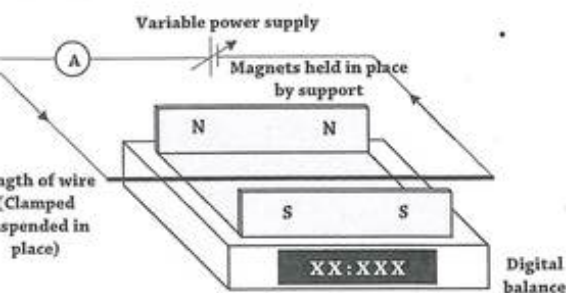


Investigation of force of a wire

The set-up below can be used to investigate the effect of current on magnetic field generated.

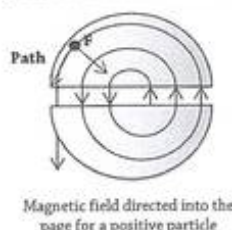
The current is varied, and the change in weight of the magnets is recorded – the change in weight is due to the force of the magnetic field generated by the wire.



Charges moving in circular paths

If a charge moves in a circular path in the presence of a magnetic field, we know that the force acting on the particle must be acting towards the centre of the circle. The magnetic field is being used to control the path direction of the moving charge. This concept is used in devices such as cyclotrons used in medical machinery to provide radiotherapy treatment.

Cyclotrons can accelerate radioactive particles and control the direction of the particle beam in order to accurately hit the target area on a patient.



Centripetal force supplied by the force exerted by the magnetic field

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

r = radius of particle path
 m = mass of particle
 v = speed of particle
 B = magnetic field strength
 Q = particle charge

Magnetic flux and flux linkage

Magnetic flux is the magnetic field strength through an area.

Magnetic flux linkage is the magnetic flux through a coil of wire – the flux is multiplied by the number of turns in the coil (N).

Magnetic flux: $\Phi = BA$

Flux linkage:

$\text{flux linkage} = N\Phi$

A search coil can be used to investigate magnetic fields – as the coil moves through a magnetic field, an emf is generated, which can be measured.

Electromagnetic induction

Lenz's law: the direction of the induced current is always such that it is **opposed to the change that causes the current**.

Faraday's law: the induced emf in a circuit is equal to the **rate of change of magnetic flux linkage** through the circuit.

Induced emf (ϵ) is the potential difference induced in a wire due to a moving changing magnetic flux.

Equation for Faraday's law:

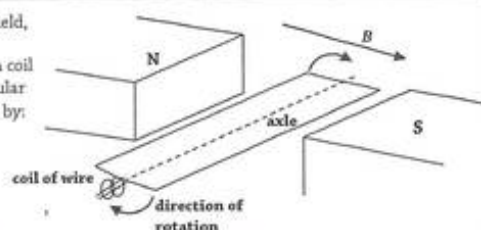
$$\epsilon = -N \frac{\Delta\Phi}{\Delta t}$$

ϵ = induced emf
 Φ = magnetic flux
 N = number of turns of coil
 t = time
 A = area of coil
 ω = angular velocity of coil

Alternating current generator

As a wire moves through a magnetic field, the wire cuts magnetic field lines, inducing an emf. The induced emf in a coil that is **rotating uniformly** with angular rotation ω in a magnetic field is given by:

$$\epsilon = BAN\omega \sin \omega t$$



The power delivered to homes and businesses comes as **alternating currents**. It's easier to use **root mean square** currents and voltages, rather than discussing power supplies as functions.

Root mean square current:

$$I_{rms} = \frac{1}{\sqrt{2}} I_0$$

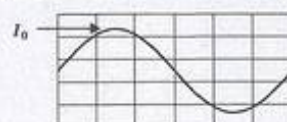
I_{rms} = root mean square current
 V_{rms} = root mean square voltage
 P = power dissipated

Root mean square p.d.:

$$V_{rms} = \frac{1}{\sqrt{2}} V_0$$

I_0 = peak current
 V_0 = peak voltage
 R = resistance

Alternating currents



Alternating currents can be seen on oscilloscopes as sinusoidal graphs – this graph shows the change of current with time

The operation of transformers

Transformer equation:

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

N_p = number of coils in primary coil
 N_s = number of coils in secondary coil

Transformers are used in the national grid to transmit electricity at **high voltages and low current**, to reduce the power loss in cables

Causes of inefficiency:

- Resistance in the coils
- Eddy currents
- Work done to produce magnetic field

Transformer efficiency:

$$\text{efficiency} = \frac{I_s V_s}{I_p V_p}$$

I_p = current in primary coil
 I_s = current in secondary coil
 V_p = voltage across primary coil
 V_s = voltage across secondary coil

