REVISION CARDS

Physics Topic 7 Electromag

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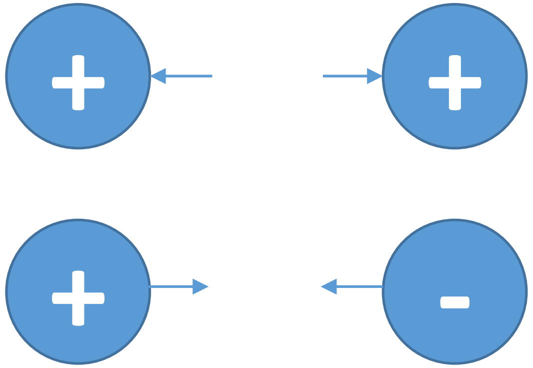
Topic 7: Electric fields

Charged objects exert electrostatic forces on each other



Same charges repel

Opposite charges attract

Force between two charges given by $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

Electric field = region in which an electrostatic force acts

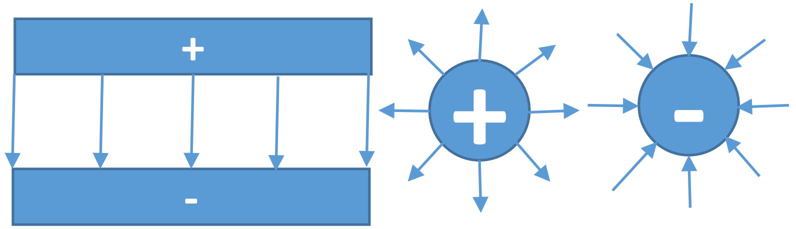
The electric field strength at a point is given by $E = \frac{F}{Q}$

Where F is the force that would be exerted on an object at that point with charge Q.

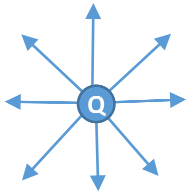
Electric potential = the potential energy per unit charge that a charged object has due to its position relative to other charges. Electric potential has the symbol V and is measured in volts.

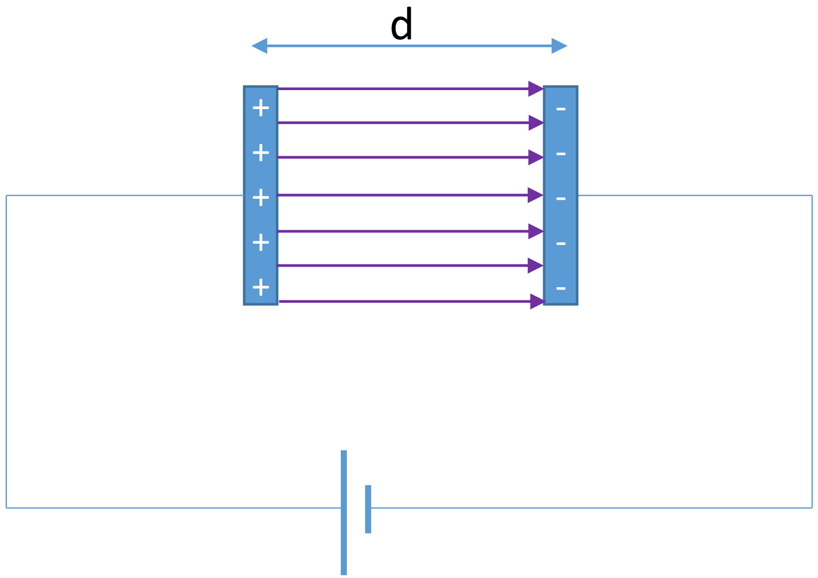
Topic 7: Electric field diagrams

Electric field lines go from positive charges to negative charges. The arrows show the direction a positive charge would move in that field.

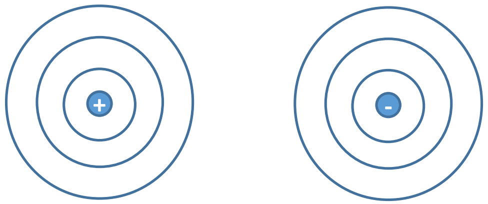


A point charge produces a radial field:





We can also represent electric fields using equipotentials:



These are a bit like contours on a map. Each ring joins points in space where the electric potential is the same.

Electric field strength at a distance r from a point charge, Q, is given by:

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

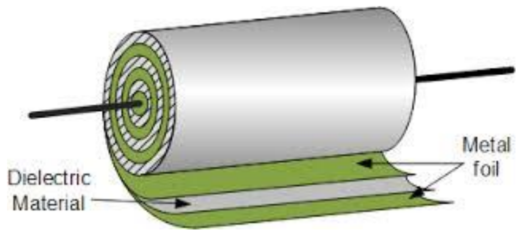
The Potential at a distance r from a point charge, Q, is given by:

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

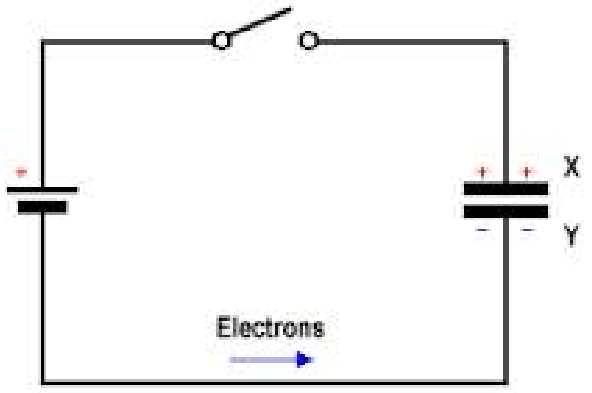
Between two parallel plates connected across a battery which provides a potential difference of V, there is a uniform electric field, with strength E given by:

$$E = \frac{V}{d}$$

Topic 7: Capacitors

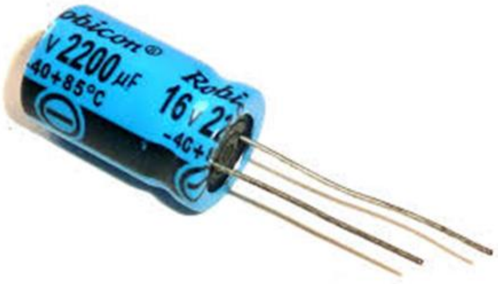


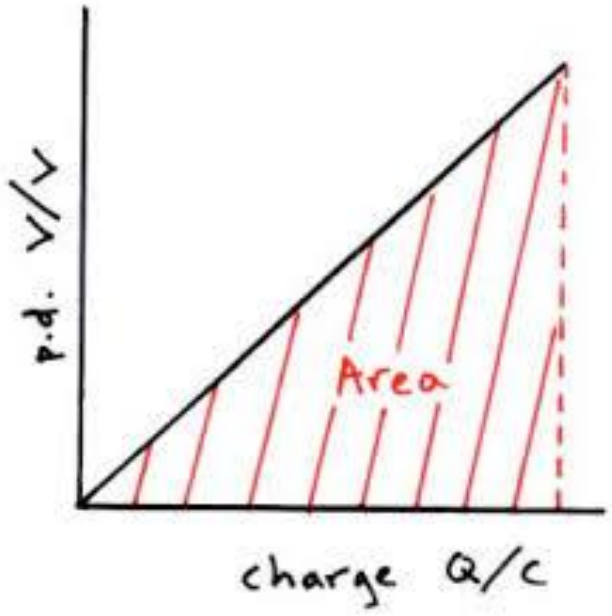
A capacitor is a circuit component designed to store charge. It consists of two plates with an insulating material between them. A positive charge builds up on one plate and a negative charge on the other.



An individual capacitor's ability to store charge is called its capacitance, which is measured in Farads (F).

Capacitance is defined as $C = \frac{Q}{V}$ where Q is the charge stored on each plate when a potential difference V is put across the circuit.





The energy (W) stored by the capacitor is the area under the graph

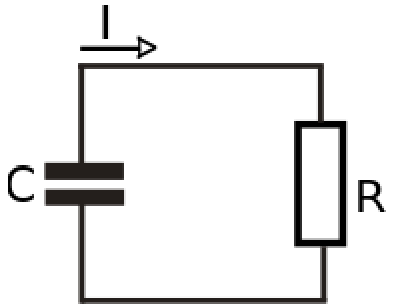
$W = \frac{1}{2}QV$

$W = \frac{1}{2}CV^2$

$W = \frac{Q^2}{2C}$

Topic 7: Resistor Capacitor Circuits

An RC circuit is a resistor and a capacitor
The capacitor discharges through the resistor



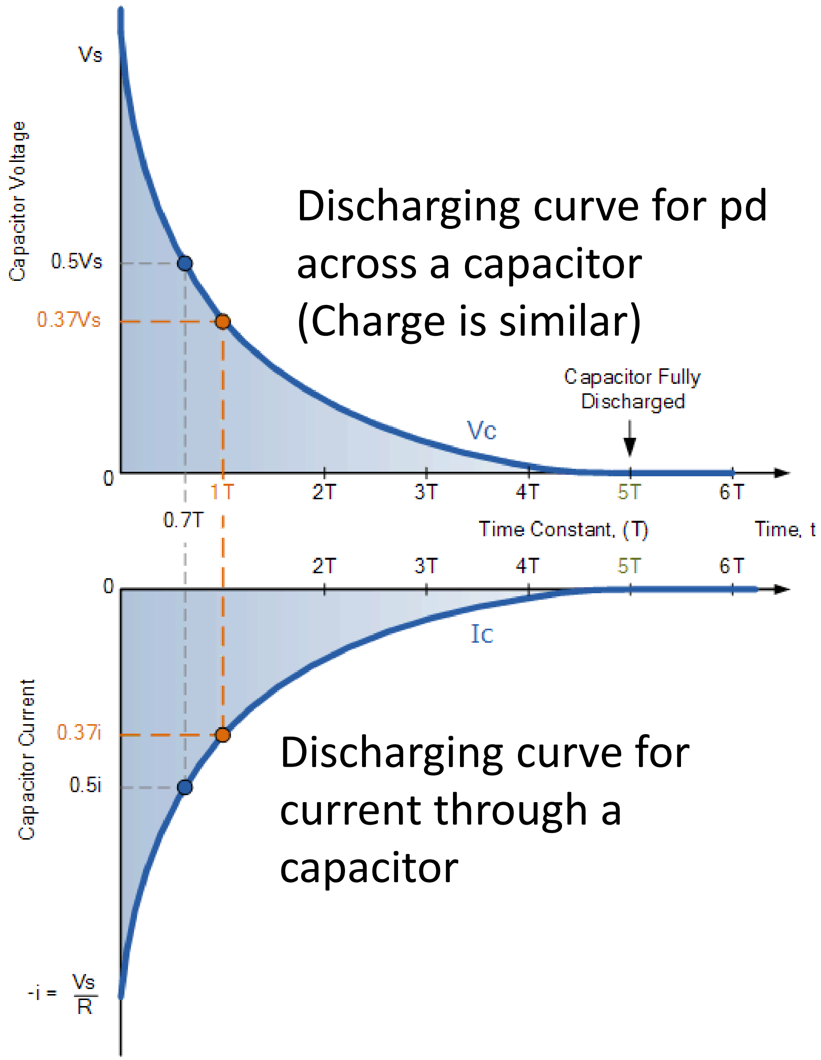
The rate of discharge depends on the time constant of the circuit: $\tau = RC$
Some equations for modelling the circuit:

$$Q = Q_0 e^{-t/RC} \qquad \ln Q = \ln Q_0 - \frac{t}{RC}$$

$$I = I_0 e^{-t/RC} \qquad \ln I = \ln I_0 - \frac{t}{RC}$$

$$V = V_0 e^{-t/RC} \qquad \ln V = \ln V_0 - \frac{t}{RC}$$

Exponential decay curves



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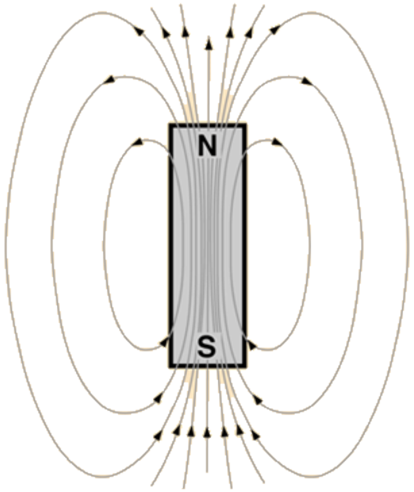
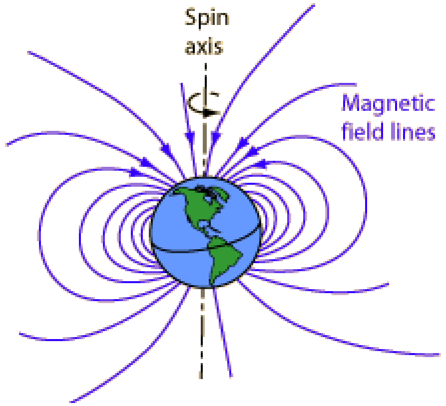
Topic 7: Magnetic Fields

Magnetic field = a region in which an electromagnetic force acts

Magnets have magnetic fields.
Magnetic field lines drawn from North to South
The closer together the lines the stronger the field is



Magnetic field of a bar magnet



Magnetic field of the Earth

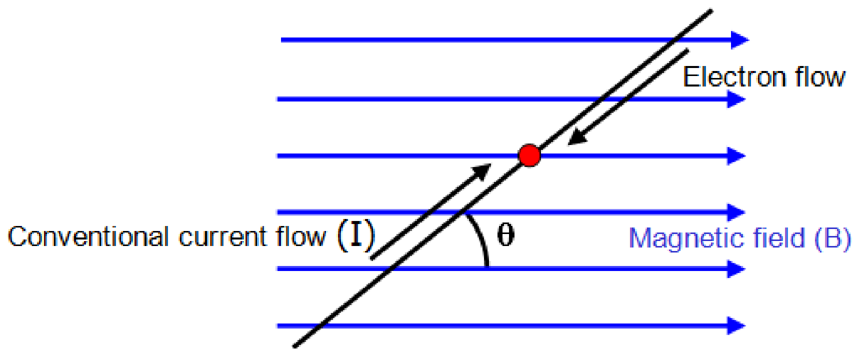
The **magnetic flux density, B**, is a measure of the strength of the magnetic field.
B is measured in Teslas (T)

Topic 7: Moving charge in a magnetic field

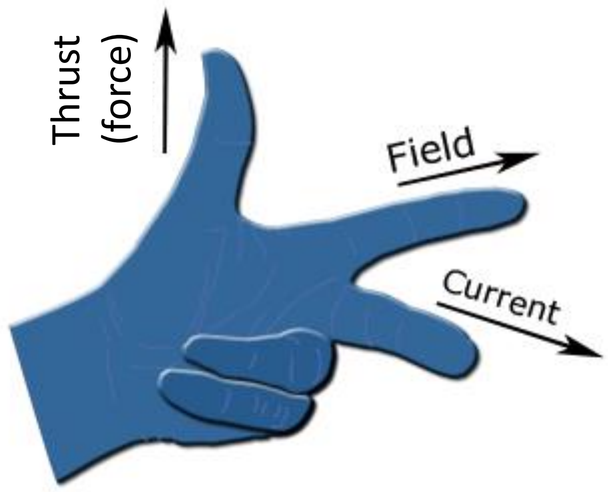
A charge moving in a magnetic field experiences a force

The **magnitude** of the force is given by $F = Bqv\sin\theta$

B = Magnetic flux density of the magnetic field
q = charge of the object
v = the velocity of the charge
θ = angle between direction of motion of charge and direction of magnetic field.



The **direction** of the force is given by Fleming's left hand rule



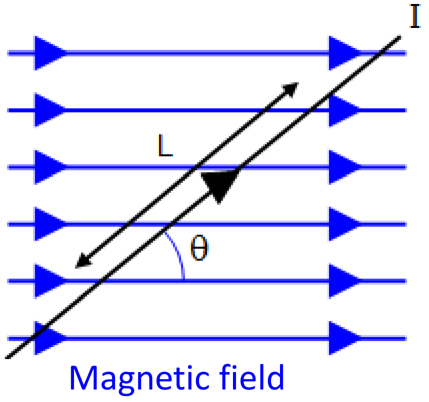
Make sure you use your **left** hand

Topic 7: Conductor in a magnetic field

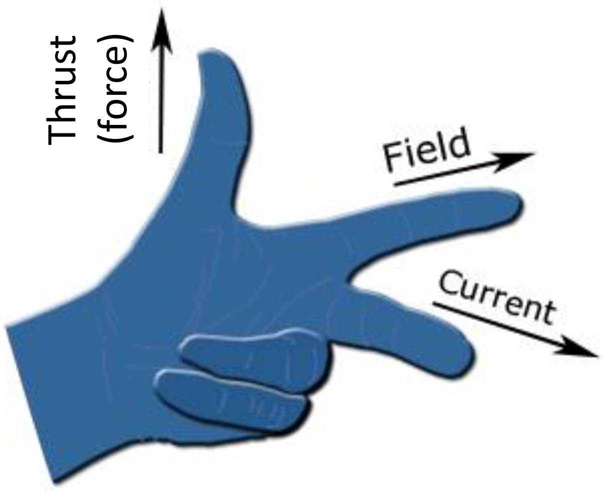
A current-carrying conductor in a magnetic field experiences a force

The **magnitude** of the force is given by $F = BIl \sin \theta$

B = Magnetic flux density of the magnetic field
I= current in the conductor
l = Length of the conductor
θ = angle between direction of current and direction of magnetic field.



The **direction** of the force is given by Fleming's left hand rule



Make sure you use your **left** hand!

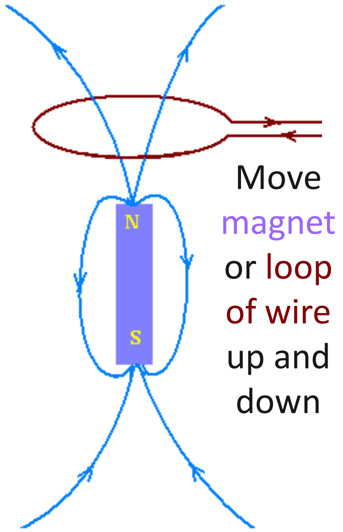
Topic 7: Flux and Flux linkage

When moving a conductor in a magnetic field:

The magnetic flux density, B, multiplied by the area swept out by a conductor, A, is called the **magnetic flux**, ϕ.
Magnetic flux is measured in Webers (Wb)

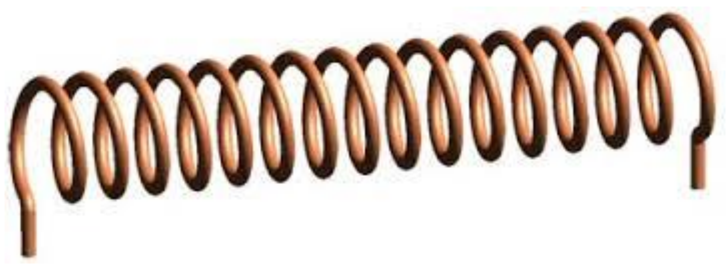
$\phi = BA$

Note: The area must be perpendicular to the field and must be measured in m2



Area of a loop of wire = πr^2

A coil of wire has lots of loops
Flux linkage $\Phi = n\phi = nBA$
Flux linkage also measured in Webers (Wb)
Eg: Flux linkage in a coil of 15 turns and area $25 cm^2$ in a field of strength 5T is given by:
$\Phi = N\phi = NBA = 15 \times 5 \times 25 \times 10^{-4} = 0.1875$ Wb.

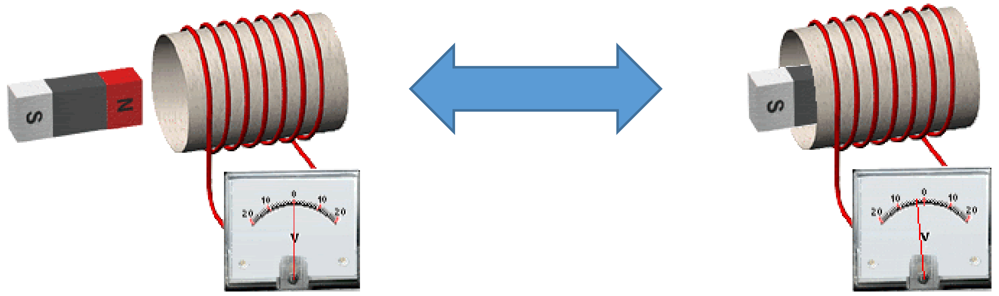


Topic 7: Induction

When the magnetic flux linkage associated with a coil changes, an emf is induced in the coil.

This could be achieved by:

- Changing the magnetic field strength
- Moving the magnet towards or away from the coil
- Moving the coil in and out of the magnetic field



The **magnitude** of the force is given by Faraday's law:

'The magnitude of emf induced in the coil is equal to the rate of change of flux linkage.'

Or, numerically: $|\xi| = \frac{d(N\Phi)}{dt}$

The **direction** of the force is given by Lenz's law:

'The current produced always opposes the magnetic field that produces it'

Or, numerically the induced emf and the change in magnetic flux will have different signs

Putting Faraday and Lenz's laws together gives us: $\xi = -\frac{d(N\Phi)}{dt}$

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Topic 7: Factors affecting emf induced

If you are inducing a current in a coil by moving a magnet relative to the coil

The higher the:

Number of turns in the coil

Speed with which the coil/magnet is moved

Diameter of the coil

Magnetic field strength

The greater the emf induced

If you are inducing a current in a secondary coil by changing the current in a primary coil

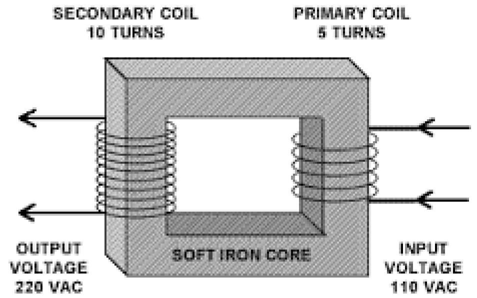
The higher the:

Voltage in the primary coil

Ratio of turns in coils: $^{Ns}/_{Np}$

The greater the emf induced in the secondary coil

This is called a transformer



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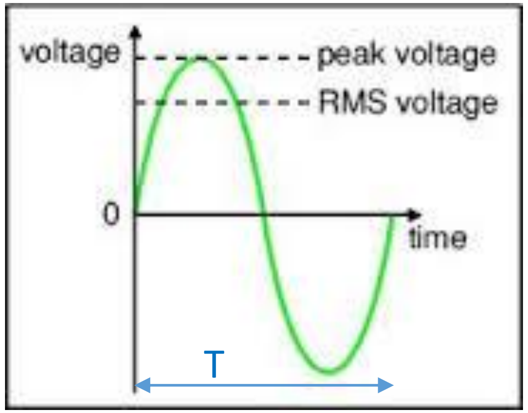
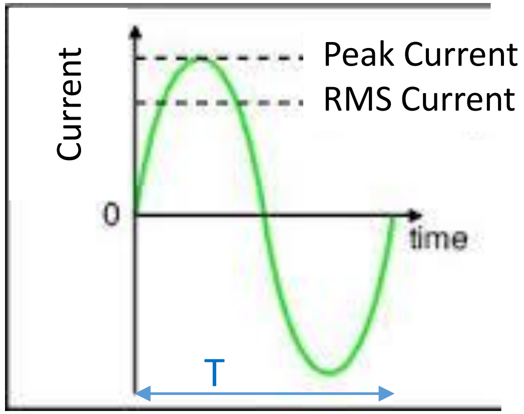
Topic 7: Alternating currents



$$v_P = Peak\ Voltage$$
$$v_{rms} = Root\ mean\ square\ Voltage$$
T= Period
F = Frequency

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



$$I_P = Peak\ Current$$
$$I_{rms} = Root\ mean\ square\ Current$$
T= Period
F = Frequency

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