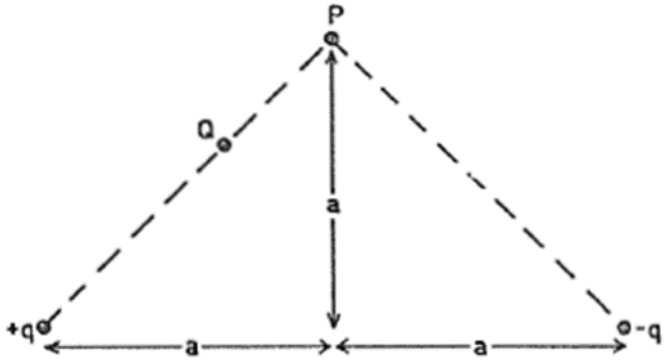
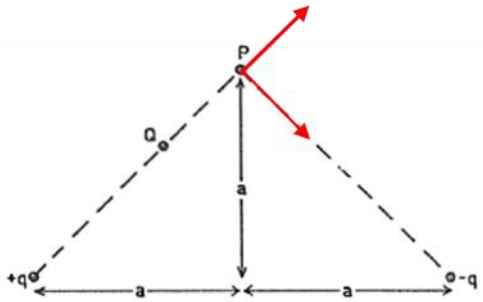
1967 Question 5 46%



Consider a point *P* equidistant from two charges + *q* and - *q* as shown.
The electric field at *P* will be

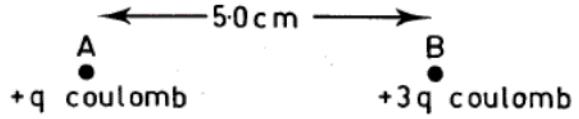
A. zero.
B. parallel to the line joining the charges.
C. perpendicular to the line joining the charges.
D. parallel to the line QP.

B



The +ve charge will repel a +ve charge at the point P. The negative charge will attract a +ve charge at the point P. These two will combine to give a net force (hence field) to the right, parallel to the line joining the two charges

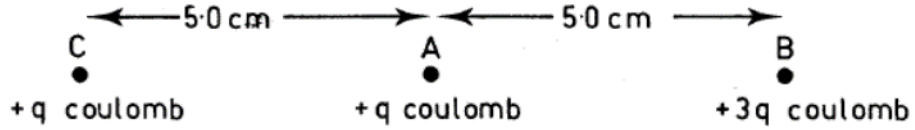
1979 Question 43 56%



The magnitude of the force exerted by A on B is 2.0 x 10^{-5} N.
What is the magnitude of the force exerted by B on A?

2.0 × 10^{-5} N
Newton's Third law gives that the force has the same magnitude but is in the opposite direction.

1979 Question 44 56%
A third charged sphere, C, is placed 5.0 cm from A.



What is the magnitude of the force exerted by C on B?

5.0×10^{-6} N
The distance has doubled.
The force varies as 1 on r^2, so the new force is one quarter of the original.

1979 Question 45 51%
What is the magnitude and direction of the net force on A? Indicate the direction of this force by writing L (to the left) or R (to the right).

Forces are vectors, so they will add together when the direction is taken into consideration.

The force of C on A is $\frac{1}{3} \times 2.0 \times 10^{-5}$ to the right.
The force of B on A is 2.0×10^{-5} to the left.
$\therefore 1.3 \times 10^{-5}$ N Left

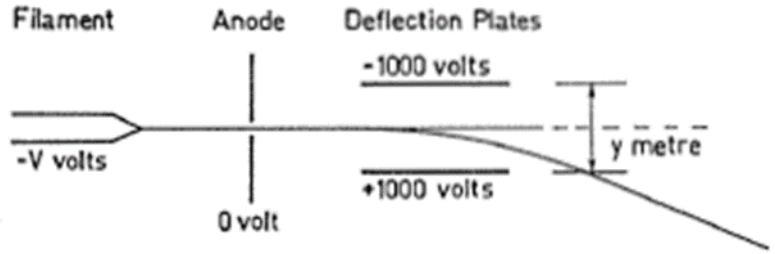
1977 Question 52 43%
Two insulated uncharged metal spheres are each given net charges of + *Q* coulomb. The force each exerts on the other is ***F*** newton when they are placed *d* m apart. What distance apart should the spheres be if the force between them is to be *3**F**?*

The force is given by $F = \frac{kQ_1Q_2}{r^2}$.
If the force needs to increase, the distance needs to decrease. i.e. the charges need to be closer together. The force varies as $\frac{1}{r^2}$. Therefore to get 3 times the force the distance needs to be $\frac{1}{\sqrt{3}}$ d.
$\therefore$ 0.58 d

1977 Question 53 44%
The spheres are now returned to their original separation of *d* m. What charge should be added to one of the spheres if the force between them is to be - *2F*?

The force is given by $F = \frac{kQ_1Q_2}{r^2}$, to get a resultant force of -2F, you need to change the sign of one charge and double its size. This means that you need to change +Q into – 2Q. To do tis you need to add -3 Q
$\therefore$ -3 Q coulombs

1973 Question 85 32%



The heated filament of a cathode ray tube is at a potential of -*V* volt. Electrons emitted from it are accelerated towards the anode which is at a potential of 0 volt
The electrons start at rest and reach the anode with a velocity of 6.0×10^7 m s^{-1}. What is the value of *V*?
Data : Charge on electron, $e = 1.6 \times 10^{-19}$ coulomb
Mass of electron, $m = 9.1 \times 10^{-31}$ kg.

The work done is the same as ΔKE. The work done is given by $qV = \frac{1}{2}mv^2$

$1.6 \times 10^{-19} \times V = \frac{1}{2} \times 9.1 \times 10^{-31} \times (6.0 \times 10^7)^2$
$\therefore 1.6 \times 10^{-19} \times V = 1.638 \times 10^{-15}$
$\therefore$ **$V = 1.02 \times 10^4$ V**

1973 Question 86 41%
The stream of electrons enters a region of uniform electric field, *E*, in the space between plane, parallel deflection plates separated by a spacing of *y* metre.
The top plate is at a potential of -1000 volt and the bottom plate at +1000 volt.
The magnitude of *E* is 2.0×10^5 newton $coulomb^{-1}$. What is the spacing between the plates *y*?

The electric field is given by $E = \frac{V}{d}$,

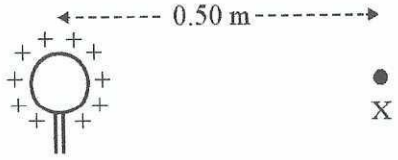
therefore $2.0 \times 10^5 = \frac{2000}{d}$
$\therefore$ **$d = 0.01$ m**

1973 Question 87 26%
What is the acceleration of the electrons in the region between the plates?

Use F = ma, where F = Eq.
$\therefore 9.1 \times 10^{-31} \times a = 2.0 \times 10^5 \times 1.6 \times 10^{-19}$
$\therefore 9.1 \times 10^{-31} \times a = 3.2 \times 10^{-14}$
$\therefore a = 3.5 \times 10^{16}$ m s^{-2}

Question 3

A Van de Graaff generator, which is a piece of electric field demonstration equipment, consists of a small sphere that is electrically charged, as shown in the diagram below.



A particular Van de Graaff generator has a sphere that has a charge of 5.0×10^{-7} coulombs on it. Take the Coulomb's law constant to be $k = 9.0 \times 10^9$ N m^2 C^{-2}.

Which one of the following best gives the magnitude of the electric field at point X in the diagram above, 0.50 m from the sphere?

$E = k\frac{q}{r^2} = \frac{9 \times 10^9 \times 5 \times 10^{-7}}{0.5^2}$

A. 1.8×10^{-2} V m^{-1}

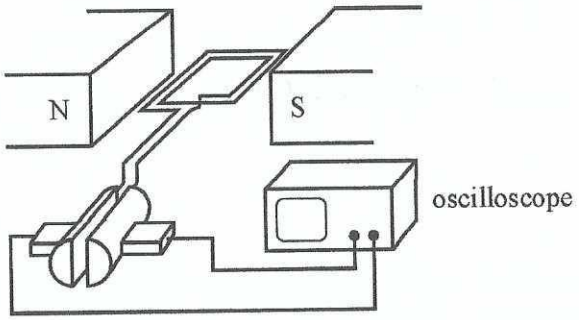
B. 3.6×10^{-2} V m^{-1}

C. 1.8×10^{4} V m^{-1}

D. 3.6×10^{4} V m^{-1}

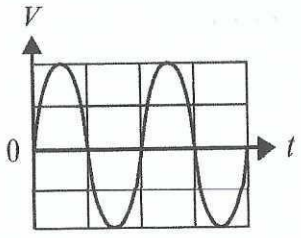
Question 4

A simple DC generator consists of two magnets that produce a uniform magnetic field, in which a square loop of wire of 100 turns rotates at constant speed, and a commutator, as shown in the diagram below.

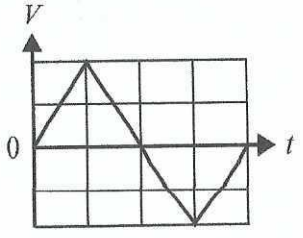


Which one of the following best shows the display observed on the oscilloscope?

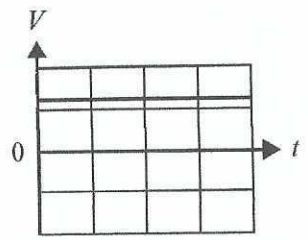
A.



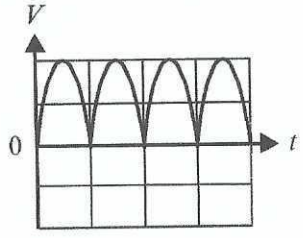
B.



C.



D.



Question 2 (6 marks)

The electron gun section of a particle accelerator accelerates electrons between two plates that are 10 cm apart and have a potential difference of 5000 V between them.

Data

mass of electron	9.1×10^{-31} kg
charge on electron	$(-)\ 1.6 \times 10^{-19}$ C

a. Calculate the electric field between the plates. Include an appropriate unit. 2 marks

$E = \frac{V}{d} = \frac{5000}{0.1}$

5×10^{4} V m^{-1}

b. Calculate the magnitude of the force on an electron between the plates. 2 marks

$F = qE$

$= 5 \times 10^{4} \times 1.6 \times 10^{-19}$

8×10^{-15} N

c. Calculate the speed of the electrons as they exit the electron gun. Ignore any relativistic effects. Assume that the initial speed of the electrons is zero. 2 marks

$qV = \frac{mv^2}{2}$

$v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 5000}{9.1 \times 10^{-31}}}$

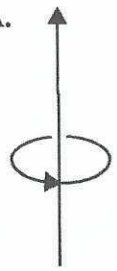
4.2×10^{7} m s^{-1}

Question 3

A straight wire carries a current of 10 A.

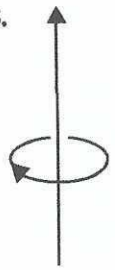
Which one of the following diagrams best shows the magnetic field associated with this current?

A.



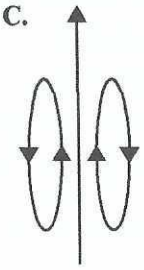
10 A

B.



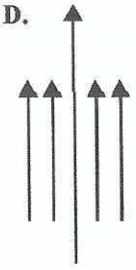
10 A

C.



10 A

D.



10 A

Question 4 81 %.

A small sphere has a charge of 2.0×10^{-6} C on it. Take $k = 8.99 \times 10^{9}$ N m^2 C^{-2}.

The strength of the electric field due to this charge at a point 3.0 m from the sphere is best given by

A. 2.0×10^{-3} V m^{-1}

B. 6.0×10^{-3} V m^{-1}

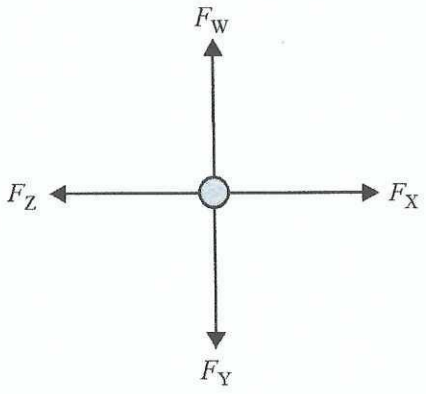
C. 9.0×10^{-3} V m^{-1}

D. 2.0×10^{3} V m^{-1}

$E = \frac{kq}{r^2} = \frac{8.99 \times 10^{9} \times 2 \times 10^{-6}}{3^2}$

Question 5

Four students are pulling on ropes in a four-person tug of war. The relative sizes of the forces acting on the various ropes are $F_W = 200$ N, $F_X = 240$ N, $F_Y = 180$ N and $F_Z = 210$ N. The situation is shown in the diagram below.



Which one of the following **best** gives the magnitude of the resultant force acting at the centre of the tug-of-war ropes?

A. 28.3 N

B. 30.0 N

C. 36.1 N

D. 50.0 N

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (5 marks)

An electric field accelerates a proton between two plates. The proton exits into a region of uniform magnetic field at right angles to its path, directed out of the page, as shown in Figure 1.

Data

mass of proton	1.7×10^{-27} kg
charge on proton	$+1.6 \times 10^{-19}$ C
accelerating voltage	10 kV
distance between plates	20 cm
strength of magnetic field	2.0×10^{-2} T

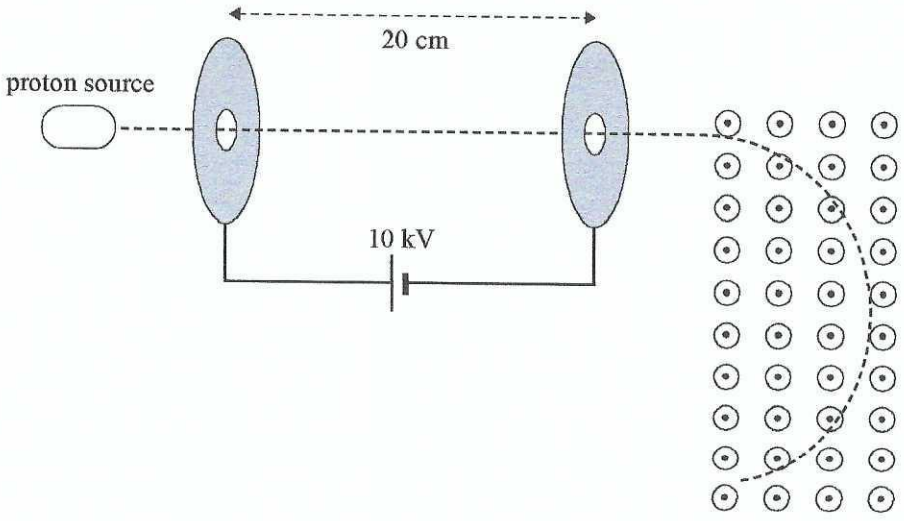


Figure 1

a. Calculate the strength of the electric field between the plates. 1 mark

82%

$E = \frac{V}{d} = \frac{10 \times 10^3}{0.2}$

50 000 V m^{-1}

b. Calculate the speed of the proton as it exits the electric field. Show your working. 2 marks

57%

$qV = \frac{mv^2}{2}$

$v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 10^4}{1.7 \times 10^{-27}}}$

1.4×10^6 m s^{-1}

c. With a different accelerating voltage, the proton exits the electric field at a speed of 1.0×10^6 m s^{-1}.

Calculate the radius of the path of this proton in the magnetic field. Show your working. 2 marks

m

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.
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If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (7 marks)

Electrons are accelerated from rest between two plates that are 50 cm apart, as shown in Figure 1.
The electrons emerge from the second plate at a speed, v, of 4.2×10^7 m s^{-1}.
Ignore relativistic effects.

Data

mass of electron	9.1×10^{-31} kg
charge on electron	-1.6×10^{-19} C

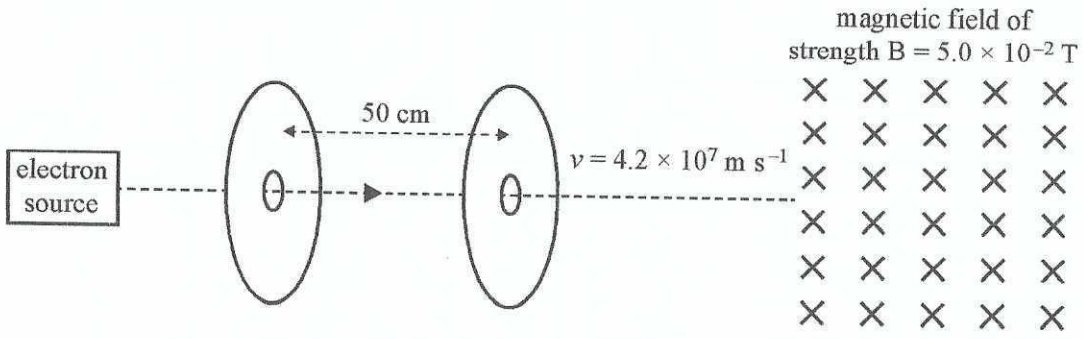


Figure 1

a. Calculate the voltage between the two plates. Show your working. 3 marks

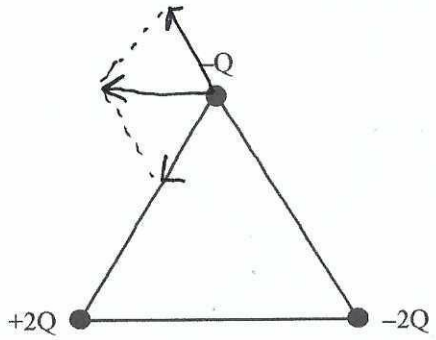
$qV = \frac{mv^2}{2}$

$V = \frac{mv^2}{2q} = \frac{(9.1 \times 10^{-31}) \times (4.2 \times 10^7)^2}{2 \times 1.6 \times 10^{-19}}$

5016 V

Question 3 60%

Three charges (–Q, +2Q, –2Q) are placed at the vertices of an isosceles triangle, as shown below.



Which one of the following arrows best represents the direction of the net force on the charge –Q?

A. ←

B. →

C. ↘

D. ↖

Question 4

The magnitude of the acceleration due to gravity at Earth's surface is g.

Planet Y has twice the mass and half the radius of Earth. Both planets are modelled as uniform spheres.

Which one of the following best gives the magnitude of the acceleration due to gravity on the surface of Planet Y?

A. $\frac{1}{2}g$

B. $1g$

C. $4g$

D. $8g$

Question 2 (2 marks) 69%

Figure 2 shows two equal positive stationary point charges placed near each other.

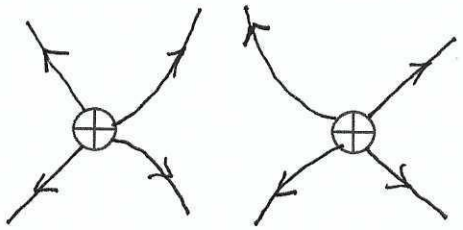


Figure 2

Sketch on Figure 2 the shape and direction of the electric field lines. Use at least **eight** field lines.

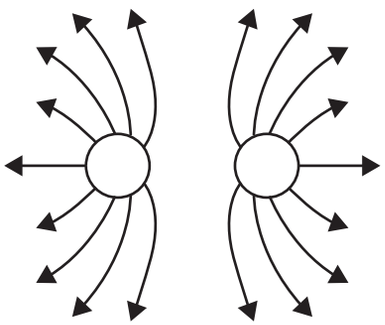
SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 **65 %**

The diagram below shows the electric field lines between two charges of equal magnitude.



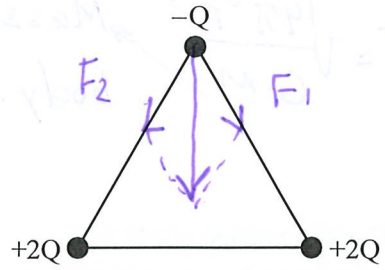
The best description of the two charges is that the

A. charges are both positive.
B. charges are both negative.
C. charges can be either both positive or both negative.
D. left-hand charge is positive and the right-hand charge is negative.

Answer: A Field lines show repulsion so both charges are the same. The field lines originate from the charges so they are both positive.

Question 2

Three charges, –Q, +2Q and +2Q, are placed at the vertices of an equilateral triangle, as shown below.



Which one of the following arrows best represents the direction of the net force on the charge –Q?

A.

B.

C.

D.

Question 3

A 45 g golf ball, initially at rest, is hit by a golf club. The contact time between the club and the ball is 0.50 ms. The magnitude of the final velocity of the ball is 41 m s^{-1}.

Which one of the following is closest to the average force experienced by the golf ball?

A. 0.18 kN
B. 0.37 kN
C. 1.8 kN
D. 3.7 kN

$Ft = \Delta p$

$F = \frac{\Delta p}{t} = \frac{45 \times 10^{-3} \times 41}{0.5 \times 10^{-3}}$

Question 4

A person has a mass of 60.0 kg.

Which one of the following is closest to the weight of this person on Earth's surface?

A. 60.0 kg
B. 60.0 N
C. 588 kg
D. 588 N

mg

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (3 marks)

A small sphere carrying a charge of –2.7 μC is placed between charged parallel plates, as shown in Figure 1. The potential difference between the plates is set at 15.5 V, which just holds the sphere stationary. The electric field between the plates is uniform.

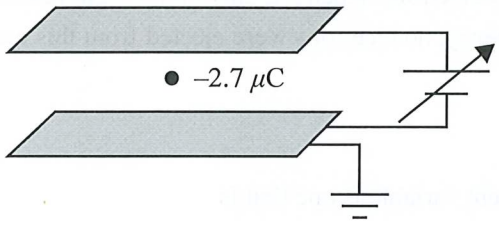


Figure 1

a. In which direction (up, down, right, left) will the sphere move if the voltage is increased? 1 mark

Up

Negative charge is attracted to positive plate. When V↑, electric force > gravity

b. Calculate the value of the electric force that is holding the sphere stationary if the plates are 2.0 mm apart. Show your working. 2 marks

$F = qE \quad E = \frac{V}{d}$

$F = \frac{2.7 \times 10^{-6} \times 15.5}{0.002}$

0.021 N

Question 2 (8 marks)

An electron is accelerated from rest by a potential difference of V_0. It emerges at a speed of 2.0×10^7 m s^{-1} into a magnetic field, B, of strength 2.5×10^{-3} T and follows a circular arc, as shown in Figure 2.

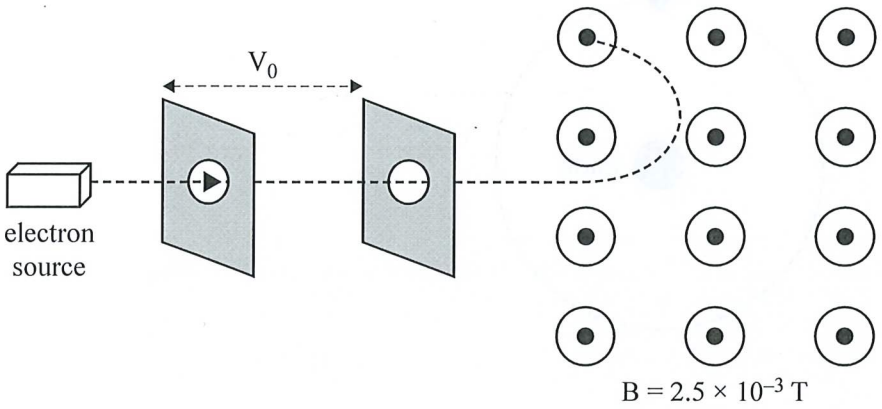


Figure 2

a. Calculate the value of the accelerating voltage, V_0. Show your working. 3 marks

$qV = \frac{1}{2}mv^2$

$V = \frac{9.1 \times 10^{-31} \times (2 \times 10^7)^2}{2 \times 1.6 \times 10^{-19}}$

1.1 kV

b. Explain why the path of the electron in the magnetic field follows a circular arc. 2 marks

Magnetic force on the electron is always at the right angle to their velocity and constant in magnitude.

c. Calculate the radius of the path travelled by the electron. Show your working. 3 marks

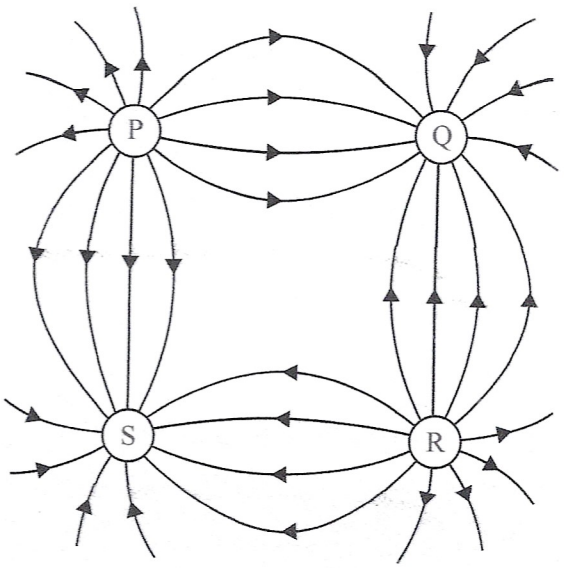
$qvB = \frac{mv^2}{r}$ $r = \frac{mv}{qB}$

$r = \frac{9.1 \times 10^{-31} \times 2 \times 10^7}{1.6 \times 10^{-19} \times 2.5 \times 10^{-3}}$

0.046 m

Question 2 92 %

The diagram below shows the electric field lines between four charged spheres: P, Q, R and S.
The magnitude of the charge on each sphere is the same.



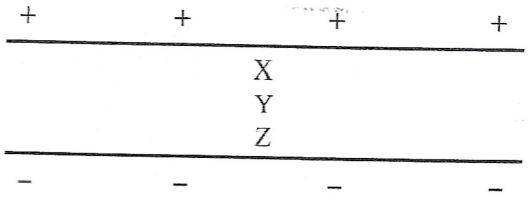
Which of the following correctly identifies the type of charge (+ positive or − negative) that resides on each of the spheres P, Q, R and S?

	P	Q	R	S
A.	−	+	−	+
B.	+	−	+	−
C.	−	−	+	+
D.	+	+	−	−

Electric field directed from positive to negative.

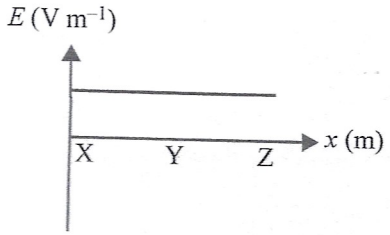
Question 3 56%.

The diagram below shows two parallel metal plates with opposite charges on each plate.
X, Y and Z represent different distances from the positive plate.

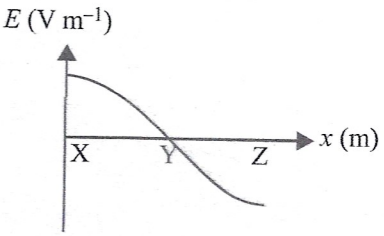


Which one of the following graphs best shows the electric field strength, E, versus the position, x, between the two parallel plates?

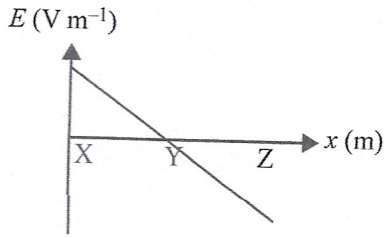
A.



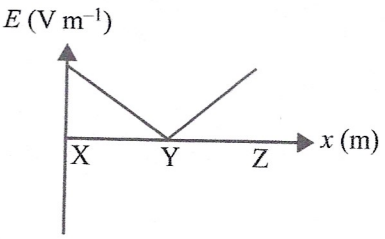
B.



C.



D.



Between parallel plates electric field is uniform.

Question 5 (9 marks)

Figure 5 shows a stationary electron (e^-) in a uniform magnetic field between two parallel plates. The plates are separated by a distance of 6.0×10^{-3} m, and they are connected to a 200 V power supply and a switch. Initially, the plates are uncharged. Assume that gravitational effects on the electron are negligible.

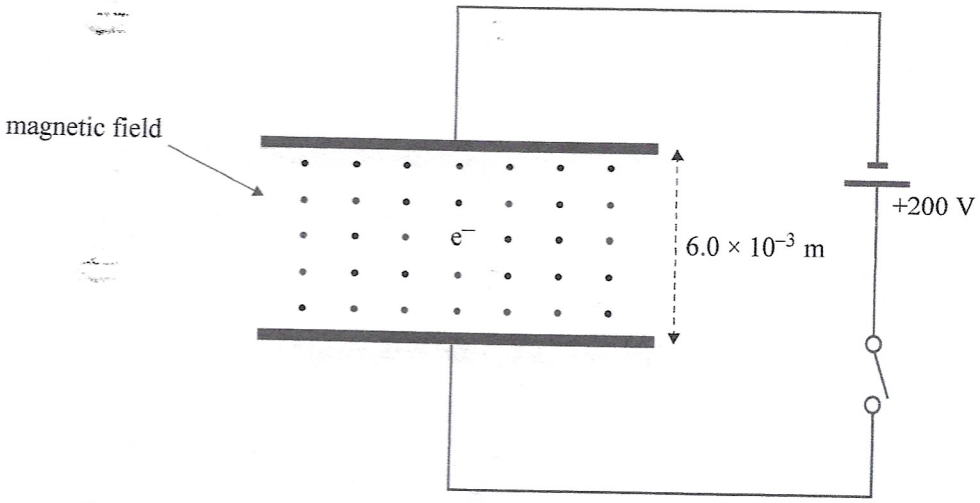


Figure 5

The switch is now closed.

b. Determine the magnitude and the direction of any electric force now acting on the electron. Show your working.

3 marks

30%.

$F = qE \quad E = \frac{V}{d}$

$F = \frac{qV}{d} = \frac{200 \times 1.6 \times 10^{-19}}{6.0 \times 10^{-3}} = 5.3 \times 10^{-15}\ N$

Negative electron attracted to positive plate

5.3×10^{-15} N	Direction Down

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (4 marks)

A particle with mass m and charge q is accelerated from rest by a potential difference, V. The only force acting on the particle is due to the electric field associated with this potential difference.

a. Show that the speed of the particle is given by $v = \sqrt{\frac{2qV}{m}}$ and state the principle of physics used in your answer. 2 marks

Conservation of energy

$qV = \frac{mv^2}{2}$

$v = \sqrt{\frac{2qV}{m}}$

b. Calculate the speed of an electron accelerated from rest by a potential difference of 200 V. 2 marks

$v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 200}{9.1 \times 10^{-31}}} =$

8.4×10^{6} m s^{-1}

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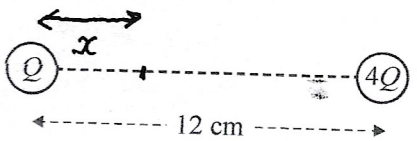
Question 4 18%

Two point charges, Q and $4Q$, are placed 12 cm apart, as shown in the diagram below.



On the straight line between the charges Q and $4Q$, the electric field is

A. non-zero everywhere.

B. zero at a point 2.4 cm from Q.

C. zero at a point 3 cm from Q.

D. zero at a point 4 cm from Q.

$$k\frac{q}{x^2} = k\frac{4q}{(12-x)^2}$$

$$\left(\frac{12-x}{x}\right)^2 = 4$$

$$\frac{12-x}{x} = 2$$

$$3x = 12$$

$$x = 4$$

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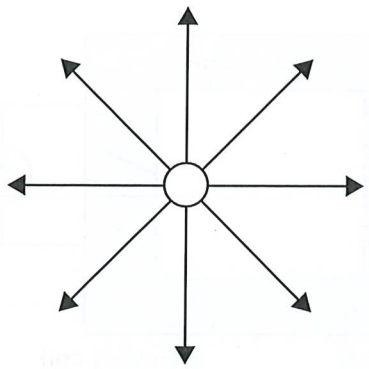
Question 2

Consider the diagram below, which shows a stationary object with field lines that extend outwards from the object.



The field shown is most likely to be identified as an example of

A. an electric field that is uniform.

B. an electric field that is non-uniform.

C. a gravitational field that is uniform.

D. a gravitational field that is non-uniform.

Gravitational field has direction to the object. Spacing between lines increases – non-uniform.

Question 3

Two identical satellites, S_1 and S_2, each of mass m, are placed into two circular orbits around Earth. Satellite S_1 has an orbital radius of $5R$. Satellite S_2 has an orbital radius of R.

Which one of the following best gives the value of $\frac{\text{gravitational force exerted on } S_1 \text{ by Earth}}{\text{gravitational force exerted on } S_2 \text{ by Earth}}$?

A. $\frac{1}{25}$

B. $\frac{1}{10}$

C. 10

D. 25

$F_1 = G\frac{mM}{(5R)^2}$ $F_2 = G\frac{mM}{R^2}$ $\frac{F_1}{F_2} = \frac{1}{25}$

Question 4

Which one of the following statements about the polarisation of waves is correct?

A. Transverse waves can be polarised.

B. Longitudinal waves can be polarised.

C. Both longitudinal and transverse waves can be polarised.

D. Neither longitudinal nor transverse waves can be polarised.

Polarisation (limiting oscillations to one plane) can be achieved only with transverse waves

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
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If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (3 marks)
Two small charges, A and B, are placed 6.0 cm apart in a straight line, as shown in Figure 1.

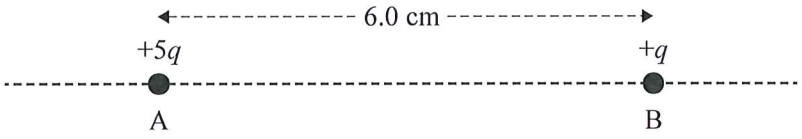

Figure 1

Charge A has a magnitude of $+5q$ coulombs and charge B has a magnitude of $+q$ coulombs.

If the force exerted by charge A on charge B is 5.1×10^{-24} N to the right, determine the value of q.

$F = K \frac{q_1 q_2}{r^2}$ $\quad 5.1\times10^{-24} = 8.99\times10^{9} \times \frac{5q}{0.06^2}$ (1)

$q = \sqrt{\frac{5.1\times10^{-24}\times 0.06^2}{5\times 8.99\times10^{9}}} = 6.39\times10^{-19}$ (1)

(1)

6.4×10^{-19} C

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DO NOT WRITE IN THIS AREA

Question 2 (3 marks)

A positively charged particle carrying a charge of $+1.5 \times 10^{-8}$ C enters a region between two large, charged plates with opposite charges, as shown in Figure 2.

The potential difference between the plates is 2.0 kV, and the kinetic energy of the charged particle as it enters the hole is 2.8×10^{-5} J. Ignore gravitational effects and air resistance.

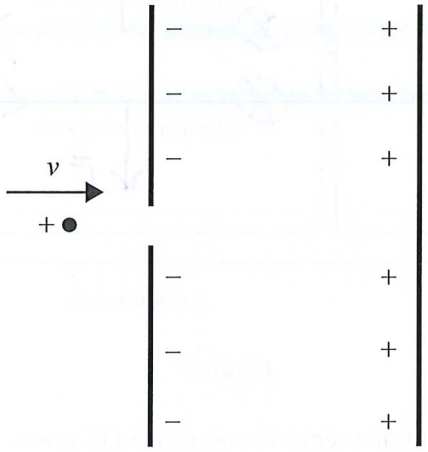

Figure 2

Ariel and Jamie discuss what they think will happen to the particle after it enters the region between the two equally but oppositely charged plates.

Ariel says that the particle has insufficient kinetic energy to reach the positively charged plate and will travel part of the way before returning towards the negatively charged plate.

Jamie says that the particle will collide with the positively charged plate and then head back towards the negatively charged plate.

Evaluate Ariel and Jamie's statements, giving clear reasons for your answer.

$E_K = qV$ when particle stop (1)

$V = \frac{2.8 \times 10^{-5}}{1.5 \times 10^{-8}} = 1.87 \times 10^3$ (1)

As $1.87 < 2$ particle will momentarily stop before reaching positive plate and then will move towards negative plate. (1)

Ariel is correct, Jamie is wrong.

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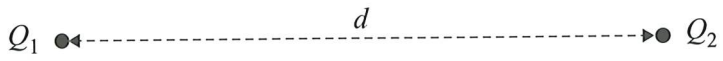
Question 2

The diagram below shows two charges, Q_1 and Q_2, separated by a distance, d.



There is a force, F, acting between the two charges.

Which one of the following is closest to the magnitude of the force acting between the two charges if both d and the charge on Q_1 are halved?

A. $\frac{F}{4}$

B. F

C. $2F$

D. $4F$

Question 3

Space scientists want to place a satellite into a circular orbit where the gravitational field strength of Earth is half of its value at Earth's surface.

Which one of the following expressions best represents the altitude of this orbit above Earth's surface, where R is the radius of Earth?

A. $\frac{\sqrt{2}R}{2} - R$

B. $\sqrt{2}R$

C. $\left(\sqrt{2}R\right) - R$

D. $2R - \sqrt{2}R$

$g = G\frac{M}{R^2}$

$g \div 2 \longrightarrow R \times \sqrt{2}$

$h = \sqrt{2}R - R = R(\sqrt{2} - 1)$