Force on Charged Particle

To be able to calculate the size and direction of the force on a charged particle in a magnetic field
To be able to describe the motion of a charged particle in a magnetic field
To know what a mass spectrometer is and how it works.

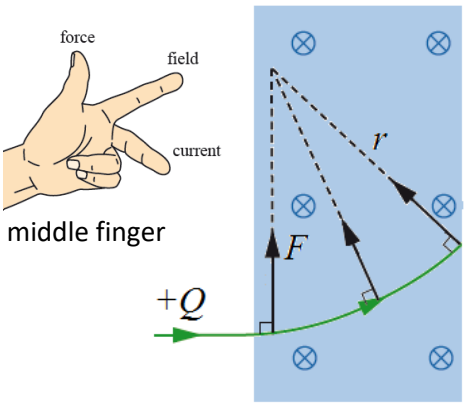
Force on Charged Particle

From our equation for the force a magnetic field will exert on a wire we can derive a equation for the force it will exert on a single charged particle.

Start with $F = BIl$. In Unit 1 we defined the current as $I = \frac{Q}{t}$ so we can sub this in to become $F = B\frac{Q}{t}l$

We can rewrite this equation $F = BQ\frac{l}{t}$ and use $v = \frac{l}{t}$ from Unit 2 to arrive at the equation: $\boxed{F = BQv}$

Moving in a Circle



If a charged particle enters a magnetic field it will feel a force. We now know the size of the force (given by equation above) and direction of the force (given by Fleming's Left Hand Rule).
If we use the left hand rule in the diagram to the right we can see that the force is always at right angles to the velocity. First finger points into the page, middle finger points along the line and our thumb points upwards.
While the particle is in the magnetic field it will move in a circle.

Radius of the circle

We can calculate the radius a charged particle will move in by using our equation for the force on a charged particle in a magnetic field and a centripetal force equation.

$F = BQv$ and $F = \frac{mv^2}{r}$ are equal to each other so we can write $BQv = \frac{mv^2}{r}$ → $r = \frac{mv^2}{BQv}$ → $\boxed{r = \frac{mv}{BQ}}$

Time for a complete circle

We can also calculate the time it takes for the charged particle to move in one complete circle.

Starting at $F = mv\omega$ we can use $\omega = 2\pi f$ to make the equation become $F = mv2\pi f$ and then $F = \frac{mv2\pi}{T}$

The centripetal force is due to the magnetic force on the charged particle so we can put these equal to each other. $BQv = \frac{mv2\pi}{T}$ cancel the *v* to become $BQ = \frac{m2\pi}{T}$ which rearranges to: $\boxed{T = \frac{m2\pi}{BQ}}$

So the time it takes to complete a full circle does not depend on the velocity.

The Mass Spectrometer

A mass spectrometer is used to analyse the types of atom that are in a sample. The atoms are given a charge, accelerated and sent into a magnetic field. If we look at the radius equation above we can see that atoms travelling at the same speed in the same magnetic field given the same charge will be deflected based on their mass. Heavy atoms will move in bigger circles than lighter ones.