Forces, movement, shape and momentum

Model Answers 2

Level	IGCSE(9-1)
Subject	Physics
Exam Board	Edexcel IGCSE
Module	Double Award (Paper 1P)
Topic	Forces and motion
Sub-Topic	Forces, movement, shape and momentum
Booklet	Model Answers 2

Time Allowed: **78 minutes**

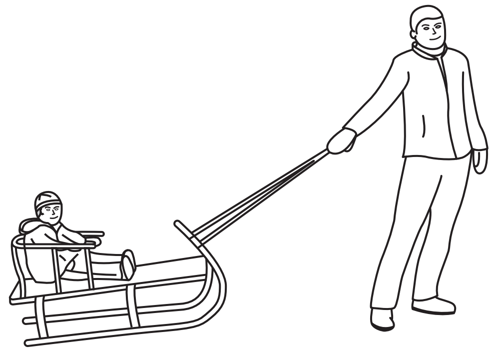
Score: **/65**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'75%	70%	60%	55%	50%	<50%

1 The diagram shows a man pulling a child on a sledge.



(a) The acceleration of the sledge is 1.5 m/s^2.

The mass of the child and sledge is 38 kg.

(i) State the equation linking force, mass and acceleration. **(1)**

(a) (i)

$$Force = Mass \times Acceleration$$

(ii) Calculate the force needed to produce this acceleration. **(2)**

(ii) Substitute in the given values of mass and acceleration.

$$Force = 38 \times 1.5 = 57\ N$$

force = 57 N

(iii) Suggest a reason why the force exerted on the sledge by the man must be greater than the force calculated. **(1)**

(iii)

- The **force** calculated is the force necessary in the **direction** of **acceleration** of the sledge.
- The man is pulling the sledge **at an angle**, so he would have to apply a **force larger than 57 N** so that the **horizontal component** can be **57 N**.
- There is also **friction** between the ground and the sledge which means that a **greater force** would be necessary to overcome this.

(b) The sledge starts from rest and accelerates at 1.5 m/s^2 until its velocity is 2.8 m/s.

(i) State the relationship between acceleration, velocity and time.

(1)

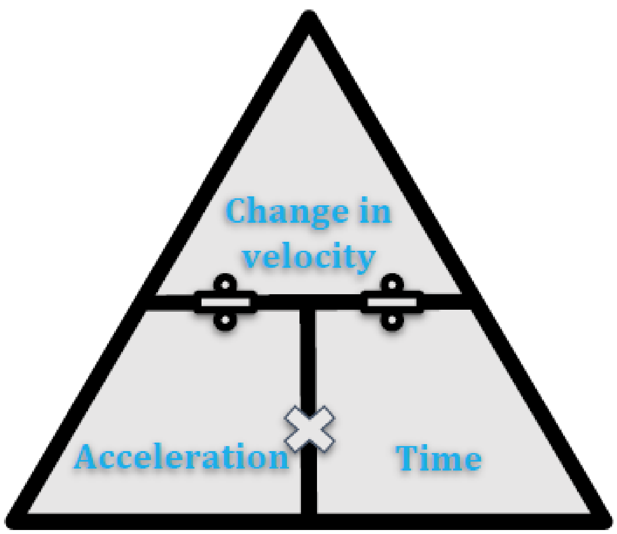
(b) (i)

$$Acceleration = \frac{Change\ in\ velocity}{Time}$$

(ii) Show that the time taken to reach 2.8 m/s is about 2 s. (2)

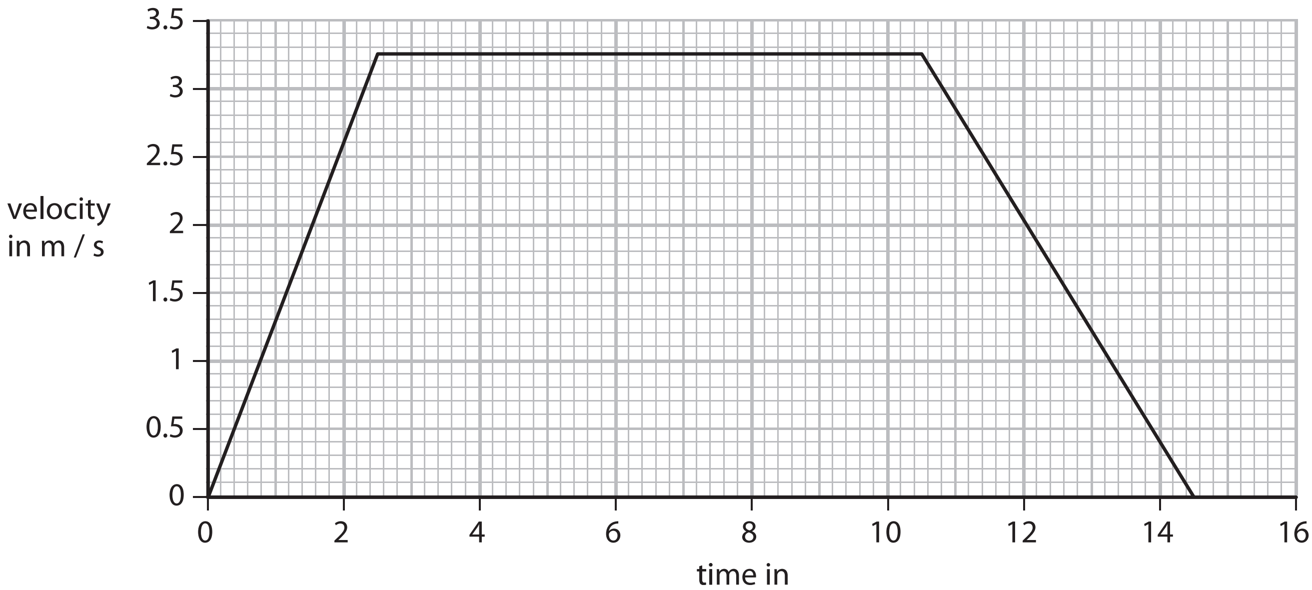
(ii)

- Rearrange the equation for time by multiplying both sides by time, then dividing both sides by acceleration.
- Assume that the initial velocity of the sledge is zero, so that 2.8 m/s is the change in velocity.
- The acceleration is given as 1.5 m/s^2.
- Substitute these values into the equation to show that the time is approximately 2 s.



$$Time = \frac{Change\ in\ velocity}{Acceleration} = \frac{2.8}{1.5} = 1.9\ s$$

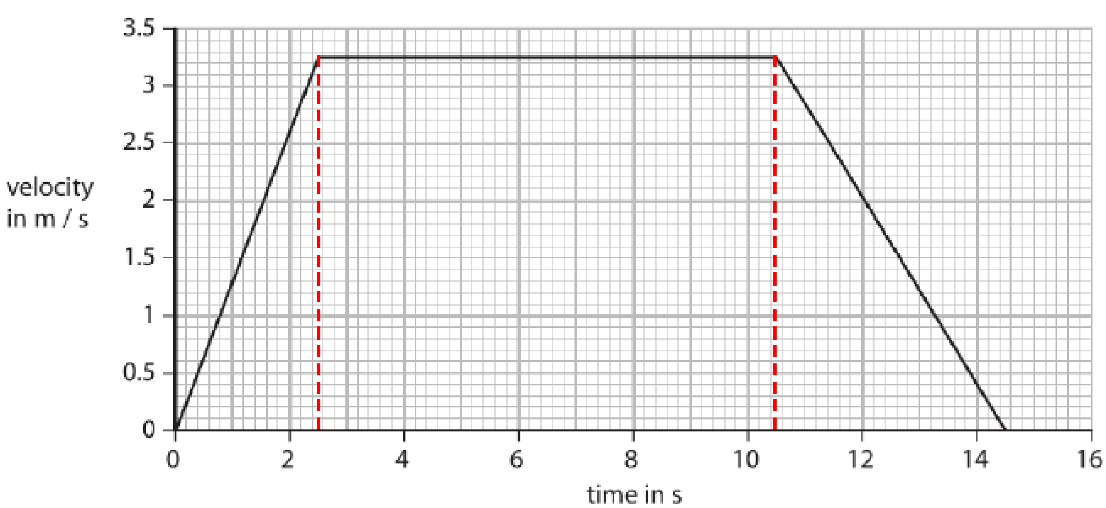
(c) This velocity-time graph shows the motion of the sledge as it travels down a hill.



(i) Calculate the distance travelled by the sledge. **(3)**

(c) (i)

- On a velocity-time graph, the distance travelled is the area under the line.
- This can be found by splitting the area into two triangles and a rectangle, as shown, and adding the areas of each.



$$Total\ distance\ travelled\ (total\ area) = \left(\frac{2.5 \times 3.25}{2}\right) + (8 \times 3.25) + \left(\frac{4 \times 3.25}{2}\right) = 36.6\ m$$

distance travelled = 36.6 m

(ii) State the equation linking average speed, distance moved and time taken.

(1)

(ii)

$$Average\ speed = \frac{Distance}{Time}$$

(iii) Calculate the average speed of the sledge for the whole journey.

(2)

(iii)

- Substitute the values of distance and time into the equation, remembering that, for average speed, the total distance and total time must be used.
- The total distance is the value calculated in part (i), and the total time can be found from the graph.

$$Average\ speed = \frac{36.6}{14.5} = 2.52\ m/s$$

average speed = 2.52 m/s

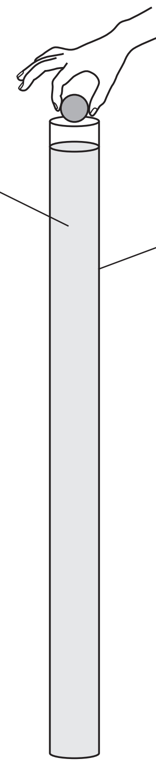
(Total for Question 1 = 13 marks)

2 A student investigates terminal velocity.

She uses a tall glass tube filled with oil.

She drops a metal ball into the tube.

The ball falls through the oil.



(a) Use ideas about forces to explain how a falling object can reach a terminal velocity. **(5)**

(a)

- When an object **falls**, the **downward force** of its **weight** causes it to **accelerate**.
- The **drag** of the **medium** through which the object is falling **opposes** the **motion** of the object, as it acts **upwards**.
- As the **speed** of the falling object **increases**, the **drag** on it **increases**.
- When the **magnitude** of the **drag force** is **equal** to the **magnitude** of the **weight**, the two will be **balanced**.
- This means that there is **no resultant force** on the object, so **no acceleration**.
- Therefore, the object will be travelling at a **constant speed**, known as **terminal velocity**.

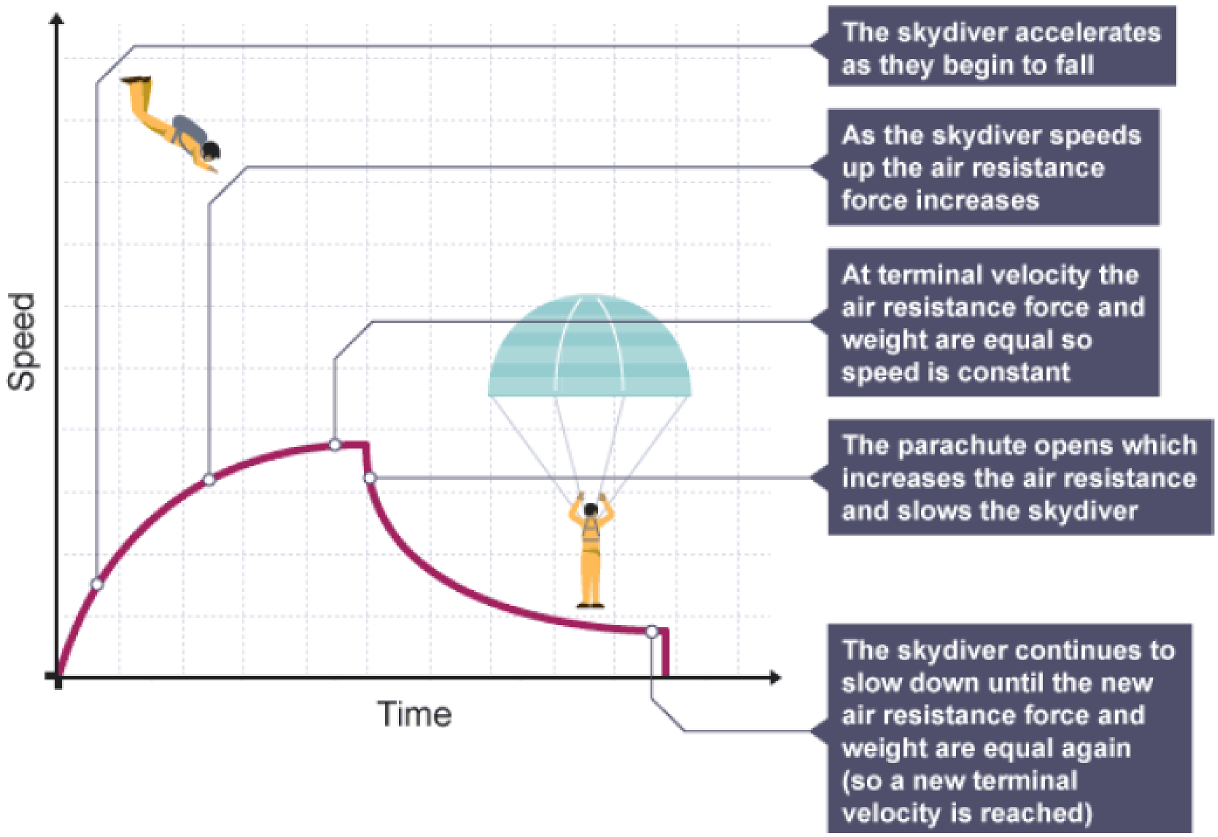


Diagram showing the three stages of falling for a skydiver

(b) Describe how the student could find out if the ball reaches terminal velocity as it falls through the oil.

In your answer, you should include

- the measuring instruments that the student will need
- the measurements that she should take
- how she could use her measurements to find out if the ball reached terminal velocity.

You may include a labelled diagram in your answer.

(5)

(b)

- The student could align a **ruler** with the side of the glass tube and use a **stopwatch** to time the ball as it falls over **set distances**.
- The **time** on the **stopwatch** could be **split** for example, for every 2 cm fallen by the ball.
- These **times** can be **recorded** and used to determine the **time taken** for the ball to fall through each 2 cm distance.
- **Terminal velocity** is reached when the **time** for the ball to fall through 2 cm **remains constant** for **consecutive readings**, since the distance is constant, and

$$Speed = \frac{Distance}{Time}$$

(Total for Question 2 = 10 marks)

3 A student investigates the motion of different falling masses by measuring the time taken for empty cupcake cases to fall from a window.

(a) The student drops one case from the window.

He repeats the experiment with two cases stuck together, then with three cases and then with four.

Name two measuring instruments that he would need for his investigation. **(2)**

(a)
- A **balance** to measure the **mass** of the cases.
- A **stopwatch** to measure the **time** for the cases to fall.
- A **metre ruler** to measure **distance** fallen.

(b) What are the dependent and independent variables in this investigation? **(2)**

(b)
- The **dependent variable** is the variable being **measured** as a result of changes in the independent variable. In this case it is the **time** for the cases to fall.
- The **independent variable** is the variable that is **changed** by the person conducting the experiment. In this case it is the **mass** of the cases.

(c) State one factor that the student should keep constant in order to make this investigation valid (a fair test). **(1)**

(c) Factors that should be kept **constant** include:

- The **height** from which the cases are dropped.
- The **type** of case used; these should be **identical** in terms of **mass** and **surface area**.
- All cases should be dropped in **still air**.
- All cases should be dropped from **rest**.

(d) The student draws this table to record his results.

Add suitable headings to his table.

(2)

.... in	.... in ....

(d)**Mass** and **time** need to be recorded. Since the cupcake cases do **not** have **much mass** and will fall for a **relatively short time**, considering the height they are dropped from, the following would be appropriate:

- **Time** in seconds (**s**).
- **Mass** in grams (**g**).

(e) State one way that the student can improve his investigation. **(1)**

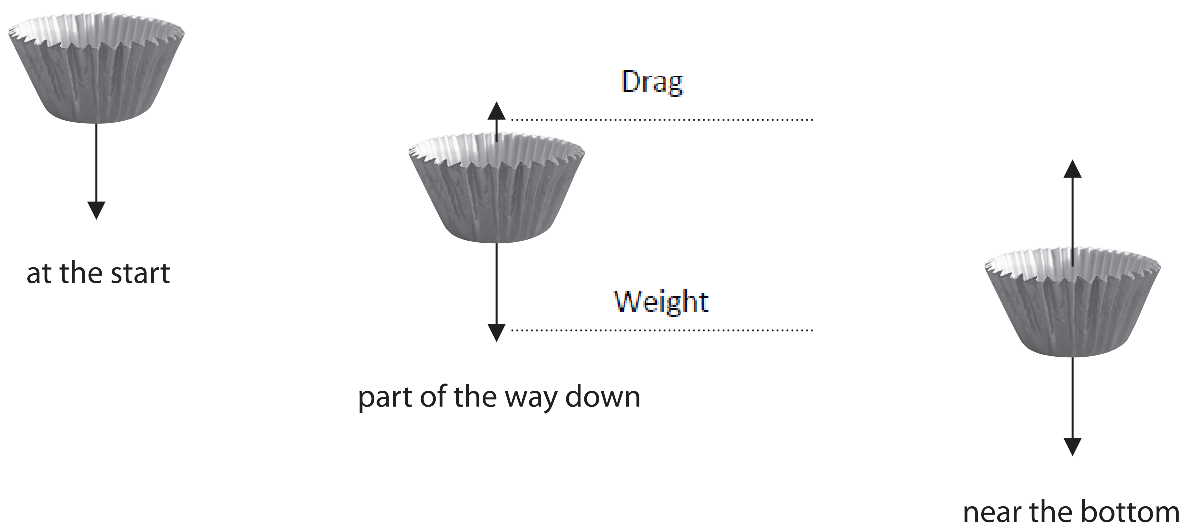
(e)
- The student could take **repeat readings** and use them to calculate an **average time** for **each mass**.
- To **reduce** the **error** in the measurements, the student could work **indoors** to **reduce** the effects of **wind**.
- **Error** could also be **reduced** by dropping the cases from a **greater height**, or using cases with a **larger surface area**, as this would **increase the time** taken for the cases to fall, **reducing the percentage error** in each measurement of time.

(f) The student notices that the cases accelerate and then fall at constant speed.

(i) The arrows in the diagrams show the size and direction of the forces acting on a case at different points in its fall.

Label the forces on the middle diagram.

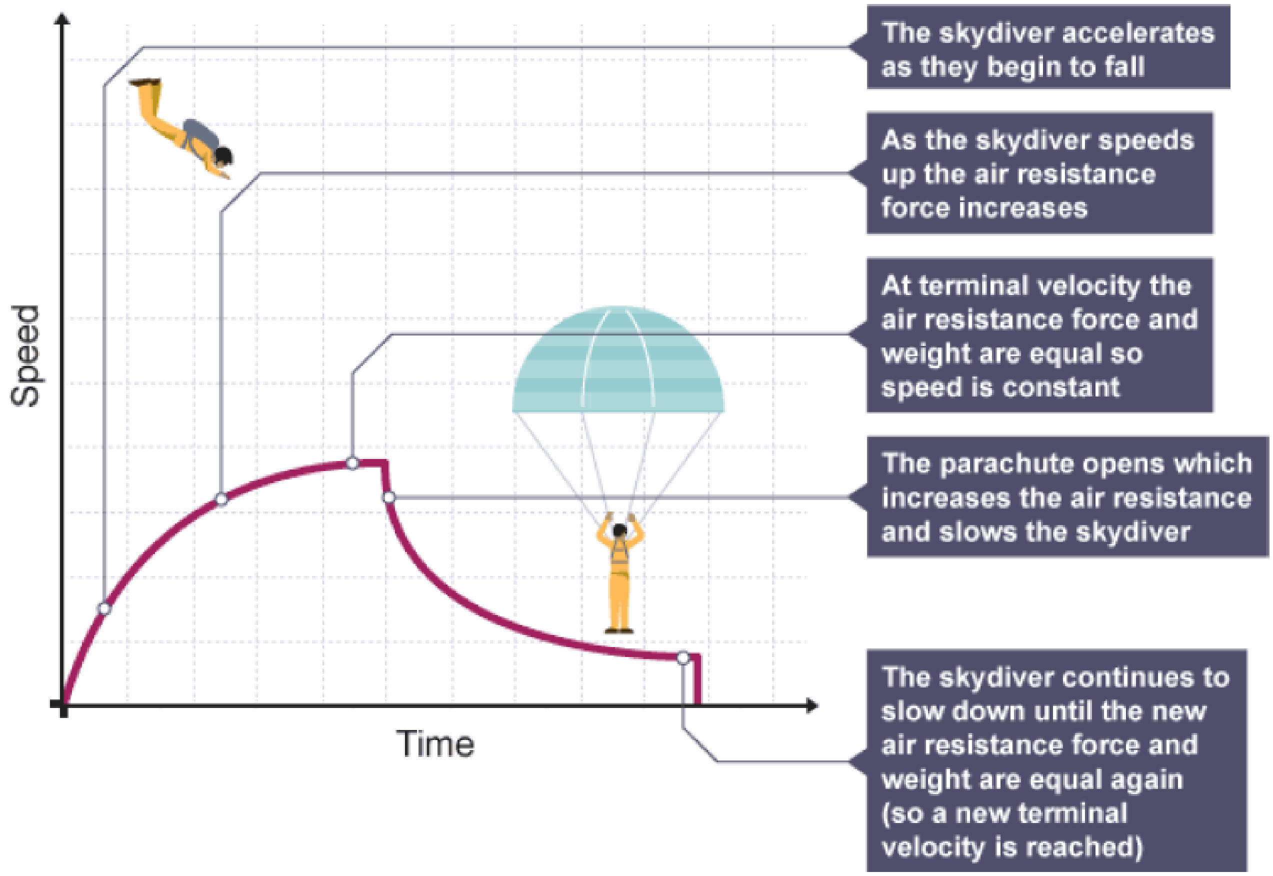
(2)



(ii) Explain why the case accelerates and then falls at constant speed. **(3)**

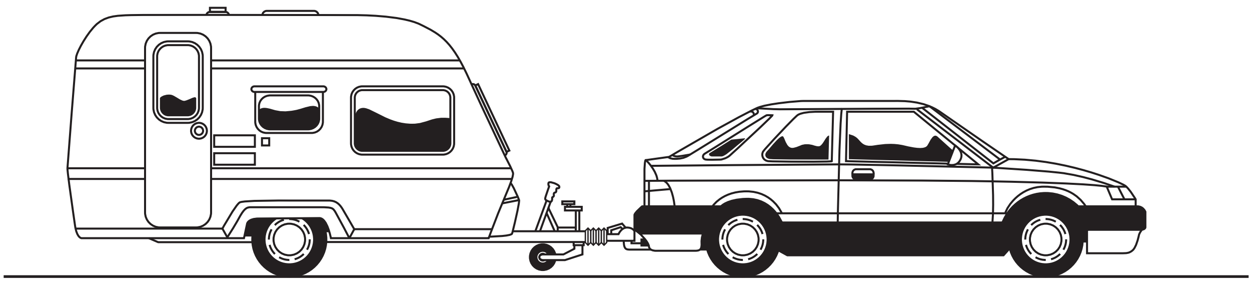
(ii)
- At the beginning, the case **accelerates**, as there is a **net downward force** due to the **weight**.
- As it falls, its **speed increases**, which causes the **drag force** on it to **increase**.
- The **net downward forcereduces** as **drag increases**, but the case is still **accelerating** as the **weight** is still **greater** than the **drag**.
- When the **upward drag force** is **equal** to the **weight** of the case, the **forces** are **balanced** so there is **no net force** on the case.
- This means that the case does **not accelerate**, and has therefore reached a **constant speed**: **terminal velocity**.

Diagram showing the three stages of motion for a skydiver



(Total for Question 3 = 13 marks)

4 A car pulls a caravan along a horizontal road.



(a) The car pulls the caravan with a resultant force of 170 N for a distance of 110 m.

(i) State the equation linking work done, force and distance. **(1)**

i. $Work\ done = Force \times distance\ moved$

(ii) Calculate the work done by the car on the caravan. **(2)**

ii. $Work\ done = 170N \times 110m$

$Work\ done = 19000J$

work done = 19000 J

(iii) State how much energy is transferred to the caravan. **(1)**

iii. same as part ii.

19000J

energy transferred = 19000 J

(b) The mass of the car is 1650 kg.

The mass of the caravan is 950 kg.

(1)

(i) State the equation linking kinetic energy, mass and velocity.

i. $KE = \frac{1}{2}mv^2$

This is the formula for kinetic energy

(ii) Calculate the total kinetic energy when the car and caravan travel together at a constant speed of 23 m/s.

(3)

ii. $KE = \frac{1}{2}mv^2$

Calculate the mass of both the car and the caravan together

$$KE = \frac{1}{2}(1650 + 950)kg \times 23m/s^2$$

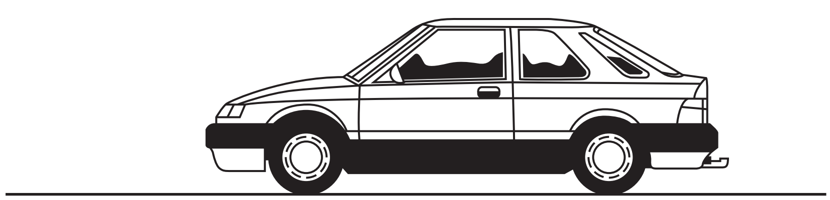
Evaluate the mass to be 2600kg

$$KE = \frac{1}{2}2600kg \times (23m\backslash s)^2$$

$$KE = 688\ 000J$$

total kinetic energy = 688 000 J

(c) The caravan is removed and the car makes the return journey without it.



Without the caravan, the car has greater acceleration and uses less fuel.

(3)

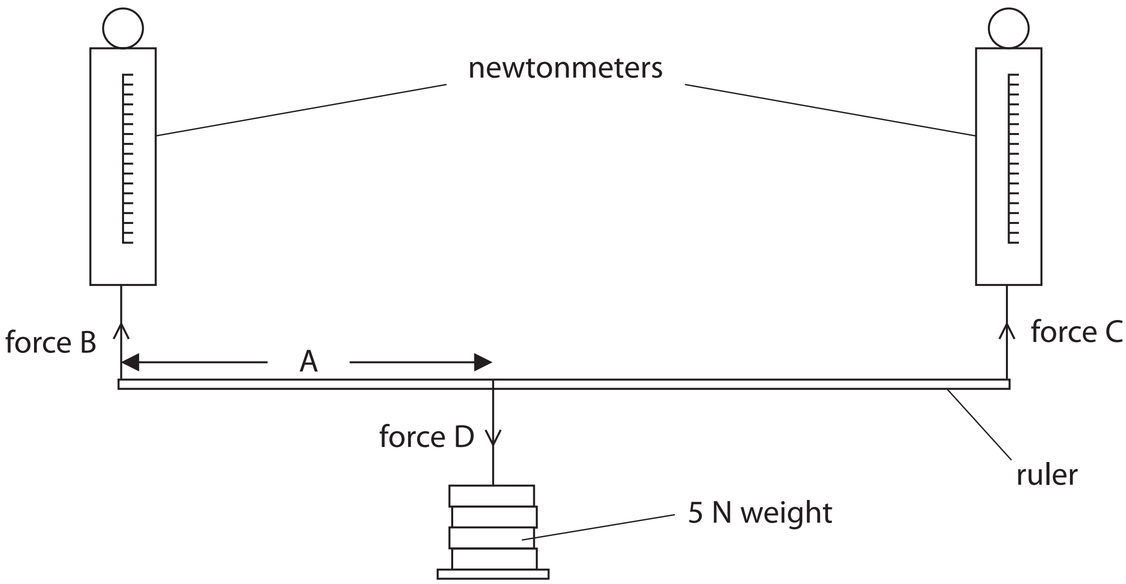
Explain these changes.

- $Force = mass \times acceleration$
- The mass has reduced which means the acceleration must increase
- The car also has a smaller profile an so air resistance will have decreased causing less work to be required.
- Less fuel is used and less work is required and the burning fuel provides work.

(Total for Question 4 = 11 marks)

5 A student investigates the vertical forces acting on the ends of a horizontal ruler when it supports a load.

The ruler hangs from two newtonmeters with a weight suspended from it as shown.



(a) The student moves the weight along the ruler and records forces B and C by taking readings from the newtonmeters.

(i) Which of these is the independent variable in this investigation? **(1)**

x **A** Distance A

☒ **B** Force B

☒ **C** Force C

☒ **D** Force D

i. A – Distance A

(ii) Which of these is a controlled variable in this investigation? **(1)**

☒ **A** Distance A

☒ **B** Force B

☒ **C** Force C

x **D** Force D

ii. D – Force D

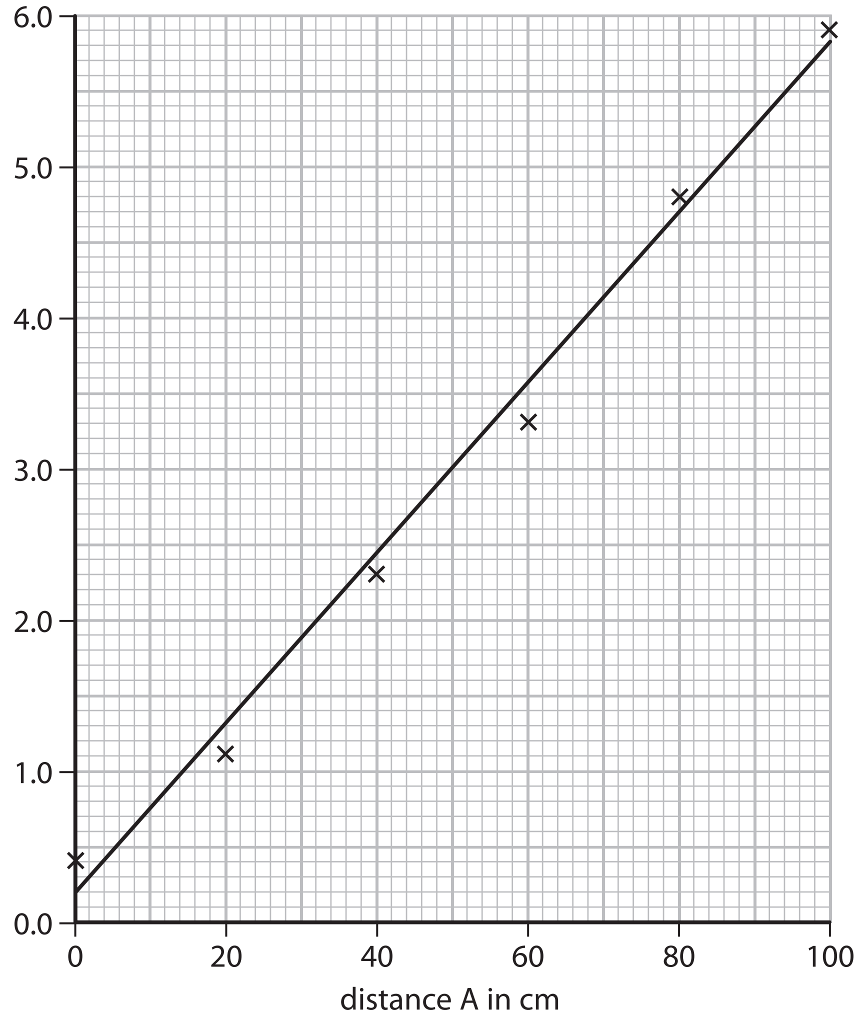
(b) The student records these readings.

Distance A in cm	Reading from newtonmeter of force B in N	Reading from newtonmeter of force C in N
0	5.1	0.4
20	4.0	1.1
40	2.9	2.3
60	2.0	3.3
80	1.1	4.8
100	0.2	5.9

She plots this graph to show how force C changes with distance A.

Force

in N



(i) Complete the student's graph by labelling the vertical axis. **(1)**

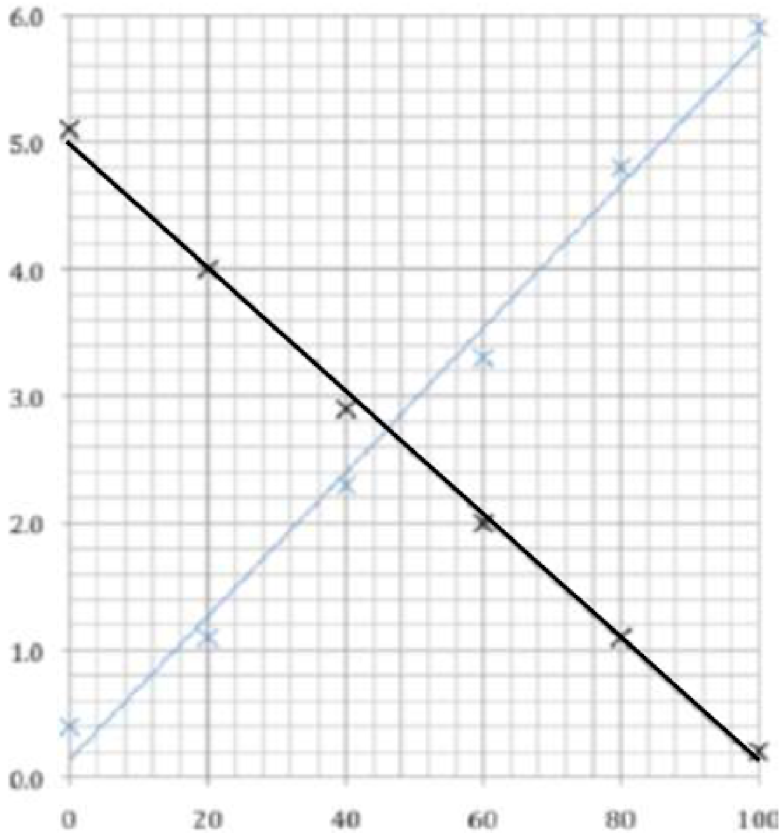
i. **Vertical axis: Force (N)** where N is newtons

(ii) Using the same grid and axes, plot a second line to show how force B varies with distance A.

(3)

(iii) Use the lines on the graph to find distance A for which force B and force C are equal.

(1)



iii. The lines cross at about **47cm**

Distance = 47 .... cm

(c) Suggest why neither force B nor force C are ever zero during the investigation.

(1)

The forces will not be zero because of the **weight of the ruler**

(Total for Question 5 = 8 marks)

6 A student investigates the extension of a rubber band when masses are added.

(a) Tick the boxes to select the correct items of apparatus that the student would need in order to complete this investigation.

Two items have already been selected. **(2)**

Item	Tick (✓) if item needed
ammeter	
steel spring	
retort stand and clamp	✓
rubber band	✓
ruler	✓
thermometer	
mass hanger	✓
masses	✓

(b) The table below shows the student's results.

Mass in g	Force in N	Extension in cm
0	0	0.0
150	1.5	2.4
350	3.5	6.3
550	**5.5**	12.8
750	7.5	18.6
1050	10.5	24.0

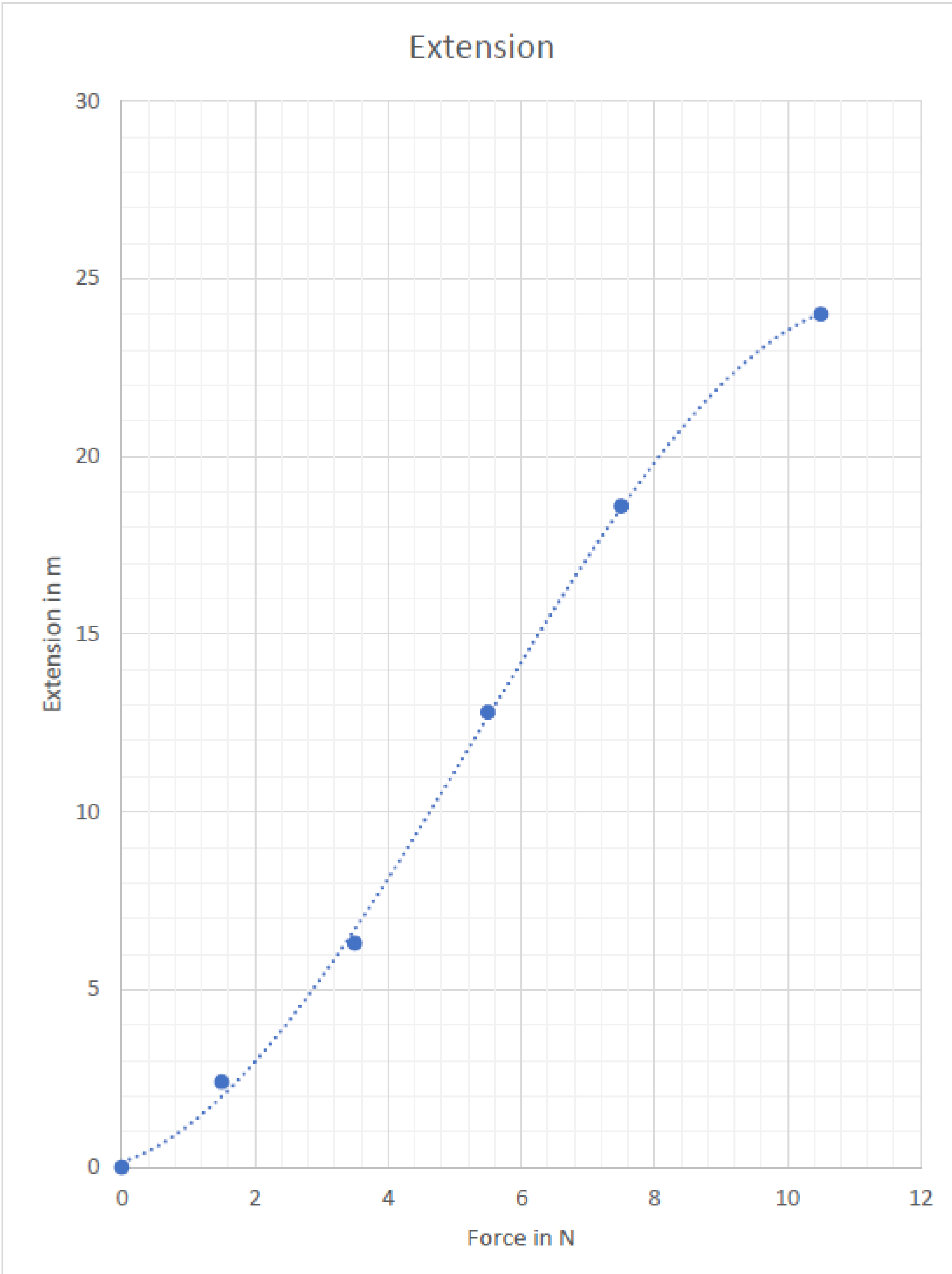
(i) Complete the table by inserting the missing force. **(1)**

i.

The missing force is **5.5N**

This comes from the force being 100 times less than the mass in grams.

(ii) Plot a graph to show how force varies with extension. **(5)**



(iii) Use the information from the graph to explain whether the rubber band obeys Hooke's Law.

(2)

iii. **No**

Hookes law states that the force should be **proportional** to the **extension**. We can see from the graph that the best fit is a **curve** as the rubber bad **does not** have a **uniform extension**.

(Total for Question 6 = 10 marks)