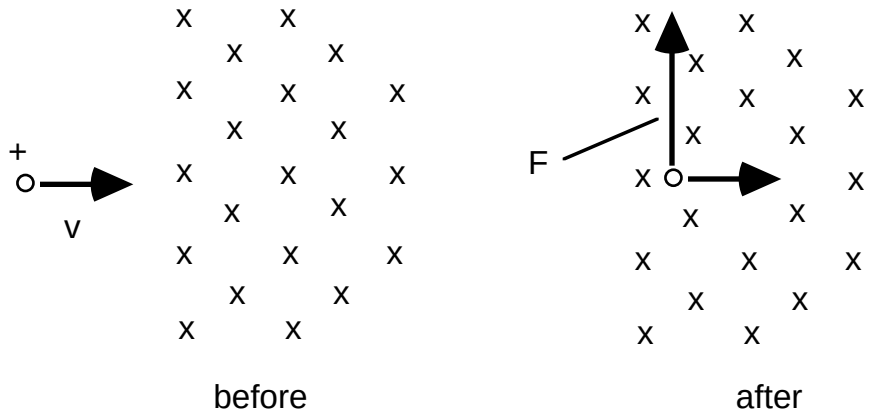
Magnetic Fields and Forces : Notes/W.S.-15

An important problem is that of a moving charge in a magnetic field. If there is no magnetic field, the charge will move in a straight line. But when the charge enters a magnetic field, there is a force which deflects the charge that is perpendicular to both the direction of motion and the field. The direction is given by the right hand rule. A stationary charge experiences no force in a magnetic field.

Example: A proton moves towards the right into a magnetic field. The x's represent a uniform B-field with the direction pointing into the page.



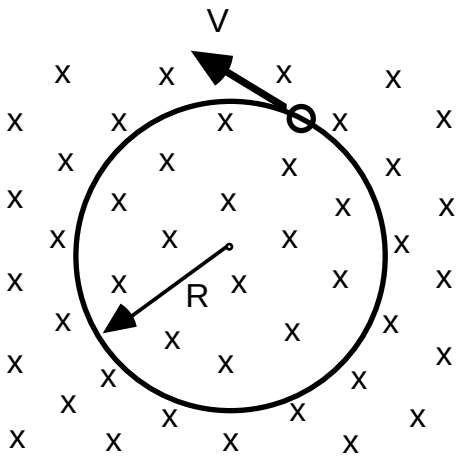
before after

The force on the proton will be up by the right-hand rule. If the region of the field is big enough or the velocity small, the proton will start to move in a circle, as the magnetic force is always perpendicular to both the field direction and the velocity vector. The magnitude of the force is given by:

$$F = q \cdot v \cdot B$$

The charge q is in coulombs, v is in m/s and B is in teslas. The direction of the force is opposite for negative charges.

In the situation shown above, the proton may start to move in a circle as shown below.



The proton moves in a circle of radius R. The velocity is V. The centripetal force is supplied by the magnetic force, so we have:

$$\frac{m \cdot v^2}{R} = q \cdot v \cdot B$$

Problems:

1) A proton enters a field of 0.75 T directed out of the paper.

a) Find the magnitude of the magnetic force, if v = 8.0×10^5 m/s [right].

b) Give the force direction when the proton first enters the field.

c) Find the radius of the circle that the proton will move in, when the it is in the field.

2) An electron enters a field of 1.2 T (into page) with a velocity of 1.8×10^7 m/s [right].

a) Find the magnitude of the magnetic force.

b) Find the direction of the force when the electron first enters the field.

c) Find the radius of the circle that the electron moves in.

d) Find the period of revolution.

3) An airplane with a charge of 50. C flies through the Earth's magnetic field with a velocity of 250 m/s. The magnetic force is 0.72 N. What is the perpendicular component of the Earth's magnetic field?

4)a) Find the force on an alpha particle (Helium nucleus) in a 1.4 T field. The velocity is 1.0×10^{4} m/s (perpendicular to field)

b) Find the radius of the circle.

Answers: 1)a) 9.6×10^{-14} N, b) down (initially), c) 1.1 cm, 2)a) 3.5×10^{-12} N, b) down (initially), c) 8.5×10^{-5} m, d) 3.0×10^{-11} s, 3) 5.8×10^{-5} T, 4)a) 4.5×10^{-15} N, b) 1.5×10^{-4} m.