Stage 3 Physics: Forces and Motion in Electric and Magnetic Fields

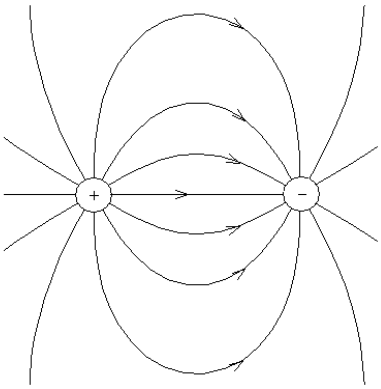
Assignment Name: _____ (40 marks)

1. The title of the unit is Forces and Motion in Electric and Magnetic **Fields.** What is meant by the word 'field' in this instance? (1 mark)

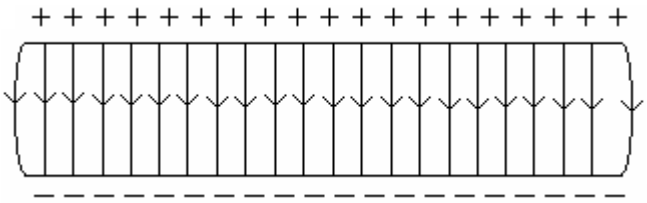
   In this instance, a 'field' is a region where a charged particle experiences a force on it.

2. Draw the field around the following situations. (4 marks)

   a. Two oppositely charged point sources

   b. Two parallel plates oppositely charged negative plate on top.

3. Determine the potential difference between two plates 23.5 mm apart if an electron experiences a force of 1.50×10^{-15} N. (3 marks)

$$E = \frac{F}{q} = \frac{V}{d}$$

$$\frac{1.50 \times 10^{-15}}{1.6 \times 10^{-19}} = \frac{V}{23.5 \times 10^{-3}}$$

$$V = \frac{1.50 \times 10^{-15} \times 23.5 \times 10^{-3}}{1.6 \times 10^{-19}}$$

$$V = 220 \text{ V}$$

4. A positively charged particle with a mass of 2.55×10^{-17} kg and a charge that is twice that of a proton, is suspended between two plates, one above the other. What is the strength of the electric field between the plates. (3 marks)

$$mg = Eq$$

$$E = \frac{mg}{q} = \frac{2.55 \times 10^{-17} \times 9.8}{2 \times 1.6 \times 10^{-19}}$$

$$E = 781 \text{ N C}^{-1}$$

5. Two parallel plates are 2.00 cm apart in a vacuum. A proton leaves the positive plate and moves to the negative plate which has a potential difference of 180 V compared to the other plate.

   a. Calculate the strength of the electric field between the two plates. (2 marks)

$$E = \frac{V}{d} = \frac{180}{0.020}$$

$E = 9.00 \times 10^{3}$ V m^{-1}

   b. Determine the force on the proton. (2 marks)

$F = Eq$
$= 9.00 \times 10^{3} \times 1.6 \times 10^{-19}$
$F = 1.44 \times 10^{-15}$ N

   c. Calculate the maximum speed of the proton. (4 marks)

energy = work = F x s
$= .44 \times 10^{-15} \times 0.02$
$= 2.88 \times 10^{-17}$ J

$E_k = \frac{1}{2} mv^2$
$2.88 \times 10^{-17} = 0.5 \times 1.67 \times 10^{-27} \times v^2$

$$v = \sqrt{\left(\frac{2.88 \times 10^{-17}}{(0.5 \times 1.67 \times 10^{-27})} \right)}$$

$v = 1.86 \times 10^{5}$ m s^{-1}

6. A small charged particle has a charge of 3.20×10^{-7} C. If it experiences a force of 5.40×10^{-4} N west, determine the magnitude and direction of the field at this point. (2 marks)

$$E = \frac{F}{q} = \frac{5.40 \times 10^{-4}}{3.20 \times 10^{-7}}$$

$E = 1.69 \times 10^{3}$ N C^{-1} West

7. An electron travelling at 8.90×10^{5} m s^{-1} enters a magnetic field of 4.00×10^{-2} T. Calculate the force on the electron when it first enters the magnetic field. (2 marks)

$F = Bvq$
$= 4.00 \times 10^{-2} \times 8.90 \times 10^{5} \times 1.6 \times 10^{-19}$
$F = 5.69 \times 10^{-15}$ N

8. A proton, initially at rest, is accelerated through a potential difference of 1.60×10^3 V and then enters a uniform magnetic field of 9.30×10^{-2} T.

   a. Calculate the velocity with which the proton enters the magnetic field. (3 marks)

E_k = work = Vq
½ mv^2 = Vq
$0.5 \times 1.67 \times 10^{-27} \times v^2 = 1600 \times 1.6 \times 10^{-19}$

$$v^2 = \frac{1600 \times 1.6 \times 10^{-19}}{(0.5 \times 1.67 \times 10^{-27})}$$

$= 3.0659 \times 10^{11}$
$v = 5.54 \times 10^5$ m s^{-1}

   b. Determine the radius of the proton within the magnetic field. (3 marks)

$$r = \frac{mv}{Bq} = \frac{1.67 \times 10^{-27} \times 5.54 \times 10^5}{(9.30 \times 10^{-2} \times 1.6 \times 10^{-19})}$$

r = 0.062176

r = 6.22×10^{-2} m

   c. Calculate the time for one revolution of the proton. (2 marks)

$$v = \frac{2\pi r}{T}$$

so $$T = \frac{2\pi r}{v} = \frac{2 \times \pi \times 0.062176}{5.54 \times 10^5}$$

T = 7.05×10^{-7} s

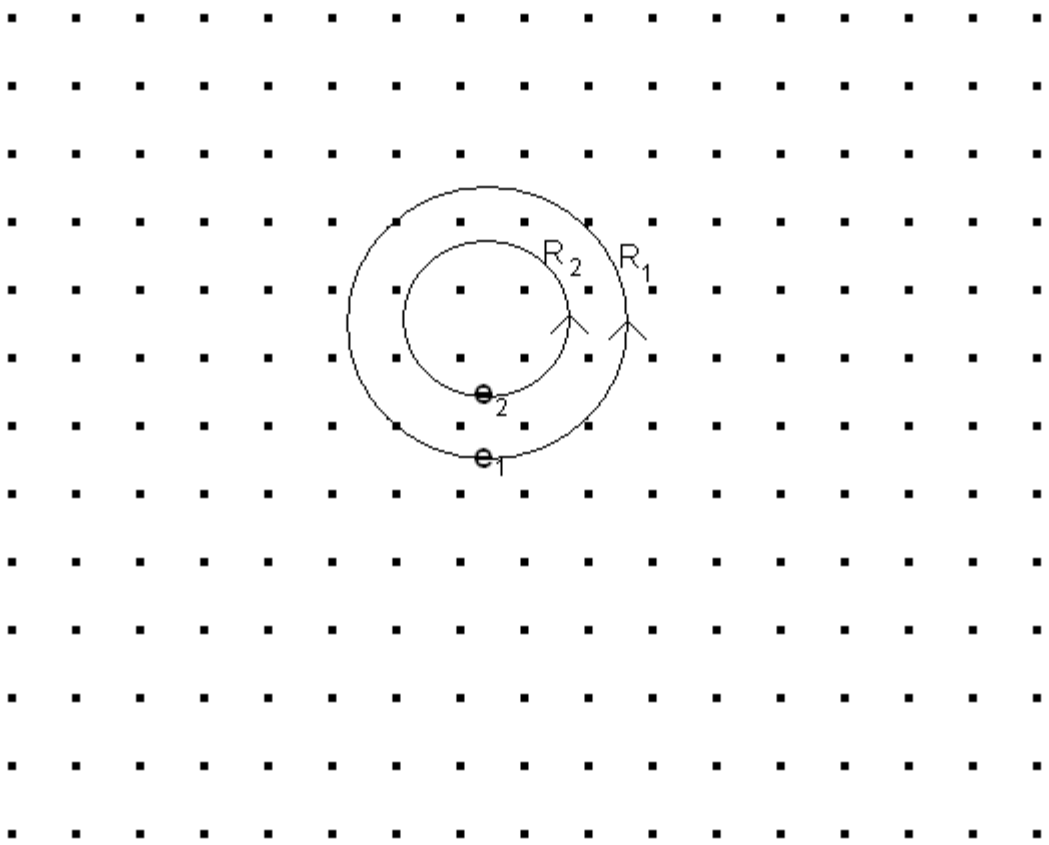
9. Explain the similarities and differences between electric and magnetic fields. (3 marks)

Both are dependent on the charge e.g. magnetic – Bvq; electric - $\frac{F}{q}$

Magnetic field: force is perpendicular to field
proportional to velocity of charged particle

Electric field: force is perpendicular to field
independent of velocity

10. a. At a university, a laboratory technician is conducting tests on the movement of electrons in a uniform magnetic field. The electrons enter the field and move in a circular path. Complete the diagram below to show the path of the fast moving electron (e_1) from the position shown in the field below. Label the path "R_1". (1 mark)



b. If the technician doubles the strength of the uniform magnetic field, and keep all other conditions constant, draw the path traced out by electron (e_2) above. Label its path "R_2". (2 marks)

c. Determine the ratio of the two radii traced out by e_1 and e_2. (3 marks)

$$\frac{R_1}{R_2} = \frac{\frac{mv}{Bq}}{\frac{mv}{2Bq}} = \frac{mv2Bq}{Bqmv} = \frac{2}{1}$$

$R_1 = 2R_2$ or $R_2 = ½ R_1$