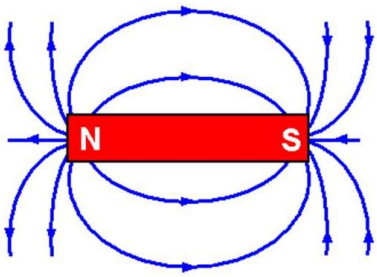
Topic 7 Magnetism and Electromagnetism

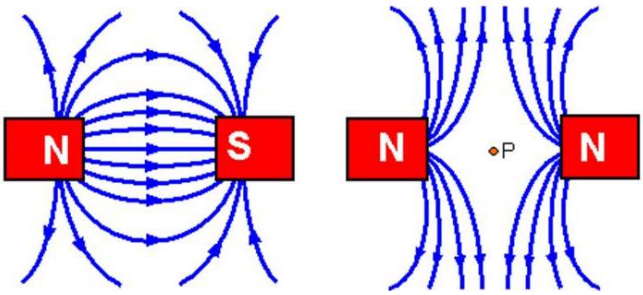
7.1 Magnets and Magnetic Fields

A permanent magnet has its own magnetic field : region in which a magnetic force is felt

Poles are the places where the magnetic force is strongest, north and south



The arrows indicate the force felt by a north pole



Like poles repel, unlike poles attract

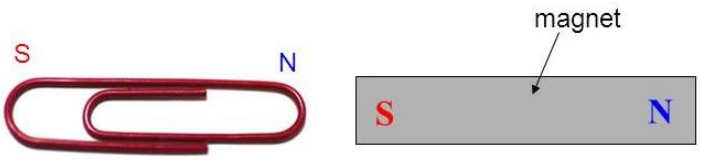
can be made into a magnet

If a permanent magnet is brought near to some magnetic material
then magnetism can be induced in the material
(created)

eg iron, cobalt, nickel

We say the material has been temporarily magnetised

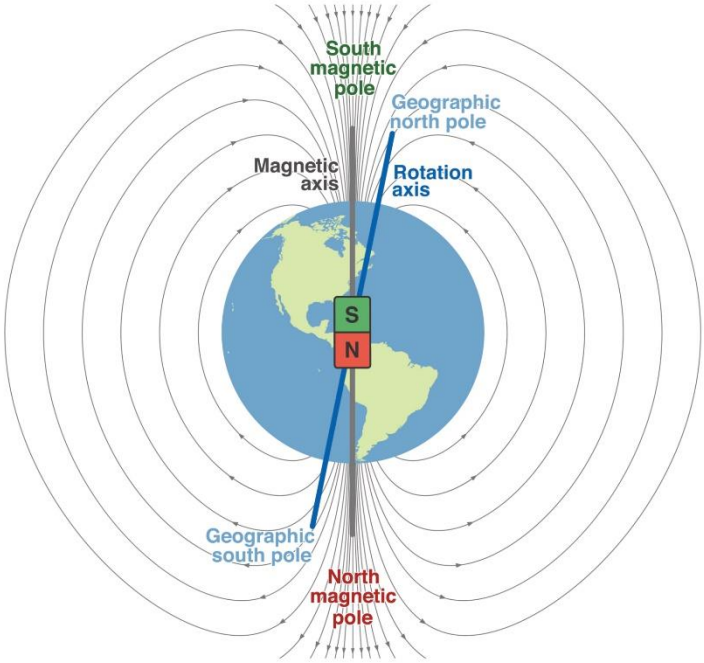
The force between a magnet and a magnetic material is always attractive



That magnetism is quickly lost if the permanent magnet is taken away

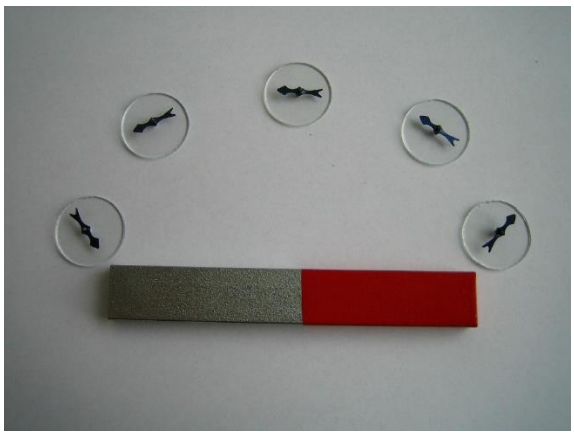
A compass is a small magnet pivoted at its centre so that it can spin and indicate the direction of a magnetic field

The Earth has an iron core which over time has become magnetised so that its south pole is at the top



A compass anywhere on the surface of Earth will point North because it is attracted to the magnetic south pole up there

Compasses can be used to draw the magnetic field round a bar magnet

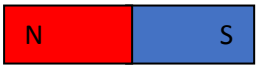


Practise what you have learned :-

1. Draw the magnetic field round the following bar magnet

2. Add a compass to the right of the magnet and indicate which way it points

3. Draw the magnetic field between the following two magnets



4. What are the two magnets doing ?

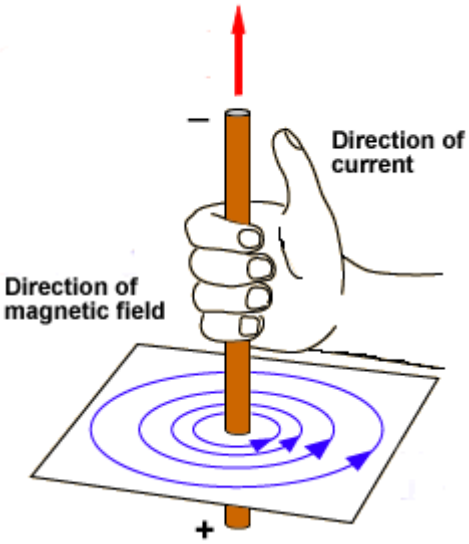
5. A magnet can be used to pick up paper clips

6.

If the blue end of the magnet is a south pole, indicate the poles on the ends of each paper clip

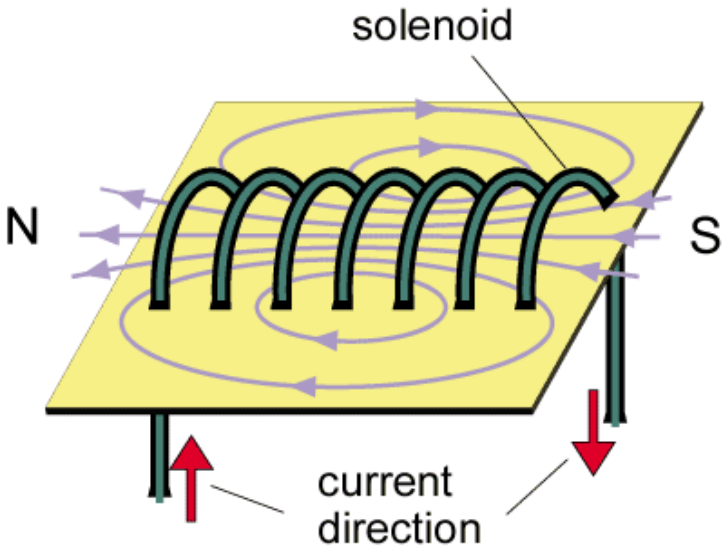
7.2 Electromagnetism

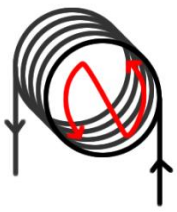
There is a magnetic field round a wire carrying a current

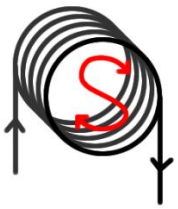


The magnetic field is strongest near the wire (field lines closer together)
The strength of the field depends on the size of the current

Winding a wire into a coil of many turns (solenoid) and passing a current through the wire creates an electromagnet







Adding an iron core to the electromagnet increases the magnetic field strength

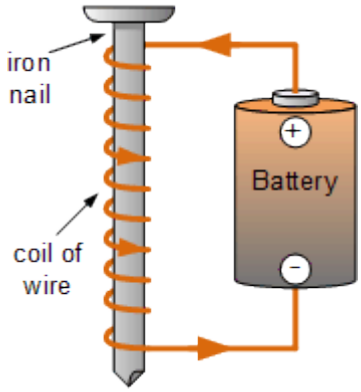
Practise what you have learned :-

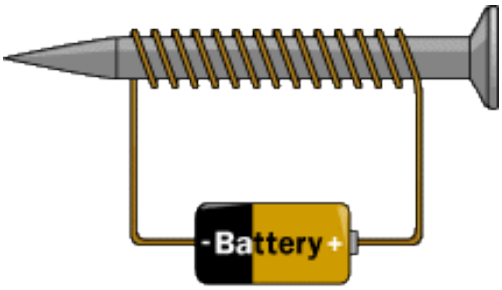
1. Draw the magnetic field round the following wires

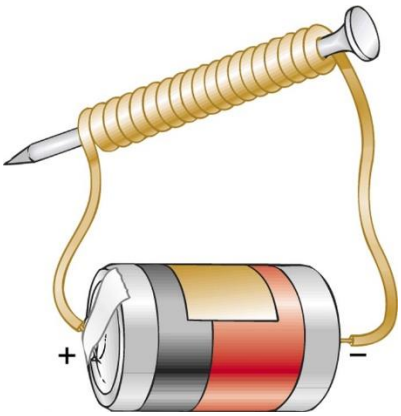
Current down

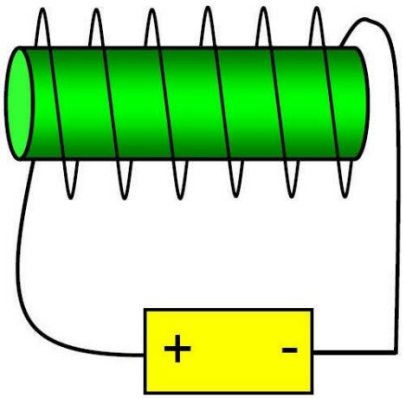
Current to right

2. Identify the poles of the following electromagnets



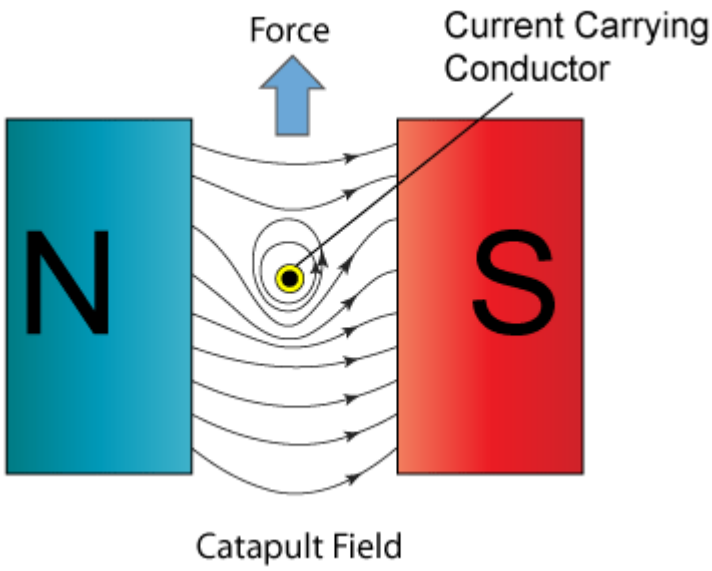




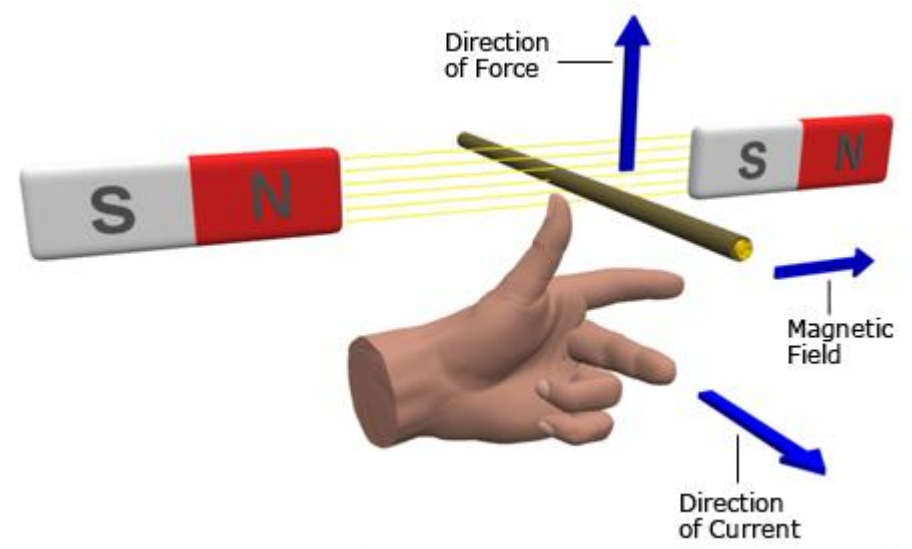


7.2.2 Fleming's left hand rule

When a wire carrying a current is placed inside the magnetic field of a magnet or magnets, a catapult field is created which exerts a force on the wire causing it to move



Fleming's left hand rule can be used to work out the direction of the motion



The size of the magnetic force increases if :-

1. the magnetic field strength (flux density), B , of the magnets is increased
2. the length of the wire, L , is increased
3. The current in the wire, I , is increased

If the wire is at right angles to the magnetic field, the magnetic force acting on it, $F = BIL$

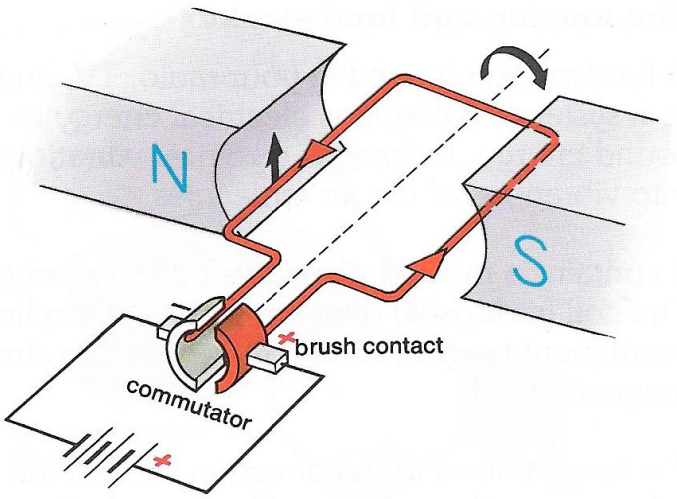
Magnetic flux density, $B = \frac{F}{IL}$ N / A m

Unit is Tesla, T

can be defined as the magnetic force on a wire of length 1m carrying a current of 1A

7.2.3 Electric Motors

A solenoid carrying a current inside the magnetic field of a magnet or magnets will rotate. This is called the motor effect

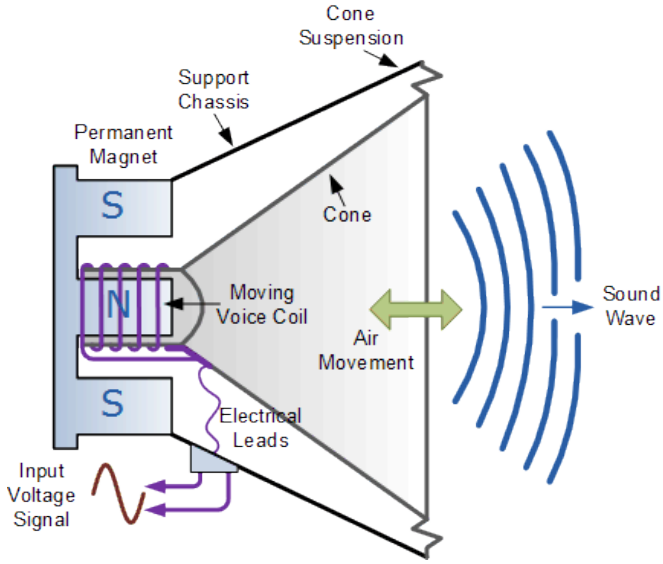


The direction of rotation depends on the direction of the magnetic field and the direction of the current

The speed of rotation increases if the magnetic flux density, number of turns or the current increases

7.2.4 Loudspeakers

Physics only

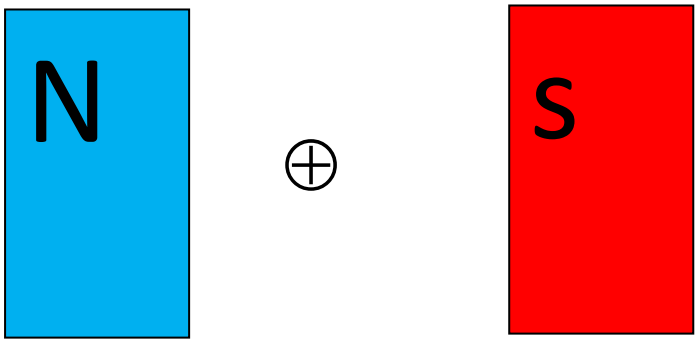


An alternating current flowing in the solenoid wrapped round the central north pole will feel a magnetic force which moves it to the right, then the left, then back to the right and so on

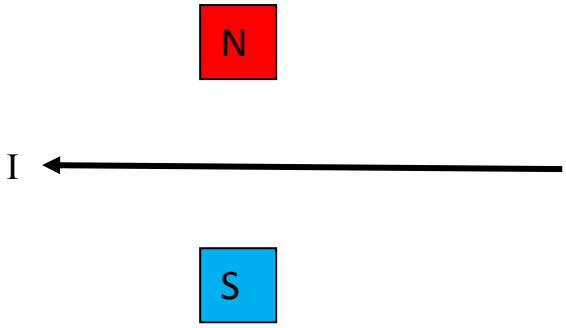
The vibrating cone creates a sound wave which travels out from the loudspeaker

Practise what you have learned :-

1. Draw the magnetic field round the wire in the following diagram

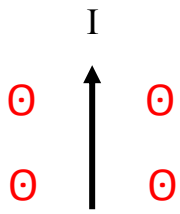


2. Work out the direction of motion of the following wires



I out of page

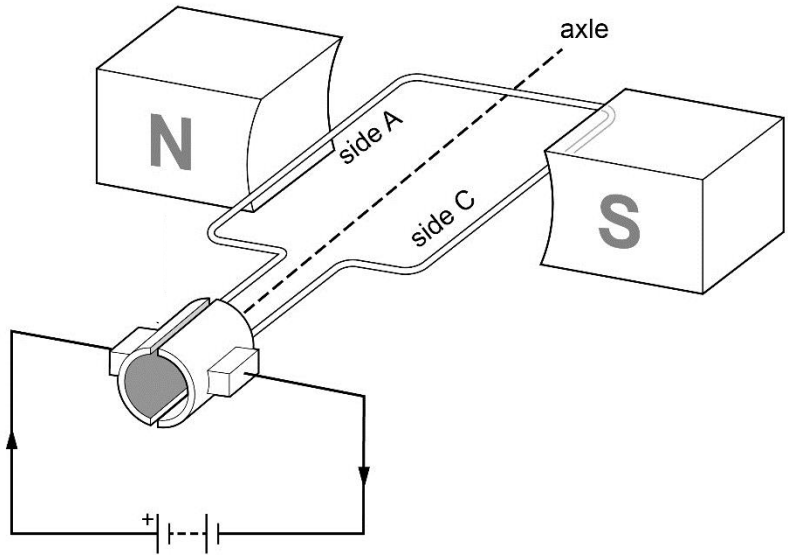
Magnetic field out of page



3. Use the equation $F = BIL$ to complete the table.

Force (N)	Current (A)	Length of wire (m)	Magnetic flux density (T)
	2	0.25	0.20
	5	0.50	0.10
0.15		0.10	0.15
0.05	10		0.02
0.02	2	0.20	
0.03		0.50	0.01

4. Explain why the following motor will turn anticlockwise



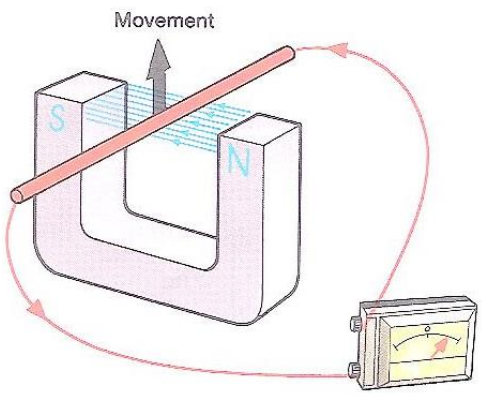
7.3.1 The generator effect Physics only

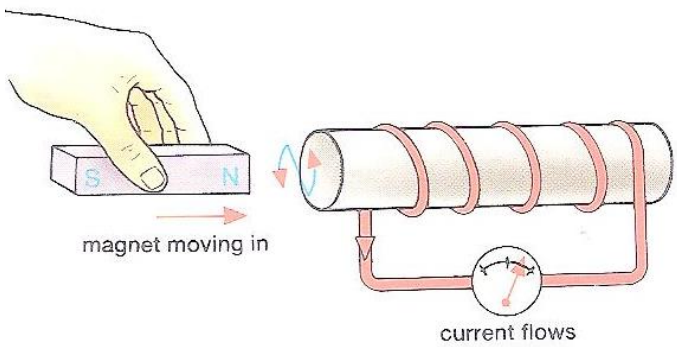
HIGHER

If a wire or coil moves in a magnetic field or if a magnetic field moves near a wire or coil, then an electric potential difference is generated across the ends of the wire or coil

The size of the potential difference increases if the magnetic flux density is increased, if the length of wire or number of turns is increased or if the speed of movement is increased

The direction of the induced potential difference depends on the direction of movement and the direction of the magnetic field

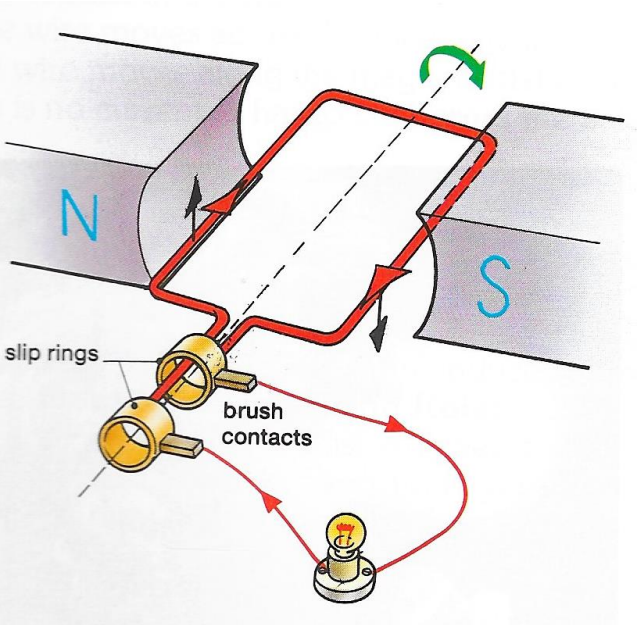




7.3.1 Use of the generator effect Physics only

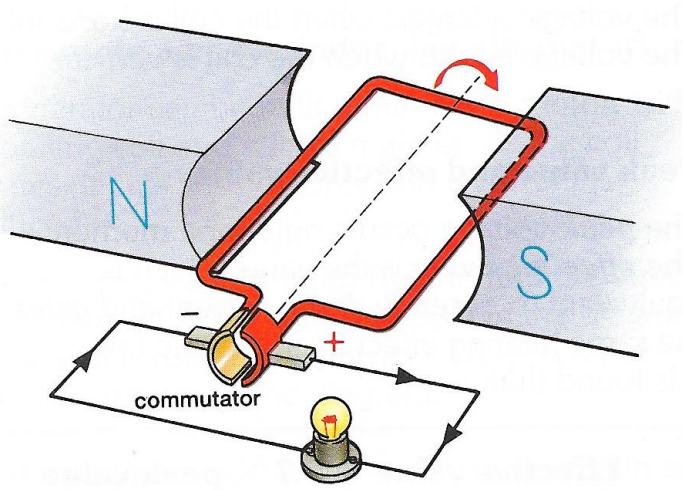
HIGHER

An alternator generates alternating current



The left hand side of the coil is always connected to the front slip ring.
When that side of the coil goes beyond the vertical and moves down the current swaps direction so an alternating current flows in the external circuit

A dynamo produces direct current

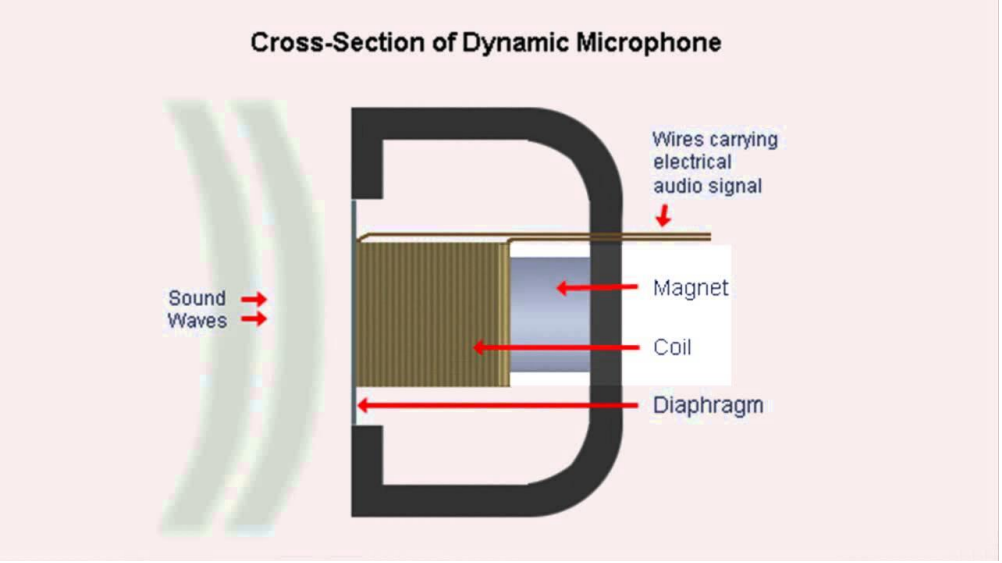


Every half turn the current changes direction in the coil but the commutator changes the contact with the external circuit so that the current always flows the same way in it

7.3.3 Microphones

Physics only

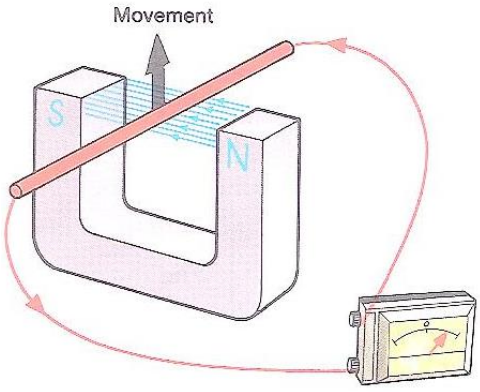
HIGHER



Incoming sound waves cause the diaphragm to vibrate, moving the magnet inside the solenoid. This induces electricity in the solenoid

Practise what you have learned :-

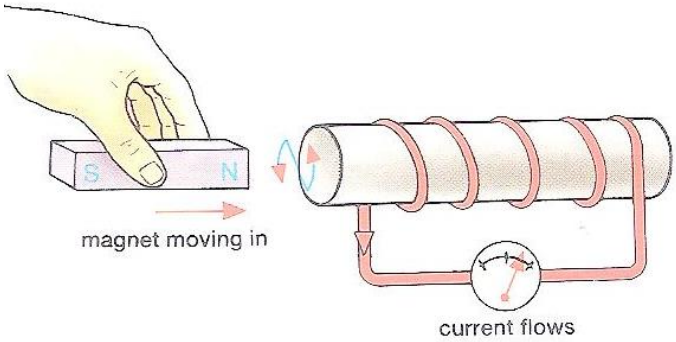
1. In the picture a positive potential difference and an anticlockwise current is being induced



(a) What is induced if the wire stops moving ?

(b) What is induced if the wire moves down ?

2. In the next picture a positive potential difference and an anticlockwise current Is being induced



(a) What is induced if the magnet is moved out of the solenoid ?

(b) What is produced if the magnet is turned round and moved into the solenoid ?

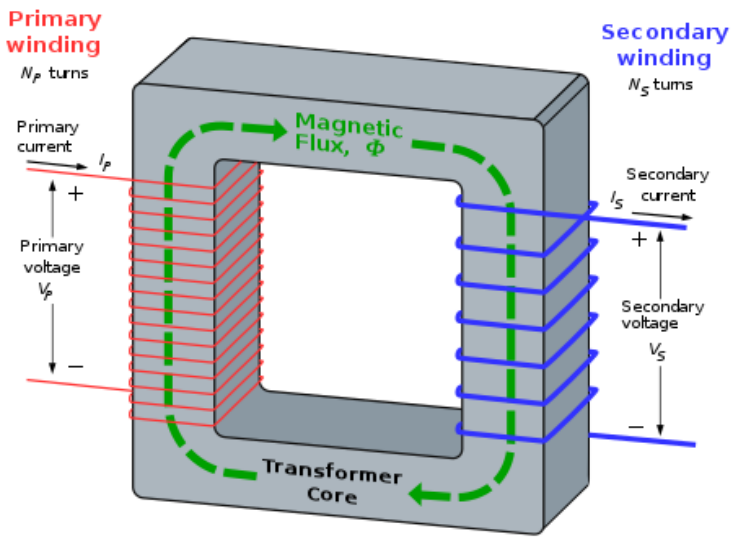
(c) What would be induced if the magnet was moved faster ?

3. What is the difference between an alternator and a dynamo ?

7.3.4 Transformers Physics only

HIGHER

Two solenoids placed near to one another, preferably with an iron core to allow a magnetic field to move through them



An alternating voltage on the primary coil has a changing magnetic field which moves through the core to the secondary coil, inducing an alternating voltage on it

Transformer formula : Turns ratio = Voltage ratio

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

A step up transformer makes the secondary voltage bigger than the primary voltage
A step down transformer makes the secondary voltage smaller than the primary voltage

If a transformer is 100% efficient then the output power is equal to the input power

Electrical power = current x voltage $I_p V_p = I_s V_s$

$P = IV$

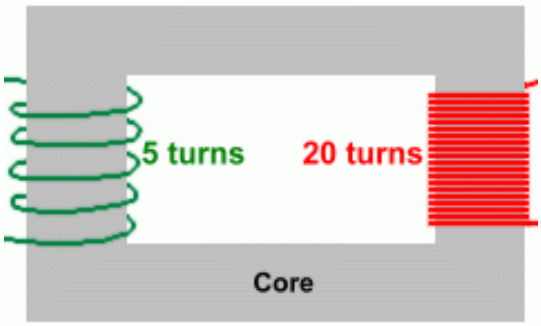
and $V = IR$

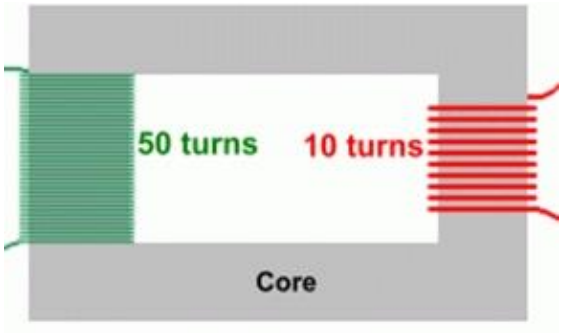
so $P = I^2R$

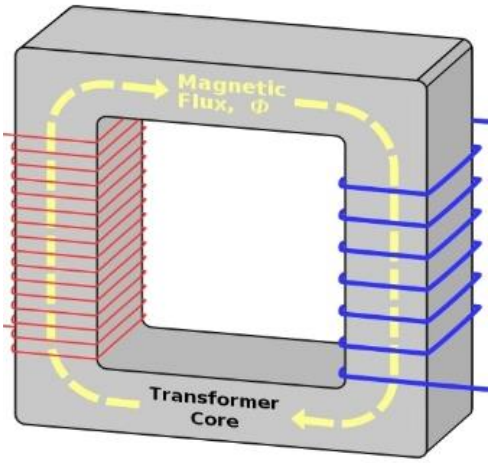
so a step up transformer makes the secondary current smaller
If a step up transformer is connected between a power station and its transmission wires then the power loss from the wires will be reduced because the smaller current will produce less heat

Practise what you have learned :-

1. Work out the secondary voltage of the following transformers if the primary voltage is 100V







2. Identify which transformers are step up type and which are step down type

3. If the primary current of the first transformer was 2A :-

(a) Work out the input power

(b) Work out the secondary current assuming the transformer is 100% efficient