Name: ____________________________ (   )   Class: 20 / ______

ANDERSON SERANGOON JUNIOR COLLEGE

2020 JC2 Preliminary Examination

PHYSICS Higher 1 — 8867/02

Paper 2 Structured Questions — **Thursday 17 September 2020**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and class in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.

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

Section A
Answer **all** questions.

Section B
Answer **all** questions.

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	
Paper 1 (30 marks)	
Paper 2 (80 marks)	
1	/10
2	/ 8
3	/ 5
4	/ 7
5	/14
6	/16
7	/20
deductions	
Paper 2 Total (80 m)	

This document consists of **19** 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 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,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
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** the questions in this section.

1 **(a)** A marble is projected up a smooth ramp with an initial speed of 2.0 m s^{-1}. The ramp makes an angle of 30° with the ground and the height of the ramp is 0.13 m as shown in Fig. 1.1.

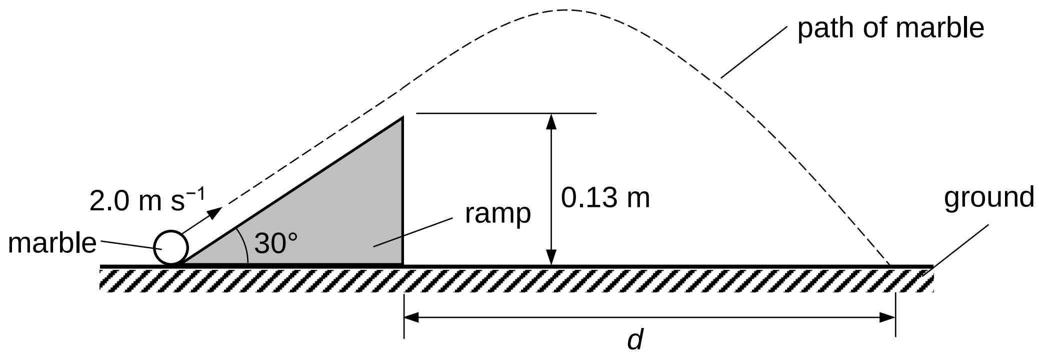

Fig. 1.1 (not to scale)

The marble then leaves the ramp and first hits the ground at a distance d from the edge of the ramp.

(i) By using energy consideration or otherwise, show that the speed of the marble when it reaches the top of the ramp is 1.2 m s^{-1}.

[2]

(ii) Hence, calculate the distance d.

d = ……………………………. m [2]

(b) Along a horizontal frictionless surface, ball A moves with speed v towards a stationary ball B as shown in Fig. 1.2. Ball A has mass 4.0 kg and ball B has mass 12 kg.

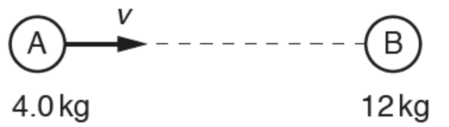

Fig. 1.2

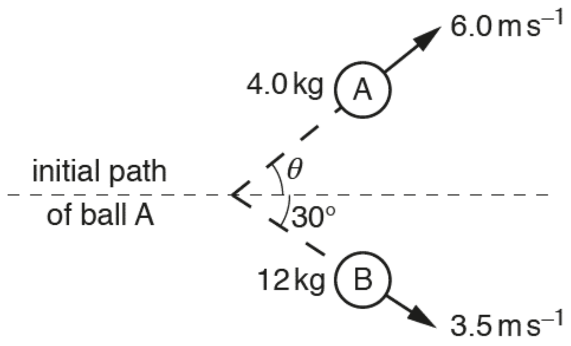

Fig. 1.3

The balls collide and then move apart as shown in Fig. 1.3.
Ball A has velocity 6.0 m s^{-1} at an angle of θ to the direction of its initial path.
Ball B has velocity 3.5 m s^{-1} at an angle of 30° to the direction of the initial path of ball A.

(i) By considering the components of momentum at right−angles to the direction of the initial path of ball A, show that θ is 61°.

[2]

(ii) Hence, determine the initial speed v of ball A.

v = ……………………………. m s^{-1} [2]

(iii) By calculation of kinetic energies, state and explain whether the collision is elastic or inelastic.

……………………………………………………………………………………………..

……………………………………………………………………………………….... [2]

[total: 10]

2 **(a)** A climber rests against a vertical wall supported by a light rope with one end fixed to a point P on the wall, as shown in Fig. 2.1.

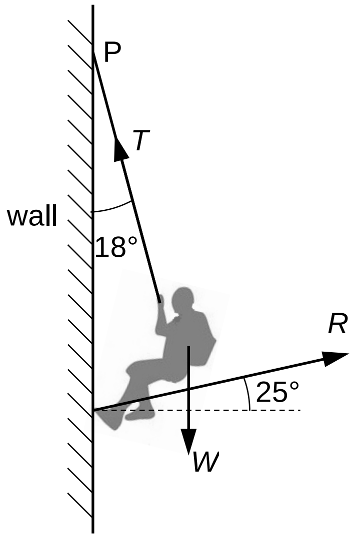

Fig. 2.1

The weight *W* of the climber is 520 N.
The rope makes an angle of 18° to the vertical and has a tension *T*.
The contact force *R* on the climber at the wall is at an angle 25° from the horizontal.

(i) Complete Fig. 2.2 by drawing a labelled vector triangle to represent the forces acting on the climber.

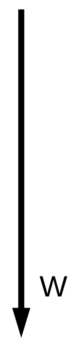

Fig. 2.2

[2]

(ii) Hence, or otherwise, calculate the tension *T.*

T = ... N [2]

(b) An oil drop of mass 2.6×10^{-14} kg has a charge equivalent to that of 8 electrons. It remains stationary between two metal plates A and B at different electric potentials, as shown in Fig. 2.3.

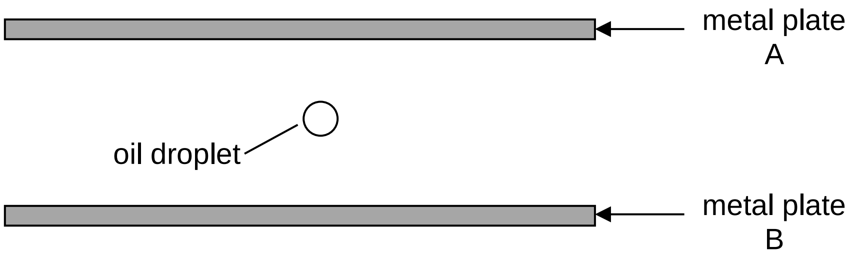

Fig. 2.3

(i) State and explain which plate is at higher electric potential.

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....

....

....[2]

(ii) Determine magnitude of the electric field strength between the plates.

electric field strength = ... N C^{-1} [2]

[total: 8]

3 A 2.0 kg mass sits on a light platform supported by a spring of force constant 1400 N m^{-1} within a column, as shown in Fig. 3.1. A force is exerted on the mass causing a total compression of 10 cm of the spring.

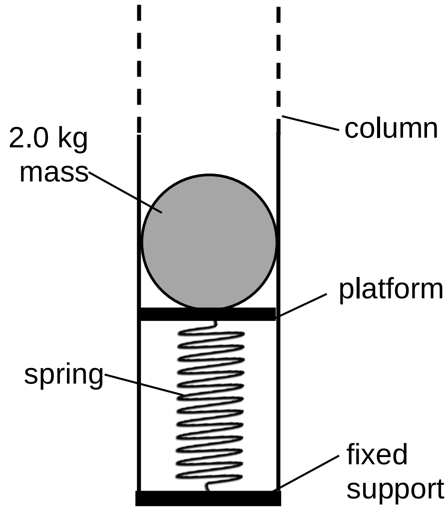

Fig. 3.1

(a) Calculate the elastic potential energy stored in the spring.

elastic potential energy = …………………………… J [1]

(b) The force is then removed and the mass moves up the column, comes to an instantaneous rest within the column before falling back onto the platform. The mass experiences an average frictional force of 3.0 N as it moves up the column.

(i) Determine the maximum height h_0 reached by the mass measured from its point of released.

h_0 = …………………………… m [2]

(ii) Explain whether the compression in the spring will be 10 cm when the mass next comes to a stop after falling back onto the platform, assuming that there is no loss in mechanical energy when the mass collides with the platform.

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…………………………………………………………………………………….………….....[2]

[Total: 5]

4 **(a)** Explain, using Newton's law of motion, why a body travelling in a circle with constant speed will experience a force.

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………………………………………………………………………………….…………..............[2]

(b) Fig. 4.1 shows a merry-go-round, a ride consisting of a circular rotating platform found in playgrounds.

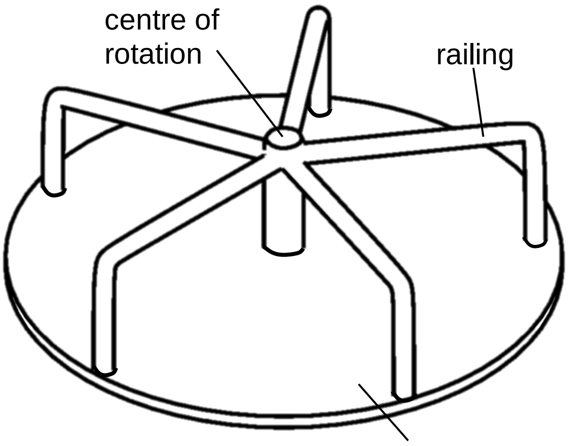

Fig. 4.1

At a particular playground, some children sit at different distances from the centre of the merry-go-round of diameter 6.5 m as shown in Fig. 4.2. The merry-go-round turns 5.5 revolutions per minute.

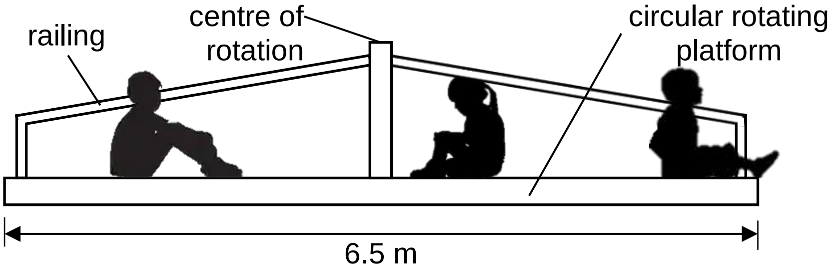

Fig. 4.2

(i) Explain whether all the children have the same linear speed.

…………………………………………………………………………………………

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…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) Calculate the angular speed of the merry-go-round.

angular speed = …………………………….. rad s^{-1} [1]

(iii) A boy of mass 32 kg sits at the edge of the merry-go-round. The maximum friction between him and the circular rotating platform of the merry-go-round is 65 N.

Determine quantitatively whether he will slide off the merry-go-round if he does not hold on to any railing.

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[total = 7]

5 **(a)** **(i)** Sketch the current−voltage (I−V) characteristic of a thermistor in Fig. 5.1.

Fig. 5.1

[1]

(ii) Explain, in microscopic terms, how the resistance of the thermistor changes with voltage, V.

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....[4]

(b) The variation with temperature of the resistance R_T of a thermistor is shown in Fig. 5.2.

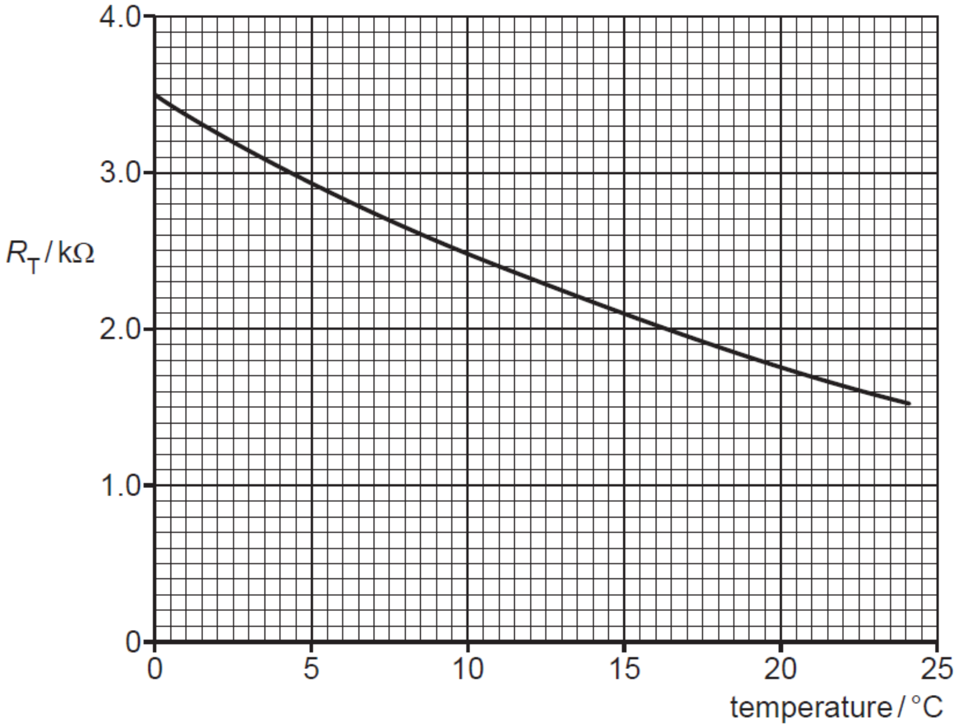

Fig. 5.2

The thermistor is connected in a circuit as shown in Fig. 5.3.

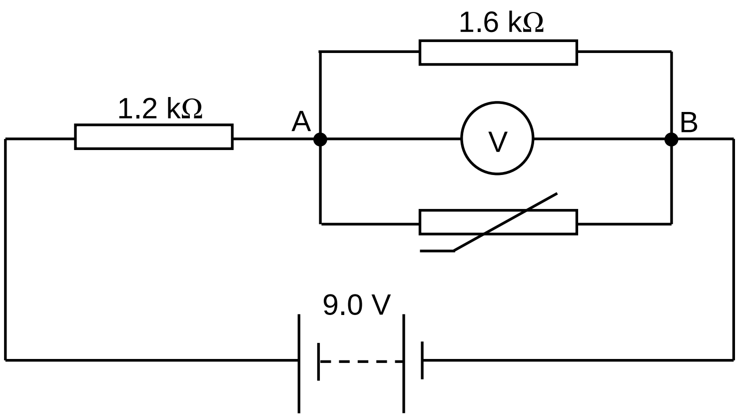

Fig. 5.3

When the thermistor is at a temperature *T*, the reading on the voltmeter is 4.0 V.

(i) Show that the effective resistance across AB is 0.96 kΩ.

[2]

(ii) Hence, determine the temperature T.

T = ………………………………. °C [2]

(c) A circuit consists of three resistors, R_1, R_2 and R_3 and two switches A and B as shown in Fig. 5.4.

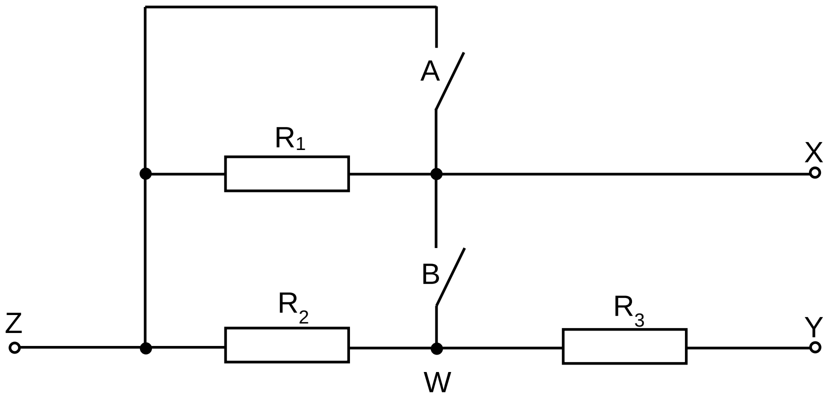

Fig. 5.4

The resistance between terminals X and Y is measured for different settings of the switches A and B. The results are shown in Fig. 5.5.

switch A	switch B	resistance between X and Y / Ω
open	open	10
open	closed	3.0
closed	open	8.0
closed	closed	3.0

Fig. 5.5

(i) Determine the resistance of R_1, R_2 and R_3.

resistance of R_1 = …………………………… Ω [1]

resistance of R_2 = …………………………… Ω [1]

resistance of R_3 = …………………………… Ω [1]

(ii) Switch A is now open and switch B is now closed. An ideal e.m.f. of 12 V is connected across Z and Y.

Calculate the potential difference between W and Y.

potential difference between W and Y = …….………..….. V [2]

[total: 14]

6 A parachutist of mass 85 kg, steps out of the doorway and falls from an aircraft cruising at a constant height above ground. He activates his parachute at some point during the fall.

The variation with time t of vertical speed v of the parachutist is shown in Fig. 6.1.

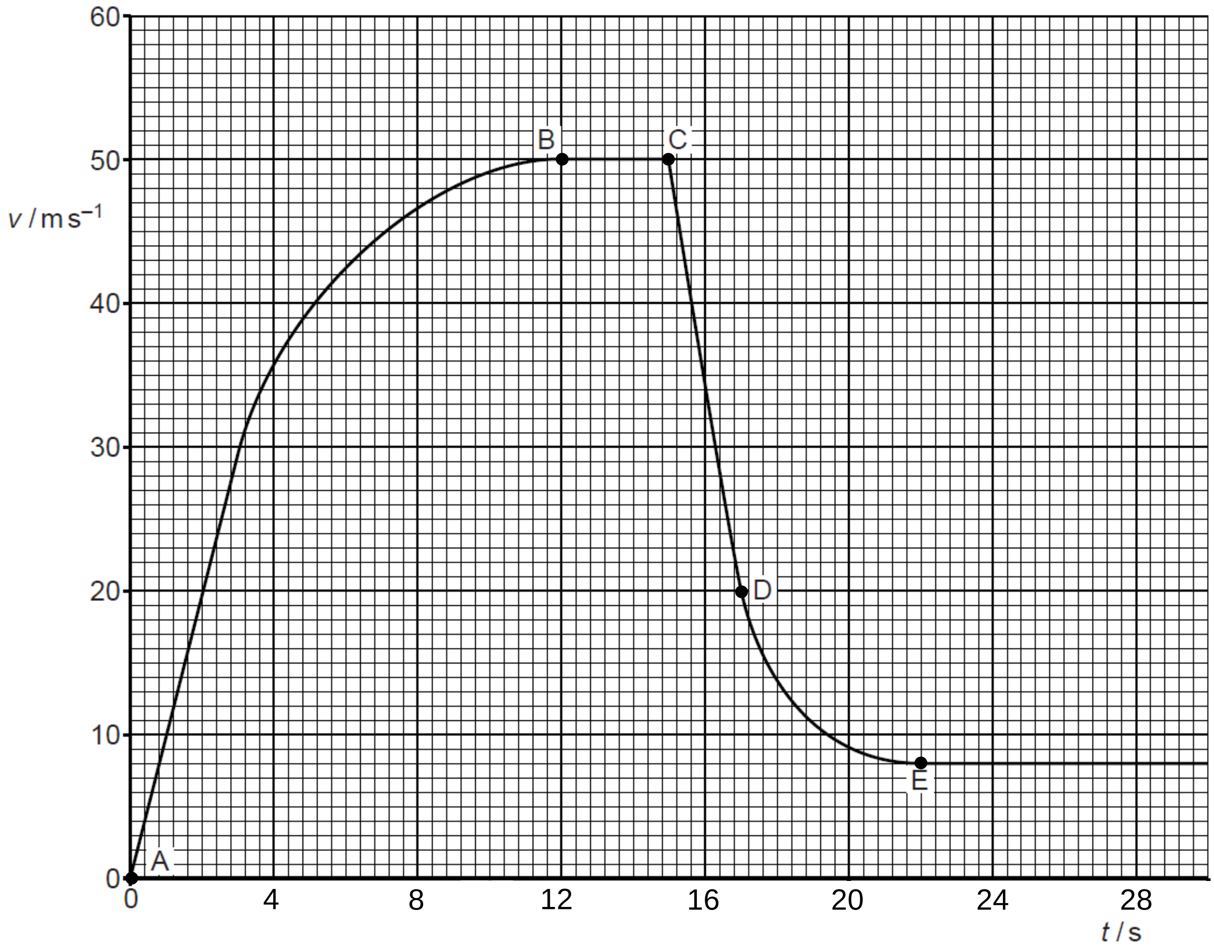

Fig. 6.1

(a) Use the information from Fig. 6.1 or otherwise to complete Fig. 6.2.

t / s	vertical acceleration / m s^{-2}
0	……………………..
6.0	……………………..

Fig. 6.2

[2]

(b) Estimate, using Fig. 6.1, the height that the parachutist falls for the first 12 s.

height = ………………………….. m [3]

(c) State the point on the graph (A, B, C, D or E) at which the parachute was activated.

point ……………………. [1]

(d) Explain the variation of the vertical resultant force acting on the parachutist from time t = 0 s (point A) to t = 15 s (point C).

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……………………………………………………………………………………………………..[3]

(e) Calculate, for the parachutist between t = 15 s (point C) and t = 17 s (point D),

(i) the change in momentum,

change in momentum = ………………………… kg m s^{-1} [2]

(ii) the average vertical resultant force,

resultant force = …………………………. N [1]

(iii) the average vertical air resistance.

air resistance = …………………………. N [2]

(f) After the first 22 s, the parachutist continues to fall at the same constant speed and reaches the ground some time later. Upon first contact with the ground, he executes the parachute landing fall and goes from an upright position to a horizontal position by buckling his body while rotating to the side as shown in Fig. 6.3.

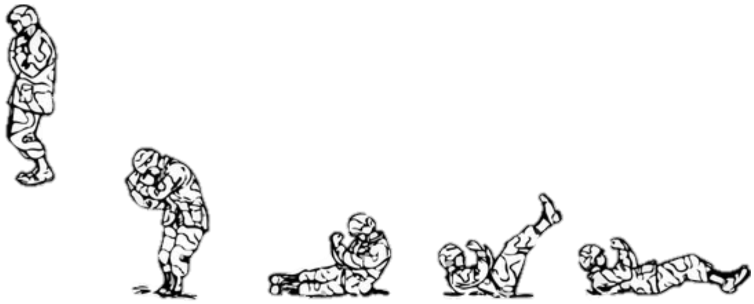

Fig. 6.3

Explain two ways in which the parachute landing fall helps to prevent injury to the parachutist.

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…………………………………………………………………………………………….. [2]

[Total: 16]

Section B

Answer **all** the questions in this section.

7 **(a)** State Newton's law of gravitation.

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.... [2]

(b) A satellite is in a circular orbit of radius r about the Earth of mass M, as illustrated in Fig. 7.1.

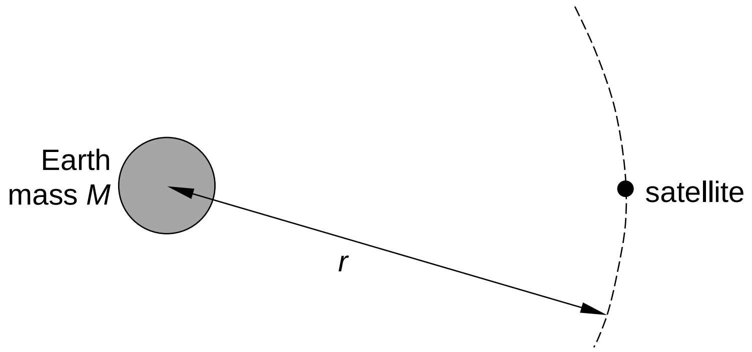

Fig 7.1

The mass of the Earth may be assumed to be concentrated at its centre.

Show that the period T of the orbit of the satellite is given by the expression

$$T^2 = \frac{39.5\, r^3}{GM}$$

where G is the gravitational constant. Explain your working clearly.

[3]

(c) A satellite of mass 655 kg is launched from the Equator and put into a geostationary orbit. The gravitational potential energy of the satellite increases by 3.45×10^{10} J during its launch from Earth's surface to the geostationary orbit.

(i) Describe what is meant by a *geostationary orbit*.

....

....

....

....

....

.... [3]

(ii) The mass M of the Earth is 5.97×10^{24} kg.
Use the expression in **(b)** to determine the radius of the geostationary orbit.

radius = ... m [2]

(iii) Calculate the linear speed of the satellite at the orbit.

linear speed = ... m s^{-1} [1]

(iv) Hence, determine the minimum launch speed of the satellite.

minimum speed = ... m s^{-1} [2]

(v) Explain why the actual launch speed is larger than the one calculated in **(c)(iv)**.

....

.... [1]

(d) Solar flares on the surface of the Sun produce high energy particles and radiation that are dangerous to living organisms. However, the Earth's magnetic field and atmosphere protects us from the direct harmful effects of solar flares.

Fig. 7.2 shows some charged particles from the Sun trapped in the Earth's magnetic field near the poles, on approaching the Earth.

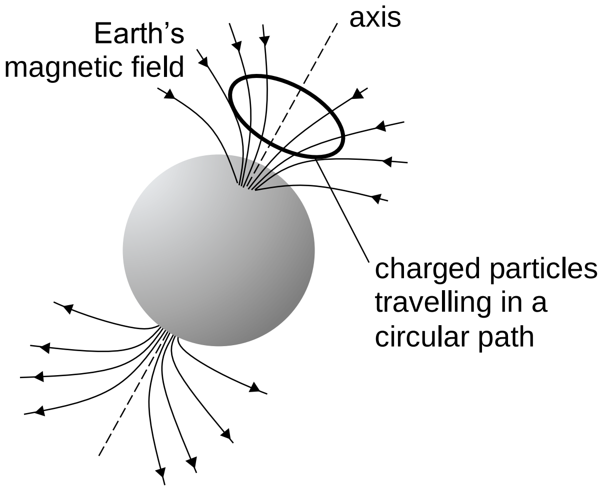

Fig. 7.2

(i) Suggest how solar flares can still affect human activities on the surface of Earth.

……………………………………………………………………………………………..................

…………………………………………………………………………………………………..... [1]

(ii) The charged particles in Fig. 7.2 travel in a circle of radius 50.0 km with a speed of 2.90×10^{8} m s^{-1}. The charge of each particle is 1.60×10^{-19} C. The magnetic flux density in the region of the circular path is 6.05×10^{-5} T.

Determine the mass of each charged particle.

mass = ………………….. kg [3]

(iii) Based on your answer in **(d)(ii)**, suggest what these charged particles could be.

……………………………………………………………………………………………….[1]

(iv) Hence, draw an arrow on the circular path in Fig. 7.2 to show the direction of motion of the charged particles. [1]

[total: 20]

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