OCR
Oxford Cambridge and RSA

Monday 17 June 2024 – Morning

A Level Physics B (Advancing Physics)

H557/03 Practical skills in physics

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) ______________________

Last name ______________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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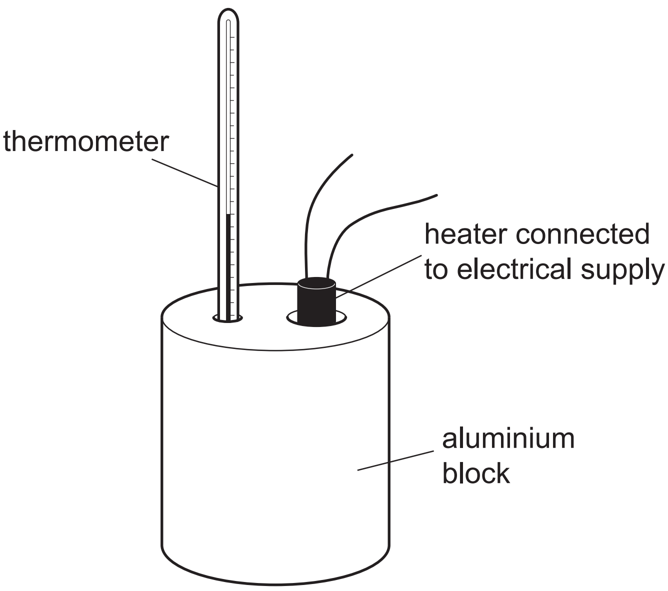
Section A

1 This question is about an experiment to find the specific thermal capacity of aluminium.

An electrical heater is placed in an aluminium block as shown in **Fig. 1.1**. A mercury in glass thermometer is inserted into a hole in the block to record the temperature of the block.

Fig. 1.1



(a) Suggest a practical technique to improve the thermal connection between the thermometer and the block.

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.... **[1]**

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(b) The heater is switched on and the temperature of the block is recorded every minute for 10 minutes. The results are recorded and plotted on the graph in **Fig. 1.2**.

(i) The absolute uncertainty in each temperature measurement is ± 1.0 °C.
Draw vertical uncertainty bars on each plot. **[1]**

(ii) Draw lines of both the maximum and minimum gradients through the data points and uncertainty bars on the graph. **[2]**

(iii) Calculate the mean rate of temperature rise in $°C\,s^{-1}$ and its percentage uncertainty.
Use the lines you drew for part **(b)(ii)**.

rate of temperature rise = ... $°C\,s^{-1}$ ± .... % **[5]**

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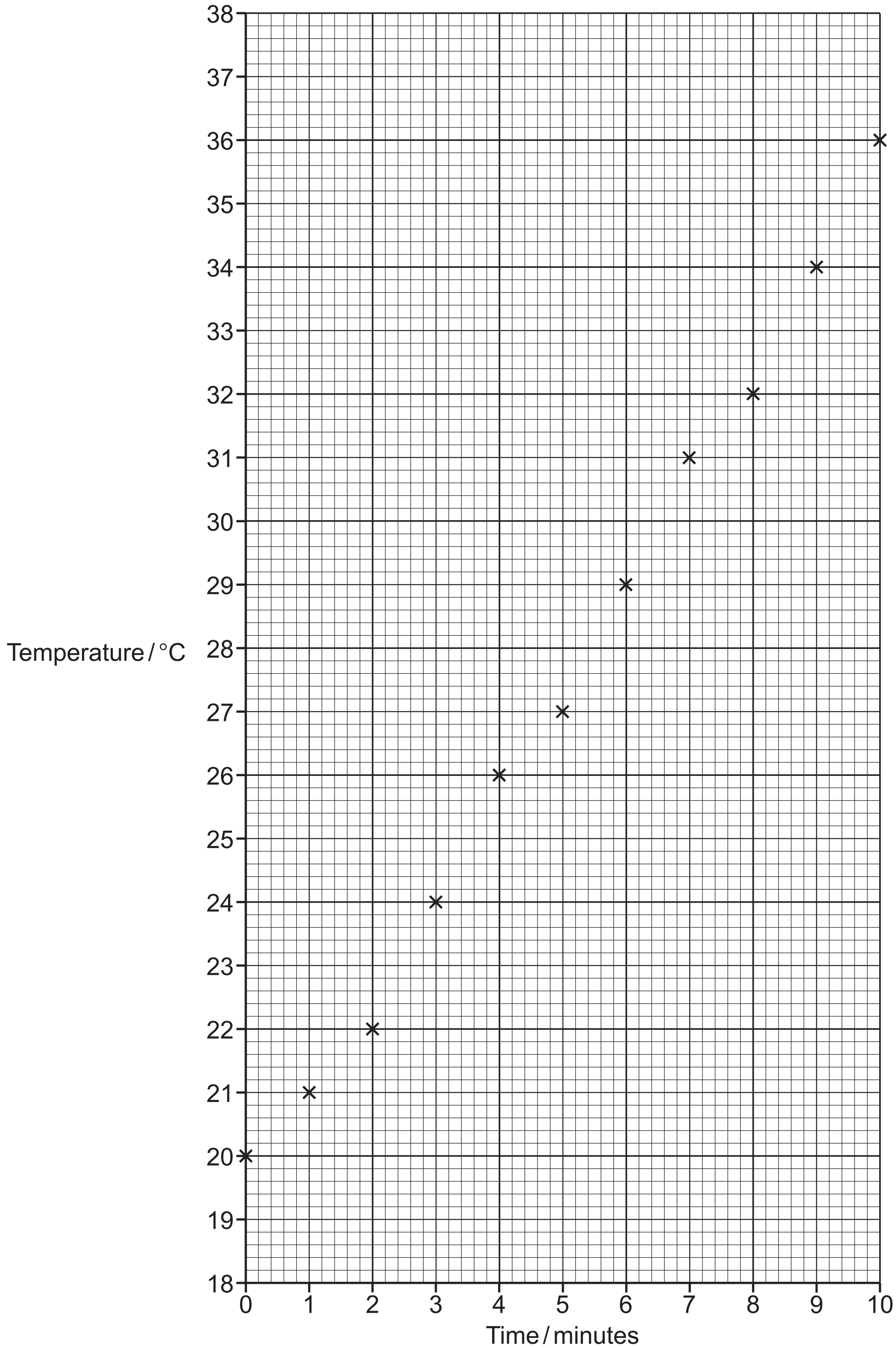
Fig. 1.2


Temperature / °C
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
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19
18
0
1
2
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4
5
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8
9
10
Time / minutes

(c)
(i) Show that:

The gradient of the graph in **Fig. 1.2** = $\frac{P}{mc}$;

where
P = power input, m = mass of the block and
c = experimentally-determined value of specific thermal capacity.

[2]

(ii) The potential difference across the heater is set at 9.6 V ± 2%.
The current is 3.76 A ± 0.9%.
Using these values and the value calculated in part **(b)(iii)**, determine the specific thermal capacity of aluminium. Find the absolute uncertainty.

mass of aluminium block = 1.00 ± 0.01 kg.

specific thermal capacity = ... ± .... J kg^{-1} K^{-1} **[4]**

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(d) The textbook value for the specific thermal capacity for aluminium is $900\,J\,kg^{-1}\,K^{-1}$. Compare this value with your calculated value and explain the main reason for the difference.

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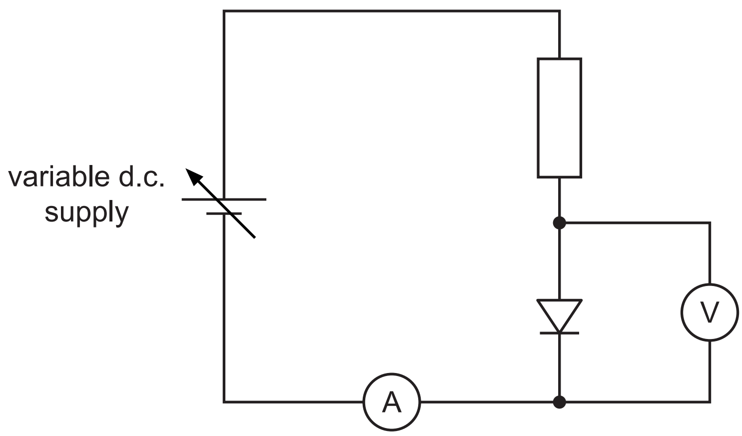
2 The circuit in **Fig. 2.1** is used to measure the current flowing through and the potential difference across a semiconductor diode.

The variable d.c. power supply has negligible internal resistance.

Fig. 2.1



(a) Calculate the conductance of the semiconductor diode when the potential difference = 0.65 ± 0.02 V and the current = 7.5 ± 0.02 mA.
Give the uncertainty in your answer.

conductance = ... ± .... Ω^{-1} **[3]**

(b) Describe how the circuit could be used to obtain values of current at different emfs in order to plot a graph of I against V. Explain the purpose of the fixed resistor in the circuit.

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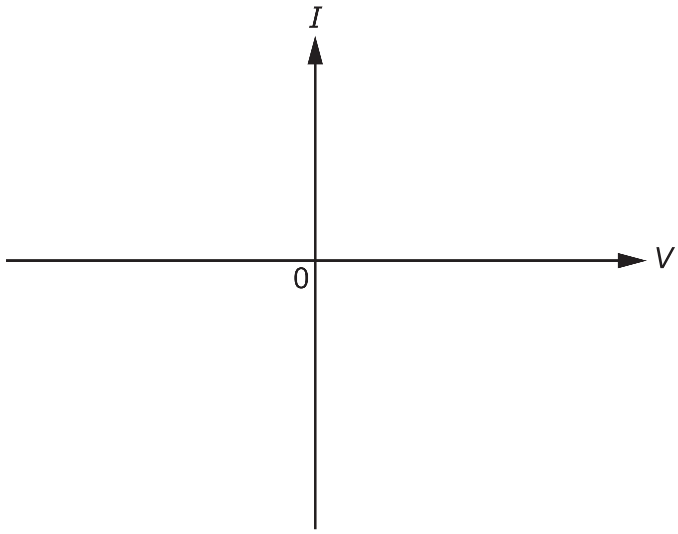
(c) Sketch on the axes below the shape of the graph you would expect to obtain for both forward and reverse bias.



[2]

(d) Explain any changes you might make to the instrumentation in the circuit in order to obtain an accurate graph.

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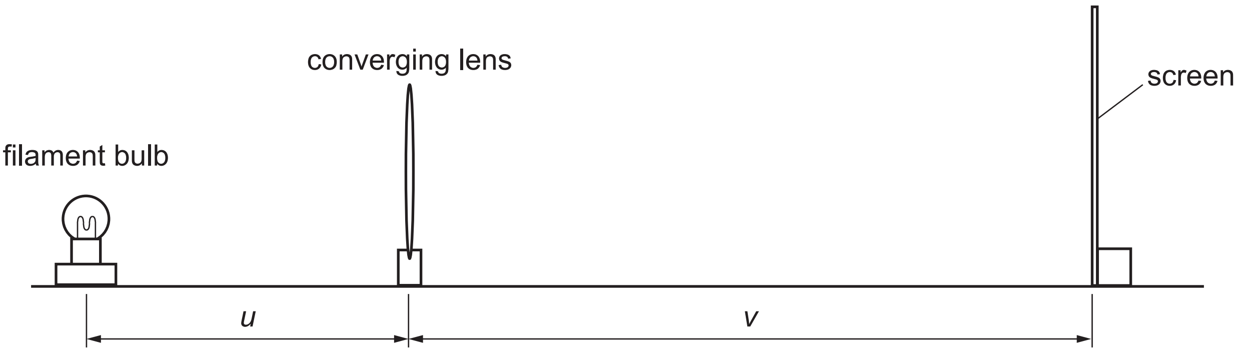
3 This question is about an experiment to find the focal length of a converging lens.

A filament lamp is placed a distance, *u*, from the lens. A screen is set up on the other side of the lens to show the image of the lamp, in order to find distance, *v*. This set up is shown in **Fig. 3.1**.

Fig. 3.1



The screen is moved back and forth until a focussed image of the filament is seen on the screen. The length *v* is then measured from the centre of the lens to the screen. The length *u* is measured from the centre of the lens to the centre of the filament bulb.

(a) Measurements of *u* and *v* are recorded in **Table 3.1**.
Complete the table by calculating the missing values of $\frac{1}{u}$ and $\frac{1}{v}$.

Table 3.1

u / m	v / m	$\frac{1}{u}$ / m^{-1}	$\frac{1}{v}$ / m^{-1}
–0.106	0.730	–9.53	1.37
–0.115	0.541		1.85
–0.129	0.394	–7.75	
–0.154	0.245		
–0.214	0.173	–4.67	5.78

[2]

(b) Draw a scale to –12 on the x-axis and to +12 on the y-axis.

Plot a graph of $\frac{1}{v}$ (on the *y*-axis) against $\frac{1}{u}$ (on the *x*-axis) on **Fig. 3.2**, and draw a straight line of best fit through the data points. **[3]**

(c) Determine a value for the focal length of the lens.
Use your line on the graph.

focal length = ... m **[3]**

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Fig. 3.2

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(d) Describe the sources of uncertainties and the limitations of this method to find the focal length of a lens.
Describe and explain methods to improve the experiment, such as the use of a monochromatic filter.

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Turn over for the next question

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Section B

4 This question is about collisions.

In 2022, the DART (Double Asteroid Redirection Test) mission completed the first attempt to redirect an asteroid by colliding a small spacecraft into it. **Fig. 4.1** depicts the spacecraft as it approached the asteroid Dimorphos.

The mass of the DART spacecraft was 570 kg, whilst the mass of Dimorphos was 4.8×10^9 kg. The DART spacecraft impacted with a velocity relative to Dimorphos of $6.0\,\text{km}\,\text{s}^{-1}$.

Fig. 4.1

DART
mass = 570 kg

Dimorphos
mass = 4.8×10^9 kg

(a) The spacecraft became embedded into Dimorphos upon impact.
Calculate the velocity of Dimorphos following the impact.
State any assumptions you make.

velocity = ... $\text{m}\,\text{s}^{-1}$ **[3]**

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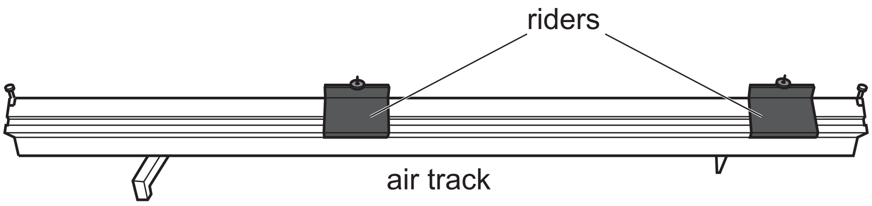
(b) A student attempts to model this collision using an air track (see **Fig. 4.2**). One of the riders available to use has a mass of 150 g.

Fig. 4.2



Suggest and explain why it may be challenging to replicate the collision of the DART mission with this apparatus.

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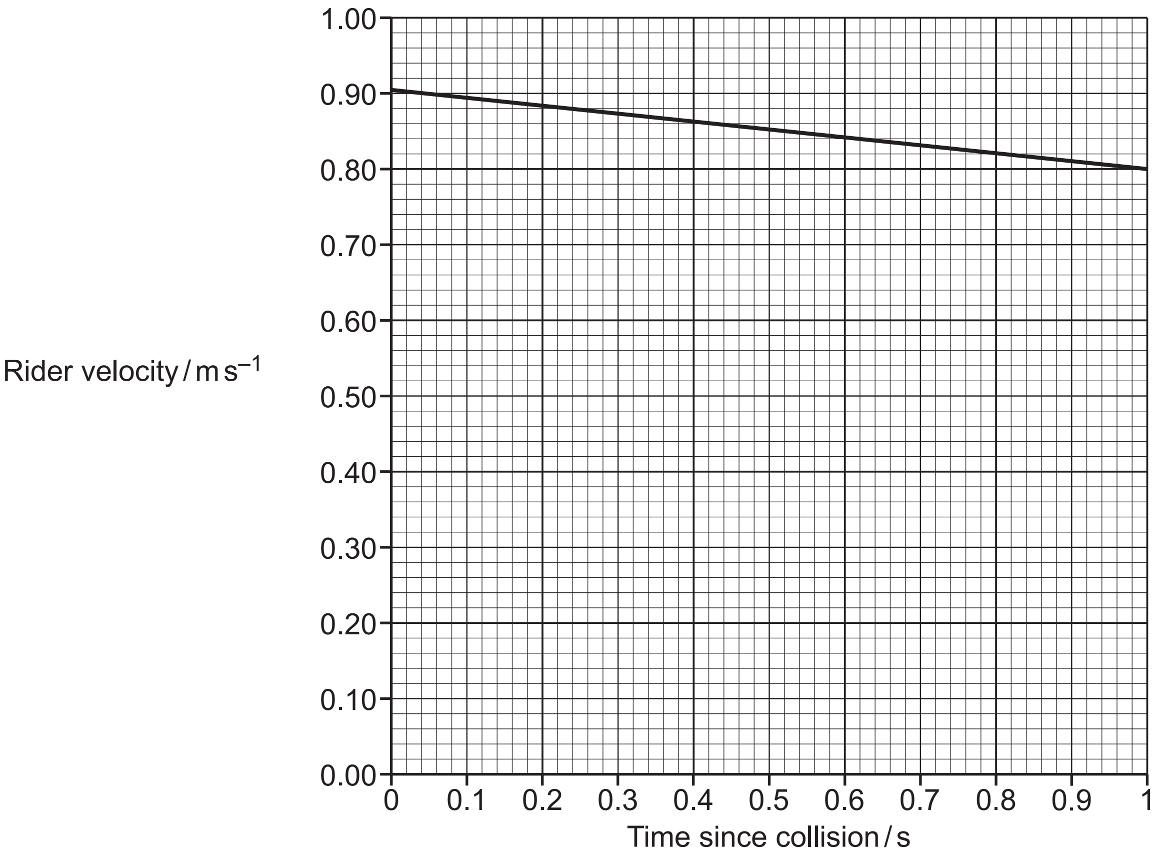
(c) The student begins an investigation with the apparatus available to them, including two riders of mass 150 g.

In the first run, the student collides the first rider with the second stationary rider. In the air track experiments, the riders do **not** move together after the collision. Using an ultrasonic ranging device, the student obtains a velocity–time graph of the second rider in the time after the collision. **Fig. 4.3** shows the graph.

In all of the student's experiments the riders do not move together after the collision.

Fig. 4.3

Velocity–time graph of the second rider for the time after the collision.



(i) Calculate the maximum initial velocity of the **first** rider, assuming it comes to rest immediately following the collision.

maximum velocity = ... m s^{-1} **[1]**

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(ii) The graph suggests there is a drag or frictional force acting on the rider as it decelerates. Use the graph to estimate the magnitude of this force.

magnitude of force .... N **[3]**

(iii) During another collision a 150 g rider collides with a stationary 250 g rider. The 150 g rider recoils with a velocity of 0.23 m s^{-1} following the impact.

Determine whether the 250 g rider will move away with a velocity greater or smaller than that shown in **Fig. 4.3** for the 150 g rider, assuming the same approach velocity as in **(i)**.

Support your conclusion with a calculation.

[2]

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(d) The DART spacecraft did not have to contend with atmospheric drag. The student decides to investigate the effect of drag on velocity of the rider following a collision. A small sail is added to the 250 g rider (**Fig. 4.4**). The data are shown in **Fig. 4.5**.

Fig. 4.4

250 g rider with sail.

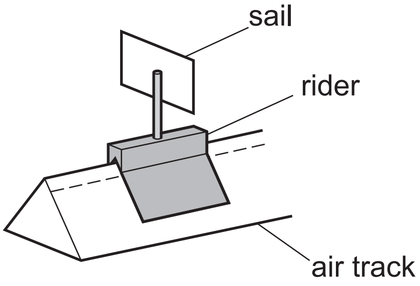
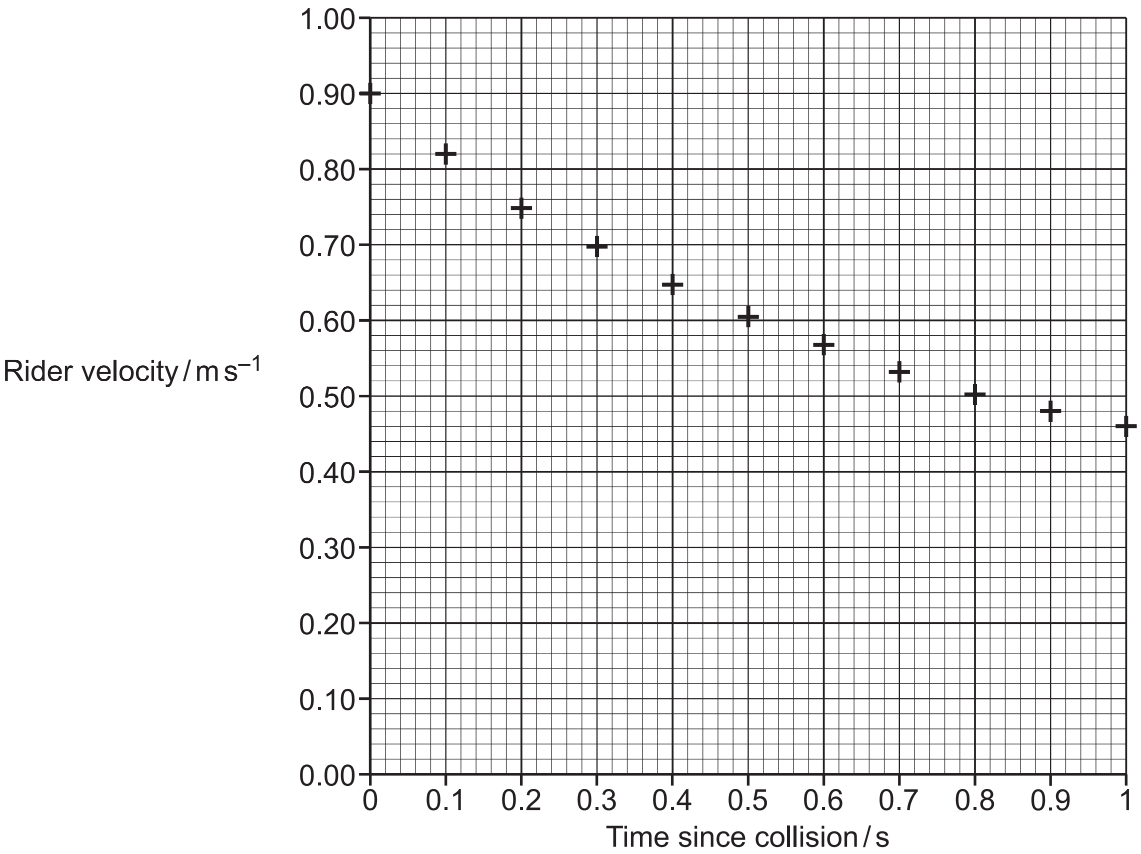


Fig. 4.5

Velocity–time graph for rider with sail in the time after the collision.



Describe and explain the shape of the graph.

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.... **[2]**

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(e)* The student decides to undertake a detailed investigation into the effect of drag on the deceleration of the 250 g rider following a collision.

The student's teacher suggests that the drag force, F_D, is proportional to the square of the object's velocity, v^2.

$F_D \propto v^2$

The student has available the following apparatus:

- air track and riders
- ultrasonic ranging device (as described earlier in the question)
- variable speed fan
- anemometer (wind-speed measuring device)
- pulley and weights.

Outline a plan for the student to test this suggestion.

Describe, with reasoning, how you would use the apparatus to investigate speed and drag.

Explain how you would use your data to prove/disprove the suggested relationship.

You may include a diagram in your response.

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[6]

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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