Surname	Centre Number	Candidate Number
Other Names		2

AS/A LEVEL

2420U10-1

S18-2420U10-1

PHYSICS – AS unit 1
Motion, Energy and Matter

TUESDAY, 15 MAY 2018 – MORNING

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**19**	
3.	**10**	
4.	**12**	
5.	**10**	
6.	**12**	
7.	**9**	
Total	**80**	

2420U101 01

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use pencil or gel pen. Do not use correction fluid.

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

The total number of marks available for this paper is 80.

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 **6*(a)***.

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Answer **all** *questions.*

1. *(a)* State in words the equation used to calculate the moment of a force about a point. [1]

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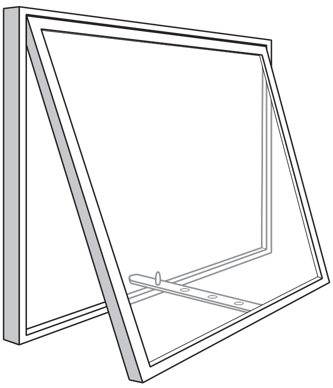
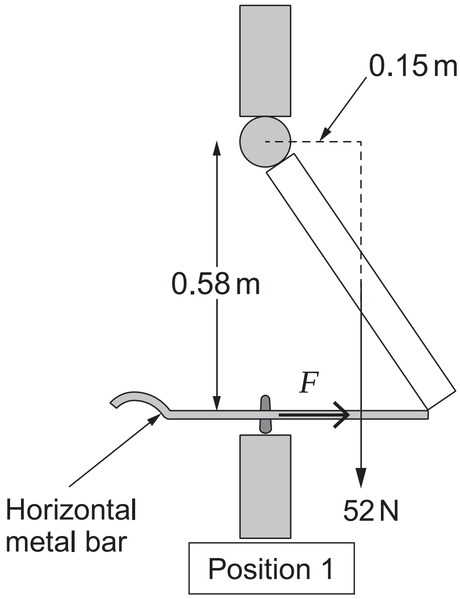
(b) The picture and diagram show a window hinged at the upper surface. The window is opened by pushing on the horizontal metal bar attached to its lower surface. Holes are drilled into the metal bar so that the window can be supported at various opening positions, one of which is shown below and labelled as Position 1. The hinge provides no resistance to the movement of the window.





(i) Show that the clockwise moment produced by the weight of the window is approximately 8 N m. [1]

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(ii) Hence calculate the force, F, the metal bar exerts on the window. [2]

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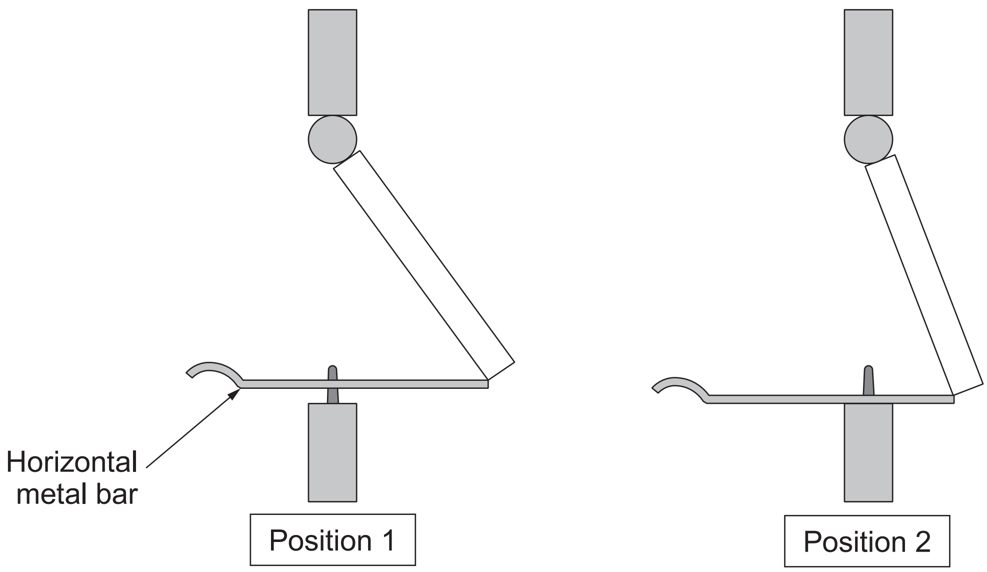
(c) Tom and Bethan discuss how the force in the metal bar changes with changing positions. Tom thinks that the force in the bar is greater when the window is in Position 2, whereas Bethan believes that the force is greater when the window is in Position 1. Discuss who is correct, giving a detailed explanation in terms of moments. Assume the metal bar is horizontal in both positions. [4]



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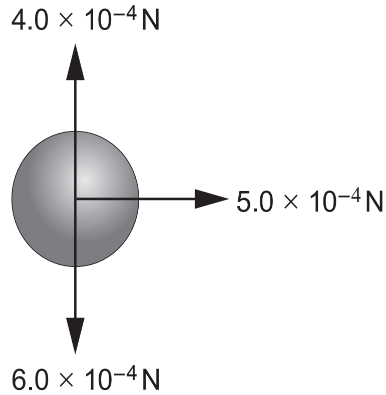
2. *(a)* The forces acting on a hailstone falling in a horizontal cross-wind can be represented as in the diagram.



(i) Calculate the magnitude and direction of the resultant force acting on the hailstone. [3]

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(ii) At a later time, the wind has stopped blowing and the hailstone falls at terminal velocity. In terms of forces, explain why the hailstone is at terminal velocity. [1]

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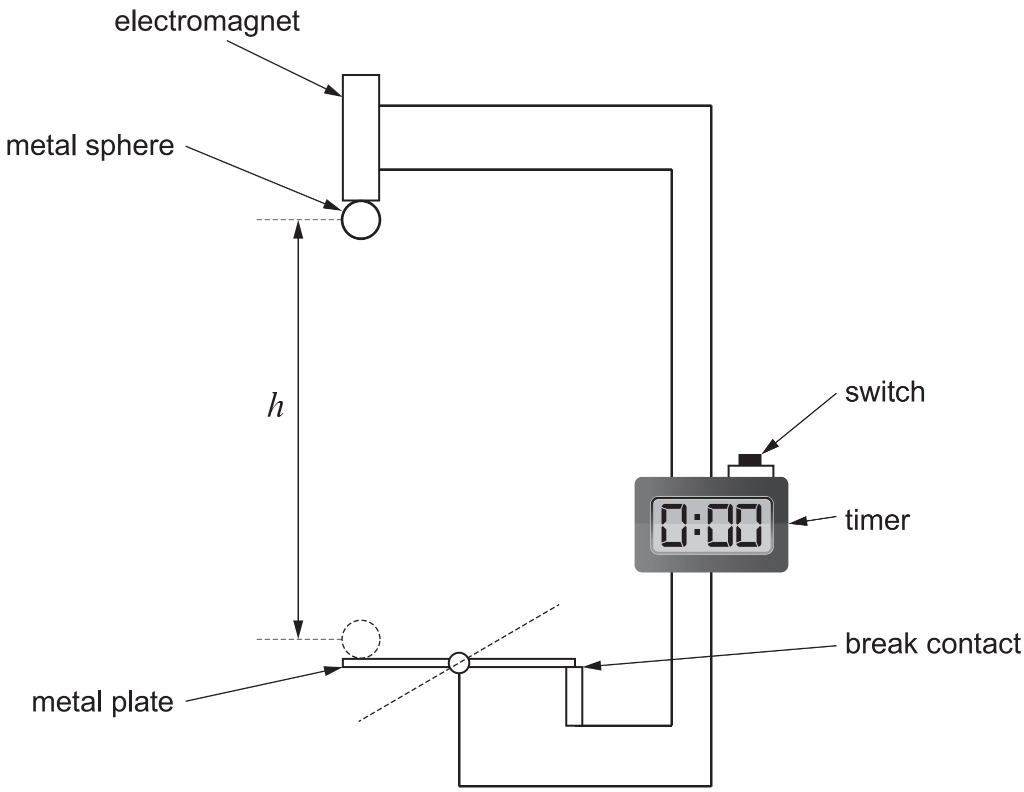
(b) Aled uses the following apparatus to measure the acceleration of free-fall, g.



When the switch is pressed, it starts the timer and disconnects the electromagnet, almost instantly releasing the metal sphere. When the sphere hits the metal plate it breaks the circuit, stopping the timer. The time taken for the metal sphere to fall through a range of different heights, h is measured.

(i) Aled is told that there is a very small time delay between the switch being pressed and the ball being released. This is a systematic error. The manufacturer states that the time delay is 0.05 s. State how Aled should account for the systematic error when taking readings. [1]

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(ii) Aled records his **corrected results (i.e. with the systematic error accounted for)** in the table below. Complete the row for time squared, t^2 giving your answers to an appropriate number of significant figures. [2]

Drop height, h/m	0.40	0.80	1.20	1.60	2.00
Corrected time, t/s	0.27	0.41	0.48	0.58	0.64
Corrected time squared, t^2/s^2					

(iii) The following relationship is used to find a value for g:

$$g = \frac{2h}{t^2}$$

Show how this relationship is obtained from an appropriate equation of accelerated motion. [2]

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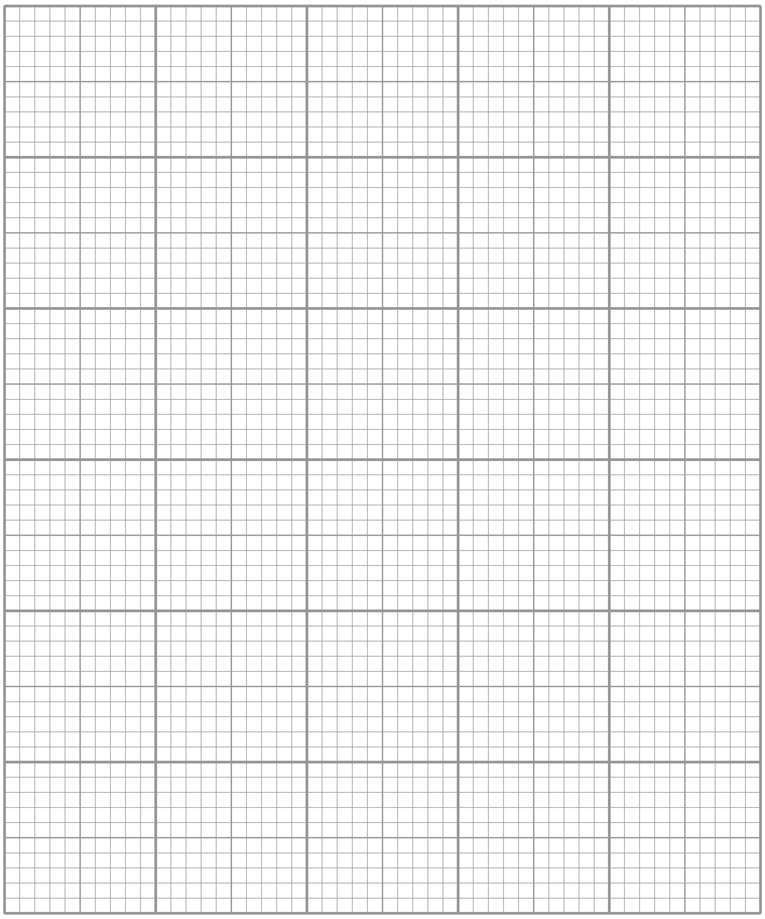
(iv) On the grid below, plot a graph of h **(vertical axis)** against t^2 **(horizontal axis)** and draw a line of best fit. [4]



(v) Use your graph to determine a value for g. [3]

(c) Discuss to what extent your graph agrees with the equation in *(b)*(iii). [3]

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3. *(a)* Describe a method to investigate the force-extension properties of rubber in the form of an elastic band **as it is loaded**. You should describe how the extension of the rubber is accurately measured. [3]

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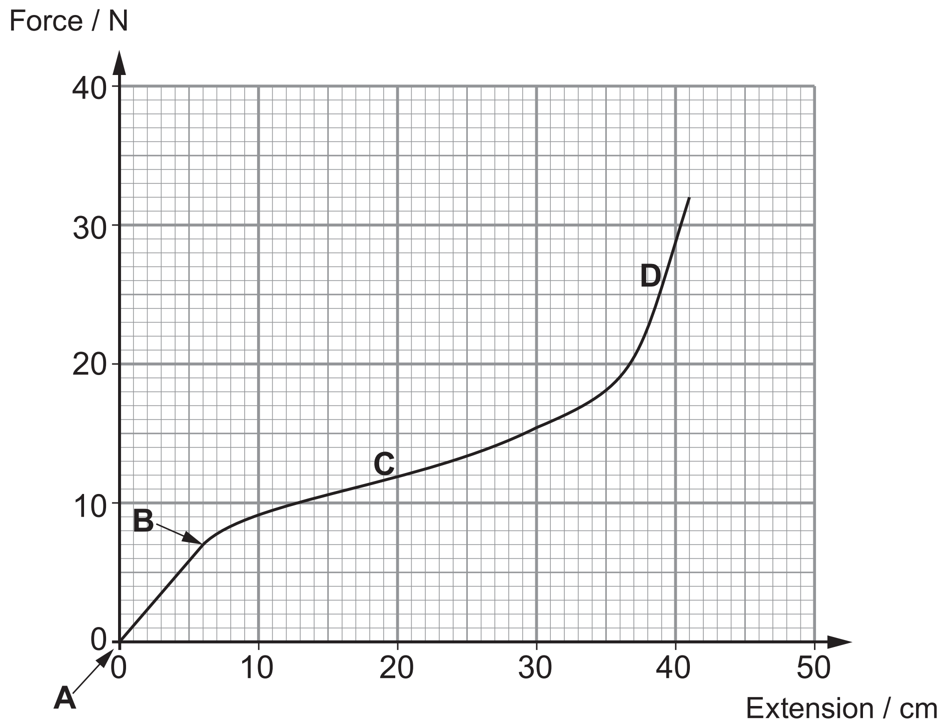
(b) The results from such an experiment for a rubber band of unstretched length 8.0 cm are plotted in a graph.



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(i) Calculate the strain in the rubber at point **B**. [1]

(ii) Determine the Young modulus of the rubber in the region **AB**. Assume the band has a total cross-sectional area of $0.050\,cm^2$. [3]

(c) By referring to the molecular structure of rubber, explain why the gradient at **C** is less than the gradient at **D**. [3]

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4. *(a)* The table shows information about some sub-atomic particles.

Particle	Symbol	Quark combination	Charge / e	Baryon number
proton	p	uud	+1	1
delta particle	Δ^{++}	uuu	....	....
electron	e^-	no quarks present	....	....
pion	π^-	....	–1	....

(i) **Complete the table.** [3]

(ii) Identify the lepton in the table. .... [1]

(b) JJ Thomson, when studying the properties of cathode rays in 1897, discovered the electron. In the early 20th century, Ernest Rutherford, carrying out a series of experiments on radioactive substances, discovered the proton. The following interaction between protons and electrons has been observed by using high energy particle accelerators.

$$e^- + p \longrightarrow e^- + \Delta^{++} + \pi^-$$

Show how charge and lepton number are conserved in the above interaction. [2]

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(c) The Δ^{++} decays in about 6×10^{-24} s as shown below.

$$\Delta^{++} \longrightarrow p + \pi^{+}$$

(i) Show clearly that both up-quark number and down-quark number are conserved in this decay. [2]

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(ii) Give **two** reasons for believing that this decay is a strong force interaction. [2]

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(d) During a press conference, the spokesman for a nuclear research centre was asked the question:

‘You have discovered many new particles, none of which have had any discernible impact on society. How do you justify the huge expense of continuing with these experiments?’

In response, the spokesman referred to the work of JJ Thomson and Ernest Rutherford. Suggest why the spokesman responded in this way. [2]

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5. *(a)* A law of motion can be expressed as:

$$\text{resultant force} = \frac{\text{change in momentum}}{\text{time}}$$

State the name of the law. [1]

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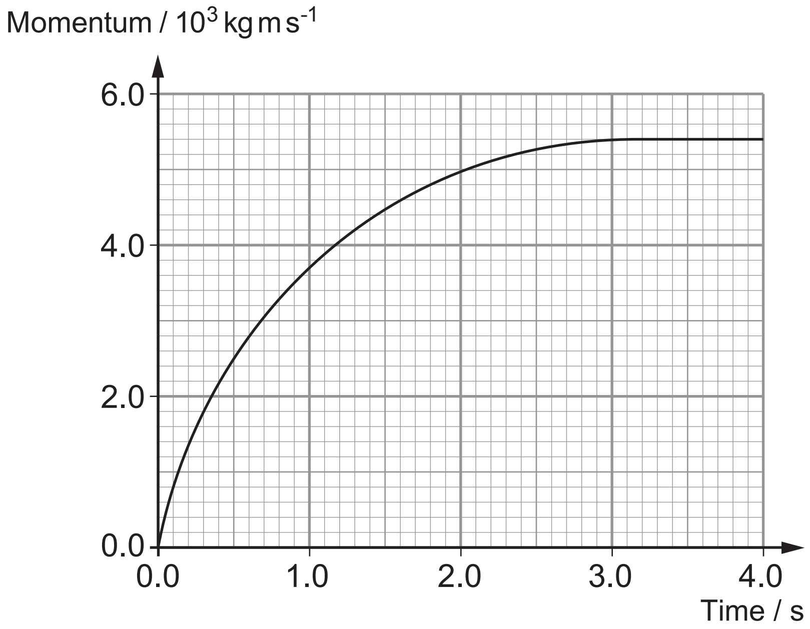
(b) The graph shows how the momentum of a spacecraft varies with time.



(i) By drawing a suitable tangent, show that the resultant force on the spacecraft at t = 1.0 s is approximately 2 kN. [2]

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(ii) Hence show that the mass of the spacecraft is approximately 5 000 kg, given that its acceleration at t = 1.0 s is 0.4 m s^{-2}. [1]

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(iii) **Label, with the letter P**, a point on the graph where the resultant force on the spacecraft is zero. [1]

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(c) At t = 4.0 s the spacecraft 'docks' (collides) with another **stationary** spacecraft of mass 7 000 kg. They join on impact.

(i) State the principle of conservation of momentum. [2]

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(ii) Calculate the velocity of both spacecraft after colliding. [3]

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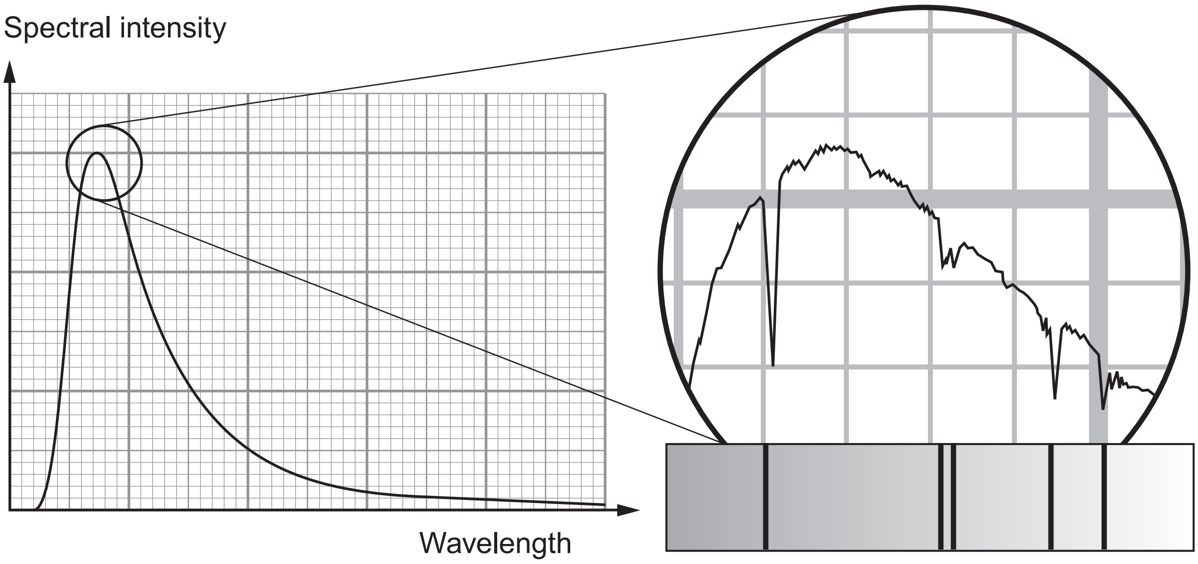
6. *(a)* A blackbody graph of spectral intensity against wavelength for a star is shown. A magnified section, showing the finer detail of the spectrum is also given. An associated line spectrum is also shown.



Explain how the graph and the spectra can be used to provide information about the star and the elements from which it is made. [6 QER]

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(b) (i) Altair is the brightest star in the Aquila constellation. It is 1.58×10^{17} m away, and the intensity of its electromagnetic radiation reaching the Earth is $1.32 \times 10^{-8}\,\mathrm{W\,m^{-2}}$. Show that its luminosity is approximately 4×10^{27} W. [3]

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(ii) Calculate Altair's **diameter** given that its surface temperature is 7 700 K. [3]

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TURN OVER FOR THE LAST QUESTION

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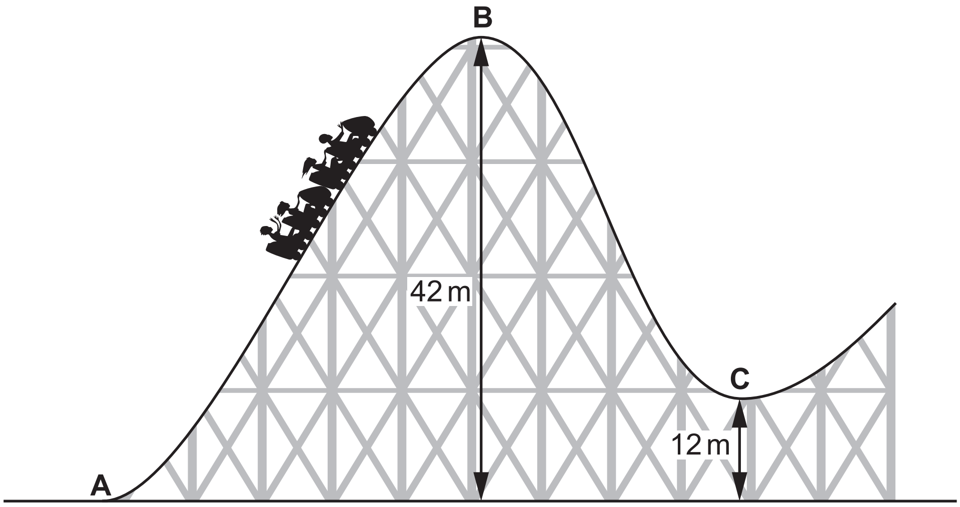
7. The diagram shows part of a rollercoaster ride at a theme park.



(a) A motor with a power output of 65 kW and a chain mechanism pulls the carriages of mass 2 600 kg from **A** to **B** in a time of 32 s.

(i) Show that the work done by the motor in 32 seconds is approximately 2 MJ. [1]

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(ii) Hence calculate the efficiency of the mechanism, assuming the carriages are momentarily at rest at **B**. [3]

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(b) At B, the carriages become disconnected from the motor and the carriages move under the influence of gravity for the rest of the ride. In moving from B to C, a distance along the track of 36 m, the carriages experience a mean resistive force of 2.8 kN. Calculate the speed of the carriages at **C**. [5]

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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