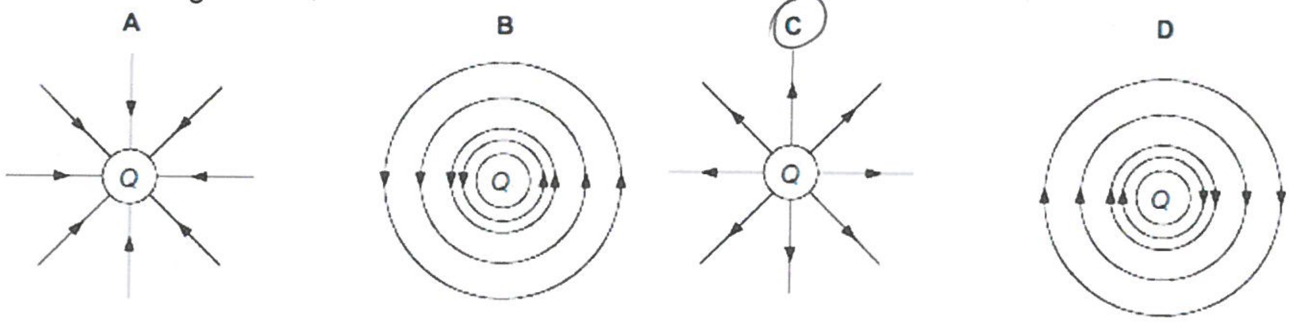
CORPUS CHRISTI COLLEGE SEQUERE DOMINUM	**Year 12** ***ATAR* Physics Unit 4** **2017** ***TEST 6*** ***Charged Particles in E and B Fields*** ***4.0%*** **NAME:** Aelns Data: See Data Sheet Approx. marks shown. ***(56 marks)***

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

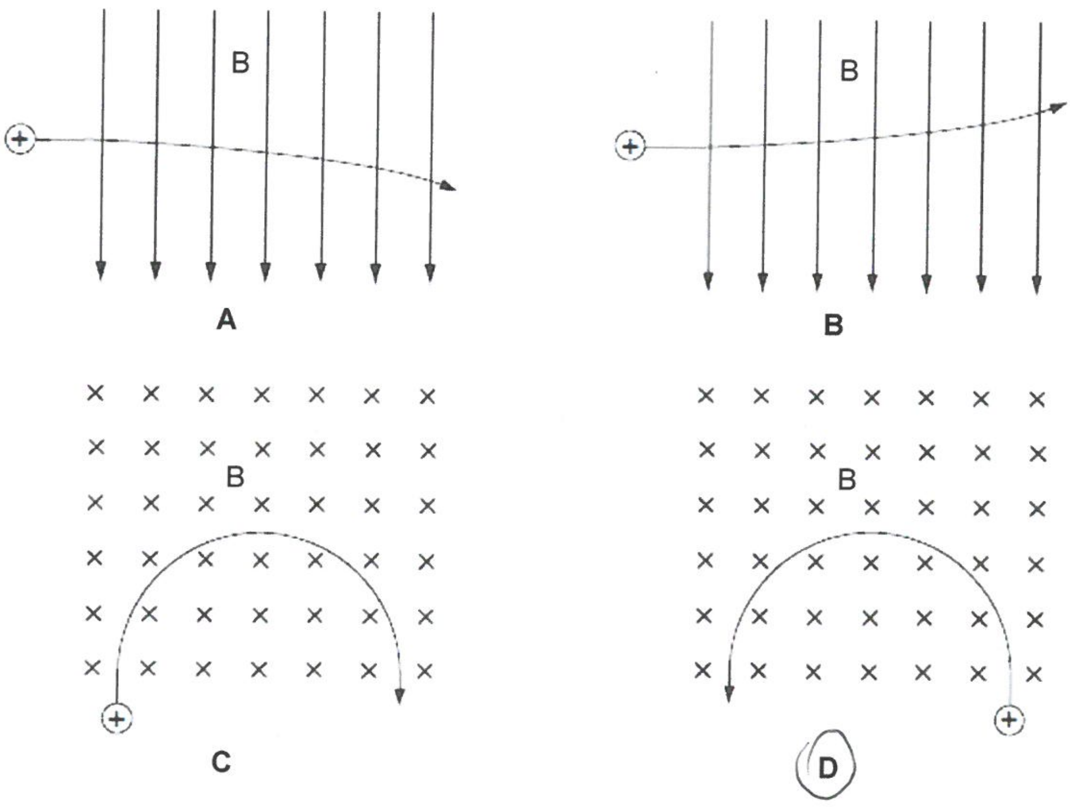
When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

1. Multiple Choice [2]

(a) Which diagram represents the electric field in the vicinity of a positive electric charge of magnitude Q?



(b) A positively charged particle is projected into a region of uniform magnetic field B. Which diagram represents the motion of the particle in the magnetic field?



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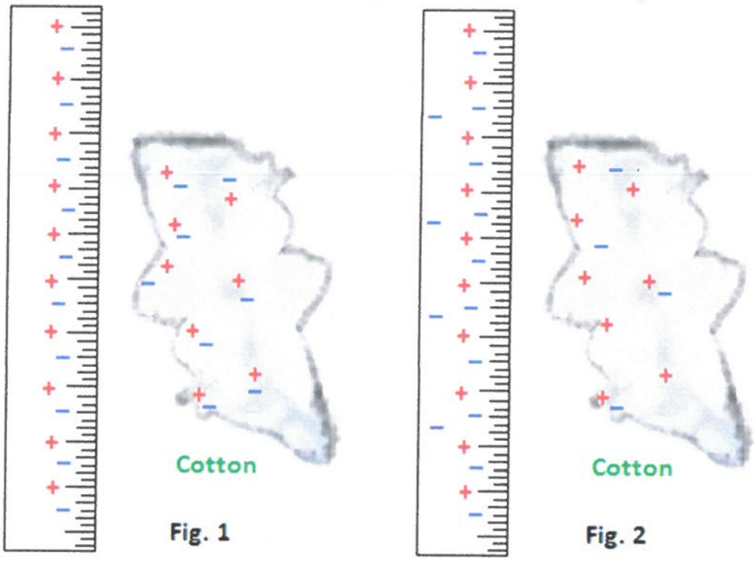
2. Figure 1 shows a piece of cotton and a plastic ruler before they are rubber together. Figure 2 shows the piece of cotton and the plastic ruler after they are rubber together.



(a) Explain briefly why the ruler becomes charged. [2]

The ruler becomes charged because it now has an excess of electrons. The plastic holds ē more tightly than the cotton & when the materials are rubbed together some of the ē are transferred from the cotton to the plastic.

(b) The plastic ruler from Figure 2 repels a rubber rod, so both the ruler and the rod have *positive* *negative* ($\frac{1}{2}$) *neutral* charges. Circle the correct answer/s.
Explain briefly. [1]

Like charges repel. ($\frac{1}{2}$)

(c) The plastic ruler from Figure 2 attracts an acetate rod, so the rod have *positive* ($\frac{1}{2}$) *negative* *neutral* charges. Circle the correct answer/s.
Explain briefly. [3]

Unlike charges attract $\frac{1}{2}$ & so a positive acetate rod would be attracted to the plastic ruler.
Also a neutral acetate rod would be attracted to the plastic ruler due to induction that results from the charge separation in the acetate rod.

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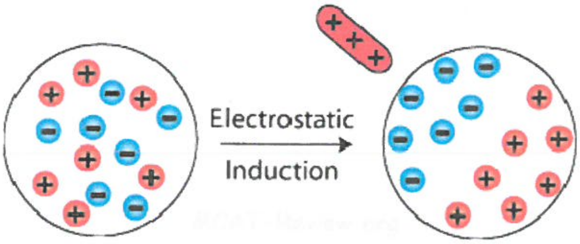
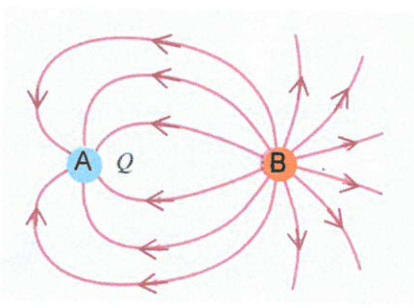
3. A student draws the following diagram to explain electrostatic induction. Comment on the accuracy of the diagram after the rod has been presented. [2]



The diagram is incorrect $(\frac{1}{2})$ The positive charges are located in the nucleus of the atoms, $(\frac{1}{2})$ these do not move due to induction $(\frac{1}{2})$
The movement of the negative charges towards rod $(\frac{1}{2})$ is correct.

4. Consider the following diagram of an electric field around 2 point charges. The magnitude of the charge on A is Q.



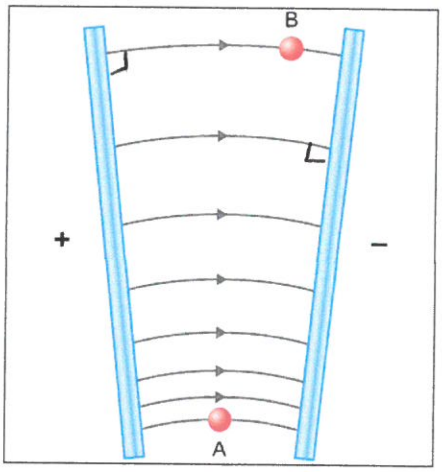
(a) State the signs of the charge on A and B. [2]

A = negative
B = positive

(b) State the magnitude of the charge on B. [1]

2Q (12 lines compared to 6 lines on A)

5. The diagram shows a pair of oppositely charged plates. Explain the electric field distribution in the diagram. [3]



Since the electric field lines must exit & enter the surfaces perpendicular to the surfaces, the lines are curved. ✓
Since $E = V/d$, as the distance between the plates ✓ increases, the electric field strength decreases.
This is represented by having fewer lines. ✓

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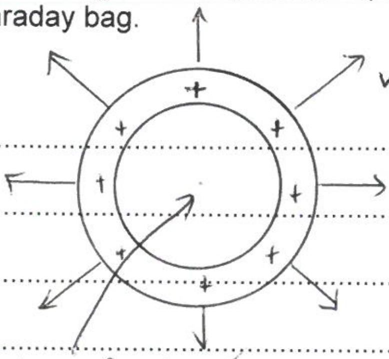
6. Faraday bags are a type of Faraday cage made of flexible metallic fabric. They are typically used to block remote wiping or alteration of wireless devices recovered in criminal investigations, but may also be used by the general public to protect against data theft.

Use a diagram to explain the operation of the Faraday bag. [4]

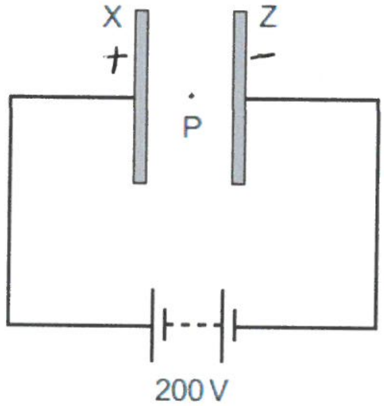


✓ radial E field (neg charge also correct)

No E field ✓

A Faraday cage operates because an external electric field causes the electric charges within the cage's metallic material to be distributed such that they cancel the fields effect in the cages interior. ✓ It acts as a shield for the device ✓ placed inside the cage. ✓ ✓

7. Two large parallel plates X and Z are placed 5.0 mm apart and connected as shown to the terminals of a 200 volt d.c. supply.



A small oil drop at P carries three excess electrons.

What is the magnitude and direction of the electrostatic force acting on the oil drop due to the electric field between the plates? [5]

$1e^- = -1.60 \times 10^{-19}\,C$

$3e^- = x$

$\therefore q = 4.80 \times 10^{-19}\,C$ ✓

$E = \frac{V}{d} = \frac{200}{5 \times 10^{-3}}$ ✓

$= 4 \times 10^{4}\ Vm^{-1}$ ✓

$F = Eq$

$= 4 \times 10^{4} \times 4.8 \times 10^{-19}$

$= 1.92 \times 10^{-14}\,N$

$\therefore$ Force $= 1.92 \times 10^{-14}\,N$ ✓ to left ✓

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8. When two small oppositely charged spheres, considered as point charges, are placed in contact and separated to 1.06 m apart, the force each exerts on the other is 12.0 N.

(a) What is the charge on each sphere after contact? [3]

$F = 9\times10^9 \dfrac{q_1 q_2}{r^2}$

$12 = 9\times10^9 \dfrac{q^2}{(1.06)^2}$ ✓

$\therefore q = \sqrt{1.498\times10^{-9}}$

$= 3.87\times10^{-5}$ C ✓

Both $+3.87\times10^{-5}$ C OR both -3.87×10^{-5} C ✓

(b) Before making contact one of the two small oppositely charged spheres has a charge of 50.0 μC. What is the original charge on the other sphere? Show your working clearly. [3]

average $\dfrac{q_1 + (-q_2)}{2} = 38.7\mu C$ ✓ OR $-38.7\mu C$ ✓

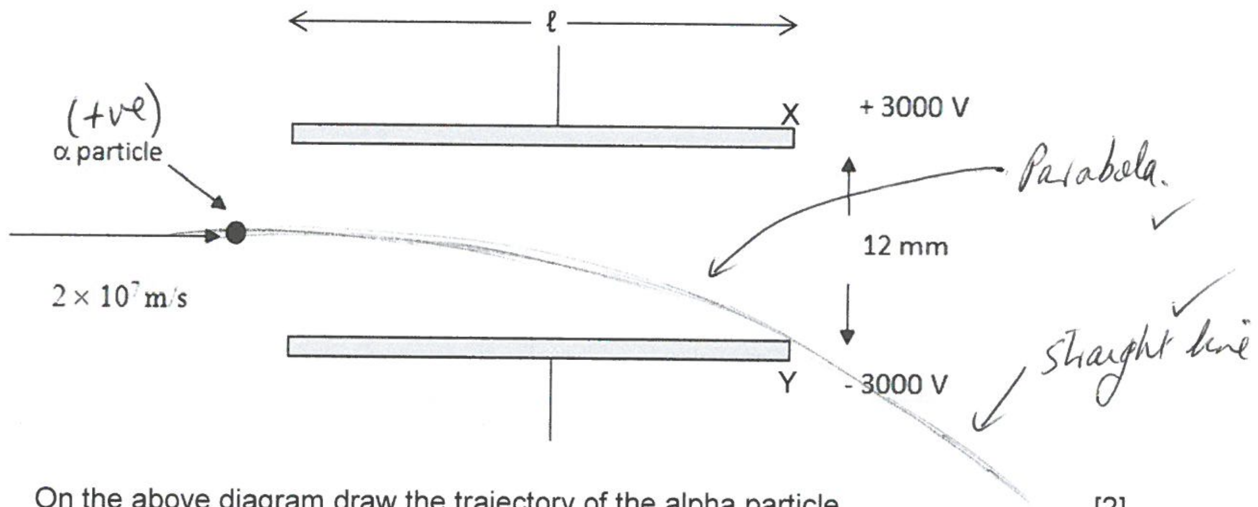
$50 + (-q_2) = 77.4\mu C$ or $-77.4\mu C$

$\therefore -q_2 = 77.4 - 50$ OR $-q_2 = -77.4 - 50$

$q_2 = -27.4\mu C$ $\quad q_2 = +127.4C$

But need opposite charges $q_2 = -127.4\mu C$ ✓ (Check $\dfrac{50 + (-127.4)}{2} = -38.7\mu C$)

9. An alpha particle of mass 6.68×10^{-27} kg travelling with an initial velocity equal to 2.00×10^7 m s^{-1} enters a region of a uniform electric field midway between the parallel plates of length ℓ shown below. The alpha particle is deflected so that it just passes out between the plates (ie at either point **X** or point **Y**)



(a) On the above diagram draw the trajectory of the alpha particle. [2]

(−1 if wrong plate)

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(b) Determine the magnitude of the electric field strength between the parallel plates. [2]

$E = \frac{V}{d} = \frac{6000}{12\times10^{-3}}$ ✓ ✓

$= \underline{5.00\times10^{5}\ V m^{-1}}$ (3sf)

(c) Find the acceleration of the alpha particle. [3]

$F = ma = Eq$ ✓

$a = \frac{5\times10^{5} \times 2(1.6\times10^{-19})}{6.68\times10^{-27}}$ ✓

$= \underline{2.40\times10^{13}\ m s^{-2}}$ (3sf) ✓

(d) Determine the time it takes for alpha particle to just pass out between the plates. [2]

vert

$s = ut + \frac{1}{2}at^{2}$

✓ $6.0\times10^{-3} = 0 + \frac{1}{2}(2.40\times10^{13})t^{2}$

$t = \sqrt{5\times10^{-16}}$ ✓

$= \underline{2.24\times10^{-8}\ s}$

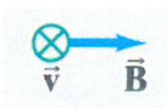
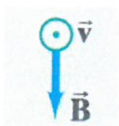
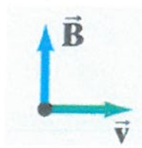
(e) Determine the length ℓ of the parallel plates. [2]

$s = vt$ ✓

$= 2\times10^{7} \times 2.24\times10^{-8}$ ✓

$= \underline{4.47\times10^{-1}\ m = 0.447 m.}$

10. Find the direction of the force on each charged particle for each diagram shown below, where v is the velocity of the charge and **B** is the direction of the magnetic field. (⊗ means the vector points inward. ⊙ means it points outward, toward you.) [4]

Particle is Mg^{2+} ion	Particle is F^{-} ion	Particle is proton	Particle is electron
			
towards bottom of page	left	No force	Into page

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11. The path of a charged particle in a uniform magnetic field is shown below in Figure 1. It travels at 2.0×10^7 m s^{-1} in a plane perpendicular to a uniform 0.010 T magnetic field.

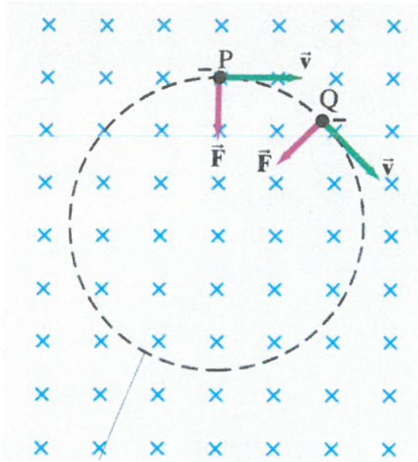

Figure 1

diam = 3.9 cm

(a) State whether the particle is *positive* or *negative.* Circle the correct answer. [1]

(b) Given that the circle shown is full size estimate the charge-to-mass ratio of the particle. [5]

$F_c = F_B$

$\frac{mv^2}{r} = Bvq$ Diameter = 3.9 cm (2sf)

$\frac{q}{m} = \frac{v}{Br} = \frac{2 \times 10^7}{0.01 \times (\cancel{3.9}\frac{}{2} \times 10^{-2})}$

$= 1.026 \times 10^{11}$

$= \underline{1.0 \times 10^{11}}\ \underline{C\,kg^{-1}}$ (2sf)

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(c) Assuming that the beam of particles in (a) is positively charged and passes undeflected at 2.0×10^7 m s^{-1} when passing through perpendicular electric and magnetic fields.

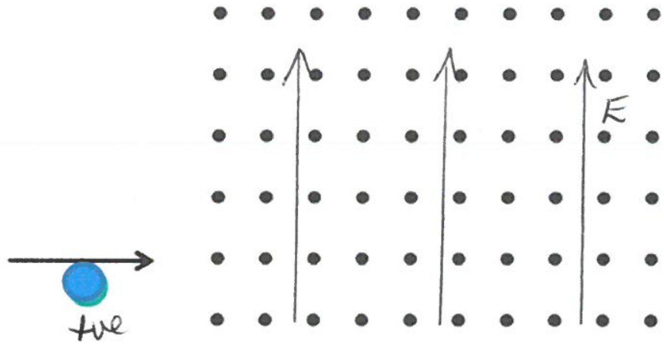

Figure 2

(i) If the magnitude of the electric field is 8.8×10^3 V m^{-1} determine the magnitude of magnetic field. Show your working clearly, including the relevant formulae from the Data Sheet. [3]

$F_{down} = F_{up}$

$(\tfrac{1}{2})\ Bqv = Eq\ (\tfrac{1}{2})$

$B = \dfrac{E}{v} = \dfrac{8.8 \times 10^3}{2 \times 10^7}$ ✓

$= \underline{4.40 \times 10^{-4}\ T}$ ✓

(ii) On Figure 2 show the direction of the electric field. [1]

End of Test

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