VICTORIA JUNIOR COLLEGE
2024 JC2 PRELIMINARY EXAMINATION
Higher 1

Name : ___________________________ CT group : ________________

PHYSICS **8867/02**

Paper 2 Structured Questions **17 September 2024**

TUESDAY

Candidates answer on the Question Paper. **8 am to 10 am (2 hours)**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE ON ANY BARCODES.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's use	
Question	**Mark**
Section A	
1	
2	
3	
4	
5	
6	
Section B	
7	
8	
g	
Units	
sf	
Total	**/ 80**

This document consists of **23** printed pages and **1** blank page

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
the Avogadro's constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + (½)\, at^2$
	$v^2 = u^2 + 2as$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$

Section A

Answer ALL questions from this section

1. A sphere is projected horizontally. The sphere is photographed onto the same film negative at intervals of 0.100 s with an uncertainty of ±0.001 s. The 7 images of the sphere are shown against a grid in Fig. 1.1. The actual uncertainty for the distances measured is 0.1 cm. Air resistance is negligible.

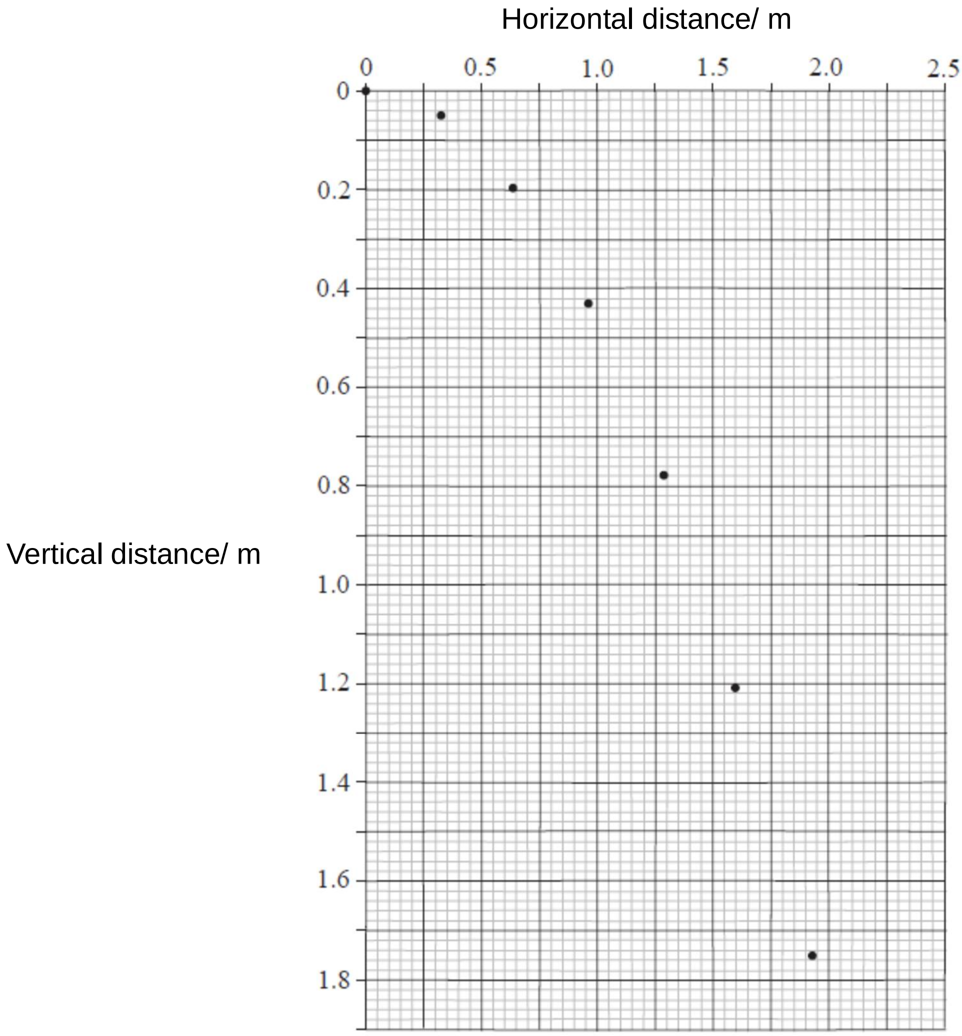

Fig. 1.1

(a) Use Fig.1.1 to determine the acceleration *g* of the sphere. [2]

g = ……………………………

(b) Explain how your choice of the data point from Fig 1.1 helps to improve the reliability of your calculation in (a). [1]

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(c) Use your answer in (a) to determine the actual uncertainty in the value of *g*. Hence give a statement of g, with its uncertainty, to an appropriate number of significant figures. [4]

g = ……………. ± ………………….

(d) Using existing data, explain how you can improve the accuracy of *g* obtained by plotting a different graph. Explain why this new method is more accurate. [2]

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2(a) Student A claims, "When a ball hits and rebounds off a wall, there is impulse on the ball, but not on the wall because the wall does not move."

Discuss whether Student A is correct. [2]

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(b) A ball B of mass 1.2 kg travelling at constant velocity collides head-on with a stationary ball S of mass 3.6 kg, as shown in Fig. 2.1.

Fig. 2.1

Frictional forces are negligible. The variation with time *t* of the velocity *v* of ball B before, during and after colliding with ball S is shown in Fig. 2.2.

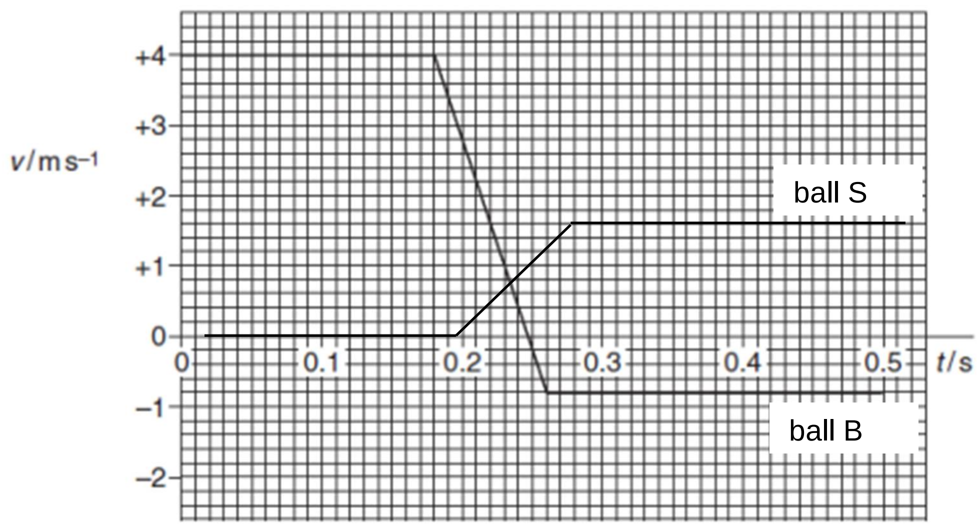

Fig. 2.2

(i) Using Fig. 2.2, explain whether momentum is conserved in this collision. [3]

(ii) Determine quantitatively whether the collision is elastic or inelastic. [2]

3(a) State what is meant by the electric field strength at a point [1]

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(b) A potential difference is applied between two horizontal plates, each 1.0 m long and separated by 2.5 cm. A beam of α-particles enters the field horizontally mid-way between the plates at a speed of 1.5×10^{7} m s^{-1}. The electric field strength between the two plates is 7.5×10^{4} N C^{-1} as shown in Fig. 3.1 which is not drawn to scale.

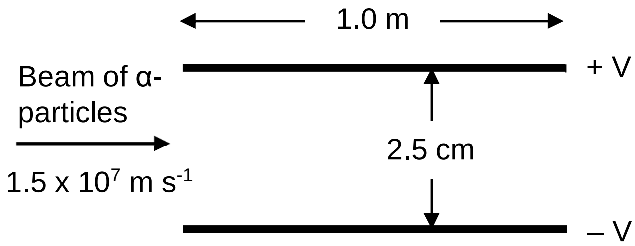

Fig. 3.1

(i) Calculate the force on each α-particle due to the electric field. [2]

Force = ………………………

(ii) Determine the time that each α-particle spends inside the field. [1]

Time = ……………………………..

(iii) Show that the α-particles will not hit the plates. [2]

(iv) Sketch on Fig 3.1, the path of the α-particles between and beyond the plates. [1]

4(a) Define magnetic flux density. [2]

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(b) Electrons are moving in a vacuum with speed 1.7×10^7 m s^{-1}. The electrons enter a uniform magnetic field of flux density 4.8 mT. The figure below shows the path of the electrons.

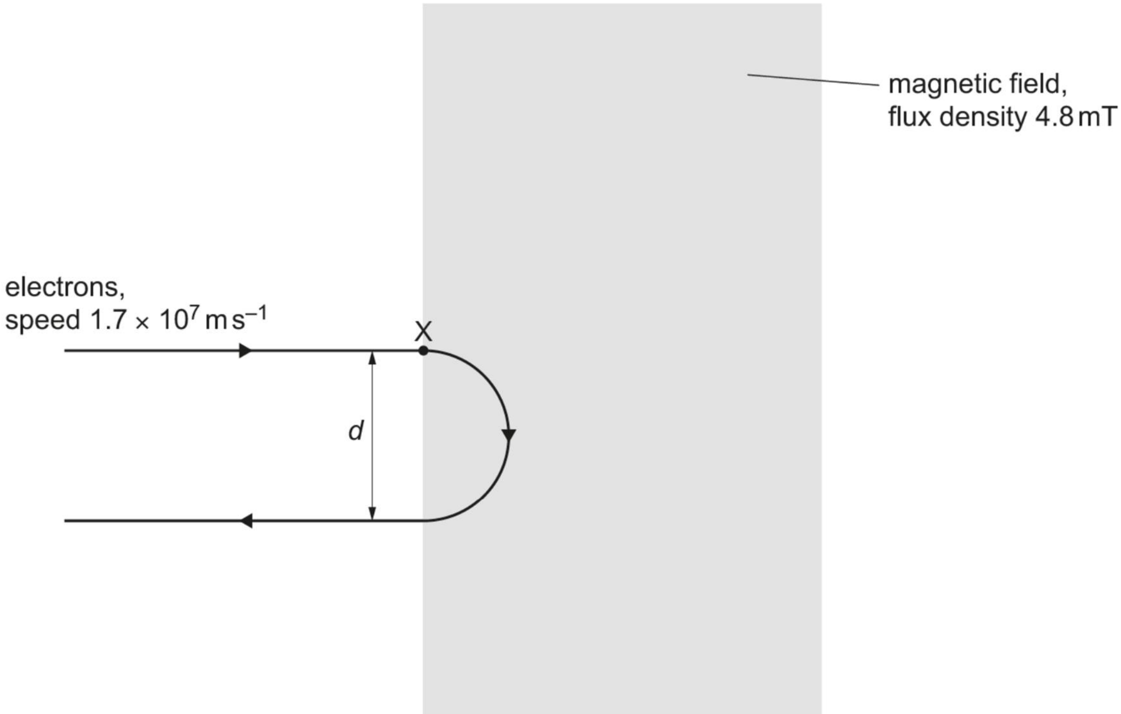

Fig 4.1

The path of the electrons remains in the plane of the page.

(i) State the direction of the magnetic flux density. [1]

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(ii) Calculate the magnitude of the force exerted on each electron by the magnetic field. [2]

Magnitude of the force = ……………………….

(iii) Use the information in (ii) to calculate the distance *d* between the path of the electrons entering the magnetic field and the path of the electrons leaving the magnetic field. [3]

d = …………………………

5(a) Explain what is meant by the term ‘binding energy of a nucleus’. [1]

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(b) Sketch a graph to show how the binding energy per nucleon of nuclei varies with the mass number of nuclei. [1]

(c) Use your graph in (b) to explain why the fission of a heavy nucleus will result in the release of energy. [3]

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(d) In a fission reaction, a $^{235}_{92}U$ nucleus absorbs a neutron and undergoes fission to produce a $^{141}_{56}Ba$ nucleus, a $^{92}_{36}Kr$ and some particles. The binding energy per nucleon of the 3 nuclei are shown below:

Nucleus	Binding energy per nucleon / MeV per nucleon
$^{235}_{92}U$	7.59
$^{141}_{56}Ba$	8.32
$^{92}_{36}Kr$	8.51

(i) Write an equation to represent the reaction. [1]

(ii) Calculate the energy released in one reaction in joules. [3]

Energy released = ………………………… J

(iii) Calculate the total energy that can be obtained from 1.00 x 10^{-4} kg of uranium-235 if all the uranium-235 nuclei completely undergo fission. [3]

Total energy obtained = ………………………… J

6(a) The International Space Station (ISS) is a habitable artificial satellite. It is maintained at 340 km above the Earth's surface, in what is known as a Low Earth Orbit (LEO). The radius of the Earth is 6.37×10^6 m. Fig 6.1 shows how the gravitational field strength of the Earth, g, varies with distance from the Earth's surface.

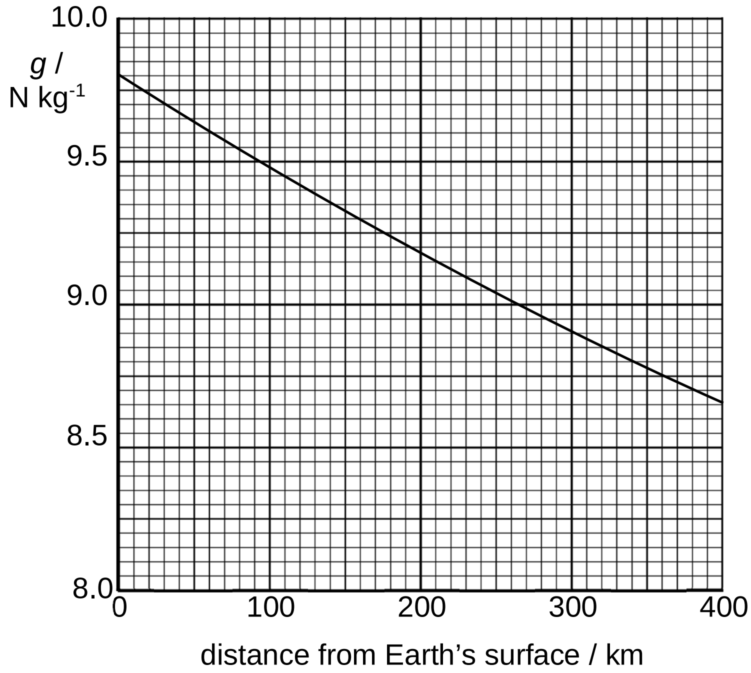

Fig. 6.1

(i) Explain why an astronaut experiences apparent weightlessness in the ISS despite a non-zero gravitational field strength at LEO. [2]

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(ii) Use Fig. 6.1 to determine the gravitational field strength g' at the ISS. [1]

g' = ……………………………………

(b) Astronauts in apparent weightlessness may lose muscle mass. Fig. 6.2 shows a model of a spring system which can be used to monitor changes in mass. A mass M is secured using springs and is set into horizontal oscillations. The period of oscillations T can then be measured.

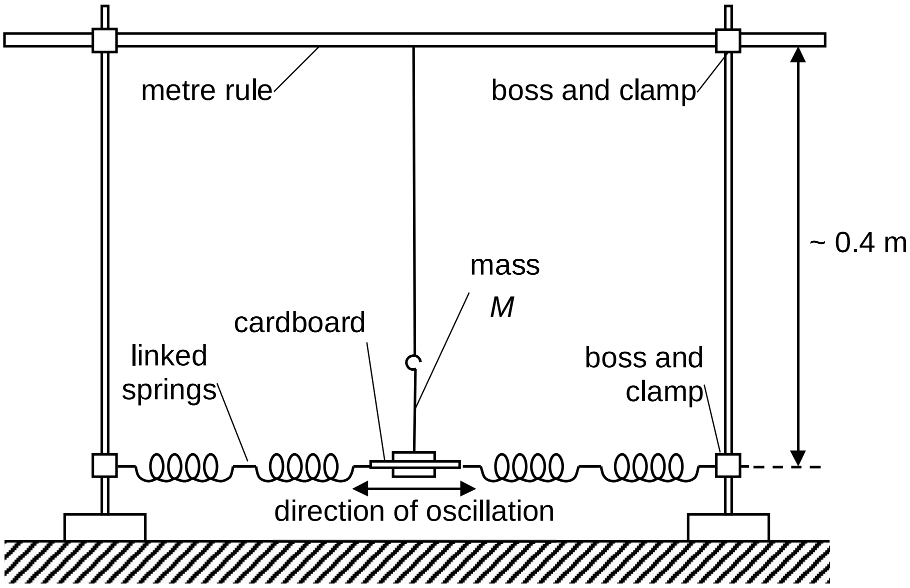

Fig. 6.2

It has been suggested that the relationship between the period of oscillation T and the mass M is given by:

$$\frac{1}{T^2} = \frac{p}{M} + q$$

where p and q are constants.

Fig. 6.3 shows the experimental results obtained using a stopwatch to measure the time taken for oscillations.

M / kg	time taken for 20 oscillations		T / s	$\frac{1}{T^2}$ / s^{-2}	$\frac{1}{M}$ / kg^{-1}
	t_1 / s	t_2 / s			
0.100	10.34	10.38	0.5180	3.727	10.0
0.150	12.07	11.93	0.6000	2.778	6.67
0.200	13.39	13.43	0.6705	2.242	5.00
0.250	14.34	14.32	0.7165	1.948	4.00
0.300	15.23	15.23	0.7615	1.724	3.33
0.350	15.70	15.64			

Fig. 6.3

(i) Complete the table in Fig. 6.3. [3]

(ii) Plot the data in Fig. 6.3 onto the graph in Fig. 6.4 and draw a line of best fit. [2]

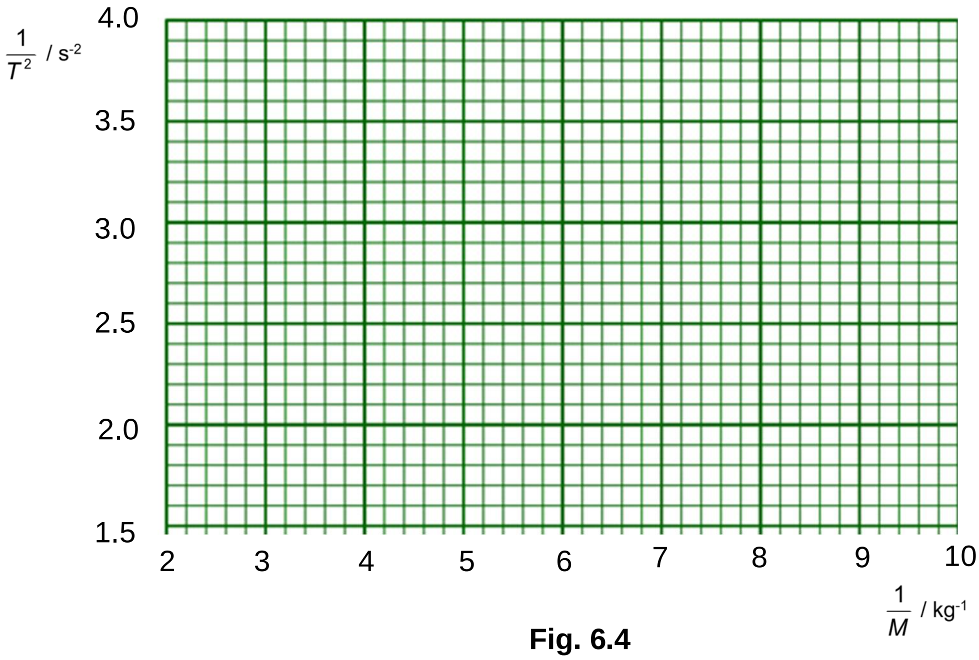

Fig. 6.4

(iii) Using Fig. 6.4, determine p and q. [4]

p = ...

q = ...

(iv) It has been suggested that the variation of period, ΔT, is related to an astronaut's mass loss by $\Delta T = \dfrac{2pT^3}{M} \times (\text{fractional mass loss})$.

Determine ΔT corresponding to an initial mass of M = 0.50 kg and a fractional mass loss of 0.10. [3]

ΔT = ...s

(v) According to medical opinion, a muscular mass loss of 10% is concerning. Taking reference from the data available, discuss if the experiment is able to detect the variation ΔT for a mass as small as 0.50 kg. [2]

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Section B

Answer ONE question from this section

7(a) A roller-coaster ride in a theme park is illustrated in Fig. 7.1.

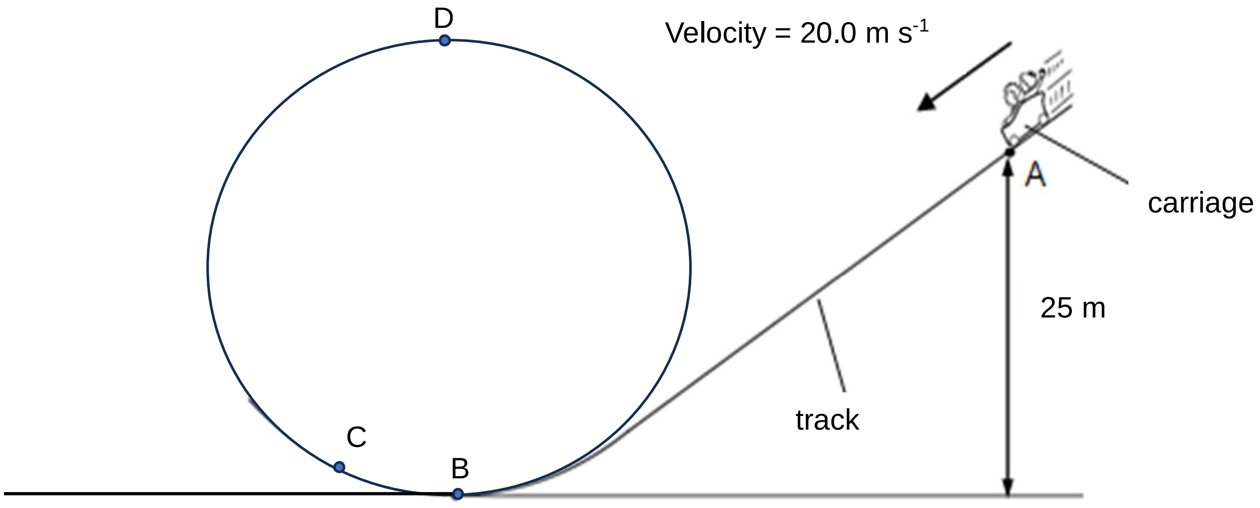

Fig. 7.1

The total mass of carriage, with passengers, is 560 kg. It has a velocity of 20.0 m s^{-1} at point A. The height of the point A is 25.0 m. At point B, the bottom of the descent, the carriage is on a path of radius 15.0 m. You may assume the frictional force along the track is negligible.

(i) State what is meant by the phrase 'velocity of 20.0 m s^{-1}'. [2]

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(ii) The carriage moves from position B to position C in a short period of time as shown in Fig. 7.1. On Fig. 7.2, draw labelled lines to complete a vector diagram to show the change in velocity Δv that takes place between position B and position C. The velocity v_c at position C is already drawn for you. [2]

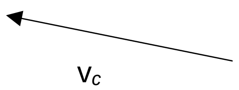

Fig. 7.2

(iii) Calculate total mechanical energy of carriage at point A. [2]

Total mechanical energy = ……………………………

(iv) Calculate the speed of the carriage at point D, the highest point on the circular track. [3]

Speed = ………………………………

(v) Hence determine the force that the track exerts on the carriage at point D. [3]

Force = ………………………………

(b) There are approximately about 600 geostationary satellites orbiting around the Earth. The mass of the Earth is 5.9×10^{24} kg and its radius is 6.4×10^{6} m.

(i) Determine the angular velocity of a geostationary satellite. [2]

Angular velocity = …………………………

(ii) Calculate the radius of the geostationary orbit. [3]

Radius = …………………………

(iii) State one application of geostationary satellites. [1]

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(iv) State one advantage and one disadvantage of using a geostationary orbit for the application stated in (b)(iii). [2]

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8(a) A metal wire X of length 6.0 cm and diameter 0.30 mm is made of a material with resistivity $1.50 \times 10^{-6}\ \Omega$ m at room temperature.

(i) Show that the resistance of X at room temperature is 1.3 Ω. [2]

(ii) The metal wire X is placed in a circuit in series with an ideal cell of e.m.f. of 1.2 V and a variable resistor. An ideal voltmeter is connected across X to measure its p.d. *V*, and an ideal ammeter is connected in series with X to measure its current *I*, as shown in Fig. 8.1:

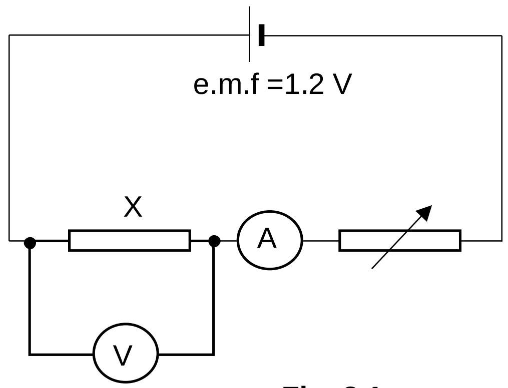

Fig. 8.1

1. Distinguish between e.m.f. and p.d. [2]

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2. As the current through X is increased, its temperature rises.
   Sketch an I – V characteristic graph for X. [1]

3. Explain how the graph in (ii)2. can be used to determine the resistance of X for a given value of V. [1]

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4. The variable resistor is set to 0.50 Ω. Using the value of the resistance of X that you found in (i), calculate the fraction of the power delivered by the cell that is dissipated through X. [2]

Fraction = ………………………………..

(b) A light bulb is placed in a circuit with a rheostat and an ideal voltmeter connected across it. The resistance of the rheostat can be varied from 0 Ω to 10 Ω. The combination is placed in series with an ideal cell of e.m.f. 3.0 V and a resistor S of 0.60 Ω, as shown in Fig. 8.2:

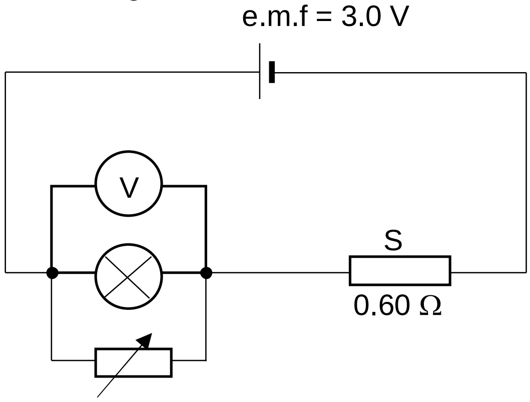

Fig. 8.2

(i) Explain how the reading on the voltmeter will change as resistance of the rheostat is varied from minimum to maximum value. [3]

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(ii) Explain the purpose of resistor S. [2]

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(iii) When the rheostat is set to the maximum setting of 10 Ω, the voltmeter reads 1.2 V.

1. Calculate the current delivered by the cell. [2]

Current = …………………………..

2. Calculate the current flowing through the light bulb. [3]

Current = ………………………….

3. A student suggests that the rheostat can act as a switch for the light bulb, since setting the resistance of the rheostat to 0 Ω will cause the current in the light bulb to drop to 0 A. Explain why it is not practical to use the rheostat as a switch. [2]

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