Newton's Laws

Foundation Tier

Revision questions

Equations

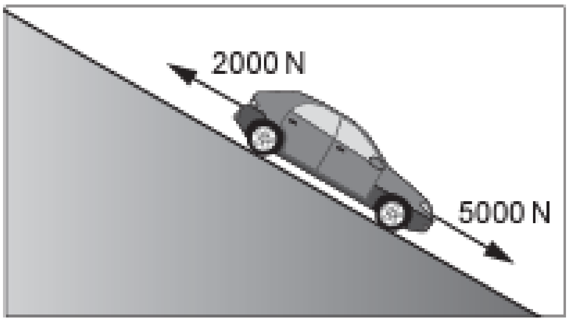
speed = $\frac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\frac{\text{change in velocity}}{\text{time}}$	$a = \frac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
force = spring constant × extension	$F = kx$

SI multipliers

Prefix	Multiplier
m	1×10^{-3}
k	1×10^{3}
M	1×10^{6}

2023 Separate Physics Q9

The diagram shows a car rolling down a slope. Two of the forces acting on the car are labelled.



(a) The car has a **weight** of 10 000 N. Use the equation:

$$\text{mass} = \frac{\text{weight}}{\text{gravitational field strength}}$$

to calculate the mass of the car. [2]
(Gravitational field strength, g, = 10 N/kg)

mass = ... kg

(b) Use the information in the diagram to answer the following questions.

(i) Calculate the resultant force acting down the slope. [2]

resultant force = ... N

(ii) Use your answers from parts (a) and (b)(i) and the equation:

$$\text{acceleration} = \frac{\text{resultant force}}{\text{mass}}$$

to calculate the acceleration of the car at the instant shown and state the unit. [3]

acceleration = ...

unit = ...

(iii) I. Explain how the resultant force on the car changes as it speeds up. [2]

....

....

....

II. State how this change in resultant force affects the acceleration of the car. [1]

....

(c) At the bottom of the slope the car continues horizontally at a constant speed of 12 m/s with a kinetic energy of 72 000 J.

(i) State **one** reason why the potential energy at the top of the hill must have been greater than 72 000 J. [1]

....

(ii) At the bottom of the hill a braking force is applied which stops the car over a distance of 15 m.

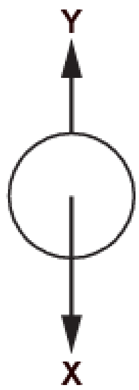
Use the equation:

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

to calculate the braking force. [2]

braking force = ... N

A ball is dropped from rest.
Two forces, X and Y, act on the ball during its fall.



(a) (i) Name the forces X and Y. [2]

X .... Y ....

(ii) State what happens to the size of the forces, if anything, as the ball speeds up. [2]

Force X ....

Force Y ....

(b) Complete the following sentences by underlining the correct phrase in the brackets. [2]

(i) The ball speeds up at the start of its fall because force Y is (**smaller than / equal to / larger than**) force X.

(ii) The ball eventually reaches a constant speed because force Y is (**smaller than / equal to / larger than**) force X.

Separate Physics 2022 Contingency paper Q11

. A group of students investigate how the surface area of a falling paper cake case affects its terminal speed.

- Cake case 1 has a mass of 0.5 g and a surface area of 100 cm^2.
- Cake case 1 is dropped from a height of 1.80 m but only timed over the final 1.50 m of the fall.

The students' results are shown in the table below.

Drop time (s)			Mean drop time (s)	Drop distance (m)
Attempt 1	Attempt 2	Attempt 3		
0.96	0.92	0.94	....	1.50

(a) (i) The students decide there are no anomalies. Explain why. [1]

....

(ii) **Complete the table** to show the mean drop time. [1]
Space for calculation.

(b) The experiment is repeated with cake case 2.
It has the same shape and the same mass as cake case 1.
However, cake case 2 has a surface area of 50 cm^2.
The students correctly calculate the terminal speed for both cake cases.

Cake case 1		
Mass (g)	Surface area (cm^2)	Terminal speed (m/s)
0.5	100	1.6

Cake case 2		
Mass (g)	Surface area (cm^2)	Terminal speed (m/s)
0.5	50	2.3

(i) A cake case reaches terminal speed when its weight is balanced by air resistance. **Tick (✓)** the **three** correct statements. [3]

Cake case 2 has the same terminal speed as cake case 1.	☐
Cake cases 1 and 2 have identical weight.	☐
At terminal speed, cake case 1 experiences a greater value of air resistance than cake case 2.	☐
At terminal speed, both cake cases experience identical values of air resistance.	☐
At terminal speed, cake case 1 experiences a smaller value of air resistance than cake case 2.	☐
At terminal speed, both cake cases have zero acceleration.	☐

(ii) Before the experiment was carried out the students made the following prediction:

"If the surface area of the cake case is halved its terminal speed will double."

Use data from the tables on the previous page to explain whether their prediction was correct. [2]

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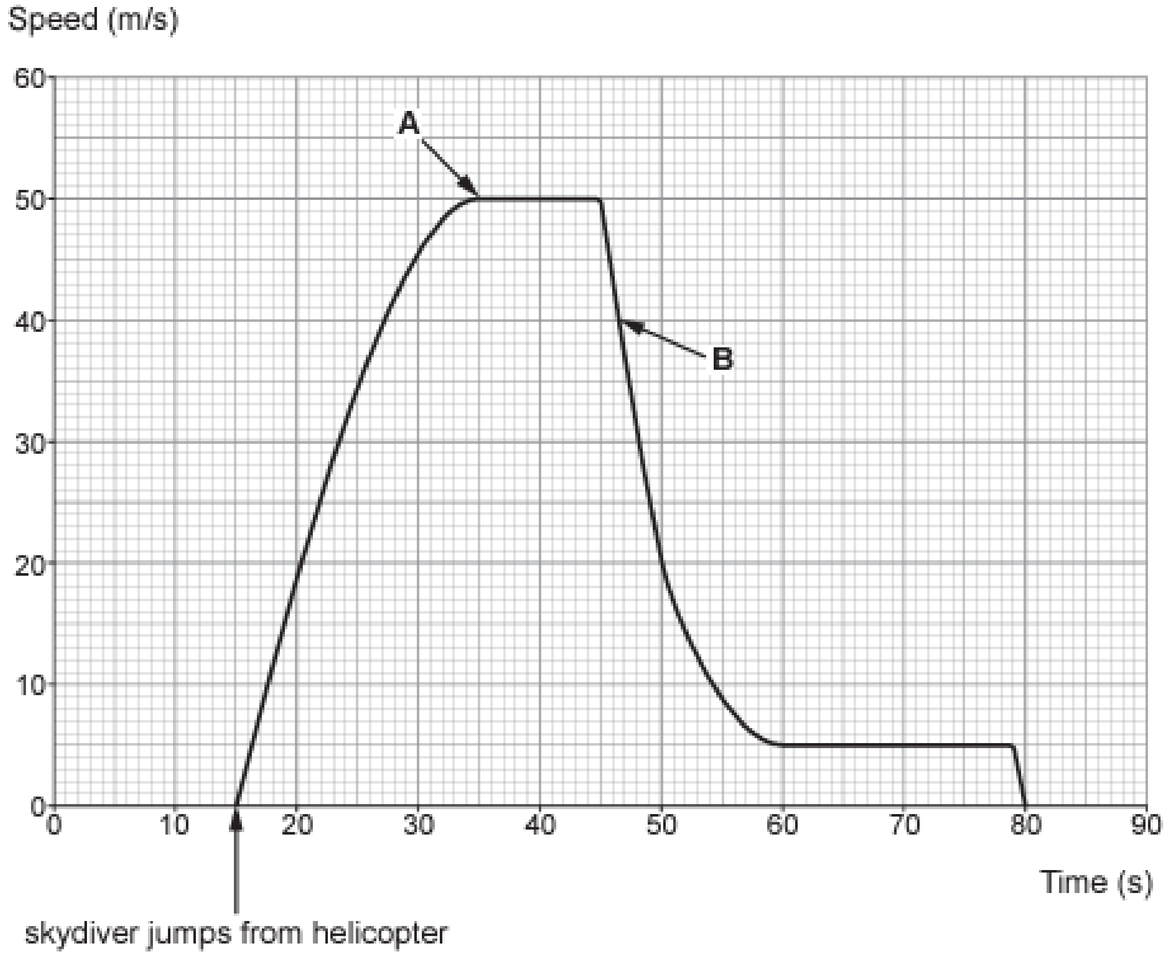
(c) A skydiver sits at the doorway of a helicopter for 15 s before jumping. His speed is recorded and displayed on the graph below.

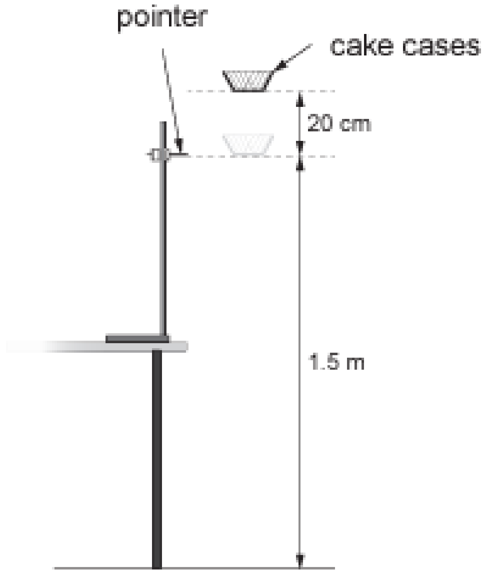


Tick (✓) the **three** correct statements. [3]

The skydiver lands on the ground 80 s after jumping from the helicopter.	☐
The terminal speed after the parachute is opened is $\frac{1}{10}$th of the terminal speed before the parachute is opened.	☐
The skydiver's weight is greatest at the point labelled **B** on the graph.	☐
The parachute is opened 30 s after the skydiver leaves the helicopter.	☐
At point **B** the weight of the skydiver is greater than the air resistance.	☐
At point **A** the skydiver stops accelerating.	☐

Separate Physics 2019 Q8

A class carries out an investigation into the relationship between the terminal speed of paper cake cases and their mass. They let the cake cases drop from about 20 cm above a pointer which is 1.5 m above the floor. They time how long they take to drop from the pointer to the floor. They assume that after 20 cm the cake cases will be travelling at terminal speed.



(a) Explain, in terms of two named forces, why the cake cases travel at terminal speed. [2]

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(b) The students take some trial readings to help them determine the number of repeat readings they need to take. Here are their results for 1 cake case.

Mass (g)	Time for cake case to travel 1.5 m (s)							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
0.5	1.16	1.19	1.17	1.29	0.72	1.22	1.24	1.15

(i) **Circle** the anomalous result. [1]

(ii) Calculate the mean time. [2]

Mean time = ... s

(iii) Use an equation from page 2 to calculate the mean speed. [1]

Mean speed = ... m/s

(c) The students then carry out their experiment. First they measure a height of 1.5 m with two metre rulers and set their pointer. They drop 1 cake case and record the time taken to drop using a stopwatch. This is repeated 5 times. They then repeat the experiment with 2, 3, 4 and 5 cake cases in a stack to vary the mass of the cake cases.

(i) State the independent variable in this experiment. [1]

....

(ii) State **one** controlled variable in this experiment. [1]

....

(iii) Explain how the data could be measured more accurately. [2]

....

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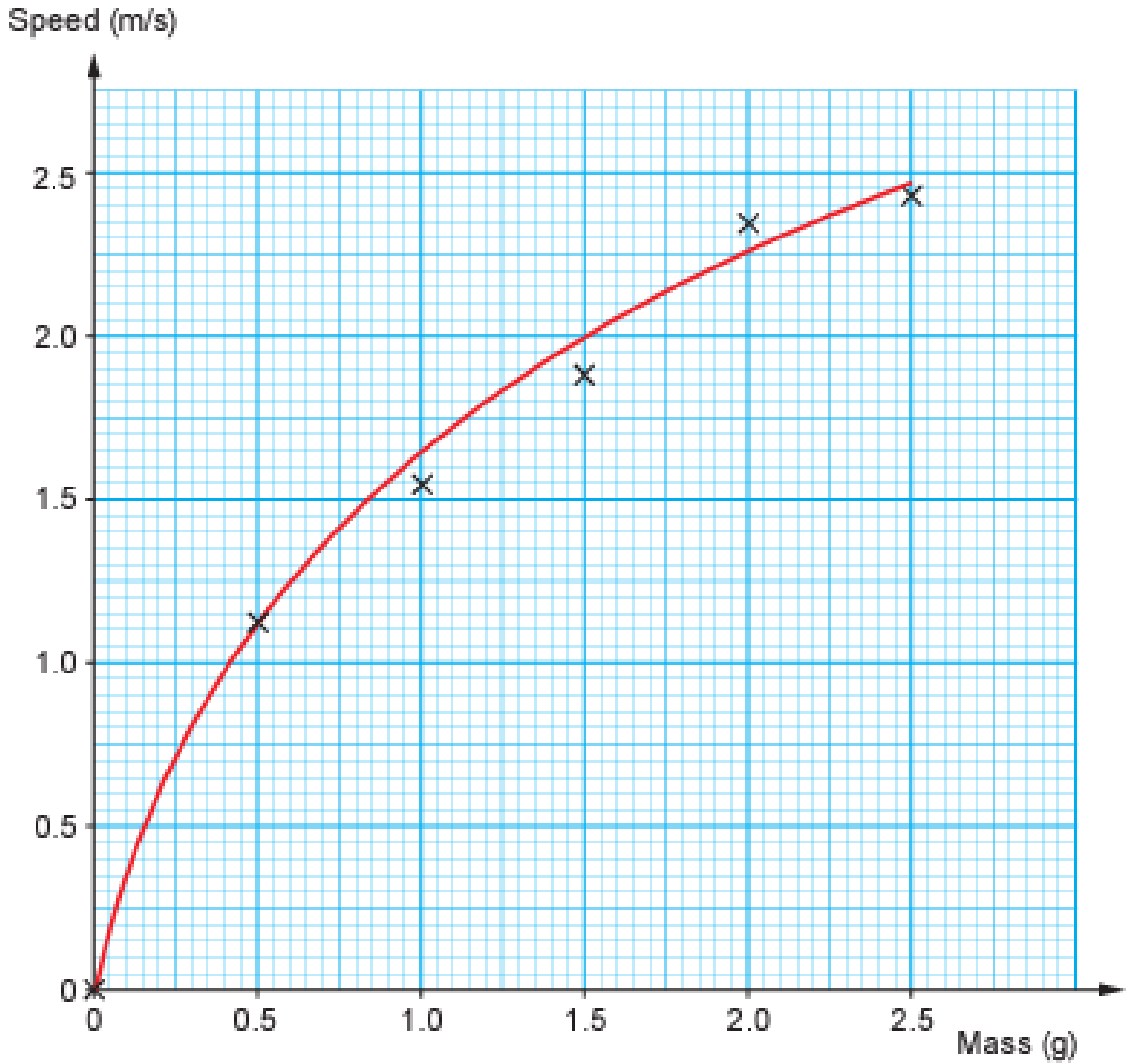
....

(d) The results from one group are shown on the graph below.



Angus concludes that when the mass doubles, the speed is always 1.5 times bigger. Explain whether the results support his conclusion. Use data from the graph to support your answer. [3]

Space for calculations.

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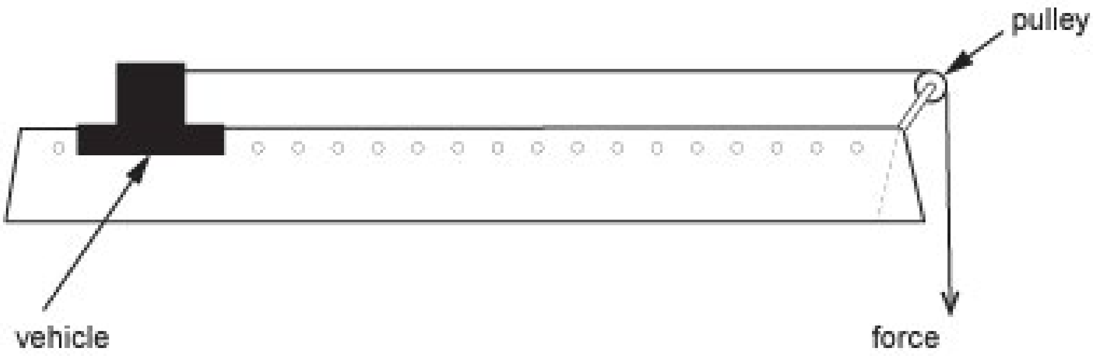
Separate 2018 Q4

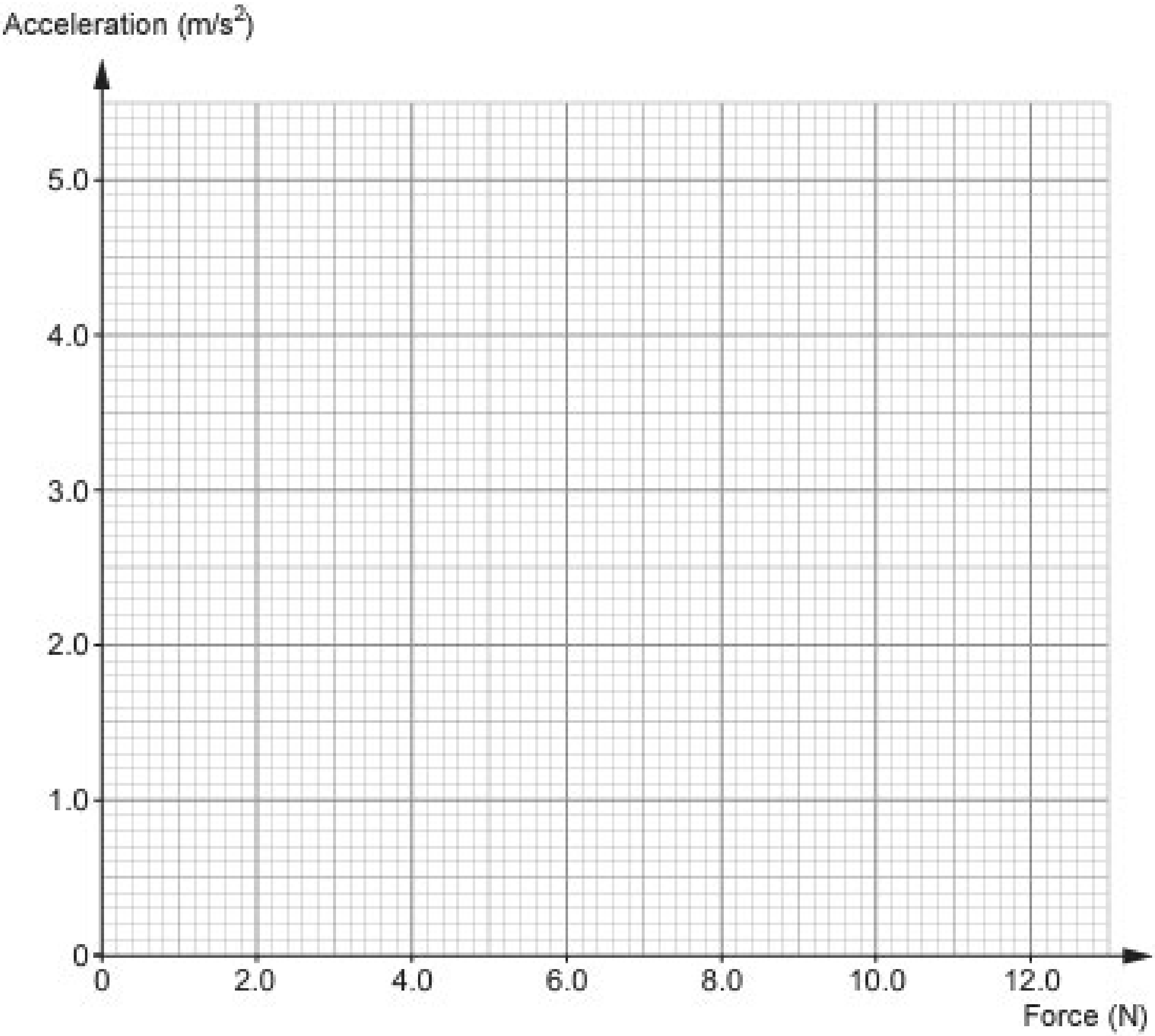
In a class experiment, a group of students use a force to accelerate a vehicle along a frictionless air track.



The acceleration of the vehicle is measured by a computer and the results are shown below.

Force (N)	2.0	4.0	8.0	10.0	12.0
Acceleration (m/s^2)	0.8	2.6	3.2	4.0	4.8

(a) Plot the data on the grid below and draw a suitable line. [3]



(b) (i) Use the graph to find the force that produces an acceleration of 2.0 m/s^2. [1]

Force = ... N

(ii) Use the equation:

$$\text{mass} = \frac{\text{resultant force}}{\text{acceleration}}$$

to calculate the mass of the vehicle. [2]

Mass = ... kg

(iii) Another group of students in the class carry out the same experiment but they use a vehicle of greater mass. **Draw a line on the graph** to show how the acceleration would change for the same values of force. [1]

(c) Eric suggests that if a force of 16 N is applied to the original vehicle the acceleration will be 5.6 m/s^2. Use the data to consider whether this suggestion is correct. [2]

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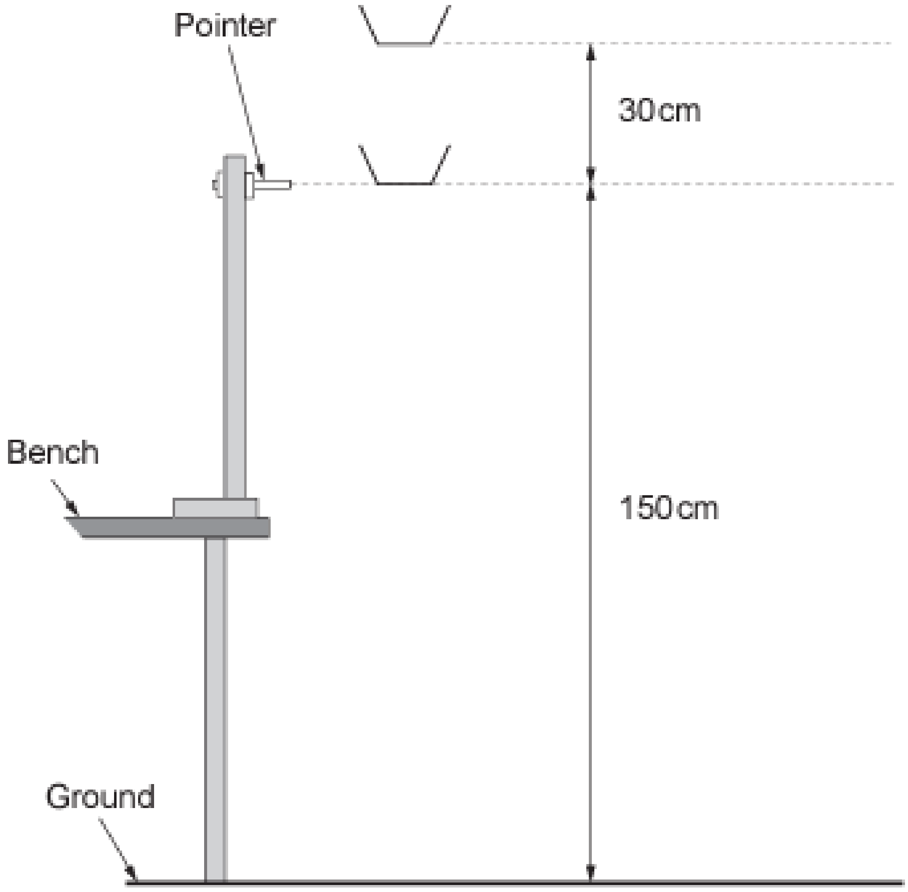
A group of students investigate the terminal speed of a number of cake cases.
They set up the following apparatus.
They drop the cake cases from rest at a point 30 cm above a pointer.
They measure the time taken for the different numbers of cake cases to fall 150 cm, from the pointer to the ground.



(a) Complete the sentences below by underlining the correct phrase in the bracket. [3]

(i) In this experiment, the independent variable is the
(number of cake cases / time of fall / height of pointer).

(ii) In this experiment, the dependent variable is the
(number of cake cases / time of fall / height of pointer).

(iii) During the first 30 cm of the fall, the cake cases
(speed up / slow down / fall at constant speed).

(b) Five separate groups in the class carry out the same experiment.
Their results and calculated values are shown below.

Distance (cm)	Number of cake cases	Time of fall (s)						Terminal speed (m/s)
		Group A	Group B	Group C	Group D	Group E	Mean	
	0							0
150	1	0.86	0.88	0.91	0.90	0.85	0.88	1.7
150	2	0.72	0.72	0.67	0.65	0.66	0.68	2.2
150	3	0.60	0.59	0.62	0.60	0.61	0.60	2.5
150	4	0.55	0.56	0.55	0.75	0.58		2.7
150	5	0.50	0.55	0.51	0.54	0.50	0.52	2.9

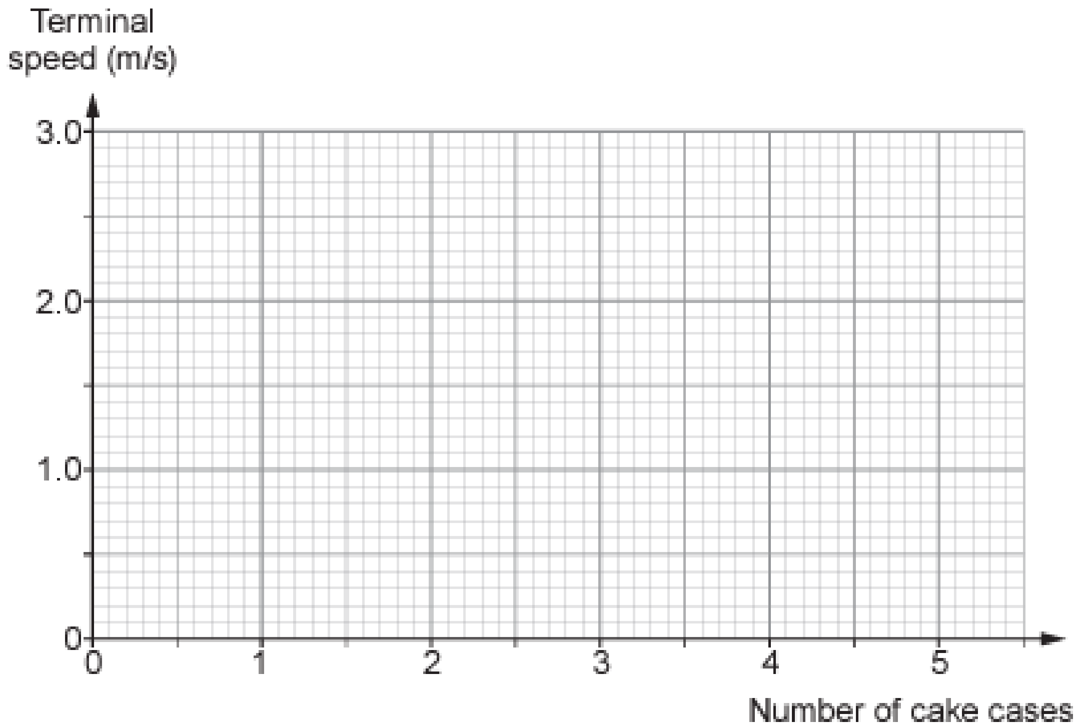
(i) **Draw a circle** around the anomalous result when **4 cake cases** are dropped. [1]

(ii) Calculate the mean time for 4 cake cases to fall 150 cm. [2]

Mean time = ... s

(c) (i) Use the table below to plot the data on the grid and draw a suitable curve of best fit. [3]

Number of cake cases	Terminal speed (m/s)
0	0
1	1.7
2	2.2
3	2.5
4	2.7
5	2.9



(ii) Complete the sentence below by underlining the correct phrase in each bracket. [2]

As the number of cake cases increases, the terminal speed **(increases / decreases / stays the same)** at **(an increasing / a decreasing / a constant)** rate.

End of questions