HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 1

CANDIDATE NAME		**CT GROUP**	22S
CENTRE NUMBER		**INDEX NUMBER**	

PHYSICS

8867/02

Paper 2 Structured Questions

13 September 2023

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre Number, index number and name in the spaces at the top of this page.
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.

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

Section A
Answer **all** questions.

Section B
Answer any **one** question.

The number of marks is given in brackets [ ] at the end of each question or part question.
You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
Paper 2		
Section A		
1		**9**
2		**11**
3		**16**
4		**12**
5		**12**
Section B		
6		**20**
7		**20**
Deductions		
Total		**80**

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

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)** Soft drink cans are being packed into a cubic crate of volume 1.0 m^3.

(i) Estimate the volume of a soft drink can.

volume of a soft drink can = ……………… cm^3 [1]

(ii) Estimate the volume of empty space in a 1.0 m^3 cubic crate filled with the maximum number of soft drink cans.

volume of empty space = ……………… m^3 [3]

(b) As part of an advertising campaign, a sports car and a jet fighter will race over a straight 2.0 km track. The velocity-time graphs of both the car and the aircraft are shown in Fig. 1.1.

The car maintains a constant acceleration of 9.0 m s^{-2} throughout the race while the jet fighter experiences an acceleration of 5.0 m s^{-2} for the first 10 seconds of the race, after which its acceleration is 15.0 m s^{-2}.

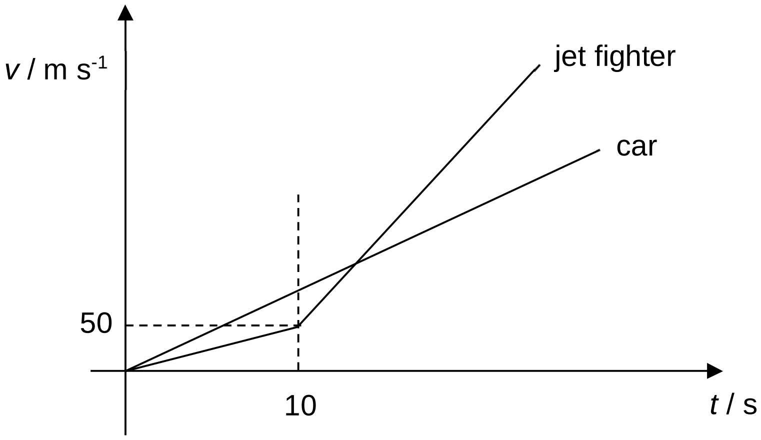

Fig. 1.1

(i) Determine the time taken for the sports car to reach a speed of 100 km h^{-1}.

time taken = ……………… s [2]

(b) **(ii)** The car wins the race. Determine the difference in finish times of the car and the jet fighter, Δt .

Δt = ……………… s [3]

[Total: 9]

2 **(a)** A wooden block at rest on a weighing scale placed on a horizontal surface registers 1.6 kg.

The same block and the weighing scale are now placed on a rough slope as shown in Fig. 2.1.

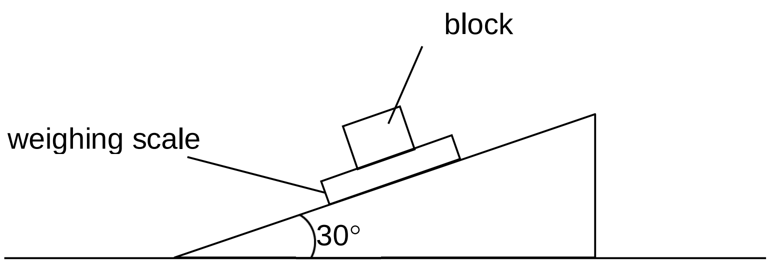

Fig. 2.1

The slope is at an angle of 30° to the horizontal.

Determine the new reading on the weighing scale. Show your working clearly.

new reading on the weighing scale = ………………….. kg [4]

2 **(b)** The same block is now suspended by a string from the ceiling.

A tennis ball of mass 58 g is shot from a launcher and strikes the block horizontally.

The ball is in contact with the block for a time of 0.2 s before it reverses its direction and moves off with a speed of 19.1 m s^{-1}. The block rises to a maximum height of 0.25 m after the collision.

(i) Show that the speed of the block immediately after the collision is 2.2 m s^{-1}.

[1]

(ii) Calculate the average force *F* between the ball and the block during the collision.

F = ………………….. N [2]

(iii) Determine the speed of the ball before the collision.

initial speed of the ball = ………………….. m s^{-1} [2]

(c) Using your answers in **(b)**, deduce whether the collision is elastic.

[2]

[Total: 11]

3 An experiment is conducted to determine the spring constant of a spring which obeys Hooke's law. The natural length of the spring is 0.100 m and g = 10 m s^{-2}.

(a) Complete the missing values in Fig. 3.1.

mass / kg	**length / m**
0.100	0.140
0.200	
	0.220
0.400	
0.500	

Fig. 3.1 [2]

(b) On Fig. 3.2, plot the data points from Fig. 3.1 and draw the best-fit line. [2]

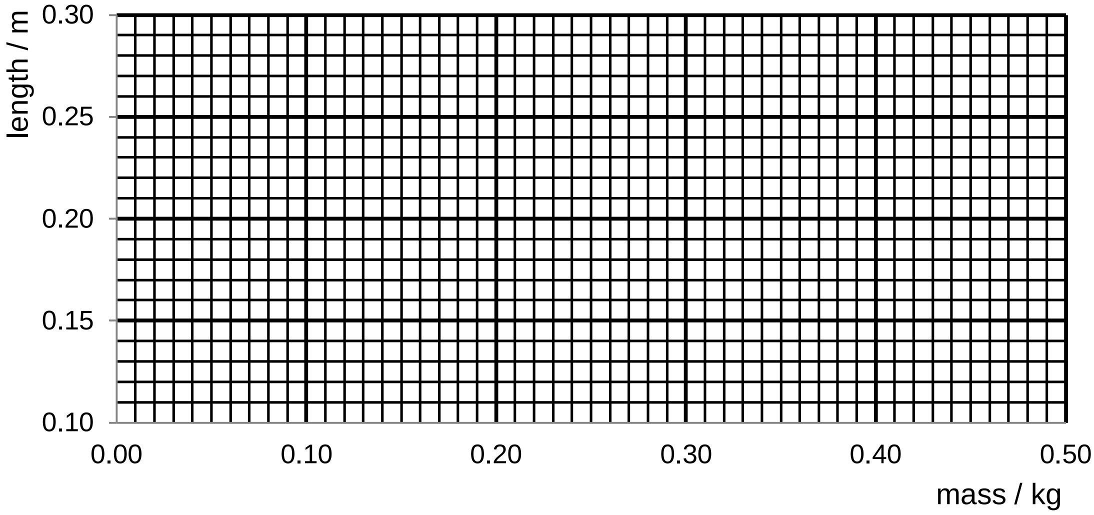

Fig. 3.2

(c) Hence or otherwise, determine the spring constant of the spring.

spring constant = ... N m^{-1} [2]

(d) A mass of 350 g is suspended from the spring such that it is at equilibrium

(i) Use Fig. 3.2 or otherwise to determine the extension of the spring.

extension = ……………………….. m [1]

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

elastic potential energy = …………………………… J [2]

(e) The mass is now supported in such a way and gently raised such that the spring is unstretched.

(i) Determine the work done on the mass to support the spring.

work done = ……………………………. J [2]

(e) **(ii)** Calculate the maximum extension of the spring when the support is removed.

maximum extension = ……………………….. m [2]

(iii) State the maximum acceleration of the mass.

maximum acceleration = ... m s^{-2} [1]

(f) Sketch on Fig. 3.2 another line that represents a spring with a greater spring constant but with the same natural length as the previous spring. Label the line S. [2]

[Total: 16]

4 **(a)** Distinguish between electromotive force (e.m.f.) and potential difference.

....

....

....

....

....[2]

4 **(b)** A thermistor and a filament bulb are connected in parallel to a battery as shown in Fig. 4.1. The e.m.f. *E* of the battery is unknown and its internal resistance is negligible.

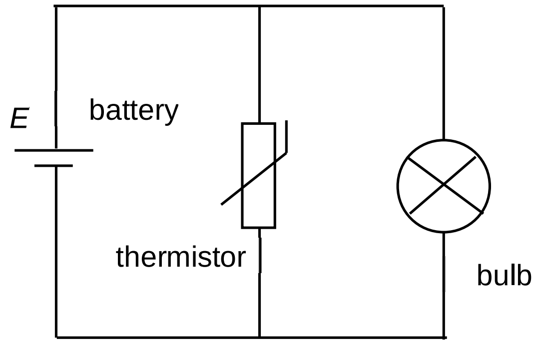

Fig. 4.1

The variations with the voltages *V* across it of the currents *I* through filament bulb and the thermistor are shown in Fig. 4.2.

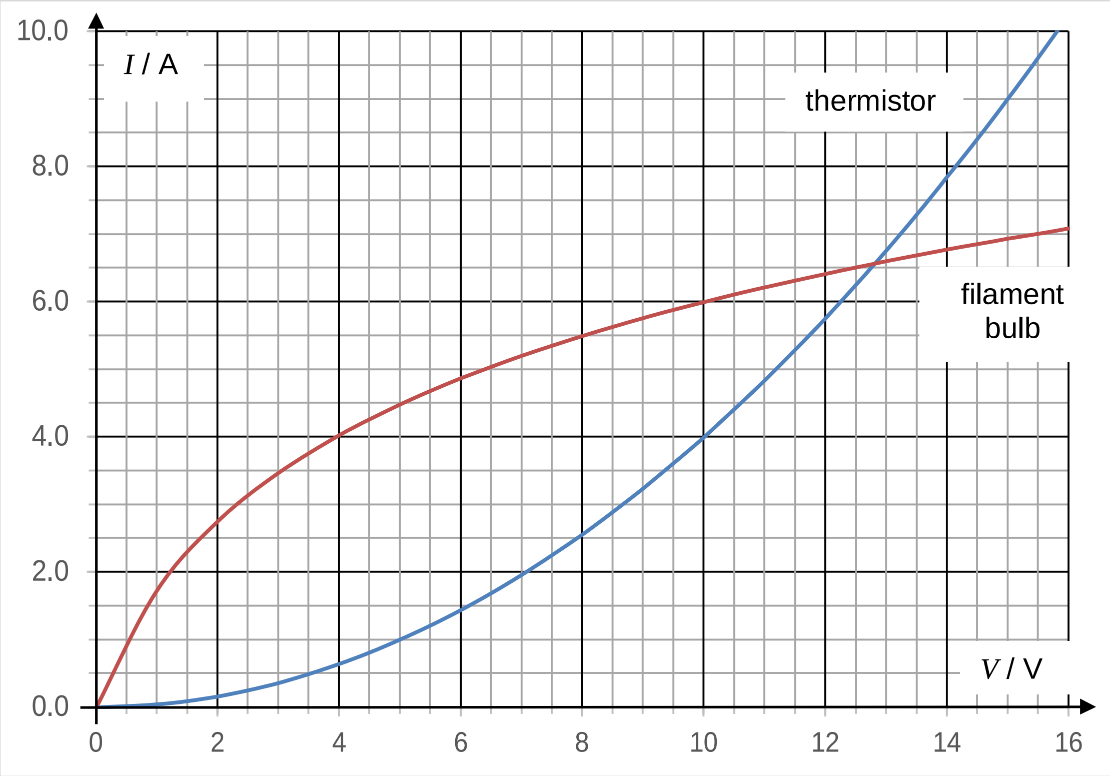

Fig. 4.2

(i) Describe the main features of Fig. 4.2 that show the characteristics of the negative temperature coefficient thermistor in terms of current, voltage and resistance.

....

....

.... [2]

(b) **(ii)** The current through the battery is 8.0 A. With reference to Fig. 4.2, determine

1. the current through the filament bulb,

current through filament bulb = ……………………….. A

2. the current through the thermistor,

current through thermistor = ……………………….. A

3. the e.m.f. of the battery.

e.m.f. of battery = ……………………….. V

[3]

(c) A filament bulb is connected in series with a fixed resistor of 2.5 Ω and a battery, as shown in Fig 4.3. The e.m.f. *E* of the battery is 14.0 V and its internal resistance is negligible.

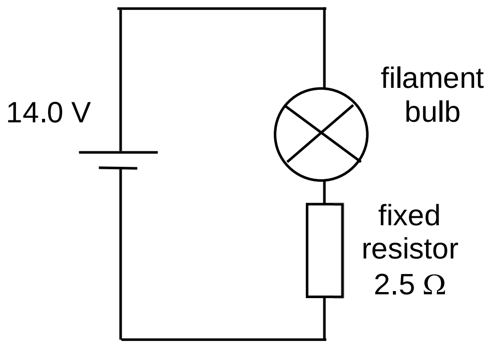

Fig. 4.3

The variation with the voltage *V* across it of the current *I* through filament bulb is shown in Fig. 4.4.

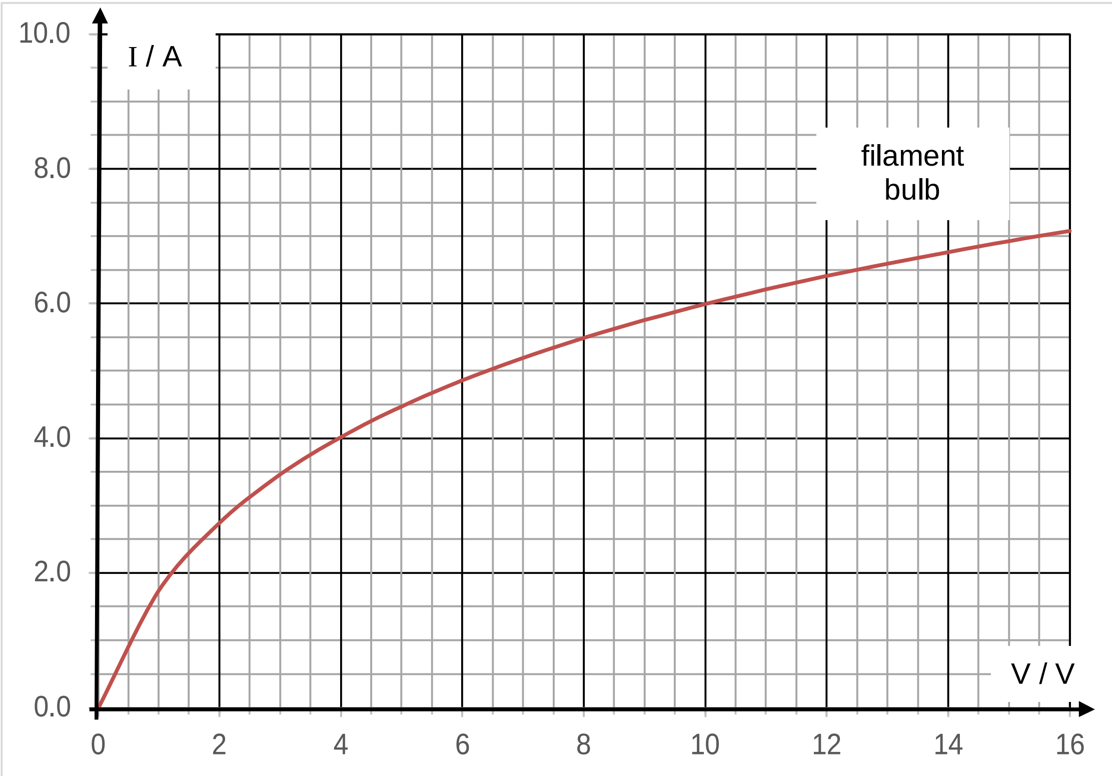

Fig. 4.4

(i) 1. Write down the equation relating the e.m.f. *E* of the battery, the resistance *R* of the fixed resistor, and the current *I* through and voltage *V* across the filament bulb.

2. Sketch a line showing this equation on Fig 4.4.

[2]

(ii) With reference to Fig. 4.4, determine

1. the current through the filament bulb,

current through filament bulb = ……………………….. A

2. the potential difference across the filament bulb,

p.d. across filament bulb = ……………………….. V

3. the potential difference across the resistor.

p.d. across resistor = ……………………….. V

[3]

[Total: 12]

5 **(a)** In the α-particle scattering experiment, α-particles travelling in a vacuum are incident on a gold foil. The α-particles are shot at the gold foil one at a time.

On Fig 5.1, complete the path of each α-particle as it passes the gold nucleus. [3]

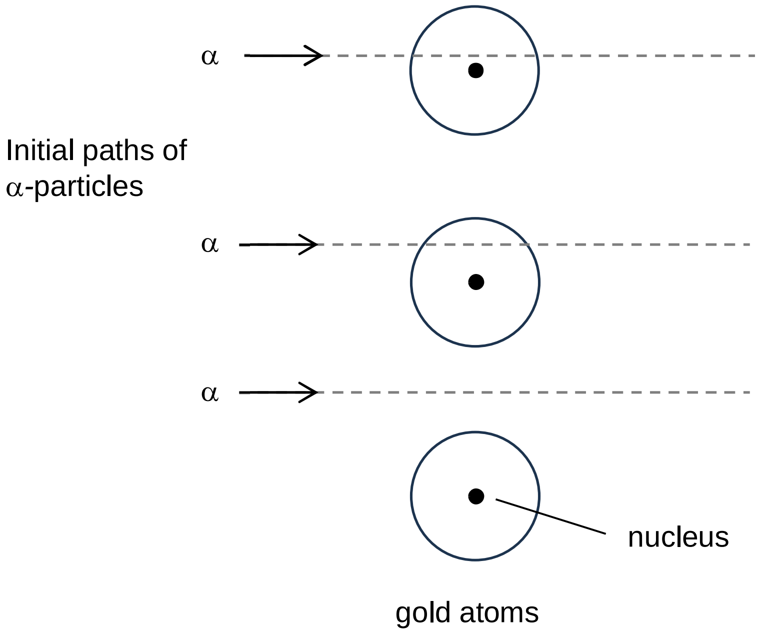

Fig. 5.1

(b) Describe and explain how the α-particle scattering experiment gives evidence for the existence and small size of the nucleus.

....

....

....

....

....

....

....

.... [4]

(c) The structure of the nucleus was clarified further by an experiment in which α-particles were fired at a piece of beryllium. A nuclear reaction took place in the beryllium and the reaction is now known to be

$$^{4}_{2}He + ^{9}_{4}Be \rightarrow ^{1}_{0}n + ^{12}_{6}C$$

(i) What information does the symbol, $^{4}_{2}He$ give about the α-particle?

.... [1]

(ii) The masses of the particles referred to in part **(c)** are as follows.

$^{4}_{2}He$	4.00260 u
$^{9}_{4}Be$	9.01212 u
$^{1}_{0}n$	1.00867 u
$^{12}_{6}C$	12.00000 u

Calculate the energy equivalence of the loss of mass which appears to take place in the reaction.

energy equivalence of the loss of mass = ... J [3]

(iii) Explain whether the products in the reaction have a higher or lower total binding energy than the reactants.

....

.... [1]

[Total: 12]

Section B

Answer **one** question from this section.

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

....

....

.... [2]

(b) The following data about Earth is provided:

- mass of Earth = 5.98×10^{24} kg
- mean radius of Earth = 6.37×10^{6} m

(i) By applying Newton's law of gravitation, derive a value for g, the acceleration due to gravity, at the Earth's surface.

value for g = ………………………. m s^{-2} [3]

(ii) State two assumptions made about the Earth in **(b)(i)**.

....

....

.... [2]

(iii) Compare and comment on the small difference between the value obtained in part **(b)(i)** and the value of 9.79 m s^{-2} which is the value obtained by making accurate measurements in Singapore, near the equator.

....

....

....

....

....

.... [3]

(c) A geostationary satellite must be placed above the equator.

(i) State what is meant by *geostationary*.

....

.... [1]

(ii) State the direction of rotation of the satellite around the Earth's axis.

....

.... [1]

(iii) Explain why the satellite must be above the equator (i.e. on the equatorial plane).

....

....

....

....

.... [2]

(d) A geostationary satellite is in orbit at a distance of 4.23×10^7 m from the centre of the Earth.

(i) Calculate the Earth's gravitational field strength (i.e. the gravitational force per unit mass) at this distance from the centre of the Earth.

Earth's gravitational field strength = ………………………… N kg^{-1} [1]

(ii) Determine the speed of the satellite.

speed of the satellite = ………………………… m s^{-1} [3]

(iii) Determine the acceleration of the satellite

acceleration of the satellite = …………………… m s^{-2} [2]

[Total: 20]

7 **(a)** Explain what is meant by

(i) an *electric field*.

……………………………………………………………………………………………………

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

(ii) the *electric field strength* at a point.

……………………………………………………………………………………………………

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

(b) A potential difference is applied between two horizontal plates, each 5.0 cm long and 7.0 cm wide and separated by 2.5 cm. The electric field strength between the two plates is 7.5 x 10^2 V m^{-1} as shown in Fig. 7.1.

A beam of electrons enters the electric field along a horizontal path halfway between the two plates. Each electron has a velocity of 4.50 x 10^6 m s^{-1}.

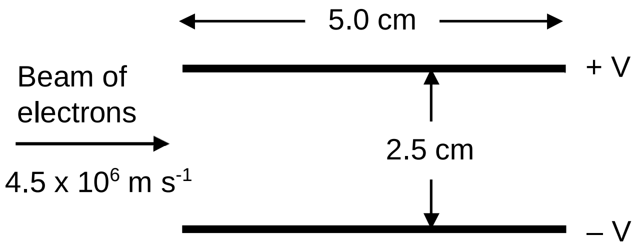

Fig. 7.1

(i) Calculate the force on each electron due to the electric field.

Force = ………………………… N [2]

(b) **(ii)** Determine the duration of time each electron remain between the parallel plates.

time = …………………….. s [2]

(iii) Determine whether the electrons will hit one of the plates. Show your working clearly.

[3]

(iv) Sketch on Fig. 7.1, the path of the electrons between and beyond the plates. [2]

(b) **(v)** In addition to the electric field, a uniform magnetic field directed perpendicularly into the page between the two plates is introduced. The beam of electrons now moves in a straight line as shown in Fig. 7.2.

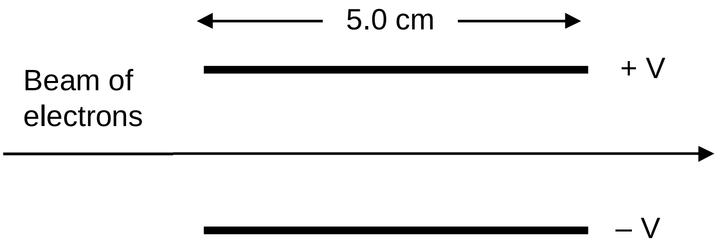

Fig. 7.2

Determine the flux density of the magnetic field.

magnetic flux density = …………………….. T [2]

(c) The undeflected beam of electrons enters a second region of uniform magnetic field as shown by the shaded region in Fig. 7.3. The magnetic flux density of 1.50 x 10^{-3} T is directed perpendicularly into the page.

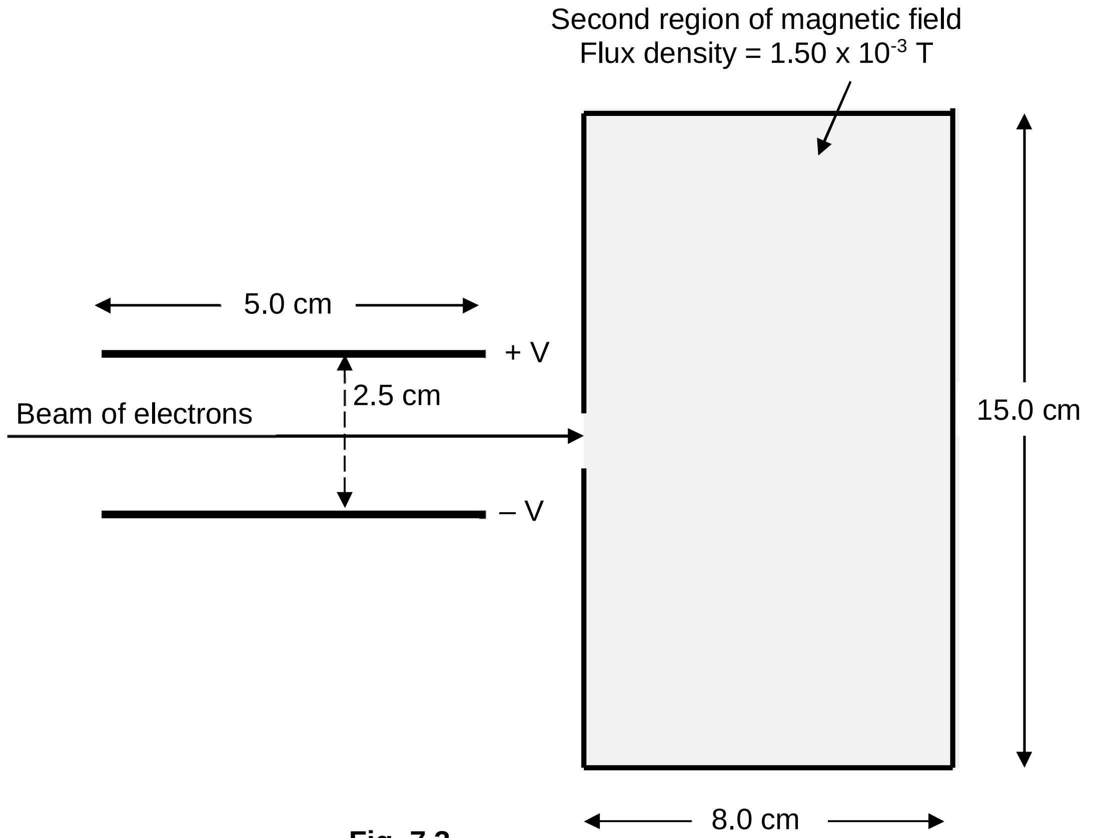

Fig. 7.3

(i) The beam of electrons moved in a circular path inside the second region of magnetic field. Explain why the path of an electron in the magnetic field is circular.

……

……

……

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

(ii) Calculate the radius of the path of an electron.

radius = ……………………… m [2]

(c) **(iii)** The beam of electrons is replaced by a beam of protons. The velocities of the protons before going between the two parallel plates ranges from of 3.00×10^6 m s^{-1} to 6.00×10^6 m s^{-1}.

Determine the speed of the protons that enters the second region of magnetic field.

Speed of protons = …………………… m s^{-1} [1]

(iv) Sketch and label the paths of a proton and an electron inside the second magnetic field in Fig. 7.3. [2]

[Total: 20]

End of paper