8 **(a)** Apart from being different types of forces, state a difference between electric force and magnetic force.

....

....[1]

(b) Two oppositely charged parallel metal plates P and Q are placed in a vacuum. The electric field is uniform in the region between the plates.

A uniform magnetic field also exists in the region between the plates. The direction of the magnetic field is into the page as illustrated in Fig. 8.1.
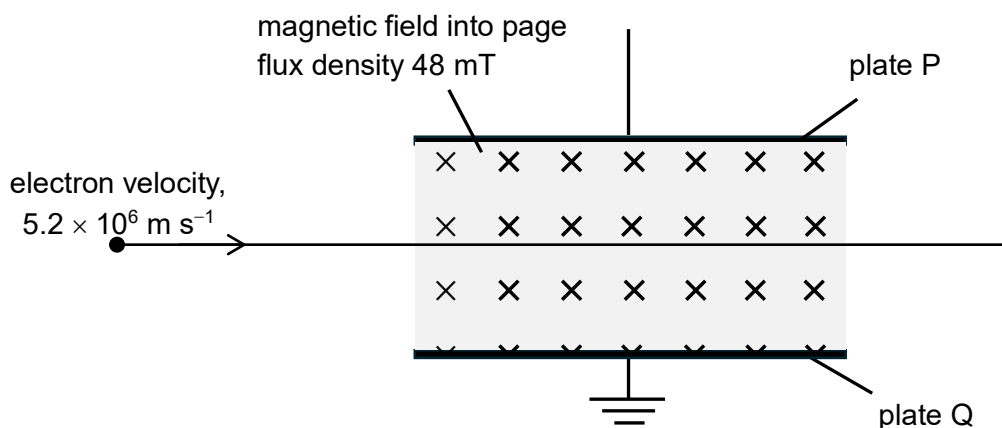

Fig. 8.1

An electron enters the region between the plates at right angles to both the electric field and the magnetic field. The electron travels through the field.

The magnetic flux density is 48 mT. The velocity of the electron is 5.2×10^6 m s^{-1}.

The magnetic force and electric force acts on the electron in opposite directions.

(i) State and explain the polarity, positive or negative, of plate P.

....

....

.....................[2]

(ii) Calculate the magnitude of the magnetic force F_M acting on the electron.

$$F_M = \text{.................................. N [2]}$$

(iii) The electron passes through the field undeflected when the magnitudes of the magnetic and electric forces are the same.

With reference to the forces acting on the electron as it passes through the plates, state and explain how the path will change if the potential across the metal plates is decreased slightly.
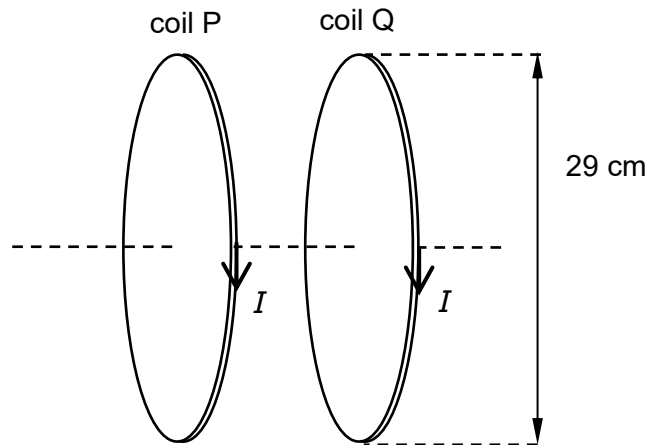
....

....

....

....

..........................[3]

(c) Two flat coils, P and Q each of diameter 29 cm are fixed so that their planes are parallel and are separated by a constant distance equal to the radius of each coil, with the direction of the current as shown in Fig. 8.2.

coil P   coil Q

29 cm

I I

Fig. 8.2

The current I in both coils is 1.3 A.

The magnetic flux density B in the region between the two coils is uniform and given by the expression

$$B = 0.72\,\mu_0\,\frac{NI}{r}$$

where N is the number of turns on each of the flat coil of radius r. The permeability of free space is μ_0.

(i) Explain how a uniform field is set up between the coils.

....

....

....

.........................[2]

**(ii)** Each coil has 160 turns. Show that the magnetic flux density B is approximately 1.3 mT.

[1]

(iii) The space between the coil in **(c)** is a vacuum.

An electron of velocity 5.2×10^6 m s^{-1} travels at right angles into the uniform field produced by the two coils.

Calculate the radius of its orbit in the magnetic field.

radius = ... m [3]

(d) The magnetic field in **(c)** is rotated. The initial direction of the electron is now at an angle of 30° to the direction of the uniform magnetic field, as shown in Fig. 8.3.

coil P coil Q

30°

initial direction of
motion of electron

direction of uniform
magnetic field
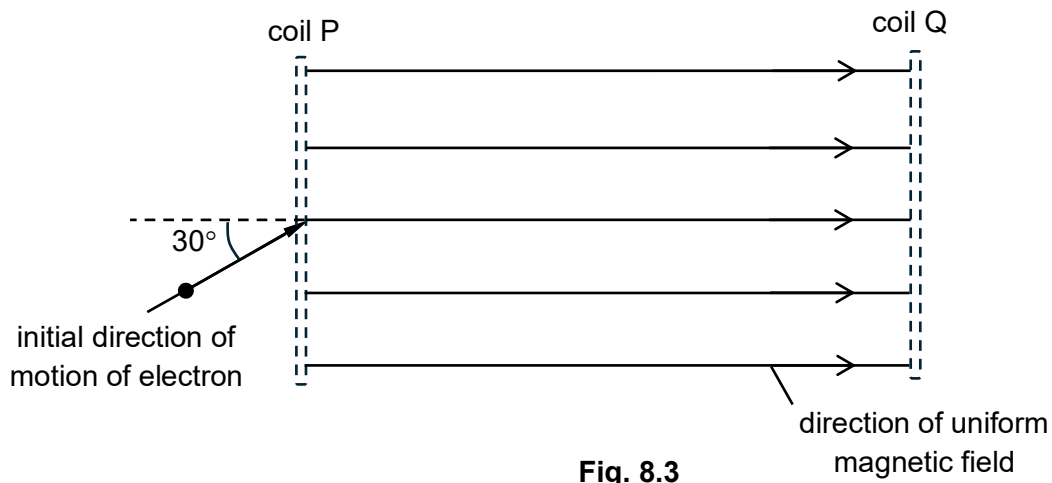
Fig. 8.3

(i) State the path of the election in the magnetic field.

.........................[1]

(ii) By considering the components of the velocity parallel to the magnetic field and at right angles to the magnetic field, explain the motion of the electron as stated in your answer in **(d)(i).**

....

....

....

....

....

.........................[3]

(iii) State and explain how the path of the electron will change if the current I in the coils were increased.

....

....

....

.........................[2]

[Total: 20]

End of Paper