EUNOIA JUNIOR COLLEGE
JC2 MID YEAR EXAMINATIONS 2024
General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CIVICS GROUP | 2 | 3 | - | | |

REGISTRATION NUMBER | | |

PHYSICS

8867/02

Structured Questions

June 2024

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
The use of an approved scientific calculator is expected where appropriate.

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 paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions from this section.

Section B

Answer **one** question from this section.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Q1	9
Q2	7
Q3	8
Q4	8
Q5	10
Q6	8
Q7	10
Q8	20
Q9	20
Total	80

This document consists of **24** printed pages and **0** 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 in the spaces provided.

1 (a) The volume of a cone, V, can be calculated using the formula

$$V = \frac{1}{3}\pi r^2 h$$

where r is the radius of its base and h is its height.

In an experiment, a metal cone is measured with a mass m of (0.170 ± 0.001) kg and a height of (12.0 ± 0.1) cm. It has a circular base with diameter d of (5.00 ± 0.02) cm.

Determine the density of the cone with its actual uncertainty.

density of cone = (………………… ± …………) kg m^{-3} [4]

(b) Two masses A and B are allowed to slide down a frictionless slope as shown in Fig. 1.1 below.

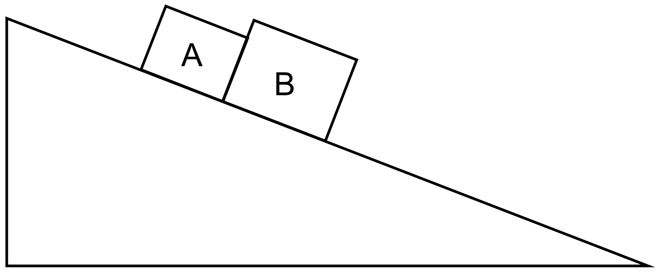

Fig 1.1

Explain if there would be normal contact force between the surface of block A and B.

....

....[1]

(c) The two masses are now pushed along a horizontal frictionless surface by a 350 N force as shown in the Fig.1.2. Mass A is 10 kg and mass B is 11 kg.

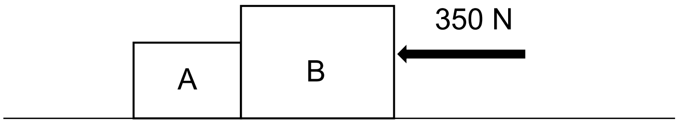

Fig 1.2

(i) Calculate the acceleration of the masses.

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

(ii) Determine the magnitude of the normal contact force by mass B on mass A.

force = ……............................... N [2]

[9 marks]

2 **(a)** Explain what is meant by acceleration.

....

....[1]

(b) The velocity-time graph in Fig. 2.1 shows the first 2.5 s of the motion of a ball which is thrown vertically downward at an initial speed of 6.0 m s^{-1}. The effect of air resistance is negligible.

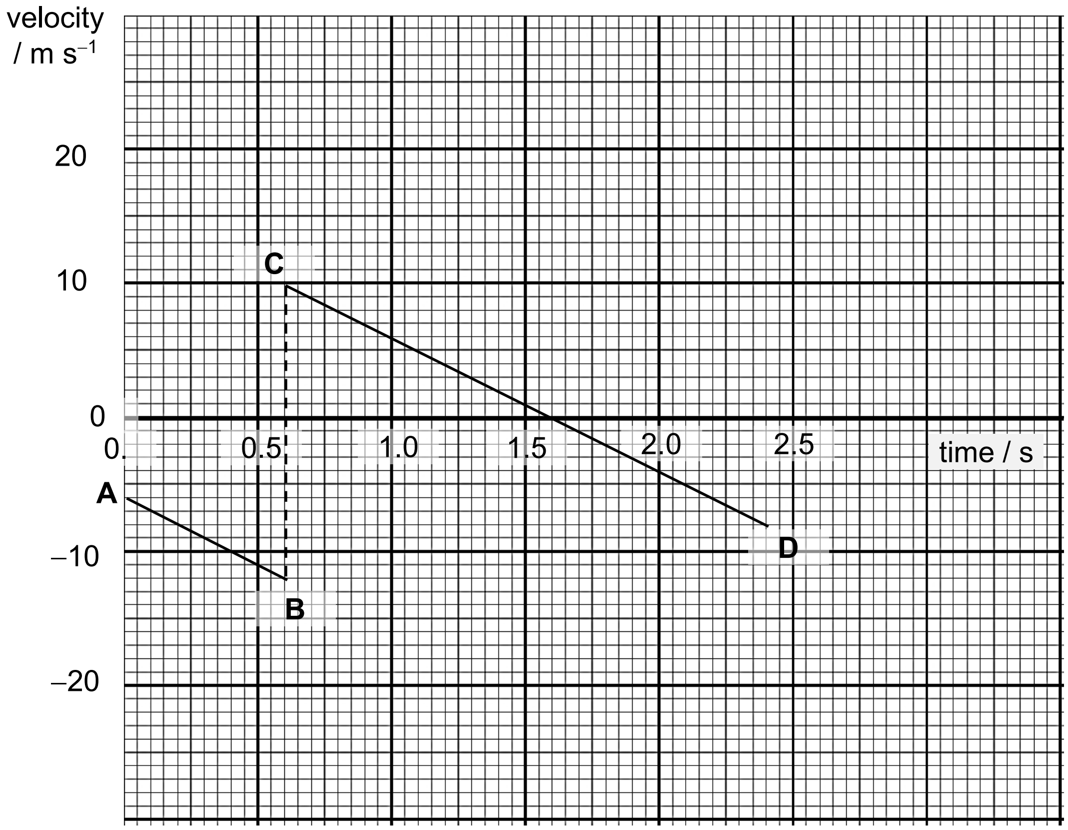

Fig 2.1

(i) Calculate the distance the ball travelled before hitting the ground.

distance = ... m [2]

(ii) Suggest why rebound speed of the ball is different from speed upon impact with the ground.

....

....[2]

(iii) Suggest why gradient of the lines AB and CD are the same.

....

....[2]

[7 marks]

3 A window panel is hinged at its top end, and supported by a rod close to its lower side, as shown in Fig. 3.1.

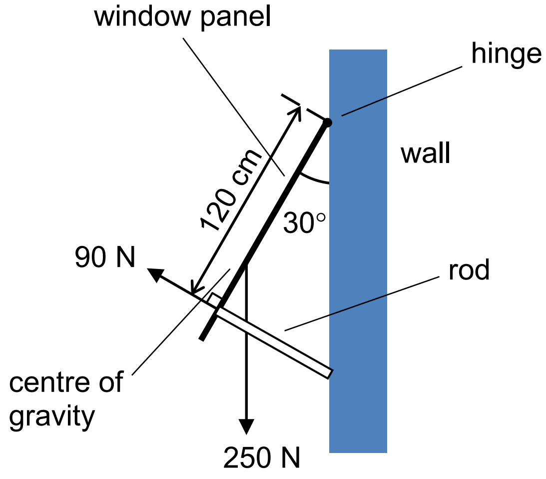

Fig. 3.1 (not to scale)

The window panel weighs 250 N and is opened to an angle 30° to the vertical.

The glass used for the window panel is not uniform and the centre of gravity of the window panel is not at its geometrical centre.

The rod exerts a force of 90 N perpendicular to the window panel, at a distance of 120 cm from the top.

(a) State two conditions required for the window panel to be in a state of equilibrium.

1. ....

2. ....[2]

(b) State what is meant by centre of gravity of the window panel.

....

....[1]

(c) Use the principle of moments to determine the distance between the centre of gravity of the window panel and the smooth hinge.

distance = ... m [2]

(d) On Fig. 3.1, draw an arrow to indicate the direction of the force on the window panel at the hinge and label it H.

[1]

(e) Determine the magnitude of the force acting on the window panel at the hinge.

force = ... N [2]

[8 marks]

4 Fig. 4.1 shows a 1.5 kg cart A with a force sensor in the front that is moving with a velocity of 3.0 m s^{-1} until it collides with a stationary cart B of an unknown mass m.

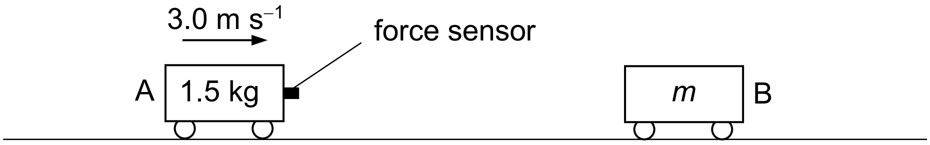

Fig. 4.1

After the collision, cart B moves off with a velocity of 2.4 m s^{-1}. Friction is negligible in the entire process.

The datalogger connected to the force sensor generated a force-time graph for the impact as shown in Fig. 4.2, showing the magnitude of force experienced by cart A.

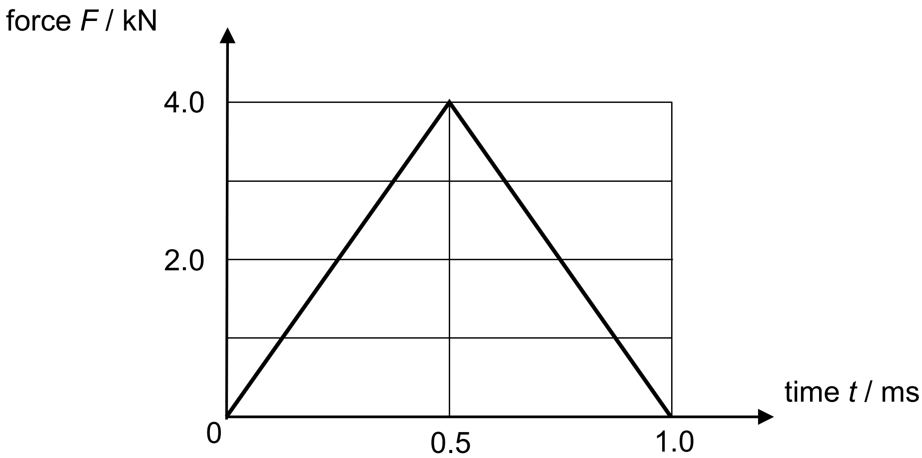

Fig. 4.2

(a) State *Newton's Second Law of Motion*.

……..

……..

……..[1]

(b) **(i)** Determine the change in momentum of cart A.

change in momentum = ……………… N s [2]

(ii) State and explain the significance of the direction of change in momentum of cart A.

…..[1]

(iii) Hence calculate the velocity of cart A after the collision.

velocity = ……………… m s^{-1}

direction: ………………………………… [2]

(c) Explain whether the collision is elastic.

……...

……..[2]

[8 marks]

5 **(a)** State the definition of power.

………

………[1]

(b) A ferry of mass 8.0×10^6 kg is reversing with an initial speed of 0.60 m s^{-1} into a harbour. The ferry comes to a stop when a constant retarding force of 1.2×10^5 N is provided.

(i) Calculate the loss of kinetic energy of the ferry as it comes to a stop.

loss in kinetic energy = …………… J [2]

(ii) Calculate the

1. deceleration of the ferry

deceleration = ……………………… m s^{-2} [2]

2. time taken by ferry to come to a stop.

time = ……………………… s [2]

(ii) Calculate the average output power of the engine.

average output power = ……………………… W [2]

(iii) Explain one other factor that may affect the distance the the ferry travels before coming to a stop in real life.

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

[10 marks]

6 **(a)** Define angular velocity.

....

....[1]

(b) Astronauts in outer space can be weakened by the long-term effects of microgravity. To keep in shape, it has been suggested that they can do some exercise using a Space Cycle as shown in Fig. 6.1, where a horizontal beam from which an exercise bike and a cage are suspended.

One astronaut sits on the exercise bike and pedals, which causes the whole Space Cycle to rotate around a pole. Another astronaut standing in the cage hence experiences artificial gravity.

When rotated at 20 revolutions per minute, the centripetal acceleration experienced by the astronaut in the cage is the same as the gravitational field strength on the surface of Earth.

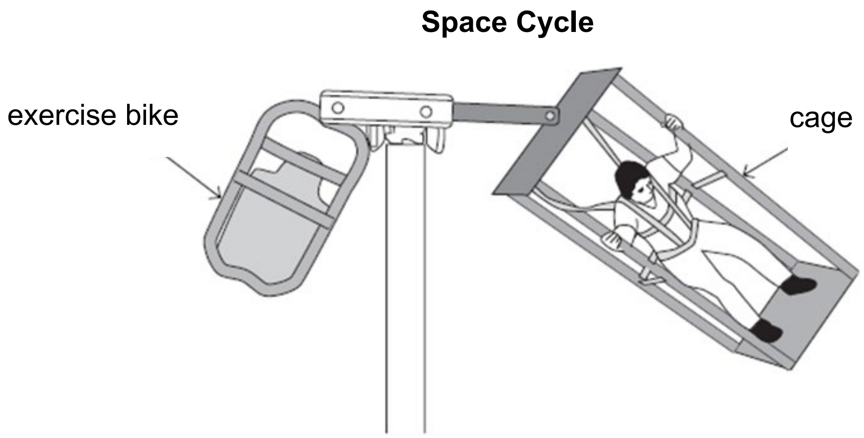

Fig. 6.1

(i) Calculate the angular velocity corresponding to 20 revolutions per minute.

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

(ii) Calculate the radius of the path followed by the cage's platform when it rotates at 20 revolutions per minute.

radius = …………………… m [2]

(iii) By observing Fig. 6.1, explain if the astronaut operating the exercise bike would experience the same artificial gravity as the astronaut sitting in the cage.

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

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

(c) The Moon takes 27.3 days to make one complete orbit of the Earth. The mean distance from the centre of the Moon to the centre of the Earth is 3.84×10^8 m. Determine the mass of Earth.

mass of Earth = …………………………… kg [3]

[8 marks]

7. **(a)** Define the electromotive force (e.m.f.) of an electrical source.

………..

....[1]

(b) Fig 7.1 shows a circuit. The resistance of the resistors are 5.0 Ω , 10 Ω and 20 Ω. The supply has e.m.f. of 24 V and negligible internal resistance.

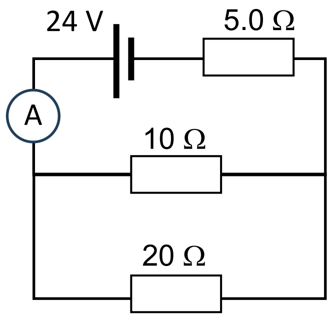

Fig. 7.1

Determine the

(i) total resistance in the circuit,

resistance = …………………… Ω [2]

(ii) current measured in the ammeter,

current = …………………… A [2]

(iii) power dissipated in the 5 Ω resistor.

power = …………………… W [2]

(c) Fig 7.2 shows a circuit consisting of a resistor connected in series with thermistor and a power supply. A voltmeter is placed across the resistor.

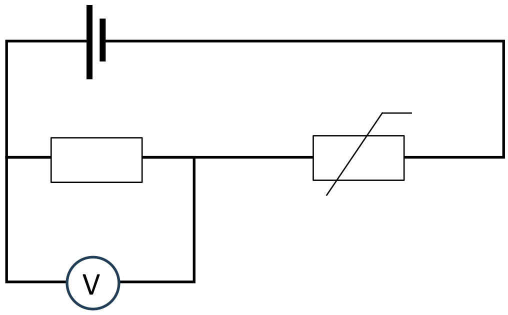

Fig. 7.2

(i) Sketch the resistance-temperature characteristic graph of a negative temperature coefficient (NTC) thermistor in Fig. 7.3 below.

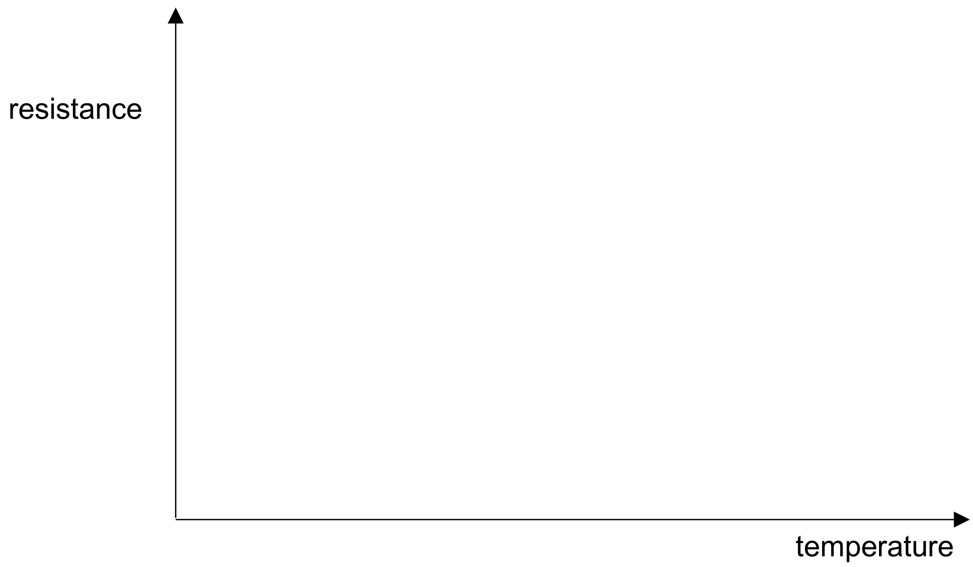

Fig. 7.3

[1]

(ii) Explain how the voltmeter reading will change as the temperature of the thermistor increases.

……..

……... [2]

[10 marks]

Section B

Answer **one** question from this section in the spaces provided.

8 **(a)** Define magnetic flux density.

………...

....[2]

(b) A coil of insulated wire is tightly wound on a non-magnetic tube to make a solenoid as shown in Fig. 8.1. The coil is connected to a supply of e.m.f. with negligible internal resistance.

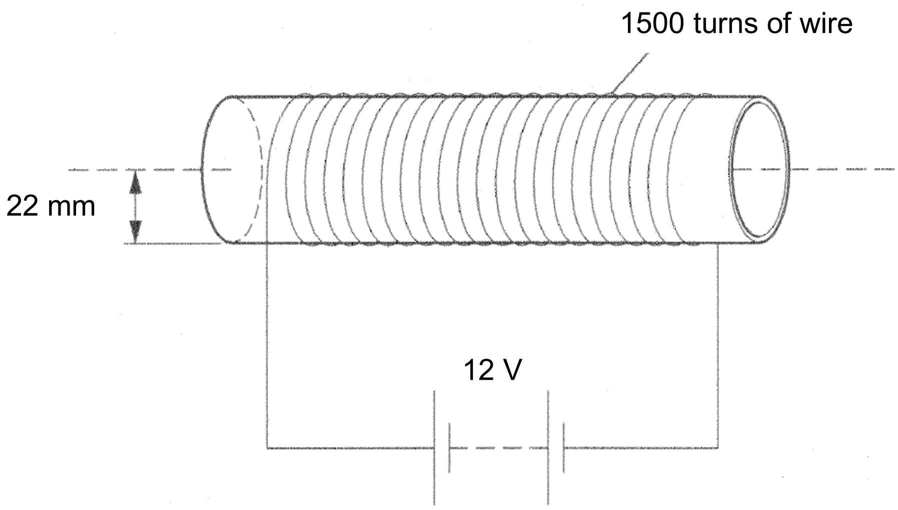

Fig 8.1

On Fig. 8.1, draw the pattern of the magnetic field **within** and **around** the solenoid. Use arrows to show the direction of the field.

[1]

(c) The magnetic flux density in the solenoid is measured using a current balance.

The current balance is a U-shaped piece of stiff wire ABCDEF pivoted at BE, as shown in Fig. 8.2.

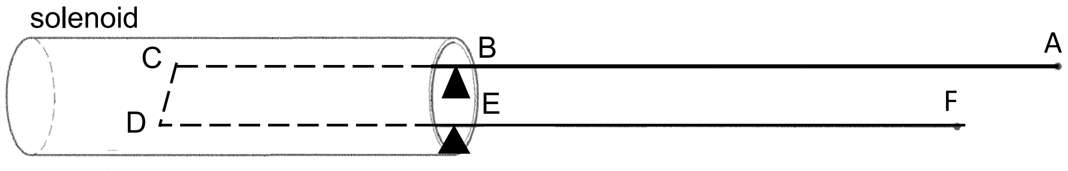

Fig 8.2

When in use, there is a turning force on the stiff wire caused by a current in CD.

(i) Explain why the current in CD causes a turning effect.

....

....

....[2]

(ii) Explain why currents in CB and DE do not contribute to the turning force.

....[1]

(iii) CD has length 25 mm, CB and DE each have length 106 mm.

The stiff wire is first balanced when there is no current in it.

When a current of 4.9 A is then passed through CD, a force of 5.7×10^{-4} N is applied at a distance of 77 mm from the pivot in order to rebalance the stiff wire, as shown in the side view of the balance in Fig. 8.3.

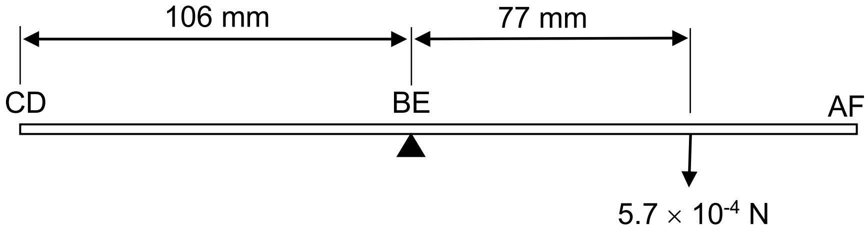

Fig 8.3

1. State the direction of the current in CD.

direction = …………………… [1]

2. Calculate the magnetic flux density in the solenoid.

magnetic flux density = …………………… T [3]

(d) In a proposed nuclear fusion reactor, one possible reaction is shown in the following nuclear equation.

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

(i) Explain what is meant by *nuclear fusion*.

……..

……..[1]

(ii) Some data for the nuclei in the reaction are given in Fig. 8.4.

Nuclide	Mass / u
deuterium ($^{2}_{1}H$)	2.0141
tritium ($^{3}_{1}H$)	3.0161
helium ($^{4}_{2}He$)	4.0026
neutron ($^{1}_{0}n$)	1.0087

Fig. 8.4

Show that the energy released in one reaction is 2.82×10^{-12} J. [2]

(iii) In a particular reactor containing a mixture of the hydrogen nuclides, there are 70.0 kg of deuterium ($^{2}_{1}H$) and 80.0 kg of tritium ($^{3}_{1}H$).

Determine the maximum number of reactions.

maximum number of reactions = …………………… [2]

(iv) If the fusion reaction process is 8.0% efficient, calculate the duration which the hydrogen mixture in **(b)(iii)** can supply power to a city with an average demand of 1.50×10^9 W.

duration = ………………………… days [3]

(v) Explain why high temperatures are necessary for fusion processes.

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

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

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

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

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

[20 marks]

9 **(a)** Define magnetic flux density.

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

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

(b) A long straight copper wire X is placed at an angle of 90° to a uniform magnetic field of flux density 6.5×10^{-5} T, as shown in Fig. 9.1.

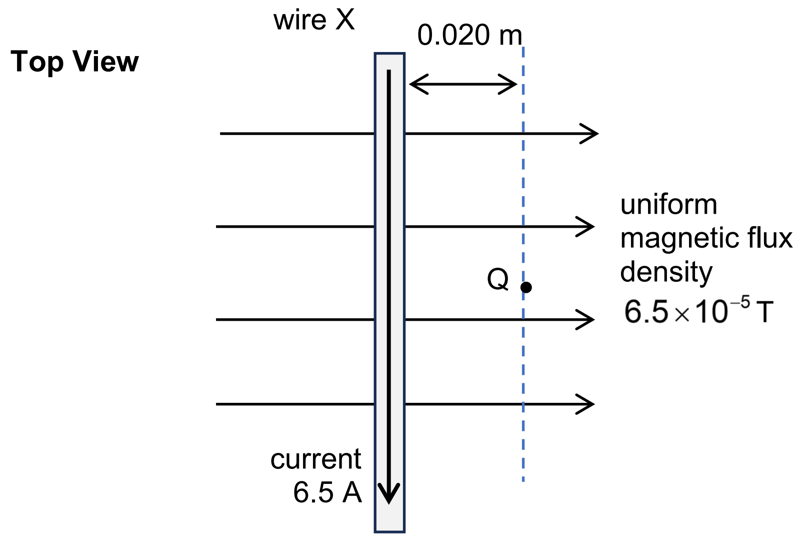

Fig.9.1

The current in the wire X is 6.5 A.

There is a force on the current-carrying wire due to the magnetic field.

(i) Calculate the force per unit length on the wire.

force per unit length = ………………………… N m^{-1} [2]

(ii) **1.** Point Q is located 0.020 m from wire X as indicated in Fig. 9.1. State the direction of the magnetic flux density at point Q due to wire X.

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

2. A similar wire Y carrying the same current as in wire X is placed parallel to wire X at point Q. The direction of the current flowing in wire Y is the same as the direction in wire X.

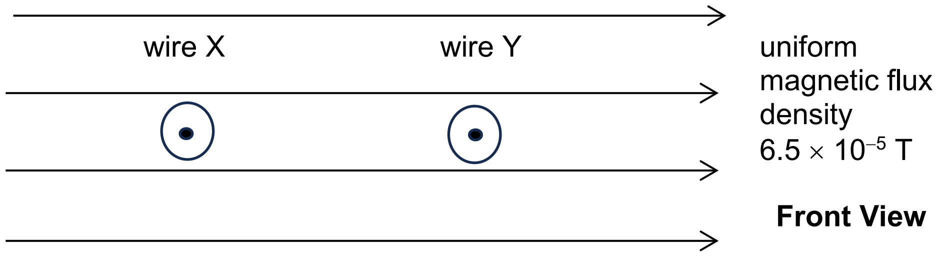

Fig. 9.2

On Fig. 9.2, draw an arrow and label it B_R to indicate the direction of the resultant magnetic flux density acting on wire Y due to wire X and the uniform magnetic field. [1]

On Fig. 9.2, draw an arrow and label it F_R to indicate the direction of the resultant magnetic force acting on wire Y. [1]

(c) (i) An electron travels through a 0.24 T magnetic field. The velocity of the electron v is 1.5×10^5 m s^{-1} at 55° to the magnetic field as shown in Fig. 9.3 below.

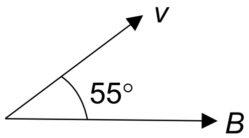

Fig. 9.3

1. Calculate the force acting on the electron due to the magnetic field.

force = ………………………… N [2]

2. The force causes the electron to accelerate. Explain whether the force does work on the electron.

……………………………………………………………………………………………..

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

3. By considering the components of velocity parallel and perpendicular to the magnetic field, explain and describe the path travelled by the electron.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(d) A student takes measurements to determine the acceleration of a ball as it rolls down a slope. He uses the apparatus shown in Fig. 9.4.

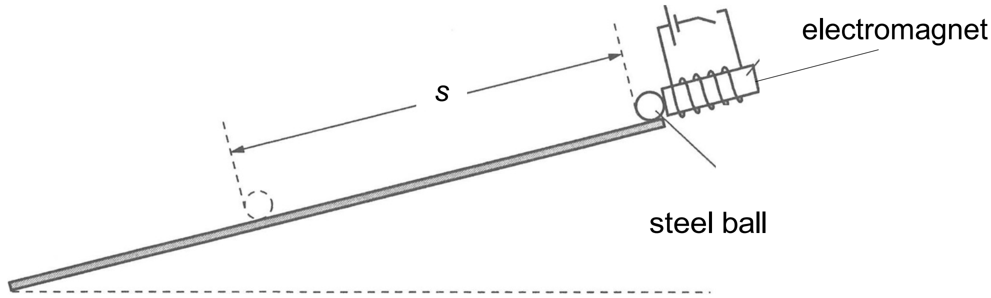

Fig. 9.4

The student measures the time *t* for the ball to roll a distance *s* down the slope after the ball has been released from the electromagnet.

The variation with t^2 of the distance *s* is shown in Fig. 9.5.

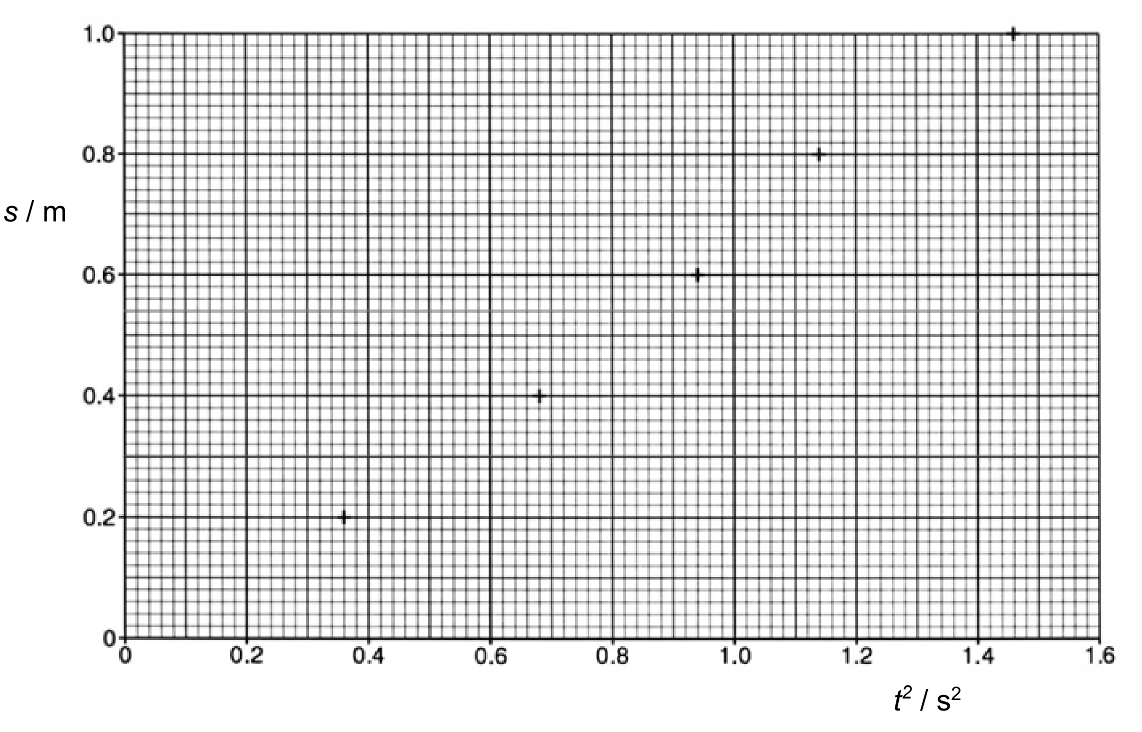

Fig. 9.5

Fig. 9.5 can be used to find the acceleration of the ball down the slope.

(i) On Fig. 9.5, draw the line of best fit. [1]

(ii) Determine the gradient of the line of best fit drawn.

gradient = ... [2]

(iii) Hence calculate the acceleration of the ball down the slope.

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

(e) State the feature of the data shown in Fig. 9.5 that indicates the presence of

(i) random error,

....

.... [1]

(ii) systematic error.

....

.... [1]

(f) State why, by drawing a line of best fit for the data points on Fig. 9.5, the effect of random error is reduced.

....

....

....[1]

[20 marks]