# Magnetic Flux and Flux Linkage

To be able to calculate and explain the magnetic flux through a coil of wire
To be able to calculate the magnetic flux linkage of a coil of wire
To be able to calculate the magnetic flux linkage of a rotating coil

## *Magnetic Flux, $\phi$*

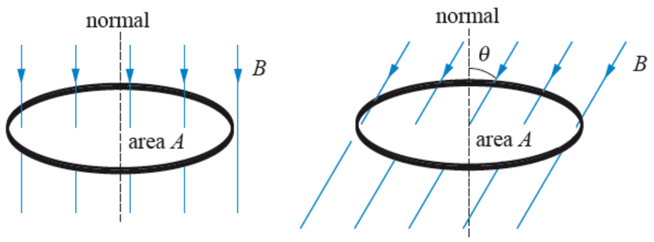
Magnetic flux is a measure of how many magnetic field lines are passing through an area of $A$ m$^2$.

The magnetic flux through an area $A$ in a magnetic field of flux density $B$ is given by: $\boxed{\phi = BA}$

This is when $B$ is ***perpendicular*** to $A$, so the normal to the area is in the same direction as the field lines.

**Magnetic Flux is measured in Webers, Wb**

The more field pass through area $A$, the greater the concentration and the stronger magnetic field.
This is why a magnet is strongest at its poles; there is a high concentration of field lines.




We can see that the amount of flux flowing through a loop of wire depends on the angle it makes with the field lines. The amount of flux passing through the loop is given by:

$\theta$ is the angle that the normal to the loop makes with the field lines.

### *Magnetic Flux Density*

We can now see why $B$ is called the magnetic flux density. If we rearrange the top equation for $B$ we get:

$B = \frac{\phi}{A}$ So $B$ is a measure of how many flux lines (field lines) passes through each unit area (per m$^2$).

A flux density of 1 Tesla is when an area of 1 metre squared has a flux of 1 Weber.

## *Flux Linkage*

We now know that the amount of flux through one loop of wire is: $\phi = BA$

If we have a coil of wire made up of $N$ loops of wire the total flux is given by: $\boxed{N\phi = BAN}$

The total amount of flux, $N\phi$, is called the *Magnetic Flux Linkage*; this is because we consider each loop of wire to be linked with a certain amount of magnetic flux.

Sometimes flux linkage is represented by $\Phi$, so $\Phi = N\phi$ which makes our equation for flux linkage $\Phi = BAN$

**Flux Linkage is measured in Webers, Wb**

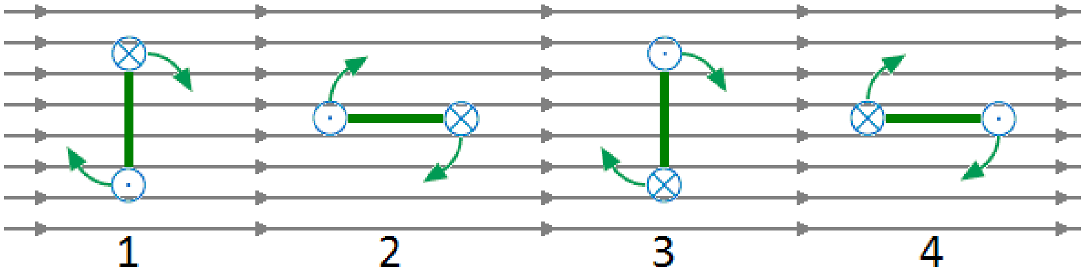
## *Rotating Coil in a Magnetic Field*

If we have a rectangle of wire that has an area of $A$ and we place it in a magnetic field of flux density $B$, we have seen that the amount of flux flowing through the wire depends on the angle between it and the flux lines.

The flux linkage at an angle $\theta$ from the perpendicular to the magnetic field is given by: $\boxed{N\phi = BAN\cos\theta}$

From our lessons on circular motion we established that the angular speed is given by $\omega = \frac{\theta}{t}$ which can be rearranged to $\theta = \omega t$ and substituted into the equation above to transform it into: $\boxed{N\phi = BAN\cos\omega t}$

When $t$ = 0 the wire is perpendicular to the field so there is a maximum amount of flux.




At 1 the flux linkage is a maximum in one direction. There is the lowest rate of change at this point.
At 2 the flux linkage is zero. There is the biggest rate of change at this point
At 3 the flux linkage is maximum but in the opposite direction. The lowest rate of change occurs here too.

At 4 the flux linkage is zero. There is the biggest rate of change at the point too but in the opposite direction.