- (b) In a crash-test laboratory, scientists use sensors to measure the forces exerted in collisions. The graphs show how the electrical resistance of 3 experimental types of sensor, **X**, **Y**, and **Z**, change with the force applied to the sensor.



Which of the sensors, **X**, **Y** or **Z**, would be the best one to use as a force sensor?

.....

Give a reason for your answer.

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

**(2)**  
**(Total 7 marks)**

5

The London Eye is one of the largest observation wheels in the world.



© Angelo Ferraris/Shutterstock

The passengers ride in capsules. Each capsule moves in a circular path and accelerates.

- (a) Explain how the wheel can move at a steady speed and the capsules accelerate at the same time.

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

(2)

- (b) In which direction is the resultant force on each capsule?

.....

(1)

- (c) The designers of the London Eye had to consider **three** factors which affect the resultant force described in part (b).

Two factors that increase the resultant force are:

- an increase in the speed of rotation
- an increase in the total mass of the wheel, the capsules and the passengers.

Name the other factor that affects the resultant force and state what effect it has on the resultant force.

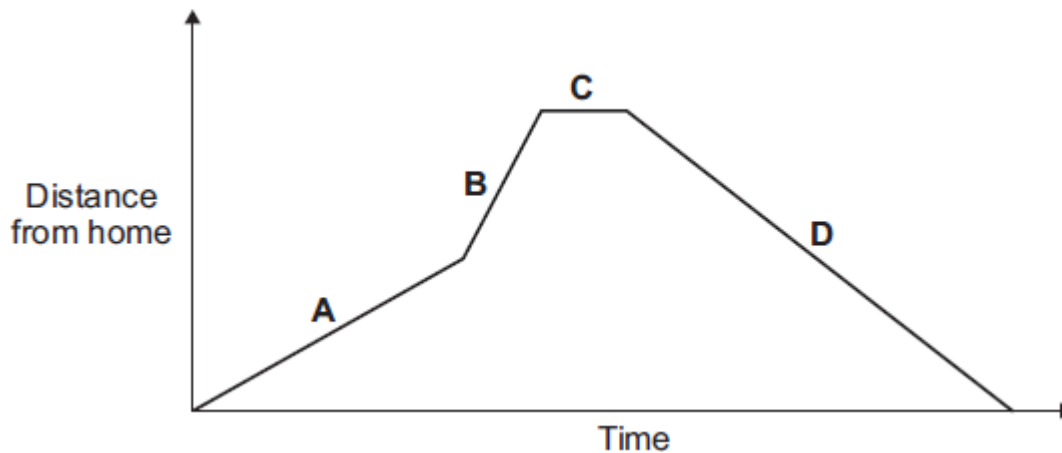
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(1)  
(Total 4 marks)

6

- (a) A person takes their dog for a walk.

The graph shows how the distance from their home changes with time.



Which part of the graph, **A**, **B**, **C** or **D**, shows them walking the fastest?

Write your answer in the box.

Give the reason for your answer.

.....  
.....

(2)

(b) During the walk, both the speed and the velocity of the person and the dog change.

How is *velocity* different from *speed*?

.....  
.....

(1)  
(Total 3 marks)

**7**

A cyclist travelling along a straight level road accelerates at  $1.2 \text{ m/s}^2$  for 5 seconds. The mass of the cyclist and the bicycle is 80 kg.

(a) Calculate the resultant force needed to produce this acceleration.

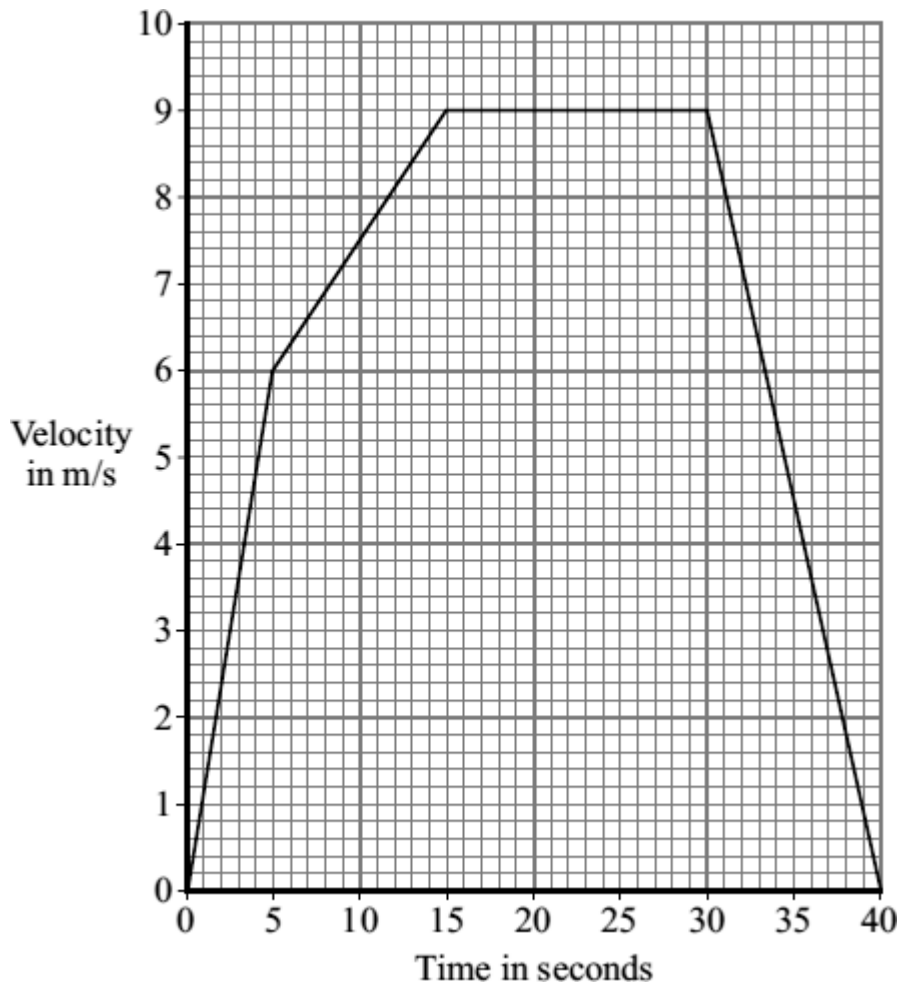
Show clearly how you work out your answer and give the unit.

.....  
.....

Resultant force = .....

(3)

(b) The graph shows how the velocity of the cyclist changes with time.



(i) Complete the following sentence.

The velocity includes both the speed and the .....of the cyclist.

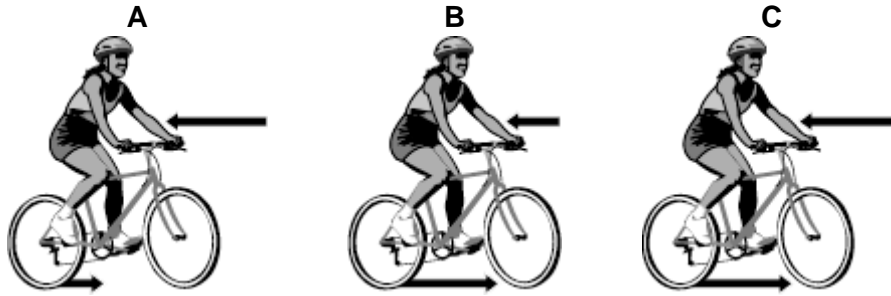
(1)

(ii) Why has the data for the cyclist been shown as a line graph instead of a bar chart?

.....  
.....

(1)

- (iii) The diagrams show the horizontal forces acting on the cyclist at three different speeds. The length of an arrow represents the size of the force.



Which **one** of the diagrams, **A**, **B** or **C**, represents the forces acting when the cyclist is travelling at a constant 9 m/s?

.....

Explain the reason for your choice.

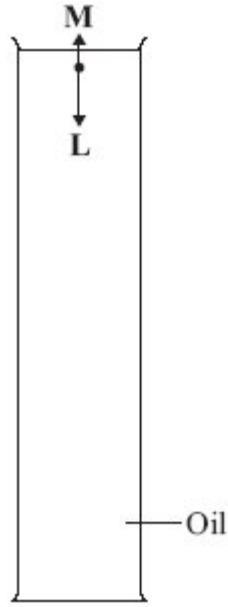
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**(3)**  
**(Total 8 marks)**



8

- (a) The diagram shows a steel ball-bearing falling through a tube of oil. The forces, **L** and **M**, act on the ball-bearing.

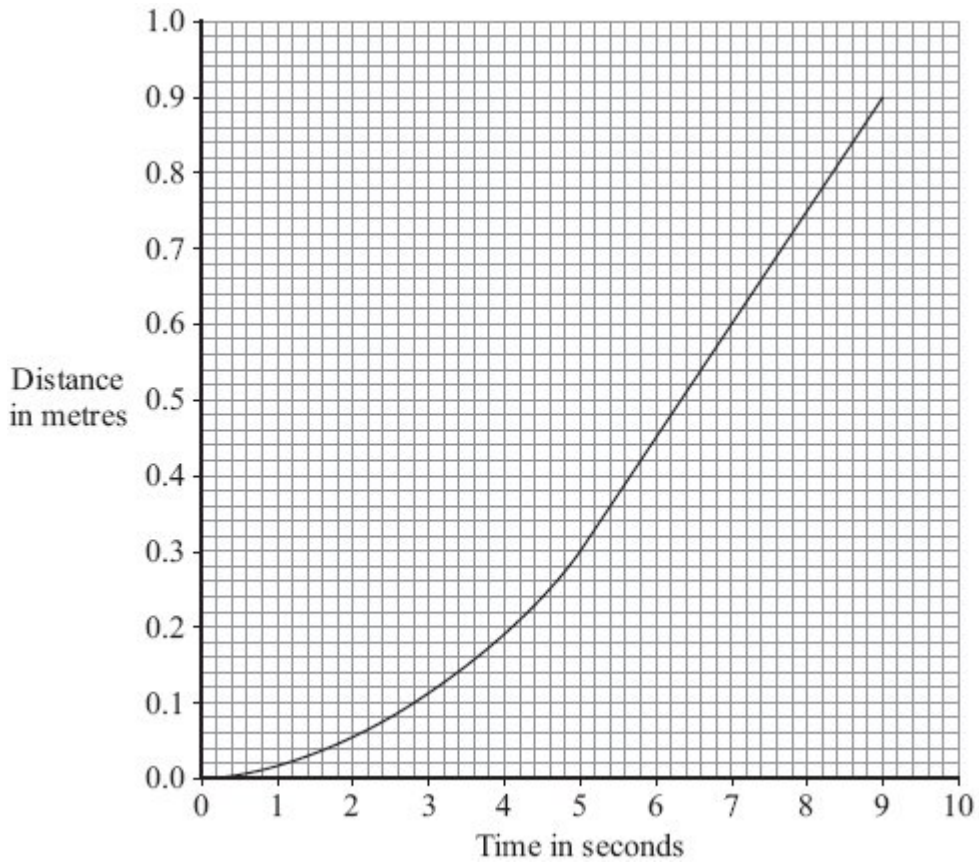


What causes force **L**?

.....

(1)

- (b) The distance – time graph represents the motion of the ball-bearing as it falls through the oil.



- (i) Explain, in terms of the forces, **L** and **M**, why the ball-bearing accelerates at first but then falls at constant speed.

.....

.....

.....

.....

.....

.....

(3)

- (ii) What name is given to the constant speed reached by the falling ball-bearing?

.....

(1)

- (iii) Calculate the constant speed reached by the ball-bearing.

Show clearly how you use the graph to work out your answer.

.....

.....

.....

Speed = ..... m/s

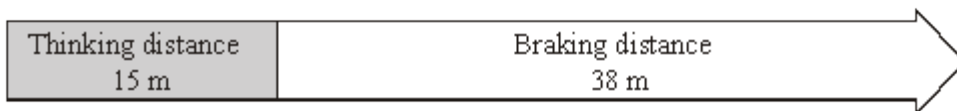
(2)

(Total 7 marks)

**9**

- (a) A car driver makes an emergency stop.

The chart shows the 'thinking distance' and the 'braking distance' needed to stop the car.



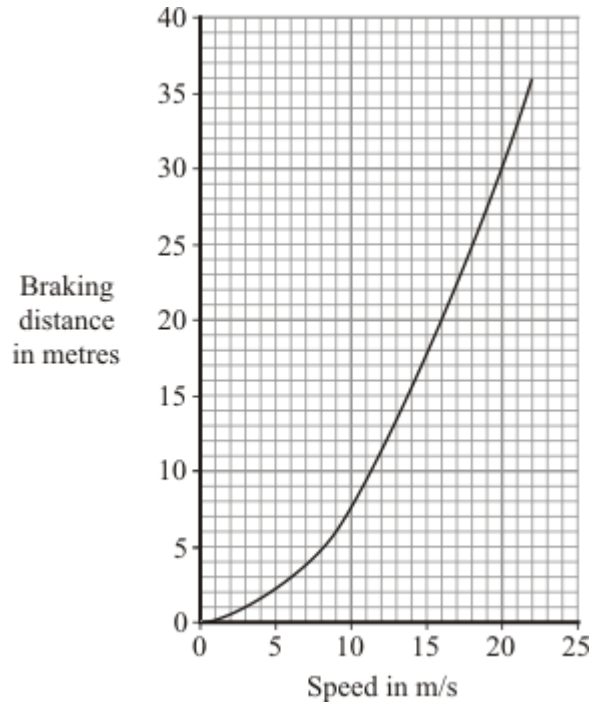
Calculate the total stopping distance of the car.

.....

Stopping distance = ..... m

(1)

- (b) The graph shows how the braking distance of a car driven on a dry road changes with the car's speed.



The braking distance of the car on an icy road is longer than the braking distance of the car on a dry road.

- (i) Draw a new line on the graph to show how the braking distance of the car on an icy road changes with speed.

(2)

- (ii) Which **two** of the following would also increase the braking distance of the car?

Put a tick (✓) next to each of your answers.

rain on the road

the driver having drunk alcohol

car brakes in bad condition

the driver having taken drugs

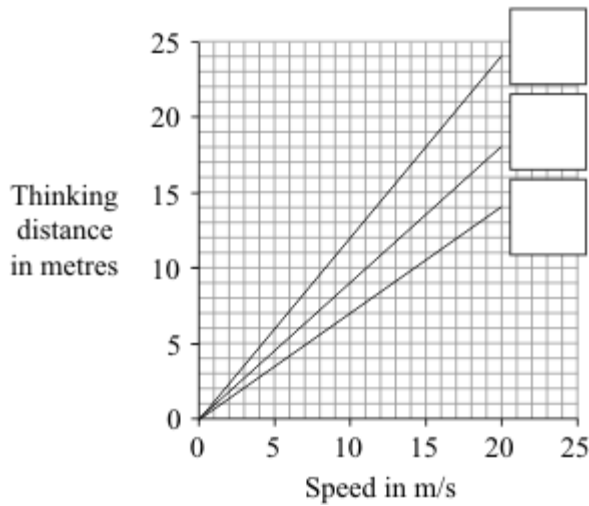
(2)

(c) The thinking distance depends on the driver's reaction time.

The table shows the reaction times of three people driving under different conditions.

Car driver	Condition	Reaction time in seconds
<b>A</b>	Wide awake with no distractions	0.7
<b>B</b>	Using a hands-free mobile phone	0.9
<b>C</b>	Very tired and listening to music	1.2

The graph lines show how the thinking distance for the three drivers, **A**, **B** and **C**, depends on how fast they are driving the car.



(i) Match each graph line to the correct driver by writing **A**, **B** or **C** in the box next to the correct line.

(2)

(ii) The information in the table cannot be used to tell if driver **C**'s reaction time is increased by being tired or by listening to music.

Explain why.

.....

.....

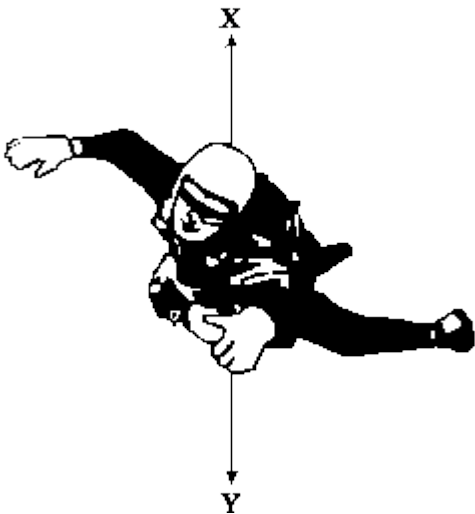
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.....

(2)  
(Total 9 marks)

10

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**.  
.....  
..... (1)

**(Total 5 marks)**

11

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



A



B

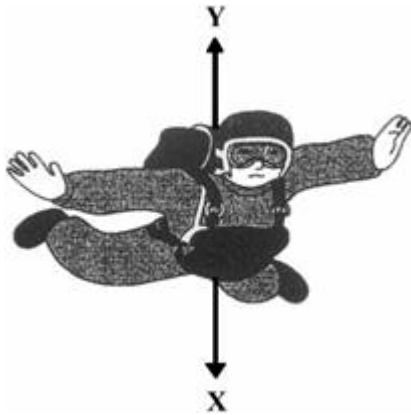
Adapted from Progress with Physics by Nick England, reproduced by permission of Hodder Arnold

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**?

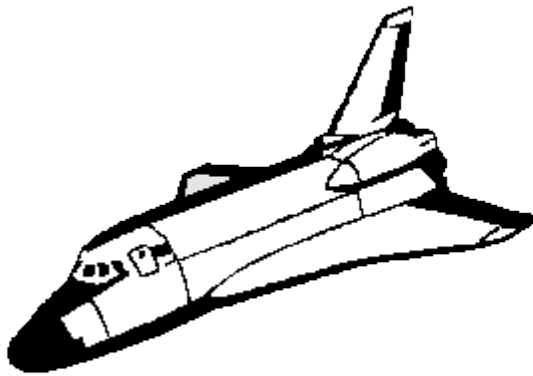
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(1)

(Total 7 marks)

12

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

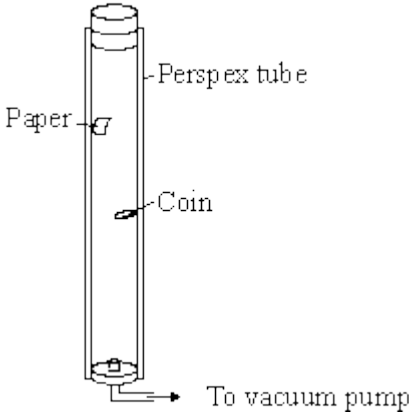
**(1)**

**(Total 9 marks)**



13

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

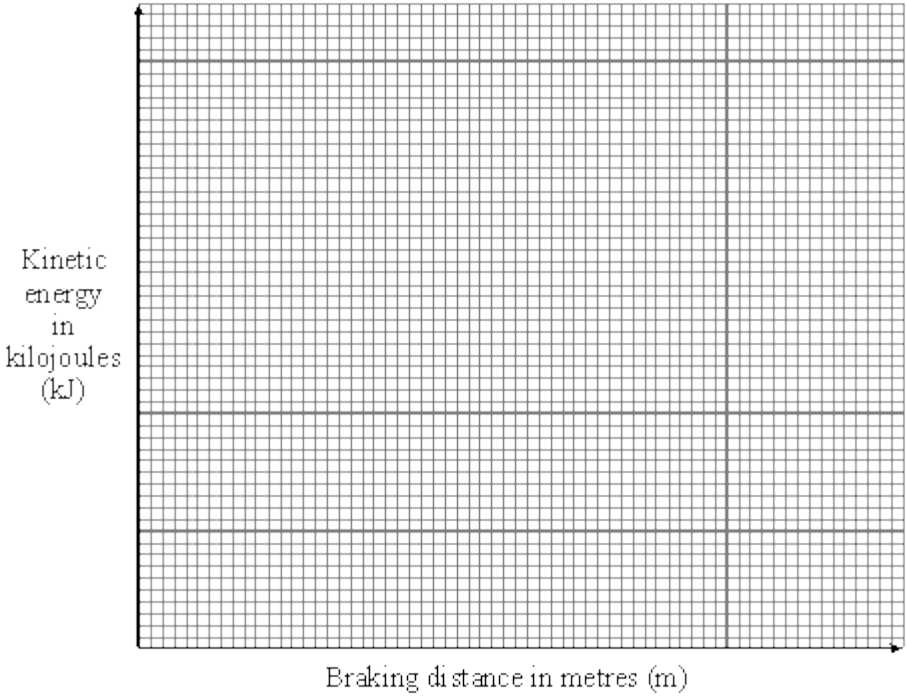
(2)  
(Total 3 marks)

14

The table shows the braking distances for a car at different speeds and kinetic energy. The braking distance is how far the car travels once the brakes have been applied.

Braking distance in m	Speed of car in m/s	Kinetic energy of car in kJ
5	10	40
12	15	90
20	20	160
33	25	250
45	30	360

- (a) A student suggests, "the braking distance is directly proportional to the kinetic energy."
  - (i) Draw a line graph to test this suggestion.



(3)

- (ii) Does the graph show that the student's suggestion was correct or incorrect? Give a reason for your answer.

.....  
.....

(1)

- (iii) Use your graph and the equation for kinetic energy to predict a braking distance for a speed of 35 metres per second (m/s). The mass of the car is 800 kilograms (kg). Show clearly how you obtain your answer.

.....  
 .....

Braking distance = ..... m

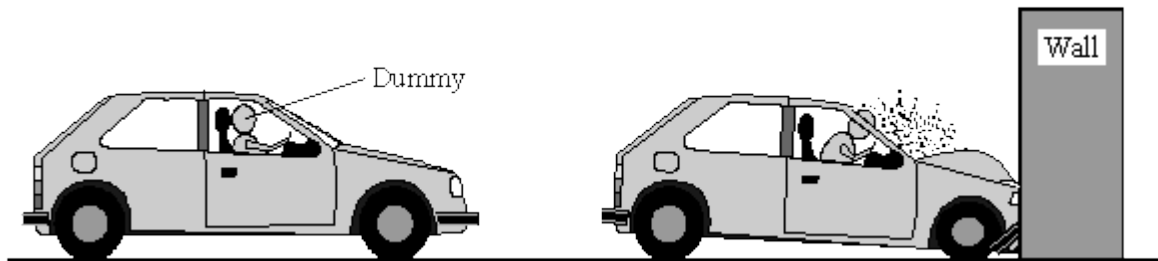
(2)

- (iv) State **one** factor, apart from speed, which would increase the car's braking distance.

.....

(1)

- (b) The diagram shows a car before and during a crash test. The car hits the wall at 14 metres per second (m/s) and takes 0.25 seconds (s) to stop.



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

.....

(1)

- (ii) Calculate the deceleration of the car.

.....

Deceleration = ..... m/s<sup>2</sup>

(1)

- (iii) In an accident the crumple zone at the front of a car collapses progressively. This increases the time it takes the car to stop. In a front end collision the injury to the car passengers should be reduced. Explain why. The answer has been started for you.

*By increasing the time it takes for the car to stop, the .....*

.....

.....

.....

(2)  
(Total 11 marks)

15

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

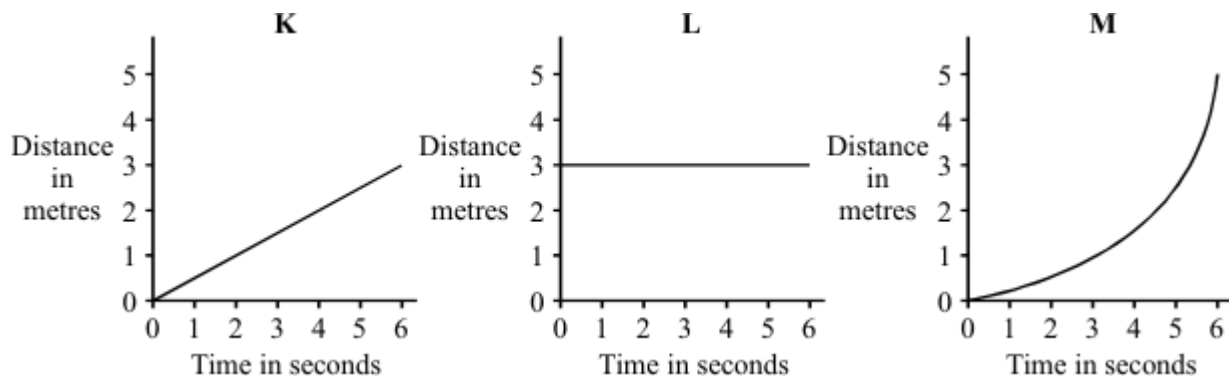


- (i) How big is force **P** compared to force **F**?

.....

(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)

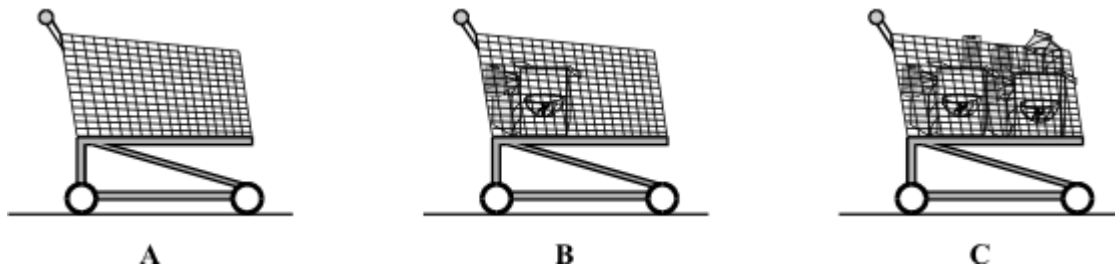
(b) Complete the sentence by crossing out the **two** words in the box that are wrong.

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.

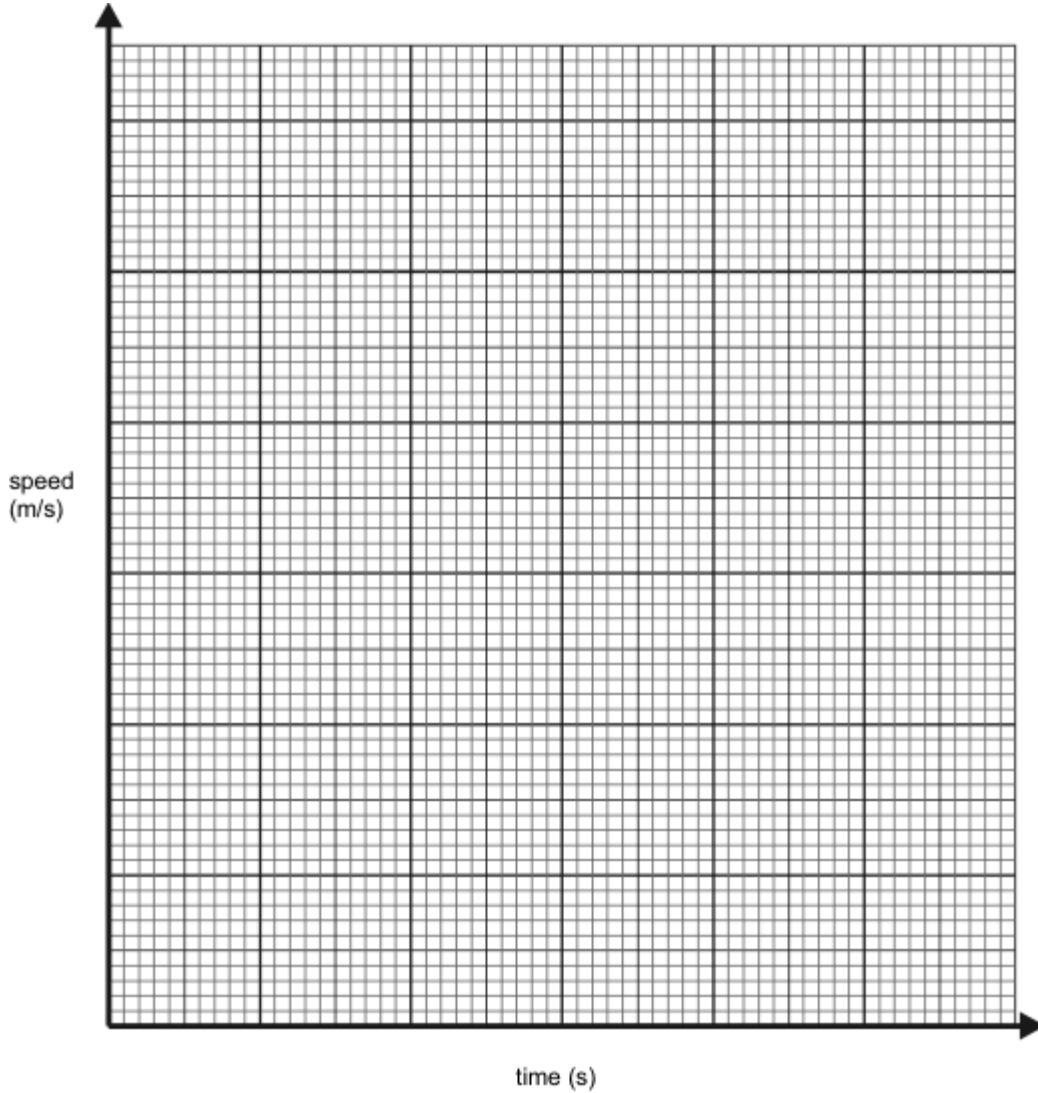
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(2)  
(Total 5 marks)

16

A driver is driving along a road at 30 m/s. The driver suddenly sees a large truck parked across the road and reacts to the situation by applying the brakes so that a constant braking force stops the car. The reaction time of the driver is 0.67 seconds, it then takes another 5 seconds for the brakes to bring the car to rest.

- (a) Using the data above, draw a speed-time graph to show the speed of the car from the instant the truck was seen by the driver until the car stopped.



(5)

- (b) Calculate the acceleration of the car whilst the brakes are applied.

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

Answer = ..... m/s<sup>2</sup>

(3)

(c) The mass of the car is 1500 kg. Calculate the braking force applied to the car.

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

Answer = ..... N

**(3)**

(d) The diagrams below show what would happen to a driver in a car crash.



(i) Explain why the driver tends to be thrown towards the windscreen.

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

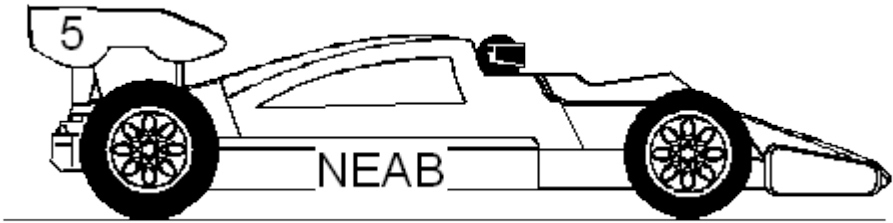
(ii) The car was travelling at 30 m/s immediately before the crash. Calculate the energy which has to be dissipated as the front of the car crumples.

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

**(8)**  
**(Total 17 marks)**

17

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.

.....

.....

.....

.....

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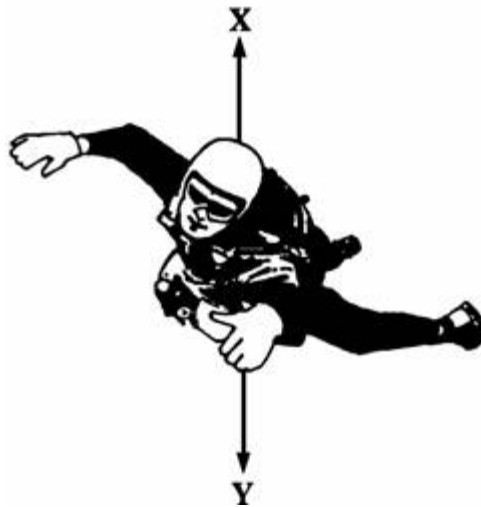
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(12)  
(Total 16 marks)

18

A sky-diver jumps from a plane.

The sky-diver is shown in the diagram below.



- (a) Arrows **X** and **Y** show two forces acting on the sky-diver as he falls.

- (i) Name the forces **X** and **Y**.

**X** .....

**Y** .....

(2)

- (ii) Explain why force **X** acts in an upward direction.

.....

.....

(1)

(iii) At first forces **X** and **Y** are unbalanced.

Which of the forces will be bigger? .....

(1)

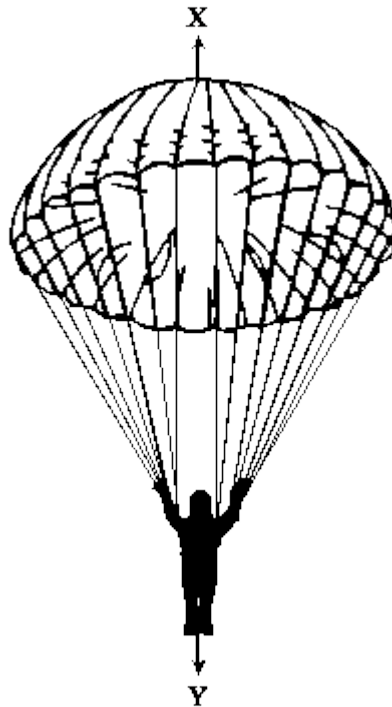
(iv) How does this unbalanced force affect the sky-diver?

.....  
.....

(2)

(b) After some time the sky-diver pulls the rip cord and the parachute opens.

The sky-diver and parachute are shown in the diagram below.



After a while forces **X** and **Y** are balanced.

Underline the correct answer in each line below.

Force **X** has

*increased / stayed the same / decreased.*

Force **Y** has

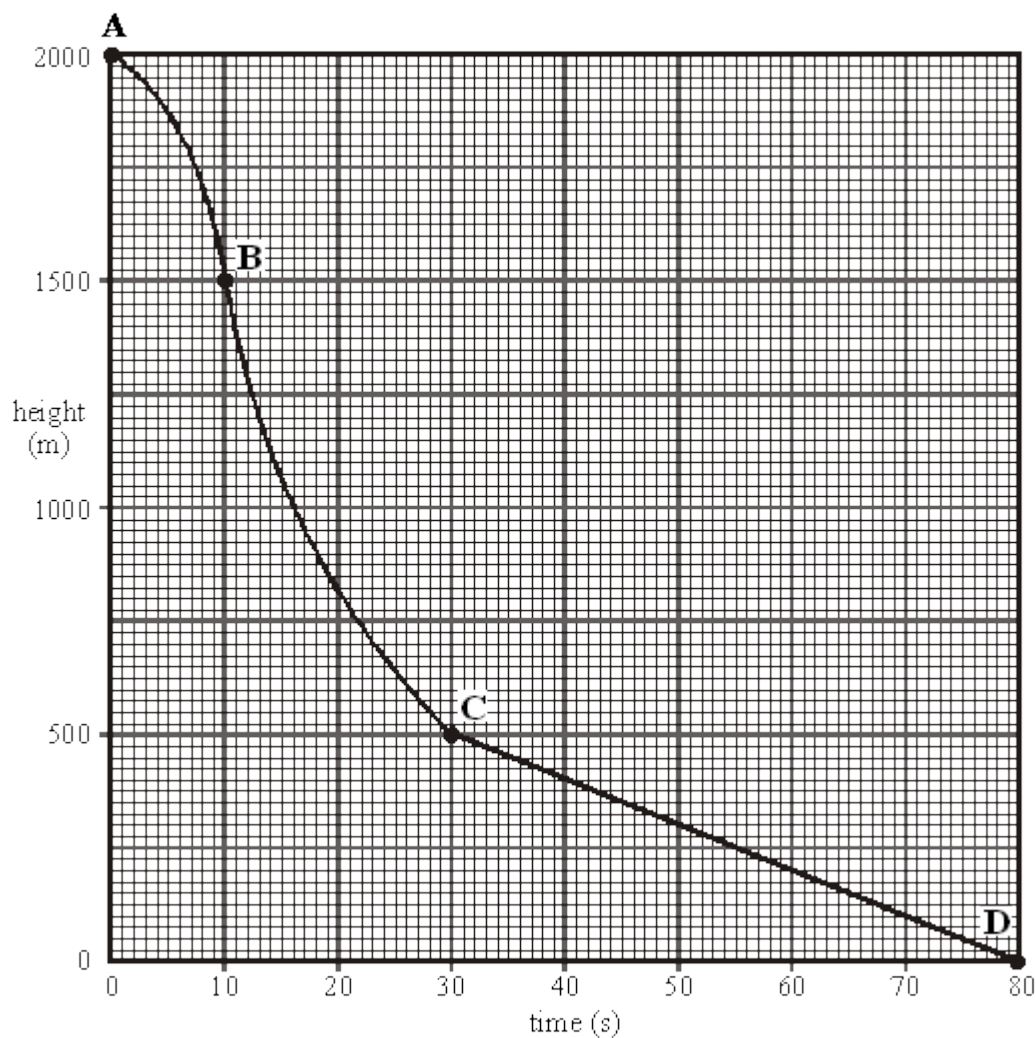
*increased / stayed the same / decreased.*

The speed of the sky-diver will

*increase / stay the same / decrease.*

(3)

(c) The graph below shows how the height of the sky-diver changes with time.



(i) Which part of the graph, **AB**, **BC** or **CD** shows the sky-diver falling at a constant speed?

.....

(1)

(ii) What distance does the sky-diver fall at a constant speed?

Distance ..... m

(1)

(iii) How long does he fall at this speed?

Time ..... s

(1)

(iv) Calculate this speed.

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

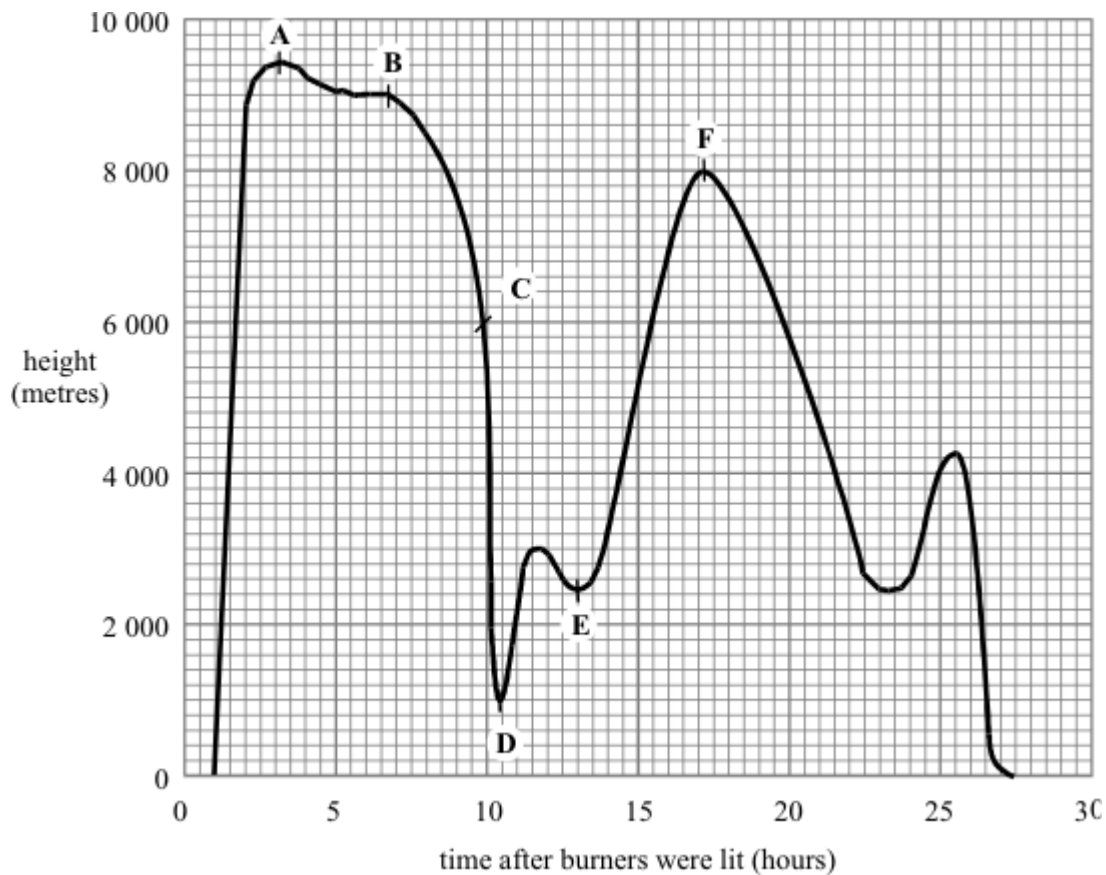
Speed ..... m/s

(2)  
(Total 14 marks)

19

A hot air balloon called Global Challenger was used to try to break the record for travelling round the world.

The graph shows how the height of the balloon changed during the flight.



The balloon took off from Marrakesh one hour after the burners were lit and climbed rapidly.

(a) Use the graph to find:

(i) the maximum height reached.

Maximum height ..... metres.

(ii) the total time of the flight.

Total time ..... hours.

**(2)**

(b) Several important moments during the flight are labelled on the graph with the letters **A, B, C, D, E** and **F**.

At which of these moments did the following happen?

(i) The balloon began a slow controlled descent to 2500 metres.

.....

(ii) The crew threw out all the cargo on board in order to stop a very rapid descent.

.....

(iii) The balloon started to descend from 9000 metres.

.....

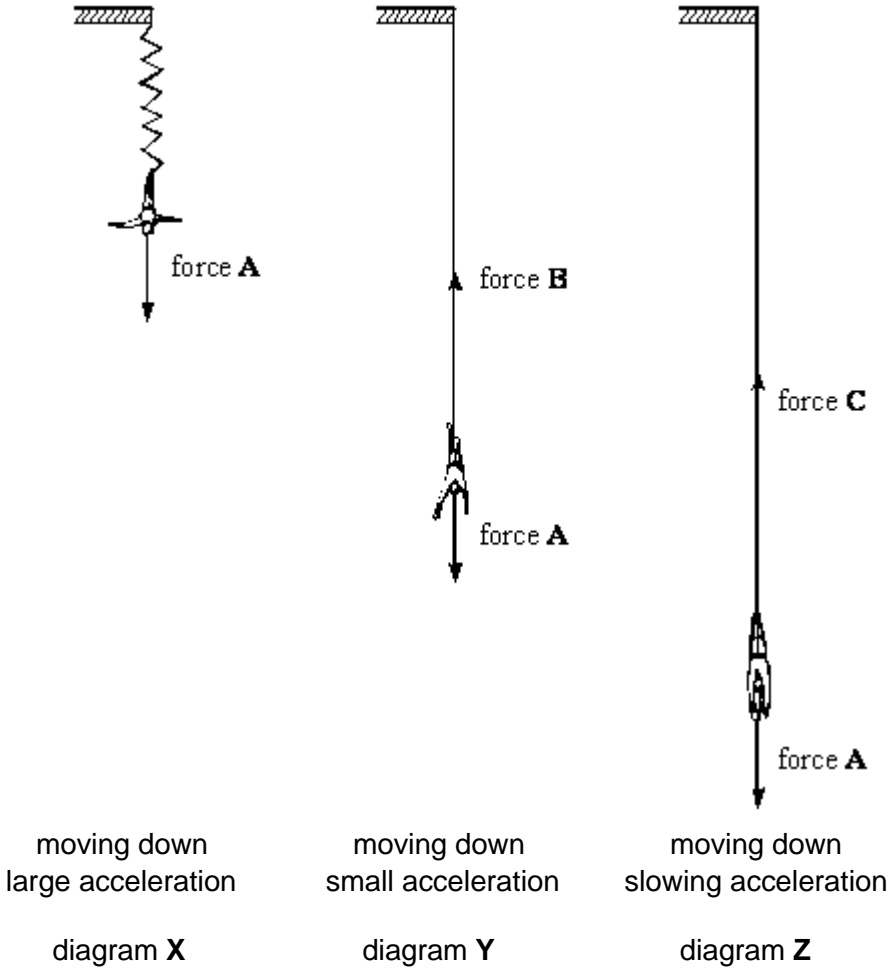
**(3)**  
**(Total 5 marks)**

20

When a bungee-jump is made the jumper steps off a high platform. An elastic cord from the platform is tied to the jumper.

The diagram below shows different stages in a bungee-jump.

Forces **A**, **B** and **C** are forces acting on the jumper at each stage.



(a) Name force **A**.

.....

(1)

(b) The motion of the jumper is shown in the diagrams.  
By comparing forces **A**, **B** and **C**, state how the motion is caused in:

(i) diagram **X**;

.....

(ii) diagram **Y**;

.....

(iii) diagram **Z**.

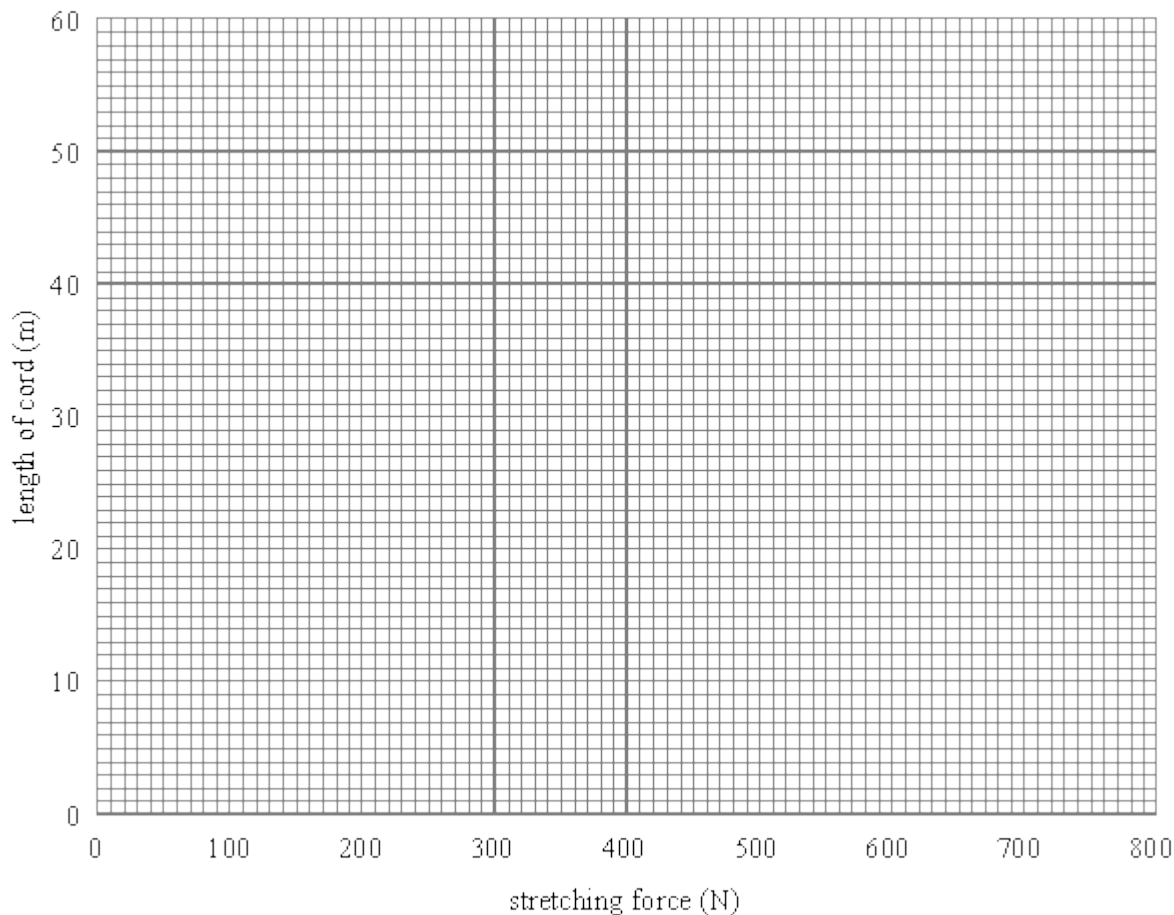
.....

(3)

(c) The table gives results for a bungee cord when it is being stretched.

STRETCHING FORCE (N)	100	200	400	600	800
LENGTH OF CORD (m)	20	24	32	40	48

(i) Plot a graph of these results on the graph paper.



(3)

(ii) Use the graph to find the length of the cord before it was stretched.

Length ..... m

(1)

(Total 8 marks)

**21**

When you transfer *energy* to a shopping trolley, the amount of *work done* depends on the *force* used and the *distance moved*.



Complete the table by using the correct units from the box.

**joule (J)**      **metre (m)**      **newton (N)**

The first one has been done for you.

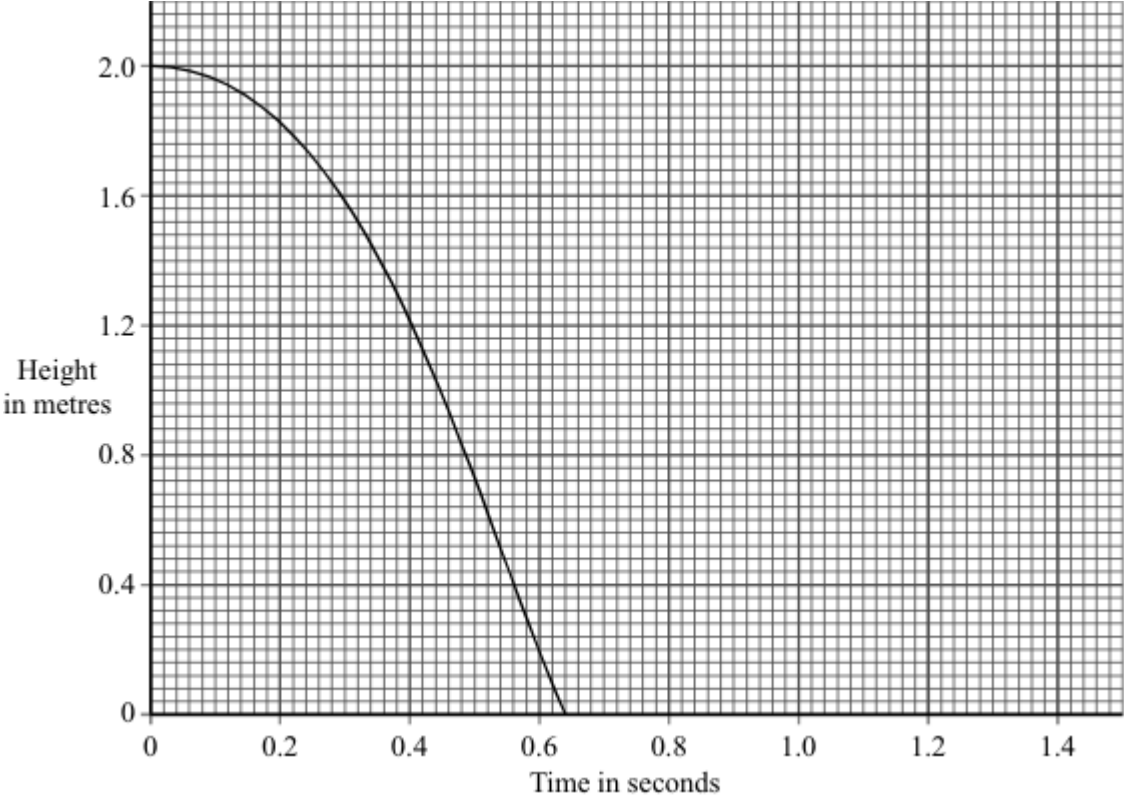
<b>Quantity</b>	<b>Unit</b>
energy (transferred)	joule
force	
distance (moved)	
work done	

**(Total 2 marks)**



22

A bouncy ball is dropped vertically from a height of 2.00 m onto the floor. The graph shows the height of the ball above the floor at different times during its fall until it hits the floor after 0.64 s.



(a) What is the average speed of the ball over the first 0.64 s? Show clearly how you work out your answer.

.....  
.....

Average speed = ..... m/s

(1)

(b) After it hits the floor the ball bounces back to a height of 1.25 m. It reaches this height 1.16 s after it was dropped. Plot this point on the grid above and sketch a graph to show the height of the ball above the floor between 0.64 s and 1.16 s.

(3)

(c) (i) The ball bounces on the floor 0.64 s after being dropped. How long after being dropped will it be before it bounces a second time?

.....  
.....

(1)

(ii) What distance will the ball travel between its first and second bounce?

.....  
.....

(1)

(d) The ball was held stationary before being dropped. On the graph and your sketch mark **two** other points **X<sub>1</sub>** and **X<sub>2</sub>**, where the ball is stationary, and in each case explain why the ball is not moving.

**X<sub>1</sub>** .....

.....

**X<sub>2</sub>** .....

.....

(2)

(Total 8 marks)

23

When a gun is fired, a very large force acts on the bullet for a very short time.

The change in momentum of the bullet is given by the following relationship:

$$\text{force (N)} \times \text{time(s)} = \text{change in momentum (kg m/s)}$$

(a) An average force of 4000 newton acts for 0.01 seconds on a bullet of mass 50g.

Calculate the speed of the bullet. (*Show your working.*)

.....

.....

.....

Answer ..... m/s

(4)

(b) The bullet is fired horizontally. In the short time it takes for the bullet to reach its target, its horizontal speed has fallen to 80% of its initial speed.

(i) Explain why the speed of the bullet decreases so quickly.

.....

.....

(2)

- (ii) Calculate the percentage of its original kinetic energy the bullet still has when it reaches its target.

(Show your working.)

.....

.....

.....

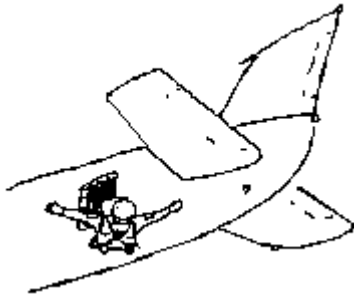
.....

(4)  
(Total 10 marks)

**24** 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)

25

A man's car will not start, so two friends help him by pushing it.



Mass of car = 800 kg

By pushing as hard as they can for 12 seconds they make the car reach a speed of 3 metres per second.

(a) Calculate the acceleration they give to the car.

.....  
.....

..... Answer ..... m/s<sup>2</sup>

(2)

(b) Whilst pushing the car the two friends together do a total of 2400 joules of work. Calculate their total power.

.....  
.....  
..... Answer ..... watts

(2)

(c) Another motorist has the same problem. The two friends push his car along the same stretch of road with the same force as before.

It takes them 18 seconds to get the second car up to a speed of 3 metres per second.

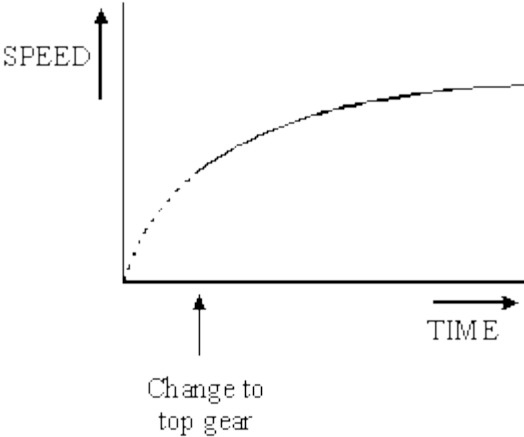
What does this tell you about the mass of the second car?  
(You can ignore forces of friction.)

.....  
.....

(2)

(d) On a flat stretch of a motorway a lorry driver changes into top gear. He then makes the lorry go as fast as he can.

The graph shows what happens to the speed of the lorry.



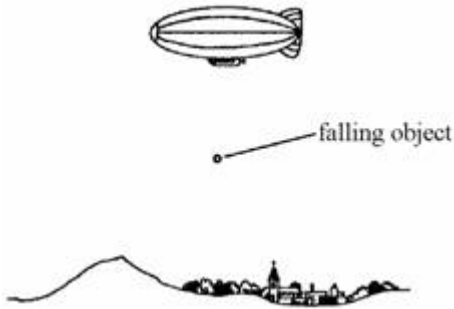
Explain why the speed of the lorry increases at first but then levels out.

.....  
.....

(3)  
(Total 9 marks)

26

A small object falls out of a balloon.



Choose words from the list to complete the sentences below.

**friction**

**gravity**

**air pressure**

**accelerates**

**falls at a steady speed**

**slows down**

- The weight of an object is the force of ..... which acts on it.
- When you drop something, first of all it .....
- The faster it falls, the bigger the force of ..... which acts on it.
- Eventually the object .....

**(Total 4 marks)**

27

The diagram shows a shuttlecock that is used for playing badminton.



The shuttlecock weighs very little.  
 When you drop it from a height of a few metres, it accelerates at first but soon reaches a steady speed.

Explain, as fully as you can:

(a) why the shuttlecock accelerates at first,

.....

.....

.....

**(2)**

(b) why the shuttlecock reaches a steady speed.

.....

.....

.....

.....

**(3)**  
**(Total 5 marks)**

## Mark schemes

1

(a) distance is a scalar and displacement is a vector

or

distance has magnitude only, displacement has magnitude and direction

1

(b) 37.5 km

*accept any value between 37.0 and 38.0 inclusive*

1

062° or N62°E

*accept 62° to the right of the vertical*

1

*accept an angle in the range 60° – 64°*

*accept the angle correctly measured and marked on the diagram*

(c) train changes direction so velocity changes

1

acceleration is the rate of change of velocity

1

(d) number of squares below line = 17

*accept any number between 16 and 18 inclusive*

1

each square represents 500 m

1

distance = number of squares × value of each square correctly calculated – 8500 m

1

**[8]**



(a) (i) friction

1

(ii) air resistance

*accept drag*

*friction is insufficient*

1

(iii) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.

**0 marks**

No relevant content.

**Level 1 (1–2 marks)**

There is an attempt to explain in terms of forces A and B why the velocity of the cyclist changes between any two points

**or**

a description of how the velocity changes between any two points.

**Level 2 (3–4 marks)**

There is an explanation in terms of forces A and B of how the velocity changes between X and Y and between Y and Z

**or**

a complete description of how the velocity changes from X to Z.

**or**

an explanation and description of velocity change for either X to Y or Y to Z

**Level 3 (5–6 marks)**

There is a clear explanation in terms of forces A and B of how the velocity changes between X and Z

**and**

a description of the change in velocity between X and Z.

**examples of the points made in the response**

***extra information***

**X to Y**

- at X force A is greater than force B
- cyclist accelerates
- and velocity increases
- as cyclist moves toward Y, force B (air resistance) increases (with increasing velocity)
- resultant force decreases
- cyclist continues to accelerate but at a smaller value
- so velocity continues to increase but at a lower rate

**Y to Z**

- from Y to Z force B (air resistance) increases
- acceleration decreases
- force B becomes equal to force A
- resultant force is now zero
- acceleration becomes zero

- velocity increases until...
- cyclist travels at constant / terminal velocity

*accept speed for velocity throughout*

6

(b) (i) 3360

*allow 1 mark for correct substitution,*

*ie  $140 \times 24$  provided no subsequent step*

*accept 3400 for 2 marks if correct substitution is shown*

2

joule / J

*do **not** accept j*

*do **not** accept Nm*

1

(ii) decreases

*accept an alternative word / description for decrease*

*do not accept slows down*

1

temperature

*accept thermal energy*

*accept heat*

1

[13]

3

(a) (i) gravitational potential (energy)

1

(ii) kinetic (energy)

1

(b) (i) slope or gradient

1

(ii) area (under graph)

*do **not** accept region*

1

(iii) starts at same y-intercept

1

steeper slope than original and cuts time axis before original

*the entire line must be below the given line*

*allow curve*

1

(c) (i) 31  
and  
31

*correct answers to 2 significant figures gains 3 marks even if no working shown*

*both values to more than 2 significant figures gains 2 marks:*

*30.952.....*

*30.769....*

*65 / 2.1 and / or*

*80 / 2.6 gains 1 mark*

*if incorrect answers given but if both are to 2 significant figures allow 1 mark*

3

(ii) student 1 incorrect because  $80 \neq 65$

1

student 2 correct because average velocities similar

*ecf from (c)(i)*

1

student 3 incorrect because times are different

1

[12]

4

(a) (i) longer reaction time

*accept slower reactions*

*do **not** accept slower reaction time unless qualified*

**or**

greater thinking distance

*accept greater thinking time*

**or**

greater stopping distance

*accept greater stopping time*

*greater braking distance negates answer*

1

(ii) lines / slopes have the same gradient

*accept slopes are the same*

**or**

velocity decreases to zero in same time / in 2.6 seconds

*accept any time between 2.4 and 2.8*

*accept braking distances are the same*

1

(iii) 12

*accept extracting both reaction times correctly for 1 mark  
(0.6 and 1.4)*

**or**

*time = 0.8 (s) for 1 mark*

*accept  $0.8 \times 15$  for 2 marks*

*accept calculating the distance travelled by car **A** as 28.5 m*

**or**

*the distance travelled by car **B** as 40.5 m for 2 marks*

3

(b) **Z**

1

different force values give a unique / different resistance

*only scores if **Z** chosen*

*do **not** accept force and resistance are (directly) proportional*

*accept answers in terms of why either **X** or **Y** would not be best eg*

***X** – same resistance value is obtained for 2 different force values*

***Y** – all force values give the same resistance*

1

[7]

5

(a) any **two** from:

- (acceleration occurs when) the direction (of each capsule) changes
- velocity has direction
- acceleration is (rate of) change of velocity

2

(b) to(wards) the centre (of the wheel)

1

(c) the greater the radius / diameter / circumference (of the wheel) the smaller the (resultant) force (required)

*accept 'the size' for radius*

*both parts required for the mark*

1

[4]

6

(a) **B**

*reason only scores if **B** is chosen*

1

gradient / slope is the steepest / steeper

*answers must be comparative*

*accept steepest line*

*ignore greatest speed*

1

- (b) (velocity includes) direction  
*'it' refers to velocity*

1

[3]

7

- (a) 96

*allow 1 mark for correct substitution  
ie  $80 \times 1.2$*

2

newton or N

*allow Newton  
do **not** allow n*

1

- (b) (i) direction

1

- (ii) velocity and time are continuous (variables)

*answers must refer to both variables  
accept the variables are continuous / not categoric  
accept the data / 'it' is continuous  
accept the data / 'it' is not categoric*

1

- (iii) **C**

1

velocity is not changing

*the 2 marks for reason may be scored even if **A** or **B** are chosen  
accept speed for velocity  
accept speed is constant (9 m/s)  
accept **not** decelerating  
accept **not** accelerating  
accept reached terminal velocity*

1

forces must be balanced

*accept forces are equal  
accept arrows are the same length / size*

**or**

resultant force is zero

*do **not** accept the arrows are equal*

1

[8]

8

(a) gravity

*accept weight*  
*do not accept mass*  
*accept gravitational pull*

1

(b) (i) Initially force L greater than force M

*accept there is a resultant force downwards*

1

(as speed increases) force M increases

*accept the resultant force decreases*

1

when  $M = L$ , (speed is constant)

*accept resultant force is 0*

*accept gravity/weighty for L*

*accept drag/ upthrust/resistance/friction for M*

*do not accept air resistance for M but penalise only once*

1

(ii) terminal velocity

1

(iii) 0.15

*accept an answer between 0.14 – 0.16*

*an answer of 0.1 gains no credit*

*allow 1 mark for showing correct use of the graph*

2

[7]

9

(a) 53 (m)

1

(b) (i) Similar shape curve drawn above existing line going through (0, 0)

*allow 1 mark for any upward smooth curve or straight upward line*  
*above existing line going through (0, 0)*

2

(ii) rain on road

1

car brakes in bad condition

1

- (c) (i) all three lines correctly labelled  
*allow 1 mark for one correctly labelled*

top line – C  
*accept 1.2*

middle line – B  
*accept 0.9*

bottom line – A  
*accept 0.7*

2

- (ii) any **two** from:

- (table has) both variables are together  
*accept tired and music as named variables*
- both (variables) could/ would affect the reaction time
- cannot tell original contribution  
*accept cannot tell which variable is affecting the drive (the most)*
- need to measure one (variable) on its own  
*accept need to test each separately*
- need to control one of the variables

2

[9]

10

- (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]

11

- (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]

12

- (a) (i) gravity/weight

1

- (ii) 2193750000000 or  $2.19 \times 10^{12}$

**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

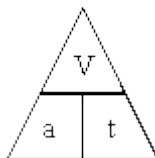
- (b) (i) acceleration =  $\frac{\text{change in velocity}}{\text{time (taken)}}$

*accept word speed instead of velocity*

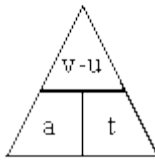
*accept*  $a = \frac{V - U}{t}$

**or** correct rearrangement

*do not accept*



*even if subsequent calculation correct*



can gain credit if subsequent calculation correct

1

(ii) 2

ignore + or – signs

$\text{m/s}^2$  1

accept  $\text{m/s/s}$  or  $\text{ms}^{-2}$

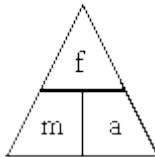
2

(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]

13

(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]

14

- (a) (i) linear scales used  
*do not credit if less than half paper used* 1
- points plotted correctly  
*all of paper used* 1
- (straight) line of best fit drawn  
*allow a tolerance of  $\pm$  half square* 1
- (ii) correct **and** straight line through origin  
**all** needed  
*e.c.f. if their (a)(i) is straight but not through the origin - incorrect  
because line does not go through origin  
credit a calculation that shows proportionality* 1
- (iii)  $62 \pm 0.5$  (m)  
*credit 1 mark for  $KE = 490000$  or  $490kJ$   
credit 1 mark for correct use of graph clearly shown* 2

(iv) any **one** from: wet **or** icy **or** worn **or** smooth road

*accept slippery slope*

brakes worn

*accept faulty brakes*

car heavily loaded

worn tyres

downhill slope

*do not accept anything to do with thinking distance e.g. driver tired or drunk*

1

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

*accept correct transformation*

*accept*  $\frac{v - u}{t} = a$

*accept*  $m/s^2 = \frac{m/s}{s}$

*do not accept acceleration =  $\frac{\text{velocity}}{\text{time}}$*

1

(ii) 56

*accept -56*

1

(iii) deceleration is reduced

*accept deceleration is slower*

*accept acceleration*

1

force on car and or passengers is reduced

*accept an answer in terms of change in momentum for full credit*

1

[11]

15

(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]

16

- (a) Each scale optimum  
 Else both half size  
 Straight line joining 30,0 to 30,0.67 to 0, 5.67  
*any 5 for 1 mark each*

5

- (b) 6  
 Else  $a = 30/5$   
*gets 2 marks*
- Else  $a = v/t$   
*gets 1 mark*

3

- (c) 9000  
 Else  $F = 6 \times 1500$   
*gets 2 marks*
- Else  $F = ma$   
*gets 1 mark*

3

- (d) (i) Driver has forward momentum  
 Which is conserved  
 Giving drive relative forward speed to car  
*for one mark each*

3

- (ii) Car stops in 75m  
*gets 1 mark*

$$W = F.d \text{ or } 9000 \times 75$$

*gets 1 mark*

$$W = 675\,000 \text{ J}$$

**OR**  $ke = \frac{1}{2} mv^2$   
*gets 1 mark*

$$ke = \frac{1}{2} \cdot 1500 \cdot 302$$
$$ke = 675\,000 \text{ J}$$

3

[17]

17

- (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)  $ke = \frac{1}{2} mv^2$   
 $ke = \frac{1}{2} 1250 \cdot 48^2$   
 $ke = 1\,440\,000$   
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]

**18**

- (a) (i) air resistance/drag/friction (or upthrust)  
weight/gravitational pull/gravity  
*for 1 mark each* 1
  
- (ii) air resistance/friction acts in opposite direction to motion 1
  
- (iii) Y 1
  
- (iv) the sky-diver accelerates/his speed increases  
in downward direction/towards the Earth/falls  
*for 1 mark each* 2
  
- (b) force X has increased force Y has stayed the same the speed of the sky-diver  
will stay the same  
*for 1 mark each* 3
  
- (c) (i) CD 1
  
- (ii) 500 } (but apply e.c.f. from (i))
- (iii) 50 } 3
  
- (iv) 10 (but apply e.c.f. from (ii) and (iii))  
*gets 2 marks*
  
- or 500/50 or d/t  
*gets 1 mark* 2

**[14]**

**19**

- (a) (i) 9400(m)  
*for 1 mark* 1
  
- (ii) 26.5(hours)  
*for 1 mark* 1

- (b) (i) F  
*for 1 mark* 1
- (ii) D  
*for 1 mark* 1
- (iii) B  
*for 1 mark* 1

[5]

20

- (a) weight or gravity or gravitational  
*for 1 mark* 1
- (b) (i) only force A acts / force A > air resistance / gravity / weight  
*for 1 mark* 1
- (ii) force A > force B  
*for 1 mark* 1
- (iii) force C > force A  
*for 1 mark*  
*(Forces A, B and C need not be used, description of forces are OK)* 1
- (c) (i) graph points all correct  $\pm$  little square  
*gains 2 marks*
- one point wrong  
*gains 1 mark*
- 2+ points wrong  
*gains 0 mark*
- appropriate line – good freehand OK  
*gains 1 mark*  
**Bar chart gets 0, but if points clear can get 2** 3



- (ii) 16 or candidates own intercept should be 16 m in range 1-19  
if no kinks on graph line  
for 1 mark

1

[8]

21

newton or N

metre or m

joules or J

all three correct 2 marks  
two or one correct 1 mark

[2]

22

(a) 3.125

accept 3.1 or 3.12

1

(b) plotted at 1.15 – 1.17, 1.24 – 1.28

across on the second from 1.2, up between first and second line

1

sketch curve steeper near 0.64 s fairly smooth curve bending

1

to become pretty well horizontal at 1.16, 1.25

1

(c) (i) 1.68 or 1.7

working is  $2(1.16 - 0.64) + 0.64 =$

(ii) 2.5 m unit required

consequential marking applies here

1

(d)  $X_1$  at 0.64 s, 0 m

it is in contact with the floor **or** the ball changes direction **or** the downward force is balanced by the reaction of the floor

*accept the ball is hitting the floor*

*do not credit it has hit the floor*

1

$X_2$  at 1.16 s, 1.25m it is at the top of its bounce

*accept the ball changes direction or has run out of KE*

2

[8]

23

(a) *any evidence of: momentum = mass  $\times$  velocity (words, symbols or numbers) appropriate re-arrangement mass as 0.05kg*

*each gains 1 mark*

**but 800**

*gains 4 marks*

4

(b) (i) *any reference to friction with air/air resistance*

*gains 1 mark*

**but idea that friction with air/air resistance is high (at high speed)**

*gains 2 marks*

2

(ii) *any evidence of: k.e.  $\propto v^2$  **or** k.e. =  $\frac{1}{2} mv^2$*

final k.e.

initial k.e.

either initial or final k.e. correctly calculated (i.e. 16000; 10240)

*each gains 1 mark*

**but (0.8)<sup>2</sup>**

*gains 3 marks*

**but 64%(credit 0.64)**

*gains 4 marks (also credit e.c.f)*

4

[10]

24

(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/s<sup>2</sup>)

*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]

25

(a) evidence of  $\frac{\text{change in speed}}{\text{time taken}}$  or  $\frac{3}{12}$

*gains 1 mark*

but 0.25 or  $\frac{1}{4}$

*gains 2 marks*

2

(b) evidence of  $\frac{\text{work done}}{\text{time taken}}$  or  $\frac{2400}{12}$

*gains 1 mark*

**but** 200

*gains 2 marks*

2

(c) *idea that*

second car has a bigger mass  
(allow bigger weight/heavier)

*gains 1 mark*

**but**

second car has 1.5 times bigger mass

**or**

second car has mass of 1200 kg

*gains 2 marks*

2

(d) friction/resistance increases with speed

*gains 1 marks*

**but**

friction with/resistance of air increases with speed

*gains 2 marks*

- increase in speed because driving force greater than friction
- steady speed when friction = driving force

**or**

increases in speed until friction = driving force

*each for 1 further mark to maximum of 3*

3

[9]

26

- gravity
  - accelerates
  - friction
  - falls at a steady speed
- each for 1 mark*

[4]

27

- (a) reference to
- weight / force of gravity / acting downwards
  - unbalanced (by any upwards force)
- for 1 mark each*

2

- (b) *ideas that* forces balance(d)
- gains 1 mark*

**but**

weight / force of gravity / downwards force balanced by friction / air resistance / drag / upwards force

*gains 2 marks*

latter increases with speed

(*accept* arrows or relevant length and direction if clearly labelled, as answers to parts (a) and (b))

*for 1 further mark*

3

[5]