OXFORD
INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL A-LEVEL
PHYSICS
(9630)

PAPER 5

Specimen 2018 Morning Time allowed: 2 hours

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formula booklet.

Instructions
- use black ink or ball-point pen
- answer **all** questions
- show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80 marks.

Please write clearly in block capitals.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

Candidate signature _____

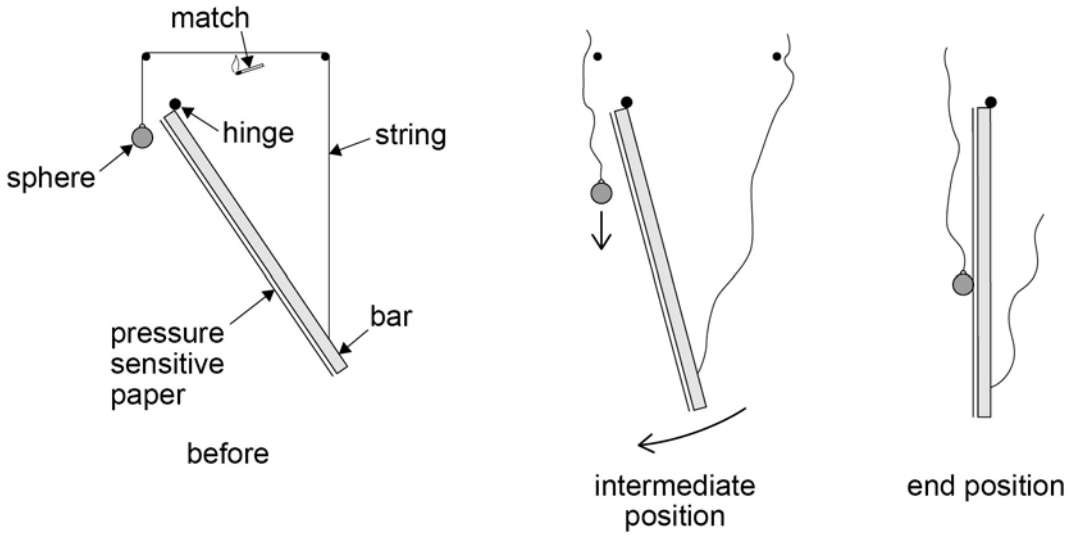
Section A

Answer **all** questions in this section.

0 1 A student undertakes an experiment to measure the acceleration of free fall, g.

Figure 1 shows a steel sphere attached by a string to a steel bar. The bar is hinged at the top and acts as a pendulum. When the string is burnt through, the sphere falls vertically from rest and the bar swings clockwise. As the bar reaches the vertical position, the sphere hits it and makes a mark on a sheet of pressure-sensitive paper that is attached to the bar.

Figure 1



The student needs to measure the distance d fallen by the sphere in the time t taken for the bar to reach the vertical position.

To measure d the student marks the initial position of the sphere on the paper. The student then measures the distance between the initial mark and the mark made by the sphere after falling.

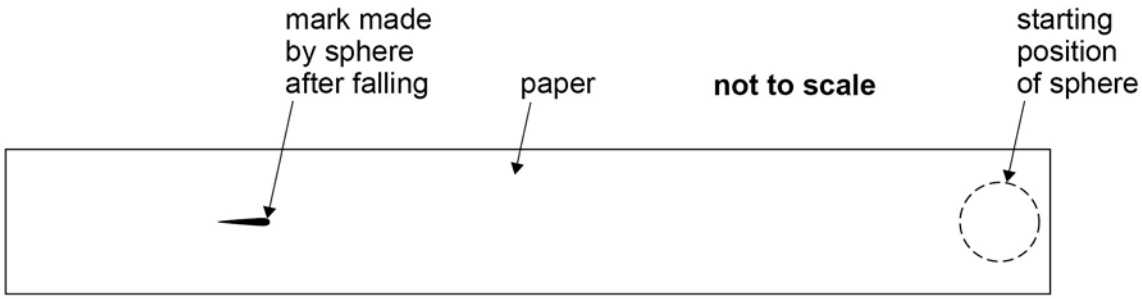
To measure t the student sets the bar swinging without the string attached and determines the time for the bar to swing through 10 small-angle oscillations.

0 1 . 1 **Figure 2** shows the strip of paper after it has been removed from the bar.

Mark on **Figure 2** the distance that the student should measure in order to determine d.

[1 mark]

Figure 2



0 1 . 2 The student repeats the procedure several times.

Data for the experiment is shown in **Table 1**.

Table 1

d / m
0.752
0.758
0.746
0.701
0.772
0.769

Time for bar to swing through 10 oscillations as measured by a stop clock = 15.7 s.

Calculate the time for one oscillation and hence the time t for the bar to reach the vertical position.

[1 mark]

time = _____ s

Question 1 continues on the next page

0 1 . 3 Determine the percentage uncertainty in the time t suggested by the precision of the recorded data.

[2 marks]

uncertainty = _____ %

0 1 . 4 Use the data from **Table 1** to calculate a value for d.

[2 marks]

d = _____ m

0 1 . 5 Calculate the absolute uncertainty in your value of d.

[1 mark]

uncertainty = _____ m

0 1 . 6 Determine a value for g and the absolute uncertainty in g.

[3 marks]

g = _____ m s^{-2}

uncertainty = _____ m s^{-2}

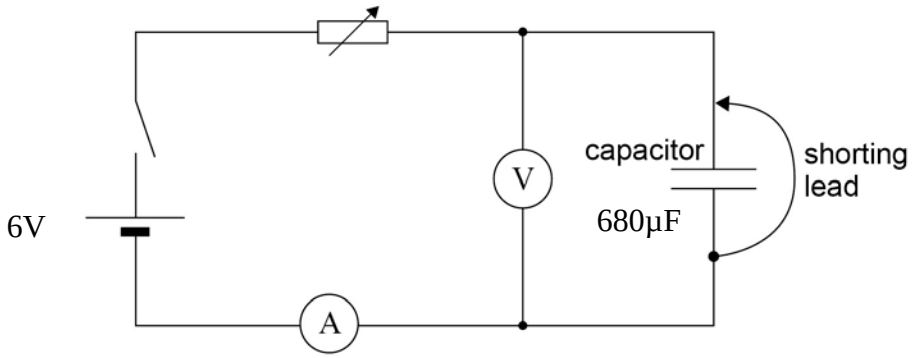
0 1 . 7 Discuss **one** change that could be made to reduce the uncertainty in the experiment.

[2 marks]

Turn over for the next question

0 2 This question is about capacitor charging and discharging.
A student designs an experiment to charge a capacitor using a constant current as shown in **Figure 3**.

Figure 3



The variable resistor is then adjusted to give a suitable ammeter reading. The shorting lead is removed and the stop clock is started at the same instant.

A student measured the potential difference (pd) across the capacitor at 10 s intervals while adjusting the variable resistor to keep the charging current constant.

The power supply has a negligible internal resistance and the variable resistor has a maximum resistance of 100 kΩ.

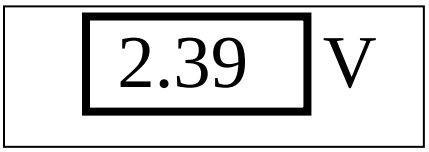
0 2 . 1 The student chooses a digital voltmeter for the experiment. A digital voltmeter has a very high resistance.

Explain why it is important to use a voltmeter with very high resistance.

[1 mark]

0 2 . 2 **Figure 4** shows the reading on the voltmeter at one instant during the experiment. The manufacturer gives the uncertainty in the meter reading as 2%.

Figure 4



Calculate the absolute uncertainty in this reading.

[1 mark]

uncertainty = _____ V

0 2 . 3 Determine the number of different readings the student will be able to take before the capacitor becomes fully charged.

[3 marks]

number = _____

0 2 . 4 The experiment is performed with a capacitor of nominal value 680 μF and a manufacturing tolerance of ± 5%. In this experiment the charging current is maintained at 65 μA. The data from the experiment produces a straight-line graph for the variation of pd with time. This shows that the pd across the capacitor increases at a rate of 98 mV s^{-1}.

Calculate the capacitance of the capacitor.

[2 marks]

capacitance = _____ μF

Question 2 continues on the next page

0 2 . 5 Deduce whether the capacitor is within the manufacturer's tolerance.

[2 marks]

0 2 . 6 The student decides to confirm the value of the capacitance by first determining the time constant of the circuit when the capacitor **discharges** through a **fixed** resistor.

Describe an experiment to do this. Include in your answer:

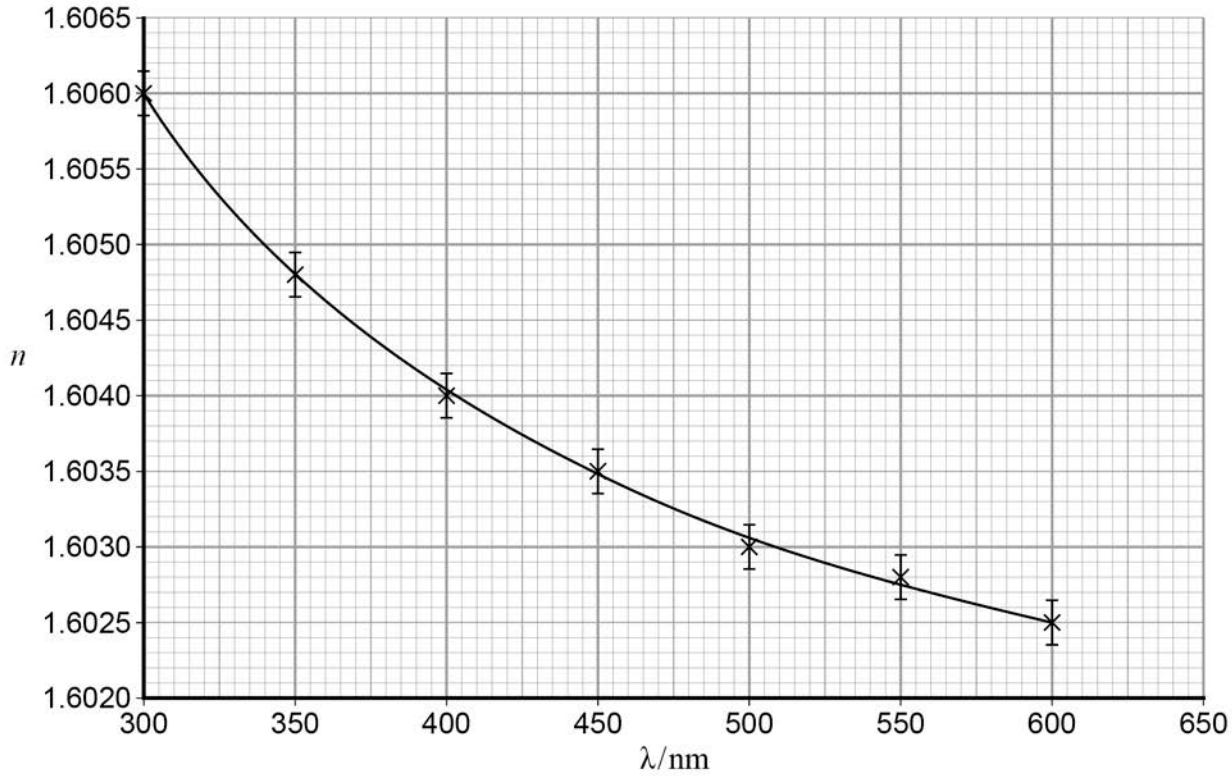
- a circuit diagram
- an outline of a procedure
- an explanation of how you would use the data to determine the time constant.

[4 marks]

Turn over for the next question

0 3 **Figure 5** shows how the refractive index n of a type of glass varies with the wavelength of light λ passing through the glass. The data for plotting the graph were determined by experiment.

Figure 5



0 3 . 1 A student says that **Figure 5** resembles that of the decay of radioactive atomic nuclei with time and that it shows half-life behaviour.

Comment on whether the student is correct.

[1 mark]

0 3 . 2 The dispersion D of glass is defined as the rate of change of its refractive index with wavelength. At a particular wavelength $D = \frac{\Delta n}{\Delta \lambda}$.

Determine D at a wavelength of 400 nm. State an appropriate unit for your answer.

[3 marks]

D = _____ unit = _____

Question 3 continues on the next page

0 3 . 3 It is suggested that the relationship between n and λ is of the form

$$n = a + \frac{b}{\lambda^2}$$

where a and b are constants. The data plotted in **Figure 5** are given in **Table 2**.

Table 2

λ / nm	n			
300	1.6060			
350	1.6048			
400	1.6040			
450	1.6035			
500	1.6030			
550	1.6028			
600	1.6025			

You are to determine a using a graph of n against $\frac{1}{\lambda^2}$ **.**

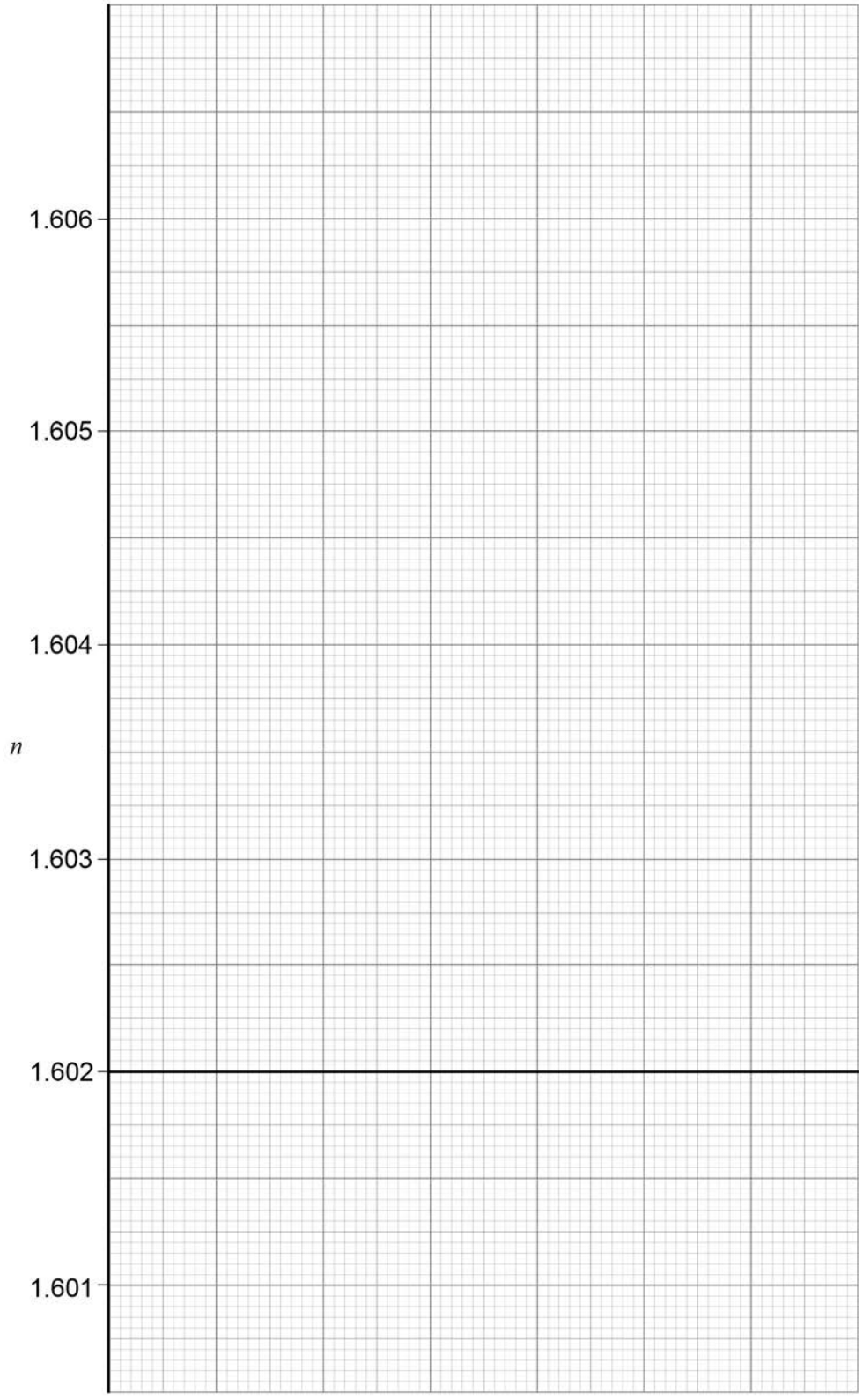
Make any calculations that you need to in order to plot your graph. The columns in **Table 2** are for you to use to calculate and tabulate the derived data that you need. You may not need all the columns.

[3 marks]

0 3 . 4 Plot your graph on **Figure 6**. The values of n are provided on the y-axis.

[3 marks]

Figure 6



Question 3 continues on the next page

0 3 . 5 Use your graph to determine a.

[1 mark]

0 3 . 6 State the significance of a.

[1 mark]

Section B

Answer **all** questions in this section.

0 4 A Simplified Aid for Extravehicular activity Rescue (a SAFER), is a device to rescue astronauts if they are accidently detached from their safety line when performing tasks outside the International Space Station. The SAFER is strapped to the astronaut and enables the astronaut to be propelled back to the Space Station.

A SAFER has a tank that initially contains 1.40 kg of nitrogen in liquid form. When the liquid is released, it expands as a gas and is released through one or more of 24 nozzles to apply a thrust. Each nozzle can produce a constant thrust of 3.56 N. Using all the nitrogen, the total velocity change that can be achieved is 3.05 $\mathrm{m\ s^{-1}}$.

initial total mass of the astronaut, spacesuit and the SAFER unit = 151 kg.
density of liquid nitrogen = 810 $\mathrm{kg\ m^{-3}}$.
molar mass of nitrogen = 0.0280 kg.

0 4 . 1 Calculate the volume of liquid nitrogen that is carried by the SAFER.

[2 marks]

volume = _____ $\mathrm{m^3}$

0 4 . 2 Calculate the volume of a container that 1.40 kg of nitrogen would occupy at a pressure of 1.0×10^5 Pa and a temperature of 25 °C.
Assume that the nitrogen behaves as an ideal gas.

[3 marks]

volume = _____ $\mathrm{m^3}$

Question 4 continues on the next page

0 4 . 3 Explain how the release of gases from a nozzle propels the astronaut.

[3 marks]

0 4 . 4 Gas is released from a single nozzle to produce only linear acceleration.

Calculate the initial acceleration produced by the SAFER.

[2 marks]

acceleration = _____ ms^{-2}

0 4 . 5 Assume that all the gas is released from a single nozzle but has negligible effect on the total mass of the astronaut and the SAFER.
Calculate the speed at which the gas leaves the nozzle.

[3 marks]

speed = _____ ms^{-1}

0 4 . 6 Calculate the mass of gas released per second by the nozzle.

[3 marks]

mass released per second = _____ kg s^{-1}

0 4 . 7 Explain how the first law of thermodynamics applies when the gas that is under pressure in the SAFER expands through a nozzle.

[3 marks]

0 4 . 8 Which of the following is a possible unit for rate of change of momentum?
Tick (✓) **one** box.

[1 mark]

N s ☐

N s^{-1} ☐

kg m s^{-1} ☐

kg m s^{-2} ☐

0 5 . 1 The Earth's surface and the base of a charged cloud can be considered to be two plates of a parallel-plate capacitor.

The base of the cloud has an area of 1.4×10^6 m^2 and is 800 m above the Earth's surface.

Show that the capacitance of an Earth–cloud system is approximately 16 nF.

$\varepsilon_0 = 8.9 \times 10^{-12}$ F m^{-1}

ε_r for air = 1.0

[2 marks]

0 5 . 2 A potential difference (pd) of 3.0×10^6 V across each metre of air will cause the air to break down and allow the cloud to discharge to the Earth.

Show that the average breakdown pd for the 800 m layer of air between the Earth and the base of the clouds is approximately 2.5×10^9 V.

[1 mark]

0 5 . 3 Calculate the maximum energy that the charged Earth–cloud system can store.

[2 marks]

maximum energy = _____ J

0 5 . 4 Calculate the maximum charge stored by the system before breakdown commences.

[1 mark]

maximum charge = _____ C

0 5 . 5 The cloud discharge is modelled by a resistor connected across a capacitor.

Calculate the resistance that would allow a cloud to discharge 99% of its charge to Earth in a time of 0.25 s. Use the value from **5.1** for the capacitance of the cloud.

[3 marks]

resistance = _____ Ω

Turn over for the next question.

0 6 This question is about a nuclear fission reactor.

0 6 . 1 Describe the changes made inside a nuclear reactor to reduce its power output and explain the process involved.

[2 mark]

0 6 . 2 State the main source of the highly radioactive waste from a nuclear reactor.

[1 mark]

In a nuclear reactor, neutrons are released with high energies. The first few collisions of a neutron transfers sufficient energy to excite the nuclei of atoms in the reactor.

0 6 . 3 Describe and explain the nature of the radiation that may be emitted from an excited nucleus.

[2 marks]

0 6 . 4 The subsequent collisions of a neutron with the moderator are elastic.

Describe what happens to the neutron as a result of these subsequent collisions with the moderator.

[2 marks]

Turn over for the next question

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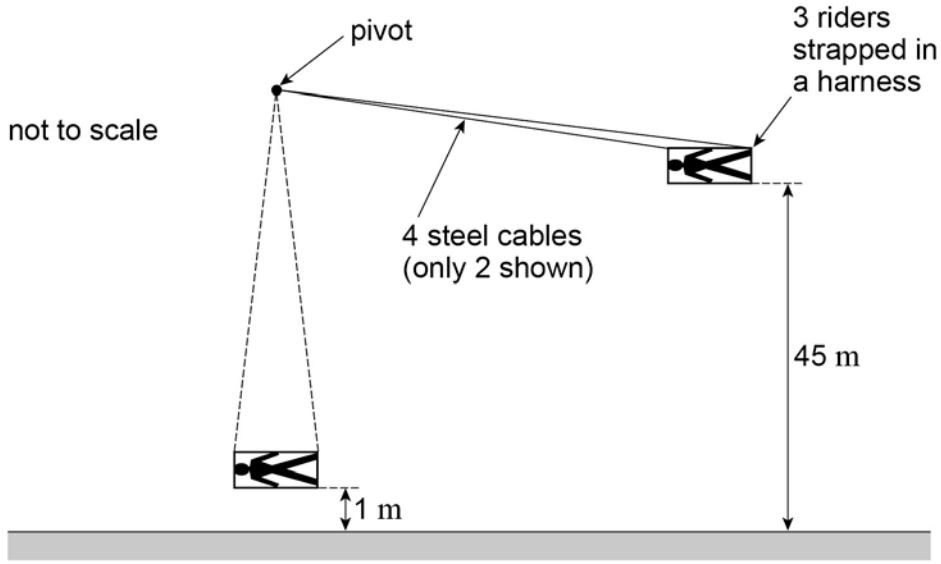
0 7 **Figure 7** shows a ride in a theme park.

Figure 7



The harness in which three riders are strapped is supported by four steel cables. An advertisement for the ride states that the riders will be released from a height of 45 m above the ground and will then swing with a period of 14.0 s. It states that they will be 1.0 m above the ground at the lowest point and that they will travel at speeds of "up to 120 km per hour".

0 7 . 1 Treating the ride as a simple pendulum, show that the distance between the pivot and the centre of mass of the riders is about 49 m.

[1 mark]

0 7 . 2 The riders and their harnesses have a total mass of 280 kg.
Calculate the tension in each cable at the lowest point of the ride, assuming that the riders pass through this point at a speed of 120 $\mathrm{km\ hour^{-1}}$. Assume that the cables have negligible mass and are vertical at this point in the ride.

[3 marks]

tension in each cable = _____ N

0 7 . 3 Show that the maximum speed stated in the advertisement is an exaggerated claim.
Assume that the riders are released from rest and neglect any effects of air resistance.

[3 marks]

END OF QUESTIONS

There are no questions printed on this page

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