Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A420U10-1

O20-A420U10-1

eduqas
Part of WJEC

FRIDAY, 9 OCTOBER 2020 – MORNING

PHYSICS – A level component 1
Newtonian Physics

2 hours 15 minutes

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1.	8	
	2.	11	
	3.	19	
	4.	8	
	5.	16	
	6.	12	
	7.	6	
Section B	8.	20	
	Total	100	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet.**

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the continuation page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

This paper is in 2 sections, **A** and **B.**

Section **A**: 80 marks. Answer **all** questions. You are advised to spend about 1 hour 35 minutes on this section.

Section **B**: 20 marks. Comprehension. You are advised to spend about 40 minutes on this section.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **7**.

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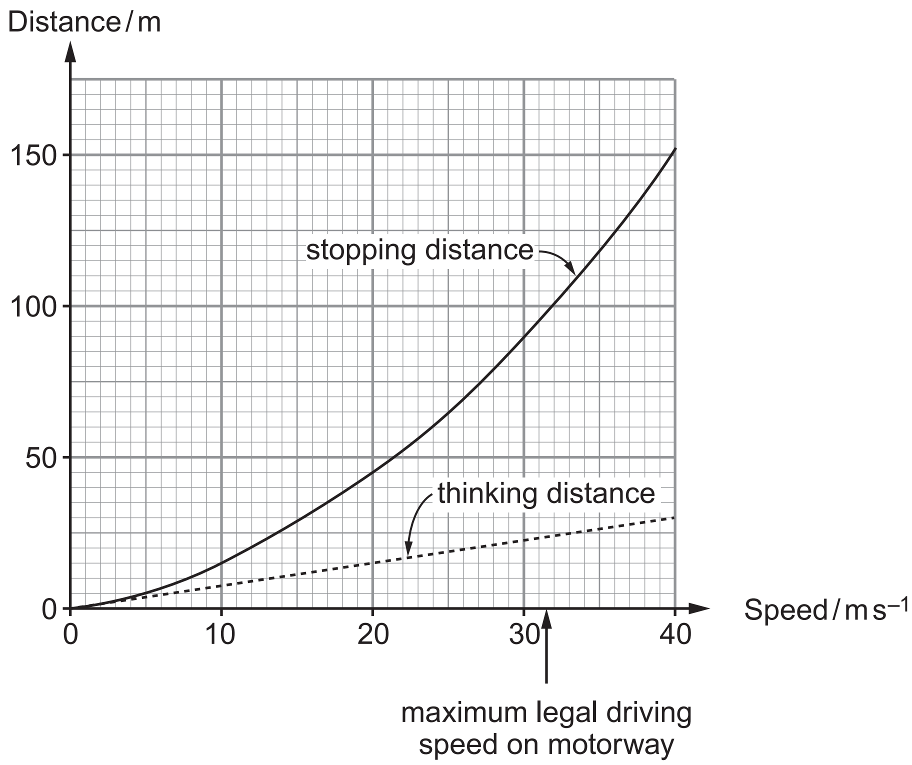
SECTION A

Answer **all** *questions.*

1. *(a)* The graphs show how a car driver's *stopping distance* and *thinking distance* are expected to depend on the speed at which the car is being driven (on a straight dry road).

thinking distance =	distance travelled between driver seeing a hazard ahead and starting to apply brakes
braking distance =	distance travelled while brakes are bringing car to rest (with constant deceleration)
stopping distance =	thinking distance + braking distance



(i) Determine the time interval that has been assumed between the driver seeing the hazard and starting to apply the brakes. [1]

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(ii) Determine the **braking** distance for a speed of $30\,\text{m}\,\text{s}^{-1}$. [1]

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(iii) Evaluate whether or not a consistent value has been used for the car's deceleration while the brakes are being applied. [3]

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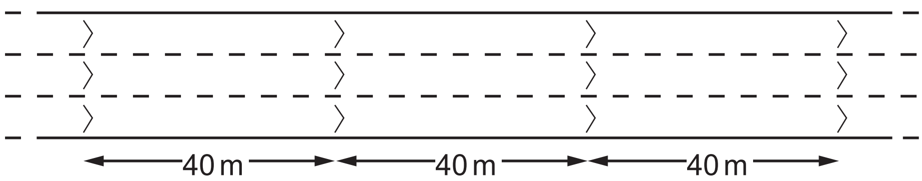
(b) Marks, called 'chevrons', are painted at 40 m intervals on the road surface along a few stretches of motorway in the U.K.



Large notices say "Keep apart 2 chevrons". Using the information in part *(a)*, discuss whether the use of chevrons is likely to help prevent accidents on motorways. You may consider whether the scheme has disadvantages and whether it could be improved. [3]

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2. *(a)* State what is meant by a body's *mean acceleration* over a period of time. [1]

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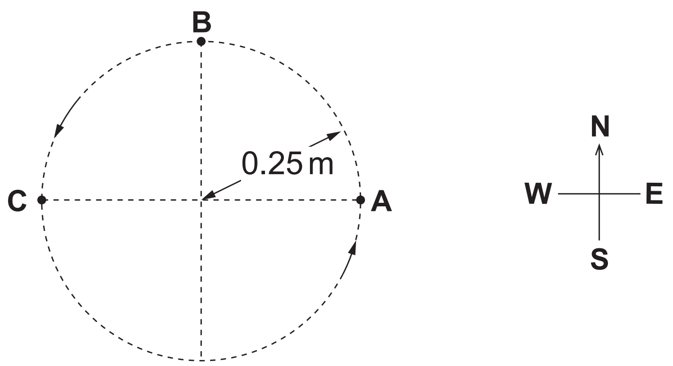
(b) Protons are 'stored' by being made to go round and round a circular path of radius 0.25 m at constant speed. They perform 5.2×10^6 revolutions per second.



(i) Show clearly that the protons' speed is approximately $8 \times 10^6\,\mathrm{m\,s^{-1}}$. [2]

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(ii) Determine the magnitude and direction of a proton's acceleration at point **B**. [3]

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(iii) Calculate a proton's mean acceleration over the semicircle **ABC**. [3]

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(c) Two students discuss the mean force on a proton over one revolution **ABCA**. Adam says that the mean force is the same as the force at B, because the force is the same all the way round. Brian says that the mean force is zero. Evaluate these opinions. [2]

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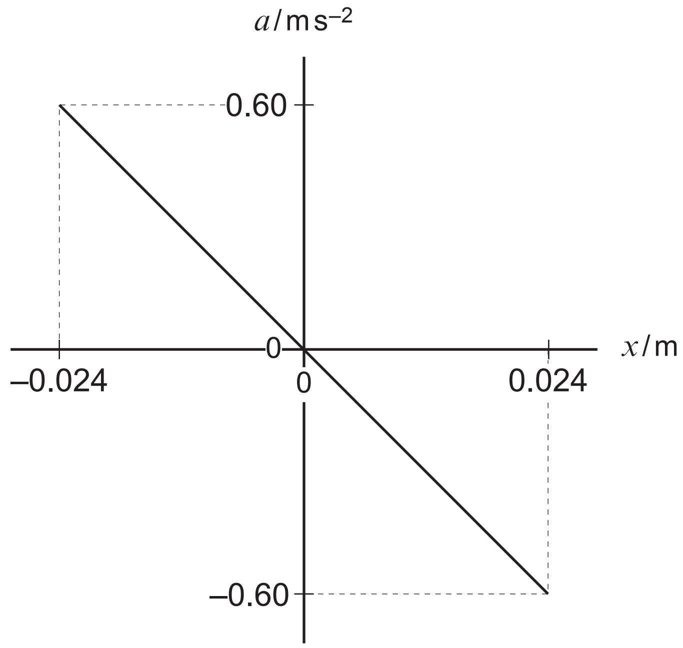
3. *(a)* The acceleration, a, of a body is plotted against its displacement, x, from a fixed point.



(i) State the features of the **graph** that show the body is performing *simple harmonic motion.* [2]

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(ii) Determine the *amplitude* of the motion. [1]

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(iii) Calculate the *periodic time* of the motion. [3]

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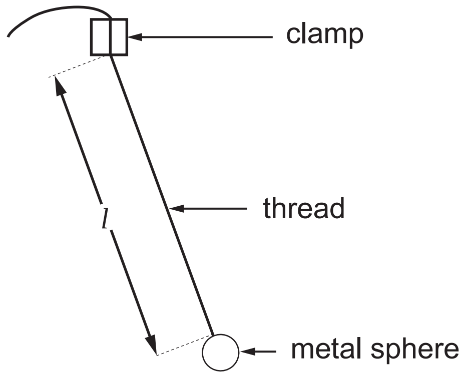
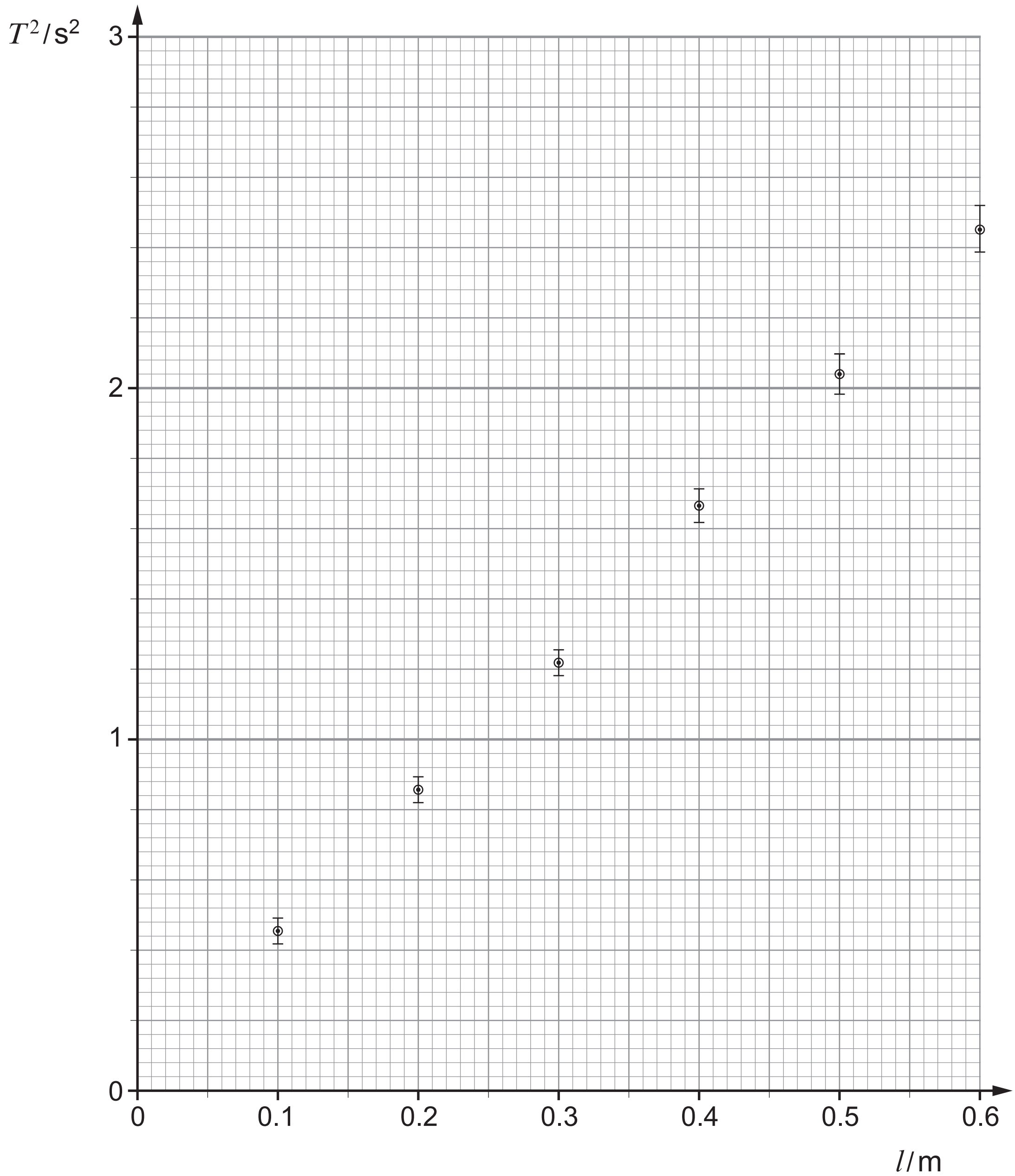
(b) Charlotte performed an experiment to determine the acceleration due to gravity, g, using a simple pendulum.



Using a metre ruler she measured the length, l, shown in the diagram. She then recorded the time for 10 small amplitude oscillations, repeated the timing and calculated values for the mean periodic time, T, and its uncertainty. She repeated the procedure for another five values of l. She plotted her values of T^2 against l on the following grid.



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(i) State why you would not expect the line of best fit to pass exactly through the origin. [1]

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(ii) Determine a value for the acceleration due to gravity, g, together with its **percentage** uncertainty. Give your reasoning clearly. [6]

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(c) A tennis ball attached by a **spring** to a fixed point is displaced vertically from its equilibrium position and released. It performs *damped oscillations*.

(i) What observed feature of the oscillations shows them to be damped? [1]

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(ii) Explain in terms of *forces* how the damping comes about. [2]

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(d) Explain what is meant by *critical damping*, **and** state one application of critical damping (or of damping that is close to critical). [3]

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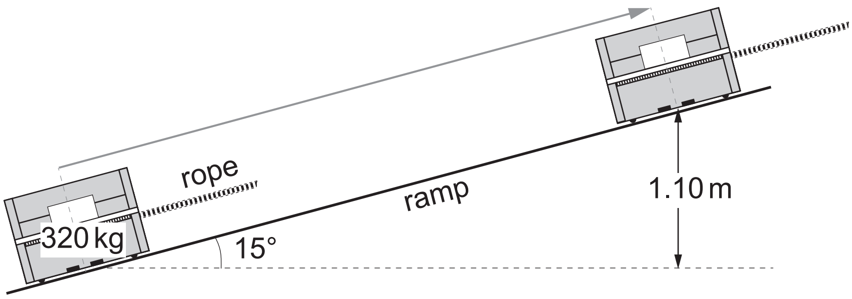
4. A piano of mass 320 kg is raised through a height of 1.10 m using a rope and a ramp angled at 15° to the horizontal. The process takes 35 s, during which the mean tension in the rope is 960 N.



(a) Show that the mean *power* used to pull the piano up the ramp is approximately 120 W. [3]

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(b) Calculate the *efficiency* of the rope and ramp as a means of raising the piano through a height of 1.10 m. [3]

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(c) Evaluate whether or not the kinetic energy given to the piano (at the beginning of the raising operation) is a major reason for inefficiency. [2]

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5. *(a)* (i) Show that the mean kinetic energy of (monatomic) gas molecules at a temperature of 1 500 K is approximately 3×10^{-20} J. [2]

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(ii) At 1 500 K, sodium is a gas of monatomic molecules, each of mass 3.82×10^{-26} kg. Calculate their rms speed. [2]

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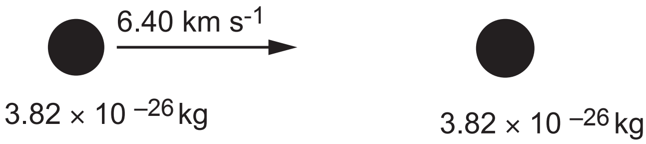
(b) A sodium molecule moving at 6.40 km s^{-1} to the East collides with an almost stationary sodium molecule.



(i) Discuss whether a molecule with a speed of 6.40 km s^{-1} could be present at some instant in sodium gas at 1 500 K and, if so, how it could have acquired this speed. [3]

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(ii) After the collision one of the two molecules is moving to the East at 4.39 km s^{-1}. Calculate the speed and direction of motion of the other molecule. [2]

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(iii) Determine whether or not the collision is elastic. [3]

(iv) Explain how Newton's 3rd law applies to the collision. [1]

(v) Soon after the collision in *(b)*, one of the molecules gives out a photon of wavelength 589 nm. Evaluate whether or not the momentum of the photon significantly affects the molecule's velocity. [3]

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6. *(a)* (i) A cylinder of gas fitted with a pressure gauge is surrounded by melting ice. The gas pressure stabilises at 96 kPa. The cylinder is then surrounded instead by boiling water. The pressure stabilises at 131 kPa. Show that this is consistent with a value of –273 °C for the absolute zero of temperature. [3]

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(ii) State the significance, in terms of molecules, of the absolute zero of temperature. [1]

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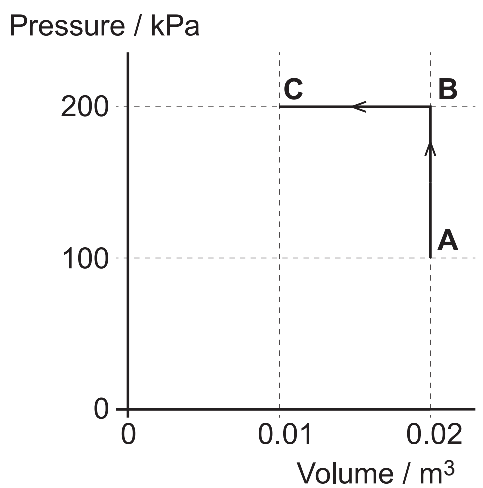
(b) A cylinder with a moveable, leak-proof piston contains 0.850 mole of an ideal gas. The gas is taken along the path **ABC** shown on the p–V grid.



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(i) Show clearly that the gas is at the same temperature at **A** and **C**, and determine this temperature. [3]

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(ii) Calculate the work done on the gas over **ABC**. [2]

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(iii) Determine the net heat flow over **ABC**, stating whether it is in or out of the system, **and** justifying your answer clearly in terms of the *1st law of thermodynamics*. [3]

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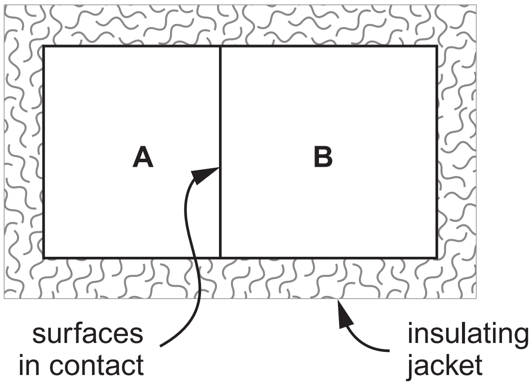
7. Two copper blocks, **A** and **B**, are placed in contact and the assembly is covered by a thermally insulating jacket. **Initially A is at a higher temperature than B.**



Describe what happens over a period of time, in terms of heat, internal energy, temperature **and** the motion of copper atoms. [6 QER]

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SECTION B

*Answer **all** questions.*

8. Read through the following article carefully.

ROCKET PHYSICS Paragraph

(including extracts from REAL WORLD PHYSICS PROBLEMS)

Picture of Saturn V Launch for Apollo 15 Mission. Source: NASA

Rocket physics, in the most basic sense, involves the application of Newton's laws to a system with variable mass. A rocket has variable mass because its mass decreases over time, as a result of its fuel (propellant) burning off. 1

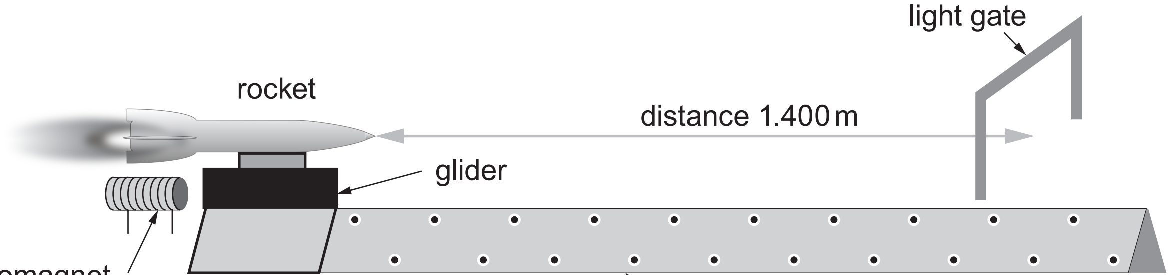
A rocket obtains thrust by the principle of action and reaction (Newton's 3rd law). As the rocket propellant ignites, it experiences a very large acceleration and exits the back of the rocket (as exhaust) at a very high velocity. This backwards acceleration of the exhaust exerts a "push" force on the rocket in the opposite direction, causing the rocket to accelerate forward. This is the essential principle behind the physics of rockets, and how rockets work. 2

Rockets tend to burn fuel at a steady rate and with a constant exhaust speed which produces a constant thrust. However, rocket science is a little more complicated than normal A level physics motion because this does not lead to a constant acceleration. This is due to the decreasing mass of a rocket as it burns its fuel (as stated previously). The usual equation of motion for a rocket is: 3

$$ma = u\frac{\Delta m}{\Delta t} \qquad \textbf{Equation 1}$$

where m is the instantaneous mass of the rocket, a its acceleration, u the velocity of the exhaust gases relative to the rocket and $\frac{\Delta m}{\Delta t}$ the rate at which the mass of the rocket is decreasing. This is a simple application of Newton's 2nd and 3rd laws of motion. 4

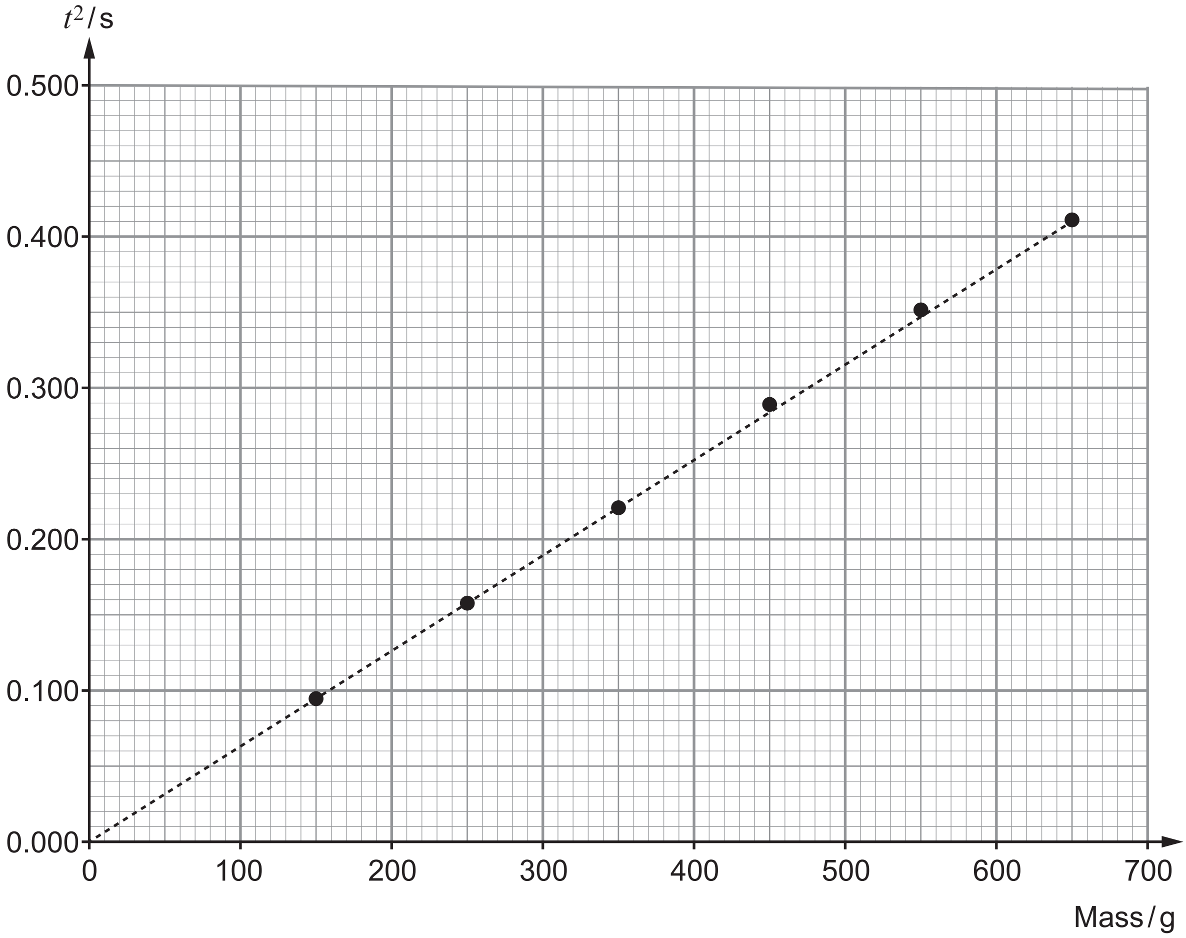
If the mass of the rocket is much greater than that of the rocket fuel, we can assume that the acceleration is constant. We can also burn the fuel slowly and then the acceleration will be nice and small so that we can carry out an experiment on an air track to check **Equation 1**. 5



Paragraph

In the set-up opposite, the rocket is attached to a glider and released from rest using the electromagnet. The timer is started automatically and the time is then recorded for the rocket to travel the 1.400 m to the light gate. This process is repeated for a series of glider masses. 6

Mass of glider and rocket / g	Time / s	Corrected time, t / s	t^2 / s
150	0.328	0.308	0.095
250	0.418	0.398	0.158
350	0.490	0.470	0.221
450	0.558	0.538	0.289
550	0.614	0.594	0.353
650	0.663	0.643	0.413



The graph shows a constant acceleration, in excellent agreement with theory. Moreover, the rate of mass loss for the rocket was measured as 1.10×10^{-2} kg s^{-1}. The exhaust gas speed was 402 m s^{-1} as measured using the Doppler shift of light emitted by the exhaust gases. These measurements provide a theoretical value of around 4.4 N for the rocket thrust and this is in excellent agreement with the graph too. 7

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Answer the following questions in your own words. Direct quotes from the original article will not be awarded marks.

(a) Explain how Equation 1 is an application of Newton's 2nd and 3rd laws of motion (see paragraphs 2 and 4). [3]

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(b) The author states in paragraph 5 that the acceleration is "constant" and "nice and small". Explain why this is true (see paragraphs 3 and 5). [3]

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(c) (i) The author has made a mistake in the table and the graph with one of the units. Identify the mistake. [1]

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(ii) Explain how the corrected time, t, was obtained from the time in the table and suggest why this correction was necessary. [2]

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(d) Use equations of uniformly accelerated motion to explain why a graph of t^2 against mass was plotted **and** why the gradient of this graph is expected to be $\frac{2.80}{F}$ (where F is the resultant force in newtons acting on the glider and rocket). [3]

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(e) Show that a rate of mass loss of $1.10 \times 10^{-2}\,\text{kg}\,\text{s}^{-1}$ and an exhaust gas speed of $402\,\text{m}\,\text{s}^{-1}$ produce a thrust of approximately 4.4 N (see paragraph 7). [1]

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(f) The gradient of the graph is 0.635 in the correct SI unit. Use this to determine whether the force of 4.4 N to which the author refers is consistent with the graph (see paragraph 7 and the graph). [2]

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(g) (i) State what is meant by Doppler shift (see paragraph 7). [2]

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TURN OVER FOR THE LAST PART OF THE QUESTION

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(ii) Describe how the exhaust gas speed might be measured “using the Doppler shift of light emitted by the exhaust gases” (see paragraph 7). [3]

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END OF PAPER

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For continuation only.