Magnetic Fields

1 Charged Particles in magnetic fields

Force is always perpendicular to the direction - no change in speed to the electrons.

If electrons are confined to a wire $F = BIl$

The same equation applies for many charges where:

$$I = \frac{Q}{t} \quad l = vt$$

$$F = B \times \frac{Q}{t} \times vt$$
$$F = BQv$$

1.1 The hall probe

This is used to measure the strength of magnetic fields. It consists of a thin slice of semiconductor material with a constant current flowing through it.

The negative charges go to the bottom of the material and so the top is positively charged, this creates a potential difference.

$$F_B = F_E$$
$$BQV = \frac{VQ}{d}$$
$$V = Bvd$$
$$V \propto B$$

By measuring the voltage across the probe the magnetic field strength can be measured.

2 Charged particles in circular orbits

Force will always be perpendicular to the direction of motion
No work is done by the magnetic field on the particles

Direction changes but not speed
Constant kinetic energy

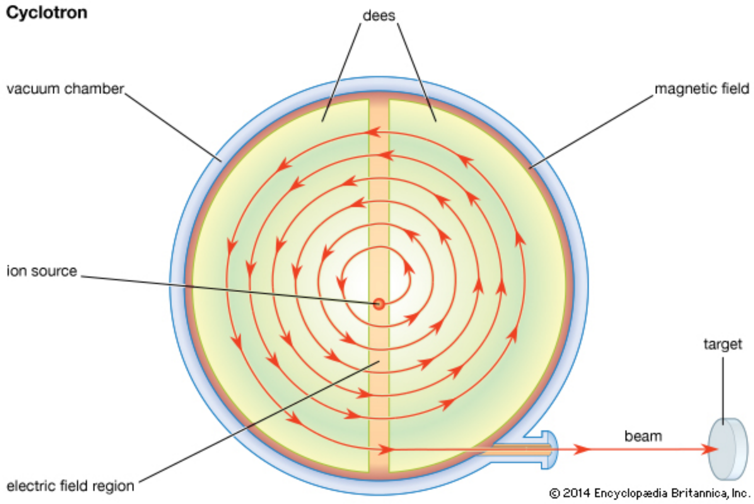
Path is circular
Causes a centripetal acceleration

$$F = BQv = \frac{mv^2}{r}$$
$$r = \frac{mv}{BQ}$$

3 Applications

3.1 Cyclotron

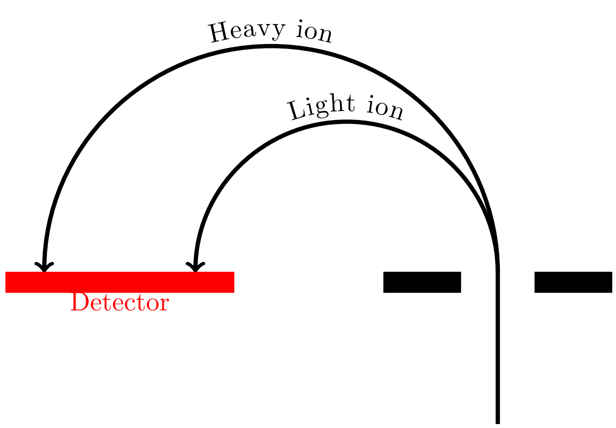
This is used in hospitals to produce high energy beams for radiotherapy.



- Proton source in centre
- Electric field in between C Cores to accelerate protons
- Magnetic field causes curved path
- r increases as v increases

3.2 Mass Spectrometer

This is used to analyse the type of atoms present in a sample

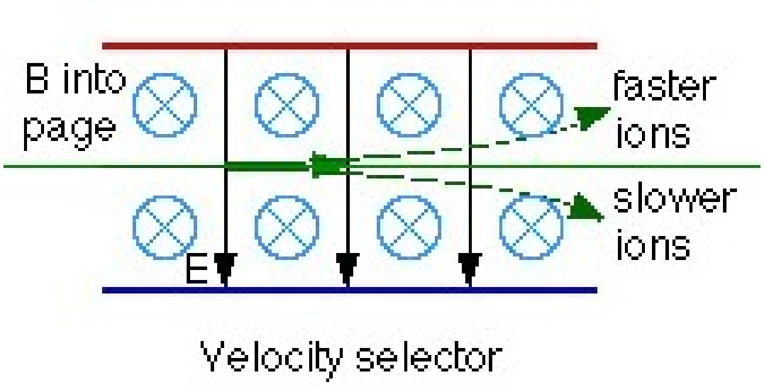


- Magnetic field out of diagram
- Atoms in the sample are ionised
- Directed in a narrow beam into the magnetic field
- Radius of path depends on specific charge

$$r = \frac{mv}{BQ}$$

$$r \propto \frac{1}{\frac{q}{m}}$$

3.2.1 Velocity selector



Negative ions fall to the bottom surface, causing the top surface to have a positive charge, creating a potential difference. For an ion to continue on a straight path the force from the magnetic field up must be equal to the force from the electric field down.

$$F = BQv = EQ$$

$$BQv = \frac{V}{d}Q$$

$$v = \frac{V}{Bd}$$

This means that only particles of speed v will travel through the gap