Key

Unit 2 – Forces & Fields

___/ 22 marks

Q14: A current-carrying conductor that is 4.00×10^{-2} m long is placed perpendicular to a magnetic field that has a strength of 6.00×10^{-2} T. During a 20.0 second time interval, 7.00×10^{19} electrons pass a point in the conductor. The magnitude of the average magnetic force exerted on the conductor, expressed in scientific notation, is ***a.bc*** $\times 10^{-d}$ N. The values of ***a, b, c,*** and ***d*** are ____, ____, ____, and ____.

*(Record your **four digit** answer in the Numerical Response boxes below)*

1	3	4	3

$I = \frac{\Delta Q}{\Delta t} = \frac{(7.00\times10^{19})(1.60\times10^{-19})}{(20)} = 0.56 A$

$F_m = qv|\vec{B}|$ or $F_m = IL|\vec{B}|$

$F_m = (0.56)(4.00\times10^{-2})(6.00\times10^{-2})$

$= 0.001344 N$

$\approx 1.344\times10^{-3} N$

$= 1.34\times10^{-3} N$

Q15: In a Millikan-type apparatus, a plastic sphere that has a mass of 6.0×10^{-15} kg is suspended in an electric field that has a strength of 2.0×10^{4} N/C. The charge on the sphere is

a) 1.6×10^{-19} C
b) 3.0×10^{-19} C
(c) 2.9×10^{-18} C
d) 2.8×10^{-17} C

$F_g = F_e$

$mg = q|\vec{E}|$

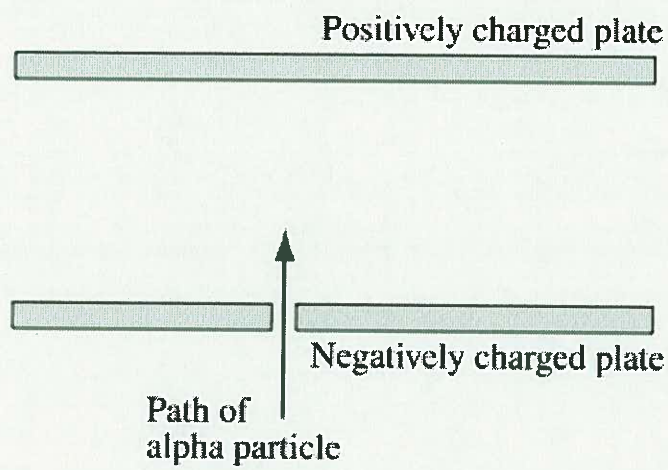
$(6.0\times10^{-15})(9.81) = (q)(2.0\times10^{4})$

$q = 2.943\times10^{-18} C$

KEY

Use the following information to answer Q16:

Two oppositely charged parallel plates have an electric potential difference of 1.2×10^2 V across them. The plates are 4.5×10^{-2} m apart. An alpha particle enters the region between the plates through a hole in the negatively charged plate and comes to rest just before it reaches the positively charged plate.



Q16: The initial speed of the alpha particle as it enters the electric field is

a) 1.1×10^5 m/s
b) 5.1×10^5 m/s
c) 5.4×10^5 m/s
d) 7.6×10^5 m/s

$E_k \rightarrow E_p$

$\frac{1}{2}mv^2 \rightarrow q\Delta V$

$\frac{1}{2}(6.65\times10^{-27})v^2 = (2\times1.60\times10^{-19})(1.2\times10^2)$

$v^2 = 11548872180.5$

$v = 107,465.679082$ m/s

$\approx 1.07\times10^5$ m/s

Alternate

$|\vec{E}| = \frac{\Delta V}{\Delta d} = 2666.\bar{6}$ N/C

$\vec{F} = q\vec{E} = 8.5\bar{3}\times10^{-16}$ N

$a = \frac{F}{m} = 1.283\times10^{11}$ m/s

$v_f^2 = v_i^2 + 2ad$

$v_i = 107,465.679081$ m

Q17: One charged object exerts a force, F, on a second charged object. If the distance between the two charged objects is doubled, and the charge on one of the objects is doubled, then the electric force that one charge exerts on the other is

a) $\frac{1}{4}F$

b) $\frac{1}{2}F$

c) F

d) $2F$

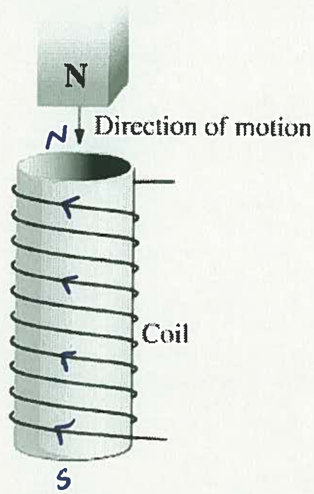
$F_e = \frac{kq_1q_2}{r^2}$

$F_{new} = \frac{k(2q_1)(q_2)}{(2r)^2} = \frac{2kq_1q_2}{4r^2} = \frac{1}{2}F$

KEY

Use the following information to answer Q18:

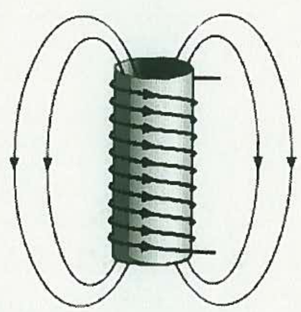
A magnet moves into a coil of wire, as shown below.



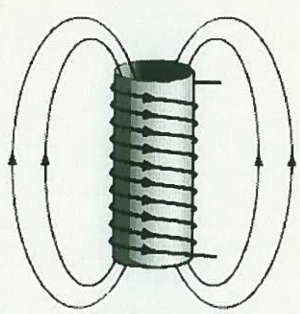
As a result of this motion, a current is induced in the coil and a magnetic field is produced.

Q18: Which of the following diagrams best shows the direction of the induced electron flow in the coil of wire and the direction of the magnetic field around the coil?

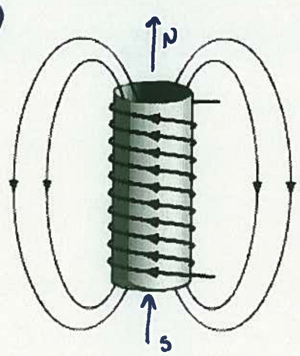
A.



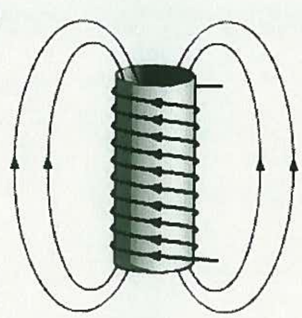
B.



C.

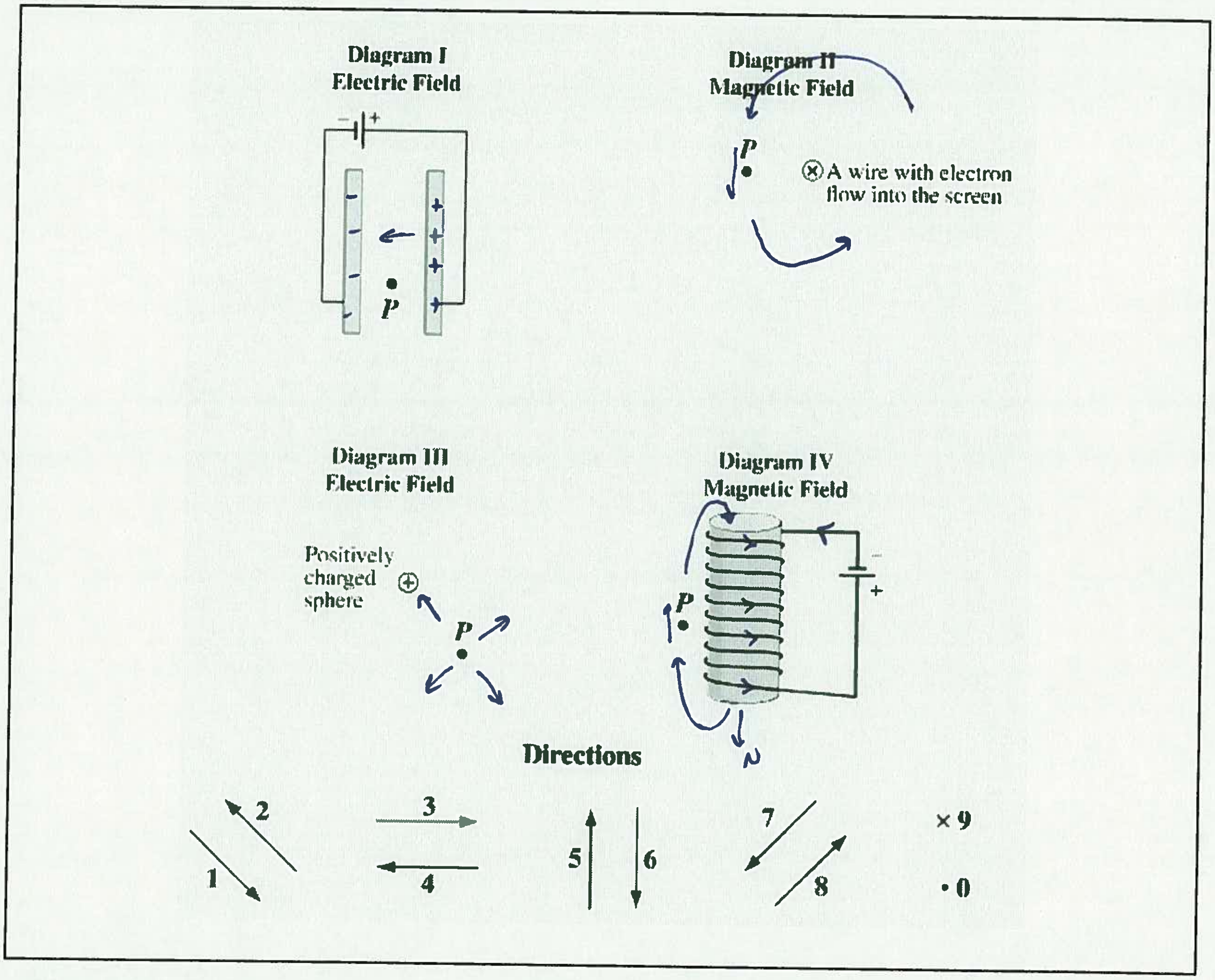


D.



KEY

Use the following information to answer Q19:



Q19: Using the numbers of the directions as given above, match the direction of the field at Point *P* in each diagram as described below.

Number:	← 4	↓ 6	↖ 2	↑ 5
Description:	**Direction of the electric field in Diagram I**	**Direction of the magnetic field in Diagram II**	**Direction of the electric field in Diagram III**	**Direction of the magnetic field in Diagram IV**

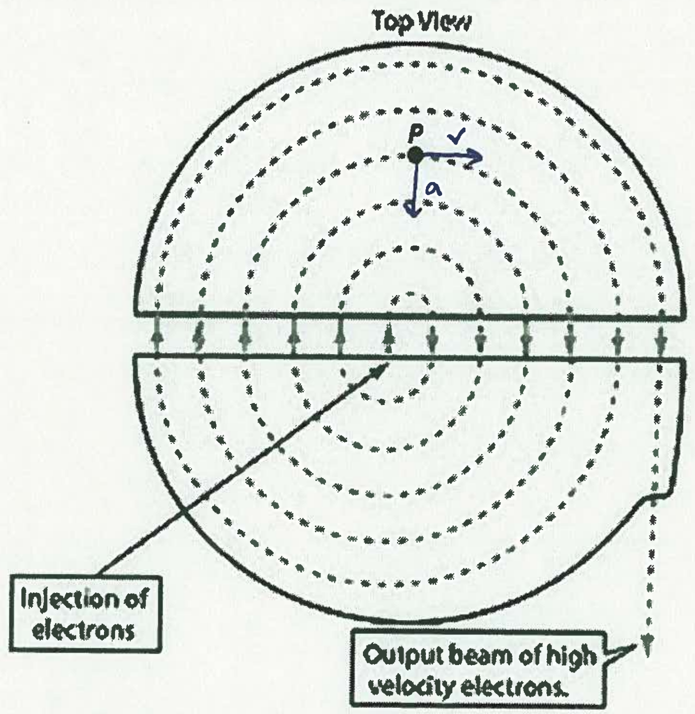
*(Record your **four digit** answer in the Numerical Response boxes below)*

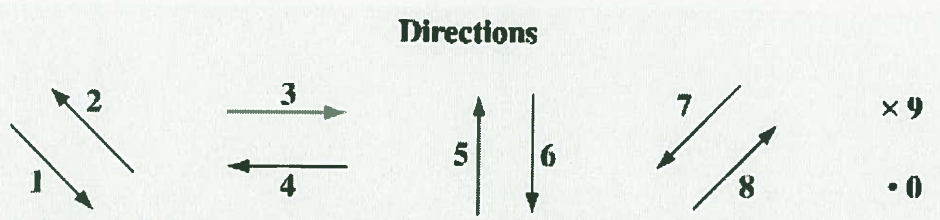
4	6	2	5

[redacted] Key [redacted]

Use the following diagram to answer Q20:

A cyclotron uses a magnetic field to move charged particles in a circular path. It also uses a high frequency power supply to repeatedly accelerate the particles.





Q20: Use the Numerical Response numbers corresponding with directions above to determine the direction of each of the following vector quantities at Point ***P***.

Direction:	→ 3	⊗ 9	↓ 6	↓ 6
Quantity:	Velocity	Magnetic Field	Magnetic Force	Acceleration

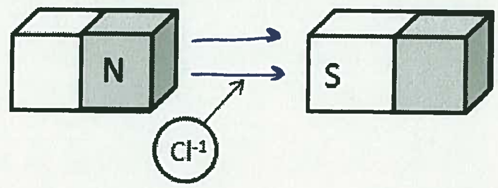
*(Record your **four digit** answer in the Numerical Response boxes below)*

3	9	6	6

■ KEY ■

Use the following diagram to answer Q21-Q22:

A chlorine ion (*Cl^{-1}*) *with a mass of 5.85 x 10^{-26} kg is projected with an energy of 8.50 keV perpendicularly into a magnetic field with a strength of 0.650 T.*



Cl^{-1} means it gained one electron, and has a net −1e charge.

Q21: Based on the information above, the magnetic force of deflection on the chlorine ion will be towards:

a. the left
b. the right
(c.) the top of the page
d. the bottom of the page

Q22: The magnitude of the magnetic force experienced by the Chlorine ion (*Cl^{-1}*) is ***a.b*** x 10^{-cd} N, where ***a,b,c*** and ***d*** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

2	2	1	4

$E_K = 8.50\ keV = \frac{8500\ eV}{1} \times \frac{1.60\times10^{-19}\ J}{1\ eV} = 1.36\times10^{-15}\ J$

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

$1.36\times10^{-15} = \frac{1}{2}(5.85\times10^{-26})v^2$

$v^2 = 4.64957... \times10^{10}$

$v = 2.15628\times10^{5}\ m/s$

$F_m = q|v||\vec{B}|$

$= (1.60\times10^{-19})(2.15628...\times10^{5})(0.650)$

$= 2.24253824444\times10^{-14}\ N$

$\approx 2.24\times10^{-14}\ N$

$= 2.2\times10^{-14}\ N$

KEY

Use the following information to answer Q23:

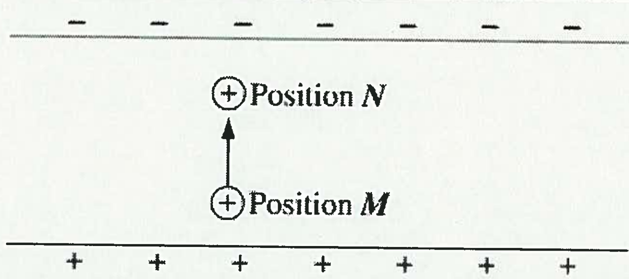
Three Types of Vector Fields
I – Electric
II – Gravitational
III – Magnetic

Q23: An electron is moving through empty space at a constant speed. The vector fields for which the electron is a source are

a) ***I*** and ***II*** only
b) ***I*** and ***III*** only
c) ***II*** and ***III*** only
(d) ***I***, ***II***, and ***III***

Has mass, so $\vec{g}$
Has charge, so $\vec{E}$
Moving charge, so $\vec{B}$

Use the following information to answer Q24:



Q24: A positively charged object is moved from Position *M* to Position *N* in a region between oppositely charged parallel plates as illustrated above. As a result of this change in position, the

a) Electric force on the object has increased Nope! Constant! $|\vec{E}| = \frac{\Delta V}{\Delta d}$ and $\vec{F} = q\vec{E}$
b) Electric force on the object has decreased
c) Electric potential energy of the object has increased
(d) Electric potential energy of the object has decreased → Converted to E_K?

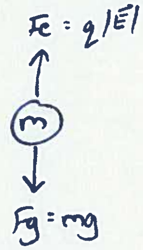
KEY

$a = 0\ m/s^2$ so $F_{net} = 0\ N$

Q25: An oil drop with a mass of 7.20 x 10^{-16} kg moves upward at a constant speed of 2.50 m/s between two horizontal, parallel plates. If the electric field strength between these plates is 2.20 x 10^4 V/m, the magnitude of the charge on the oil drop is ***a.b*** x 10^{-cd} C, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

3	2	1	9



$\vec{F_e} = F_g$

$q|\vec{E}| = mg$

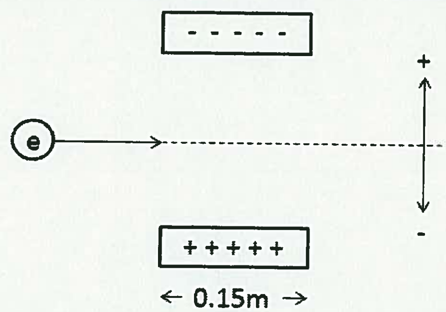
$q(2.20\times10^4) = (7.20\times10^{-16})(9.81)$

$q = 3.2\times10^{-19}\ C$

(or 2e)

Use the following information to answer Q26:

Two parallel plates are 0.45m apart, with a Potential Difference of 13.5V, as shown below. An electron is fired horizontally at 2.4 x10^5 m/s through the plates



Q26: As it passes through the plates, it experiences a vertical deflection of _____ m.

*(Record your **four digit** answer in the Numerical Response boxes below)*

1	.	0	3

① $|\vec{E}| = \frac{\Delta V}{\Delta d} = \frac{13.5}{0.45} = 30\ N/C$

② $\vec{F} = q\vec{E} = (1.60\times10^{-19})(30) = 4.8\times10^{-18}\ N$

③ $a = \frac{F_{net}}{m} = \frac{4.8\times10^{-18}}{9.11\times10^{-31}} = 5.268935236\times10^{12}\ m/s^2$

x-comp

$v_x = \frac{d_x}{t}$

$2.4\times10^5 = \frac{0.15}{t}$

$t = 6.25\times10^{-7}\ s$

y-comp

$d = v_i t + \frac{1}{2}at^2$

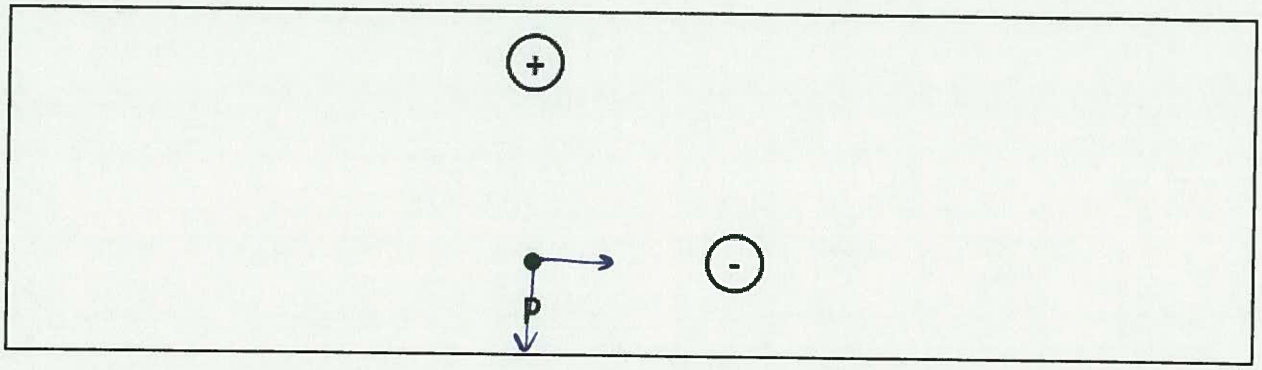
$= \frac{1}{2}(5.2689...\times10^{12})(6.25\times10^{-7})^2$

$= 1.0290889132\ 8m$

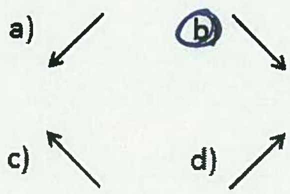
$\approx 1.03\ m$

KEY

Use the following diagram to answer Q27:



Q27: A positively charged object of charge +q and a negatively charged object of charge –q are placed equal distances from a point, P, as per the diagram above. The electric field at point P is:



Q28: Two charged spheres, separated a certain distance, attract each other with an electrostatic force of 8N. What will be the new force if the charge on both spheres is halved and the separation distance is halved?

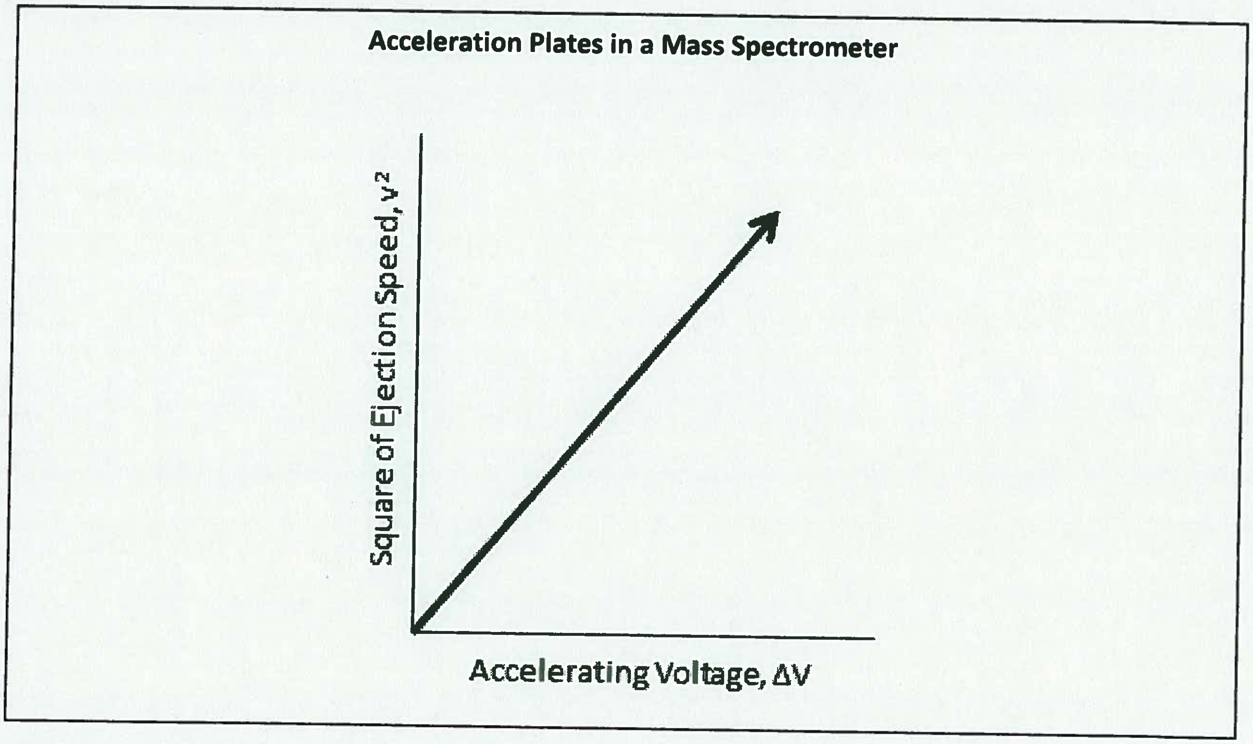
a) 2 N
b) 4 N
c) 8 N
d) 16 N

$F_e = \frac{kq_1q_2}{r^2} = 8N$

$F_{new} = \frac{k(\frac{1}{2}q_1)(\frac{1}{2}q_2)}{(\frac{1}{2}r)^2} = \frac{\frac{1}{4}kq_1q_2}{\frac{1}{4}r} = \frac{kq_1q_2}{r^2} = 8N$

KEY

Use the following information to answer Q29:



Q29: Which of the following expressions best describes the slope of the graph above?

(a) $\frac{2q}{m}$ b. $\frac{2m}{q}$ c. $\frac{q}{2m}$ d. $\frac{m}{2q}$

Acceleration Plates

$E_p \rightarrow E_K$

$q\Delta V \rightarrow \frac{1}{2}mv^2$

$\frac{1}{2}mv^2 = q\Delta V$

$mv^2 = 2q\Delta V$

$v^2 = \frac{2q\Delta V}{m}$

$v^2 = \left(\frac{2q}{m}\right)\Delta V + 0$

$y = (\text{slope})\,x + b$

Q30: Two parallel plates are 0.50m apart. The magnitude of the uniform electric field is 2.5×10^3 N/C. If an electron is pulled to the far right terminal and released, then the electron is moving at ***a.bc*** x 10^d m/s when it strikes the left terminal, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

2	1	0	7

$E_p \rightarrow E_K$

$q\Delta V \rightarrow \frac{1}{2}mv^2$

$|\vec{E}| = \frac{\Delta V}{\Delta d}$

$2.5\times10^3 = \frac{\Delta V}{0.5}$

$\Delta V = 1250\,V$

$(1.60\times10^{-19})(1250) = \frac{1}{2}(9.11\times10^{-31})v^2$

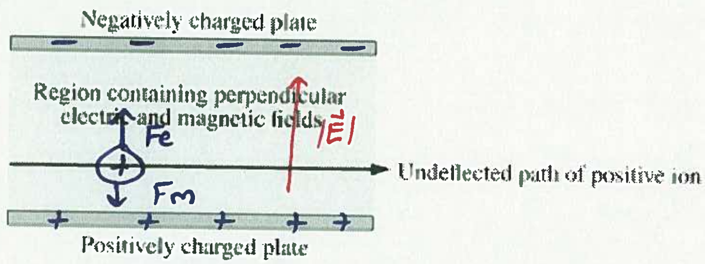
$v = 2.0954186\times10^7$ m/s

$\approx 2.10\times10^7$ m/s

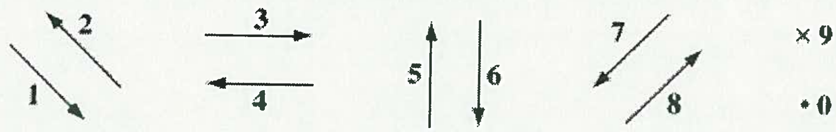
KEY

Use the following information to answer Q31:

A positively charged ion travels through a region that contains perpendicular electric and magnetic fields. The ion passes through the region undeflected at a constant speed.



Directions



Q31: Match the numbers on the directions given above with the descriptions given below.

Direction:	↑ 5	↑ 5	↓ 6	⊙ ∅
Description:	**Direction of the electric force on the ion**	**Direction of the electric field in the region**	**Direction of the magnetic force on the ion**	**Direction of the magnetic field in the region**

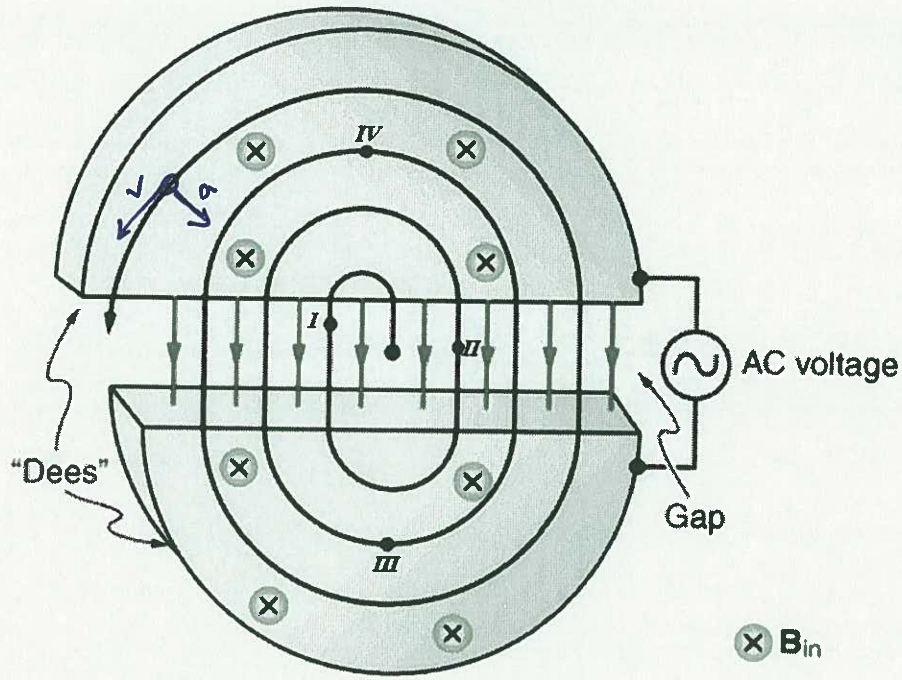
*(Record your **four digit** answer in the Numerical Response boxes below)*

5	5	6	∅

Key

Use the following information to answer Q32-34:

Top view of a Cyclotron



A uniform magnetic field of 3.40mT is directed into the page. At an instance in time, the electric field between the plates is directed downward.

Q32: At the instance shown above, a __*i*__ particle is currently at __*ii*__.

	i	*ii*
(A.)	Positive	Position *I*
B.	Positive	Position *II*
~~C.~~	Negative	Position *I*
~~D.~~	Negative	Position *II*

Magnetic field into page, so particle must be positive.

At position I because that is where the $\vec{E}$-Field would accelerate it.

KEY

Q33: If a proton were travelling at 7.50×10^5 m/s while at Position ***III***, and the potential difference between the plates is 6.25×10^2 V, what is the speed of the proton while at Position ***IV***?

a. 7.50×10^5 m/s
(b.) 8.26×10^5 m/s
c. 1.67×10^6 m/s
d. 1.48×10^7 m/s

$E_{Ki} + E_{Pi} \rightarrow E_{Kf}$

$\frac{1}{2}mv_i^2 + q\Delta V \rightarrow \frac{1}{2}mv_f^2$

$\frac{1}{2}(1.67\times10^{-27})(7.50\times10^5)^2 + (1.60\times10^{-19})(6.25\times10^2) \rightarrow \frac{1}{2}(1.67\times10^{-2}$

$v_f = 8.25990\times10^5$ m/s

Q34: If the proton is at Position ***III*** and travelling at 7.50×10^5 m/s, the radius of curviture is

a. 1.26×10^{-3} m
b. 4.34×10^{-1} m
(c.) 2.30 m
d. 4.60 m

$F_m = F_c$

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

$r = \frac{mv}{qB} = \frac{(1.67\times10^{-27})(7.50\times10^5)}{(1.60\times10^{-19})(3.40\times10^{-3})}$

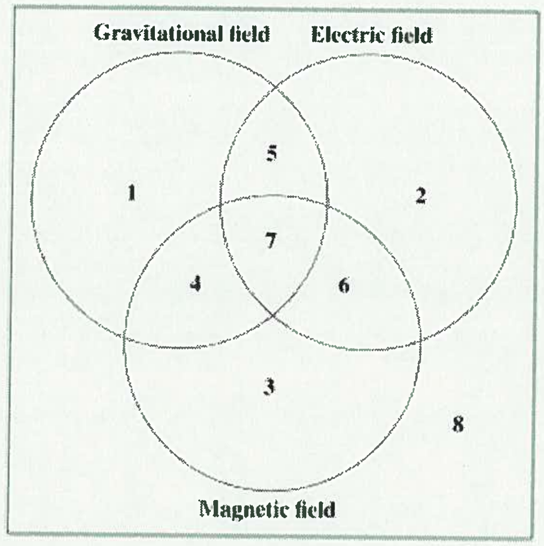
$r = 2.30$ m

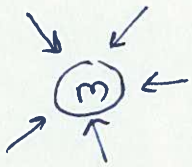
KEY

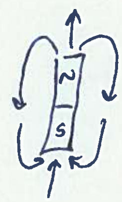
Use the following information to answer Q35:

The Venn diagram below can be used to compare gravitational fields, electric fields, and magnetic fields.

Venn Diagram* of Fields







*In this Venn diagram, the numbered regions represent aspects of fields that are unique to one field (regions 1, 2, and 3), shared by two of the fields (regions 4, 5, and 6), shared by all three of the fields (region 7), or are not an aspect of any of the fields (region 8).

Q35: Match the numbers of the regions in the Venn diagram above with the descriptions given below.

Number:	7	6	5	8
Description:	Can be directed toward the source	Can be directed away from the source	Is inversely proportional to the distance squared	Is directly proportional to the distance squared

Nope.

Mag field varies per $1/r^3$.

*(Record your **four digit** answer in the Numerical Response boxes below)*

7	6	5	8