VICTORIAN CERTIFICATE OF EDUCATION
2020

STUDENT NAME	MARK
	……../42 **……...%**

PHYSICS

SAC 1: How do things move without contact?

Reading time: 5 minutes
Writing time: 50 minutes

QUESTION AND ANSWER BOOK

Section	*Number of questions*	*Number of marks*
Part A - Multiple choice	10	10
Part B - Short answer	4	32
Total	**14**	**42**

- Students are permitted to bring into the examination room: one single sided A4 sheet of notes, pens, pencils, highlighters, erasers, sharpeners, rulers, and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper, white out liquid/tape or a CAS calculator.

Materials supplied

- Question and answer book and a formula sheet.

Instructions

- Write your **name** in the space provided above on this page.
- Unless otherwise indicated, the diagrams in this paper are **not** drawn to scale.
- All written responses must be in English and in **blue or black pen.** Diagrams and graphs may be drawn in pencil.
- For full marks to be available,all working must be shown in the Short Answer section for all questions.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices (watches) into the test room.

Fields and application of field concepts

electric field between charged plates	$E = \frac{V}{d}$
energy transformations of charges in an electric field	$\frac{1}{2}mv^2 = qV$
field of a point charge	$E = \frac{kq}{r^2}$
force on an electric charge	$F = qE$
Coulomb's law	$F = \frac{kq_1q_2}{r^2}$
magnetic force on a moving charge	$F = qvB$
magnetic force on a current	$F = IlB$
radius of a charged particle in a magnetic field	$r = \frac{mv}{qB}$

gravitational potential energy near the surface of Earth	$mg\Delta h$
kinetic energy	$\frac{1}{2}mv^2$
Newton's law of universal gravitation	$F = G\frac{M_1M_2}{r^2}$
gravitational field	$g = G\frac{M}{r^2}$

Prefixes/Units

p = pico = 10^{-12}	n = nano = 10^{-9}	μ = micro = 10^{-6}	m = milli = 10^{-3}
k = kilo = 10^{3}	M = mega = 10^{6}	G = giga = 10^{9}	t = tonne = 10^{3} kg

Data

acceleration due to gravity at Earth's surface	$g = 9.8\ \text{m s}^{-2}$
mass of the electron	$m_e = 9.1 \times 10^{-31}\ \text{kg}$
magnitude of the charge of the electron	$e = 1.6 \times 10^{-19}\ \text{C}$
Planck's constant	$h = 6.63 \times 10^{-34}\ \text{J s}$ $h = 4.14 \times 10^{-15}\ \text{eV s}$
speed of light in a vacuum	$c = 3.0 \times 10^{8}\ \text{m s}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
mass of Earth	$M_E = 5.98 \times 10^{24}\ \text{kg}$
radius of Earth	$R_E = 6.37 \times 10^{6}\ \text{m}$
Coulomb constant	$k = 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$

Part A: Multiple choice answers (1 marks each = 10 marks)

Please circle the best answer from the selection below.

Question 1.

An experiment on Earth, requires that an electron is accelerated horizontally, in a straight line. The field(s) that could achieve that objective are:

a) Earth's gravitational field,

b) an electric field,

c) a magnetic field

d) an electric and magnetic field

Question 2.

Consider the electric field strength, *E,* at a distance of 2 cm from a positive point charge. The electric field strength at a distance of 6 cm from the charge is:

a) $\frac{1}{9}$ *E*

b) $\frac{1}{6}$ *E*

c) $\frac{1}{3}$ *E*

d) 3 *E*

Question 3.

In another solar system a planet has three times Earth's mass and one half the Earth's radius. If your mass is ***M*** kg, what would be your weight on this alternative planet?

(Assume that the masses of the Earth and of the other planet are uniformly distributed.)

a) 6 ***M***

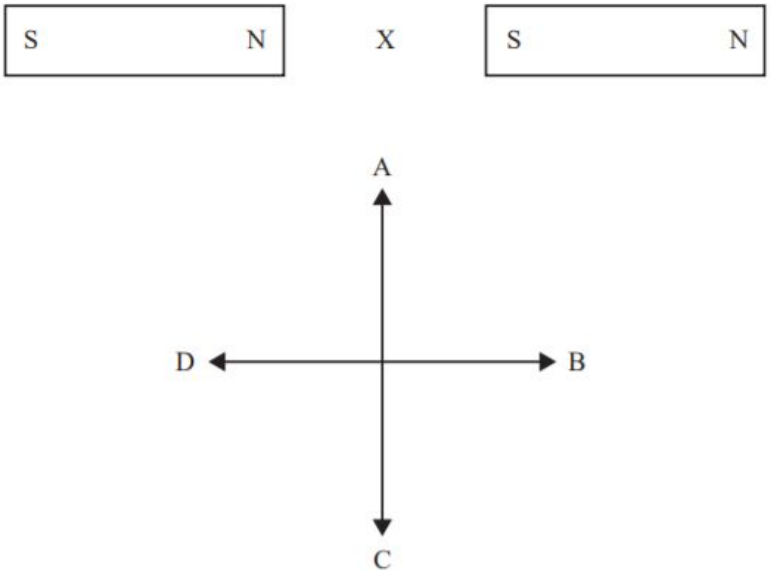
b) 7.4 ***M***

c) 12 ***M***

d) 118 ***M***

Question 4.

Two identical bar magnets are placed end to end as shown below. Point X is midway between the bar magnets.



Which one of the following best shows the direction of the magnetic field at point X?

a) A

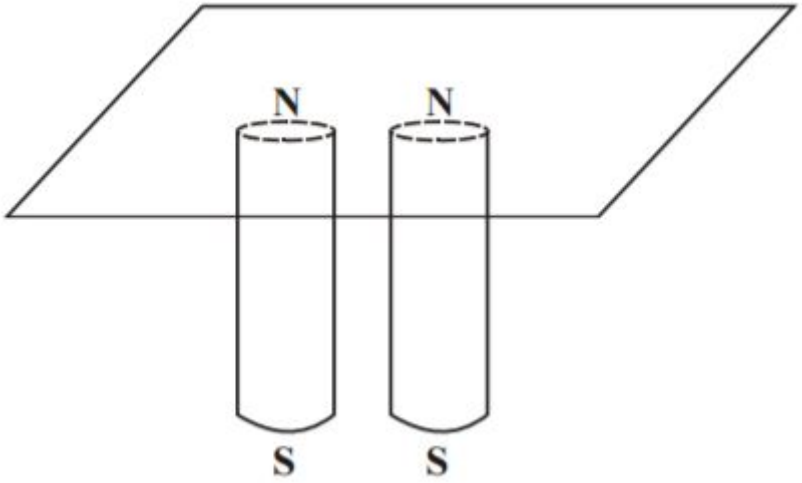
b) B

c) C

d) D

Question 5.

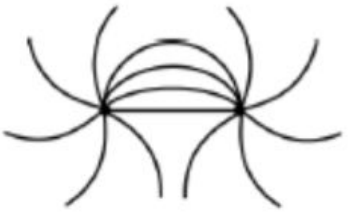
Two long, identical bar magnets are placed under a horizontal piece of thin cardboard, as shown below. The cardboard is covered with fine iron filings. The two north poles are a small distance apart and touching the cardboard. When the cardboard is gently tapped, the iron filings move into a pattern that shows the magnetic field lines.



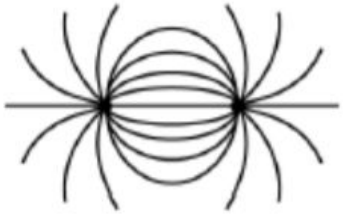
Which one of the following best illustrates the pattern that results?

A.

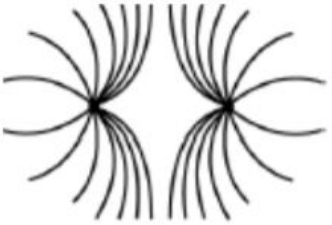
B.



C.



D.



Question 6.

Which one of the following fields cannot produce repulsion?

a) gravitational field

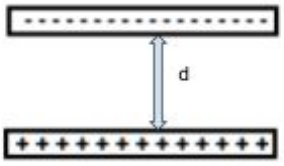
b) magnetic field

c) electric field

d) electric and magnetic field

The following information applies to questions 7, 8 and 9.

Two large parallel plates are charged as shown in the diagram below. The electric field between them is measured to be 500 N C^{-1} and there is a 10.0 V potential difference across the two plates.



Question 7.

The separation, d, of the two plates is:

a) 2.0 mm

b) 10.0 mm

c) 20.0 mm

d) 100.0 mm

Question 8.

The direction of the electric field created between the two plates is:

a) up the page

b) down the page

c) into the page

d) out of the page

Question 9.

What is the energy gained by an alpha particle (α^{2+}), q_α = 2e, if it is accelerated from rest in this field from the positive plate?

a) 10.0 eV

b) 10.0 keV

c) 20.0 eV

d) 20.0 keV

Question 10.

Which one of the following statements is ***FALSE***?

a) The acceleration of a 1.0 kg mass gives a value for the magnitude of the gravitational field strength.

b) Magnetic field lines outside a bar magnet travel from the North pole to the South pole.

c) Gravitational field lines always travel from a small mass to a larger mass.

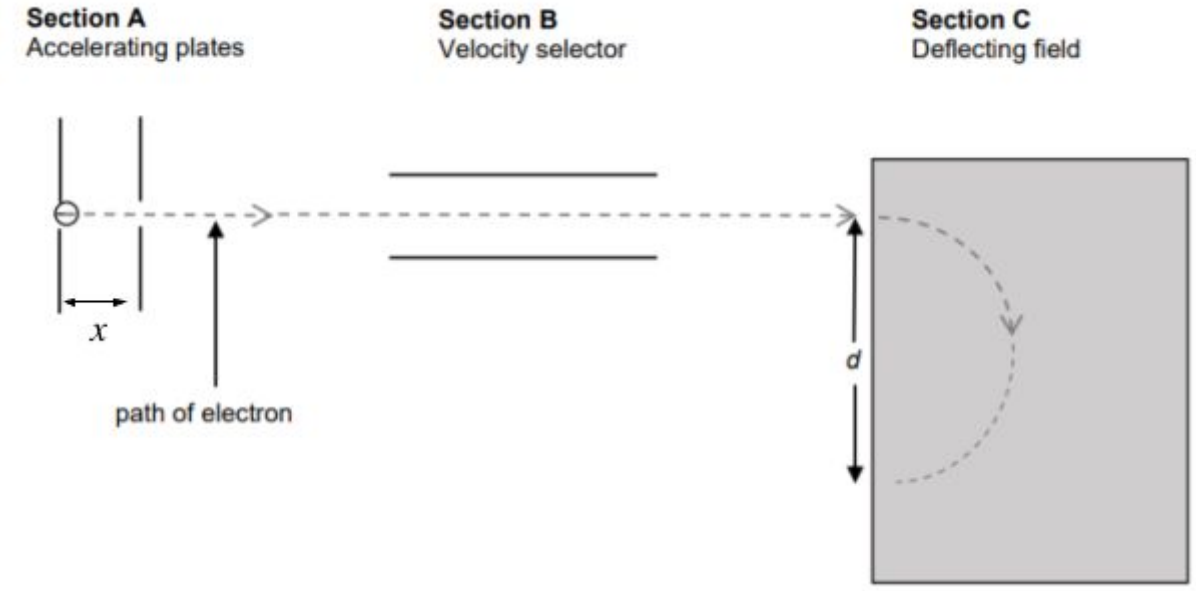
d) Electrical field strength is indicated by the density of the field lines.

END MULTIPLE CHOICE SECTION A

Part B: Short Answer Questions (32 marks)

Question 1. (12 marks)

A mass spectrometer is an instrument used to measure the mass of atoms and molecules. The figure below shows a schematic diagram of a mass spectrometer used to investigate a negatively charged mass.



a) Section A of the mass spectrometer in the diagram above is used to accelerate the negatively charged particle to the right, from rest. Circle the correct options from those provided in brackets in the following statements:

Statement 1

(An electric / A magnetic) field is used to accelerate the electron to the right in Section A. The direction of the field is (to the right / to the left / into the page / out of the page / up the page / down the page).

Statement 2

In order to move the negatively charged particle in the direction shown in the shaded Region in Section C, the direction of the magnetic field must be (to the right / to the left / into the page / out of the page / up the page / down the page).

2 marks

The negatively charged particle has a charge of 3.2 x 10^{-19} C and a mass of 2.7 x 10^{-26} kg. Measurements show that the distance, d, in the above figure is 0.020 m and the magnetic field strength in the shaded region in Section C, is 0.10 T.

b) Show that the speed of the particle as it enters the region of the magnetic field is 1.2 x 10^4 m s^{-1} ***2 marks***

c) Determine the potential difference between the plates in Section A that would be required to accelerate the particle from rest to the speed found in the question above, 1.2 x 10^4 m s^{-1} ***3 marks***

d) The separation of the plates, x, in Section A is 0.010 m. Determine the size of the electric field in Section A that would be required to accelerate the particle from rest to the speed of 1.2 x 10^4 m s^{-1}, as found in Question 1b. ***2 marks***

e) Circle the following term or terms that best describe the field between the plates in Section A of the mass spectrometer shown above:

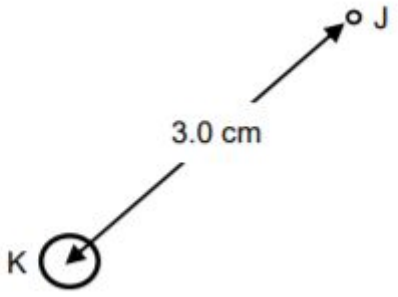
radial *changing* *uniform* *non-uniform*

1 mark

f) Describe the motion of the negatively charged particle while it is in Section C, the magnetic field, using appropriate physics reasoning to explain. ***2 marks***

Question 2. (5 marks)

Particle K, shown in the diagram below, has a charge of + 4.0 x 10^{-14} C. An electron, J, is located 3.0 cm from the centre of particle K.



a) What is the electric force exerted on J by K? ***3 marks***

b) If the gravitational force exerted by J on K was the same magnitude as the electrical force on it, determine what the mass of particle K would need to be. ***2 marks***

_____

_____

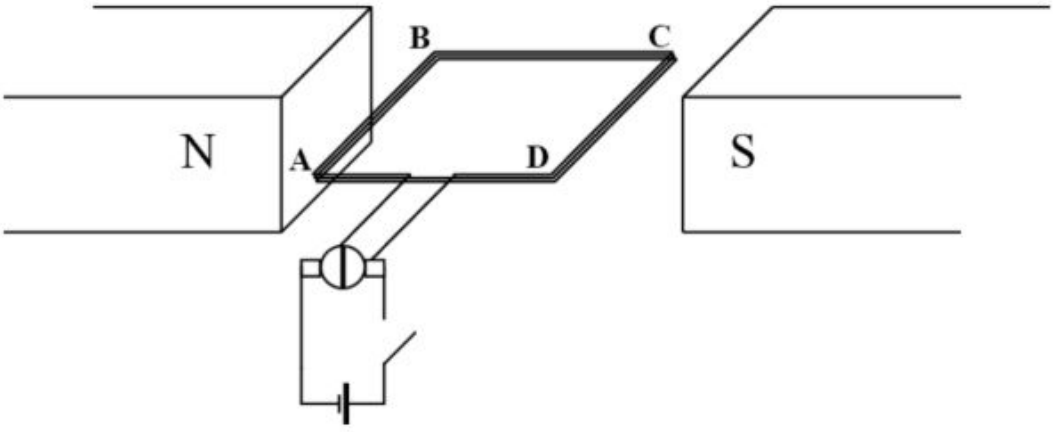
_____

_____

_____

Question 3. (6 marks)

The schematic diagram below shows a DC motor with multiple turns in a constant magnetic field.



a) When the switch is closed, current flows through the loops of wire in the coil. Draw on the diagram above, the direction of the coil's rotation, if any, and explain why.
3 marks

_____

_____

_____

_____

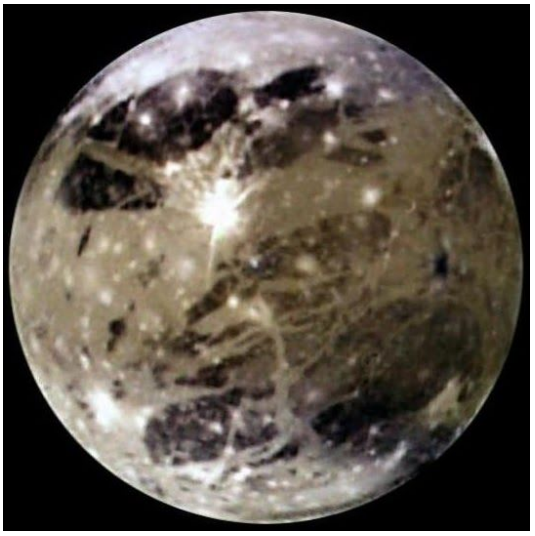
_____

_____

b) Describe what happens in the coil when it has completed 90° of rotation from its beginning position, and the impact on the rotation of the motor.

3 marks

Question 4. ***(9 marks)***



Ganymede is one of the four Galilean moons of Jupiter.

Ganymede has a diameter of 5260 km and a mass of 1.63×10^{23} kg.

Ganymede orbits Jupiter every 7.15 days.
Ganymede is synchronous in that it keeps the one face always facing Jupiter, so it has a rotational period of 7.15 days.

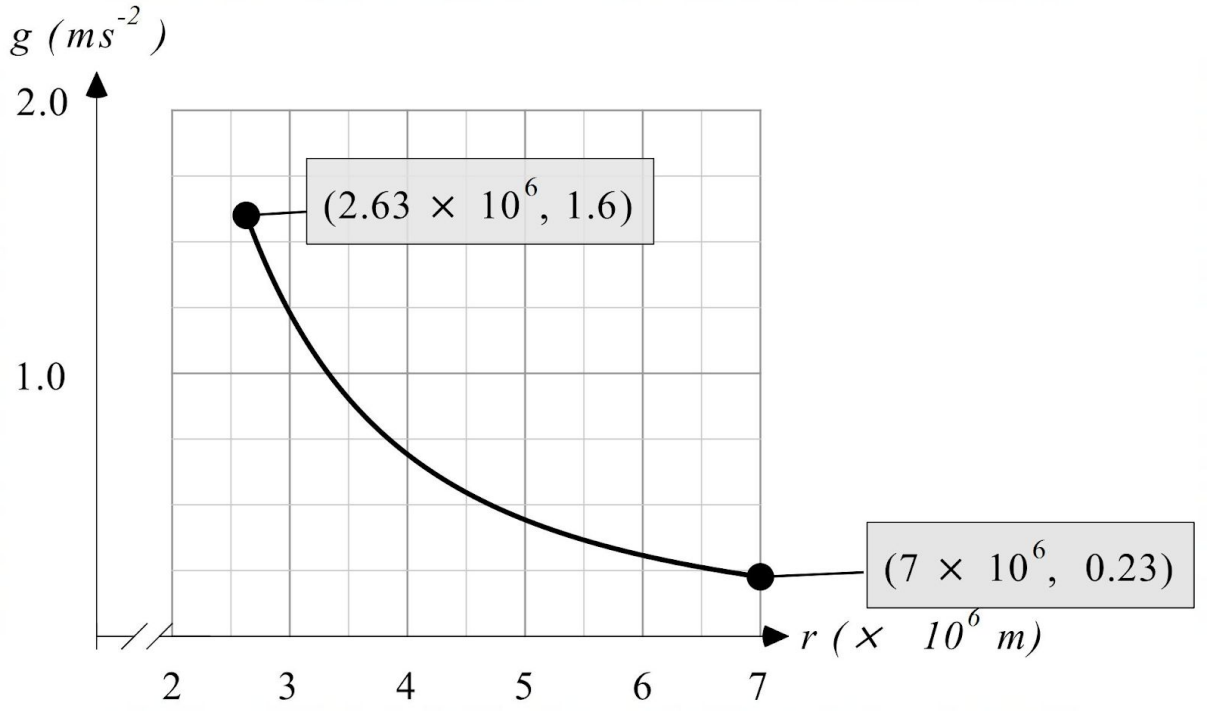
Ganymede's orbital radius is 1.07×10^{6} km.

($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2})

a) Show that the gravitational field strength on the surface of Ganymede is 1.6 N kg^{-1} ***2 marks***

b) Use the data given to calculate the mass of Jupiter. ***3 marks***

d) A 200.0 kg asteroid, at a distance of 7 x 10^6 m from the centre of Ganymede, is on a collision course with this moon. The asteroid is travelling at a speed of 1.0 km s^{-1}. Using the information in the graph below and the data provided at the beginning of this question, find the speed of impact of the asteroid when it hits Ganymede. (R_G= 2.63 x 10^6 m.) ***4 marks***



END SHORT ANSWER SECTION B

END OF SAC

VICTORIAN CERTIFICATE OF EDUCATION 2020

STUDENT NAME	MARK
uggested marking scheme.	...../42 .....%

PHYSICS

SAC 1: How do things move without contact?

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Writing time: 50 minutes

QUESTION AND ANSWER BOOK

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Part A: Multiple choice answers (1 marks each = 10 marks)

Please circle the correct answer ***on the multiple choice answer sheet*** provided with this booklet.

Question 1.

An experiment on Earth, requires that an electron is accelerated horizontally, in a straight line. The field(s) that could achieve that objective are:

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c) a magnetic field

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Question 2.

Consider the electric field strength, *E*, at a distance of 2 cm from a positive point charge. The electric field strength at a distance of 6 cm from the charge is:

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b) $\frac{1}{6}$ *E*

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Question 3.

In another solar system a planet has three times Earth's mass and one half the Earth's radius. If your mass is ***M*** kg, what would be your weight on this alternative planet?

(Assume that the masses of the Earth and of the other planet are uniformly distributed.)

a) 6 ***M***

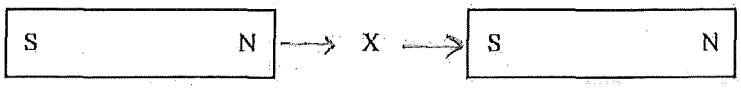
b) 7.4 ***M***

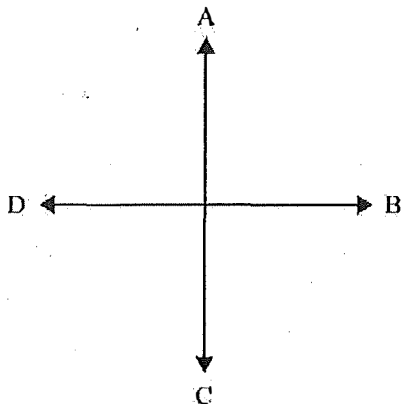
c) 12 ***M***

d) 118 ***M***

Question 4.

Two identical bar magnets are placed end to end as shown below. Point X is midway between the bar magnets.





Which one of the following best shows the direction of the magnetic field at point X?

a) A

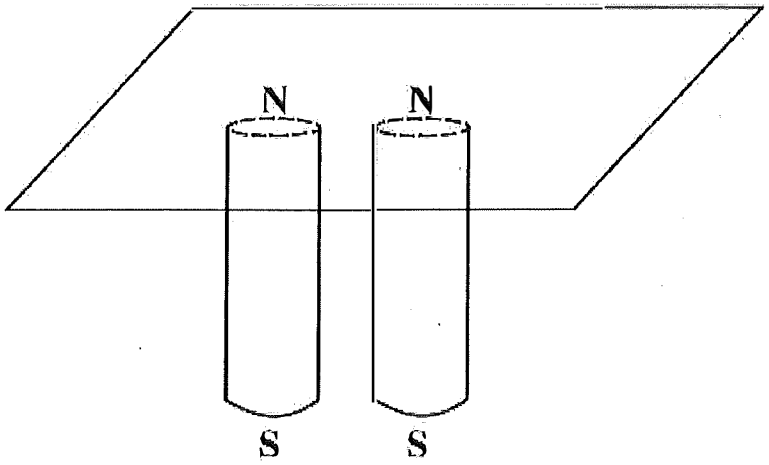
b) B

c) C

d) D

Question 5.

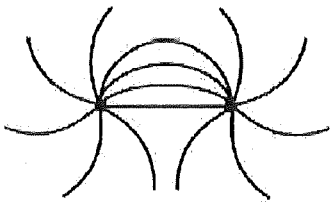
Two long, identical bar magnets are placed under a horizontal piece of thin cardboard, as shown below. The cardboard is covered with fine iron filings. The two north poles are a small distance apart and touching the cardboard. When the cardboard is gently tapped, the iron filings move into a pattern that shows the magnetic field lines.



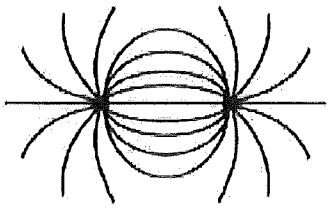
Which one of the following best illustrates the pattern that results?

A.

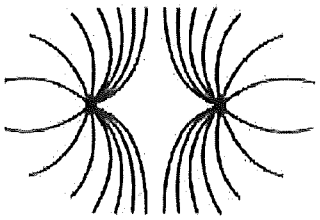
B.



C.



D.



Question 6.

Which one of the following fields cannot produce repulsion?

a) gravitational field

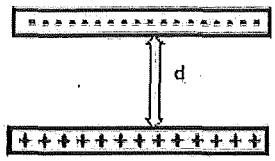
b) magnetic field

c) electric field

d) electric and magnetic field

The following information applies to questions 7, 8 and 9.

Two large parallel plates are charged as shown in the diagram below. The electric field between them is measured to be 500 N C^{-1} and there is a 10.0 V potential difference across the two plates.



Question 7.

The separation, d, of the two plates is:

a) 2.0 mm

b) 10.0 mm

c) 20.0 mm

d) 100.0 mm

Question 8.

The direction of the electric field created between the two plates is:

a) up the page

b) down the page

c) into the page

d) out of the page

Question 9.

What is the energy gained by an alpha particle (α^{2+}), q_α = 2e, if it is accelerated from rest in this field from the positive plate?

a) 10.0 eV

b) 10.0 keV

c) 20.0 eV

d) 20.0 keV

Question 10.

Which one of the following statements is ***FALSE***?

a) The acceleration of a 1.0 kg mass gives a value for the magnitude of the gravitational field strength.

b) Magnetic field lines outside a bar magnet travel from the North pole to the South pole.

c) Gravitational field lines always travel from a small mass to a larger mass.

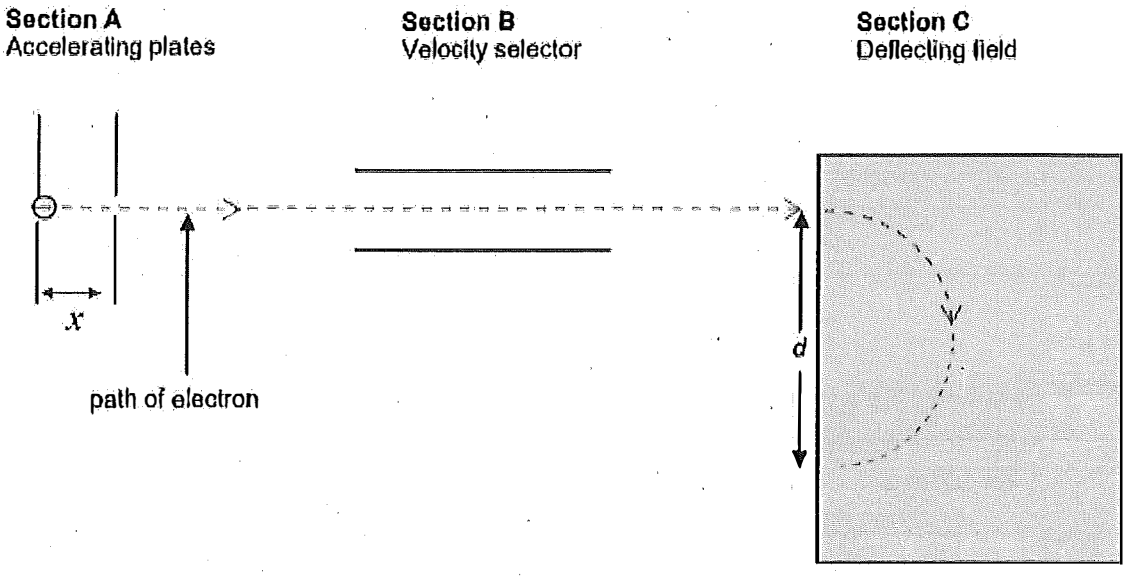
d) Electrical field strength is indicated by the density of the field lines.

END MULTIPLE CHOICE SECTION A

Part B: Short Answer Questions (36 marks)

Question 1. **(12 marks)**

A mass spectrometer is an instrument used to measure the mass of atoms and molecules. The figure below shows a schematic diagram of a mass spectrometer used to investigate a negatively charged mass.



a) Section A of the mass spectrometer in the diagram above is used to accelerate the negatively charged particle to the right, from rest. Circle the correct options from those provided in brackets in the following statements:

Statement 1

0·5 (An electric / A magnetic) field is used to accelerate the electron to the right in Section A. The direction of the field is (to the right / to the left / into the page / out of the page / up the page / down the page). 0·5

Statement 2

In order to move the negatively charged particle in the direction shown in the shaded Region in Section C, the direction of the magnetic field must be (to the right / to the left / into the page / out of the page / up the page / down the page). 1

2 marks

The negatively charged particle has a charge of 3.2 x 10^{-19} C and a mass of 2.7 x 10^{-26} kg. Measurements show that the distance, d, in the above figure is 0.020 m and the magnetic field strength in the shaded region in Section C, is 0.10 T.

b) Show that the speed of the particle as it enters the region of the magnetic field is 1.2 x 10^4 m s^{-1} ***2 marks***

$q = 3.2 \times 10^{-19}$ C

$m = 2.7 \times 10^{-26}$ kg

$r = d/2 = 0.010$ m

$B = 0.10$ T

$\Sigma F = F_c = F_B \quad \therefore Bqv = \frac{mv^2}{r}$

$v = \frac{Bqr}{m}$ (1)

$v = \frac{0.10 \times 3.2 \times 10^{-19} \times 0.010}{2.7 \times 10^{-26}}$

$= 11851.85$ (1)

$= 1.2 \times 10^4$ m.s^{-1}

c) Determine the potential difference between the plates in Section A that would be required to accelerate the particle from rest to the speed found in the question above, 1.2 x 10^4 m s^{-1} ***3 marks***

$\Delta E_K = qV = \frac{1}{2}mv^2$ (1)

$\therefore 3.2 \times 10^{-19} V = \frac{1}{2} \times 2.7 \times 10^{-26} \times (11851)^2$ (1)

$V = 5.925$

$V = 5.9$ V (1)

d) The separation of the plates, *x*, in Section A is 0.010 m. Determine the size of the electric field in Section A that would be required to accelerate the particle from rest to the speed of 1.2 x 10^4 m s^{-1}, as found in Question 1b. ***2 marks***

$E = \frac{V}{d} = \frac{5.925}{0.01} = 592.5$ V.m^{-1} or NC^{-1} (1)

(1) Consequential on c)

e) Circle the following term or terms that best describe the field between the plates in Section A of the mass spectrometer shown above:

radial *changing* *uniform* *non-uniform* (1)

1 mark

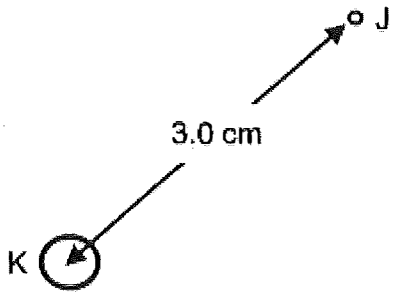
f) Describe the motion of the negatively charged particle while it is in Section C, the magnetic field, using appropriate physics reasoning to explain. ***2 marks***

- In Section C there is a constant magnetic field into the page that produces a force of constant magnitude on the particle ($F = qvB$) perpendicular to the velocity of the particle (1)

- This force acts radially inward causing centripedal acceleration, resulting in circular motion. (1)

Question 2. **(5 marks)**

Particle K, shown in the diagram below, has a charge of + 4.0 x 10^{-14} C. An electron, J, is located 3.0 cm from the centre of particle K.



a) What is the electric force exerted on J by K? ***3 marks***

$F_{J\text{ on }K} = \frac{k q_1 q_2}{r^2} = \frac{9.0\times10^{9} \times 4.0\times10^{-14} \times 1.6\times10^{-19}}{(0.03)^2}$ (1)

$= 6.4\times10^{-20}$ N towards K

(1) (1) (direction required)

b) If the gravitational force exerted by J on K was the same magnitude as the electrical force on it, determine what the mass of particle K would need to be. ***2 marks***

If $F_g = 6.4 \times 10^{-20}$ N $\therefore \frac{GM_K m_T}{r^2} = 6.4 \times 10^{-20}$

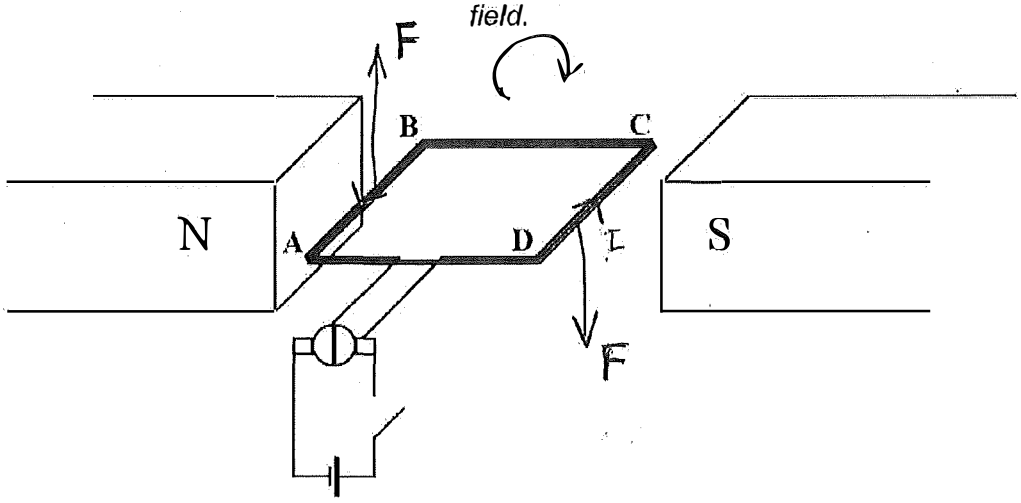
$\therefore M_K = \frac{6.4 \times 10^{-20} \times 0.03^2}{6.67 \times 10^{-11} \times 9.1 \times 10^{-31}}$ (1)

$= 9.4898 \times 10^{17}$

$= 9.5 \times 10^{17}$ kg (1)

Question 3. (6 marks)

The schematic diagram below shows a DC motor with multiple turns in a constant magnetic field.



a) When the switch is closed, current flows through the loops of wire in the coil. Draw on the diagram above, the direction of the coil's rotation, if any, and explain why. ***3 marks***

Coil will turn clockwise. (1)

Closed switch $\Rightarrow$ I flows D $\rightarrow$ C (1)

Using RHS rule on side DC, I D $\rightarrow$ C with B left to right means a downward force. (OR) (1)

On side AB, I flows B $\rightarrow$ A, using RHS rule, force will be up.

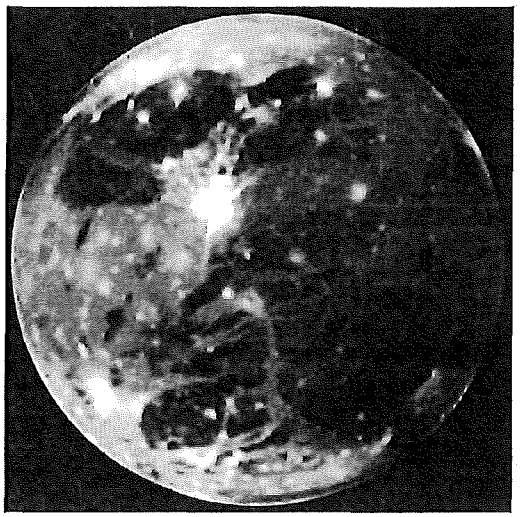
b) Describe what happens in the coil when it has completed 90° of rotation from its beginning position, and the impact on the rotation of the motor.

3 marks

After 90° from position shown, I_{DC} will still produce a downward force. until the split and then connection to the opposite polarity supply. Momentum will carry the turning coil past the vertical and then the SRC will reverse the direction of the current (1) to C → D ∴ producing an upward force on CD and a downward force on AB. (1)

The current reversal occurs every half rotation causing the reversal of forces at that time ∴ ensuring the coil continues rotating in the same direction. (1)

Question 4. ***(9 marks)***



Ganymede is one of the four Galilean moons of Jupiter.

Ganymede has a diameter of 5260 km and a mass of 1.63×10^{23} kg.

Ganymede orbits Jupiter every 7.15 days.
Ganymede is synchronous in that it keeps the one face always facing Jupiter, so it has a rotational period of 7.15 days.

Ganymede's orbital radius is 1.07×10^{6} km.

($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2})

a) Show that the gravitational field strength on the surface of Ganymede is 1.6 N kg^{-1} ***2 marks***

$g = \frac{GM}{R^2} = \frac{6.67 \times 10^{-11} \times 1.63 \times 10^{23}}{(2630 \times 10^3)^2} = 1.572$ (1) (1)

~ 1.6 N.kg^{-1} as required.

b) Use the data given to calculate the mass of Jupiter. ***3 marks***

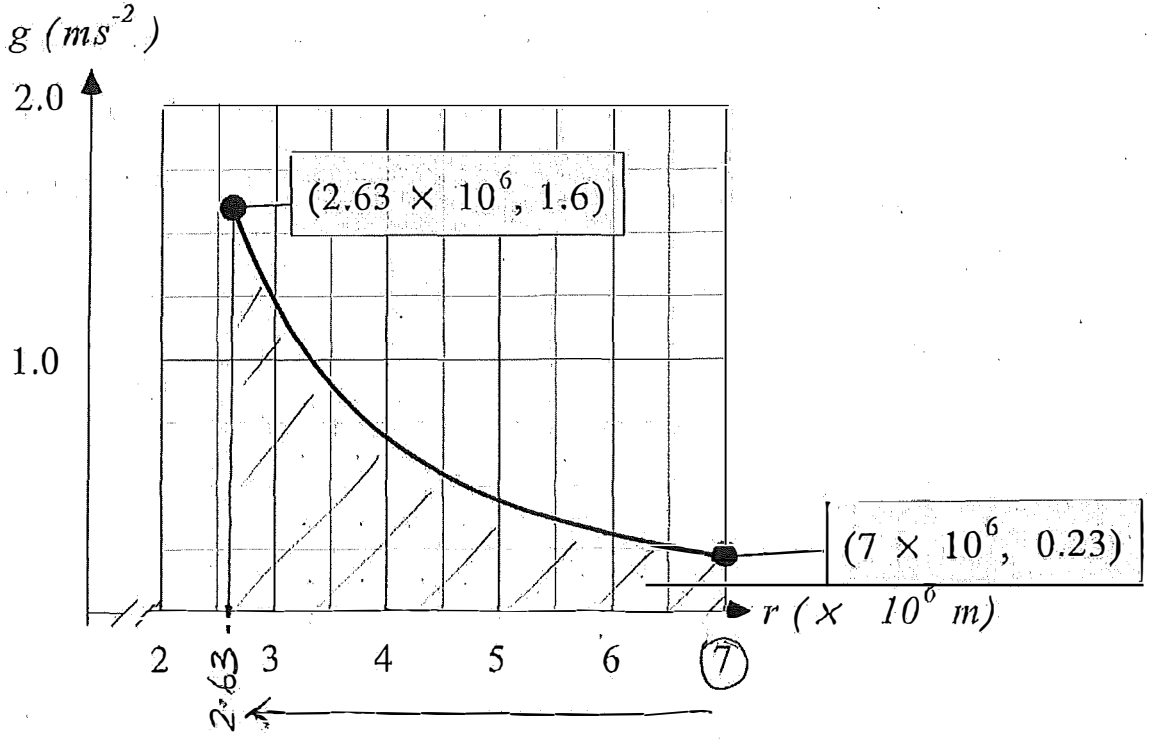
$\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$ $\quad M_J = \frac{R^3 4\pi^2}{GT^2}$ (1)

$R = 1.07 \times 10^6 \times 10^3$ m $\quad = \frac{(1.07 \times 10^9)^3 \times 4\pi^2}{6.67 \times 10^{-11} \times (617760)^2}$ (1)

$T = 7.15 \times 24 \times 60 \times 60$ $\quad = 1.90 \times 10^{27}$ kg (1)

$= 617760$ s.

d) A 200.0 kg asteroid, at a distance of 7 x 10^6 m from the centre of Ganymede, is on a collision course with this moon. The asteroid is travelling at a speed of 1.0 km s^{-1}. Using the information in the graph below and the data provided at the beginning of this question, find the speed of impact of the asteroid when it hits Ganymede. (R_G= 2.63 x 10^6 m.) ***4 marks***



$u = 1.0 \times 10^3 \text{ m.s}^{-1}$

$E_{Ki} = \frac{1}{2} m u^2$

$= \frac{200}{2} \times (10^3)^2$

$= 10^8 \text{ J}$ (1)

$E_{Kf} = E_{Ki} + \Delta E_K$ (1)

$= 10^8 +$ [area under graph 7 → 2.63 x m]

ea. square $= 0.5 \times 10^6 \times 0.25 = 1.25 \times 10^5 \frac{\text{J}}{\text{kg}}$

no. of squares = 20

$\therefore \Delta E_K = 20 \times 1.25 \times 10^5 \times 200$

$= 5.0 \times 10^8 \text{ J}$ (1)

$\therefore E_{Kf} = \frac{1}{2} m v^2 = 1 \times 10^8 + 5 \times 10^8 = 6 \times 10^8 \text{ J}$

$v = \sqrt{\frac{2 \times 6 \times 10^8}{200}} = 2449.5 \text{ m.s}^{-1}$

$= 2.45 \text{ km.s}^{-1}$ (1)

END SHORT ANSWER SECTION B

END OF SAC