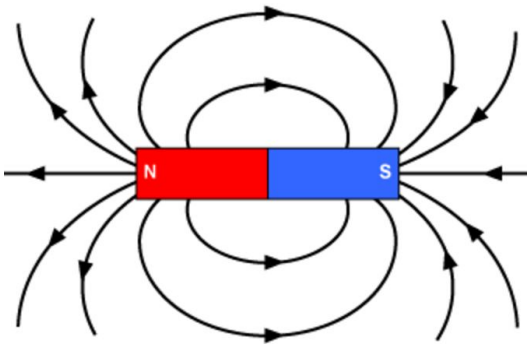
Chapter Seven: Electromagnetism

Magnetism and magnetic forces

-A magnetic field is a region where a force acts on a magnet or a magnetic material

-The closer the field lines the stronger the field (this is always near the poles)

-The field lines will always go out of north and into south

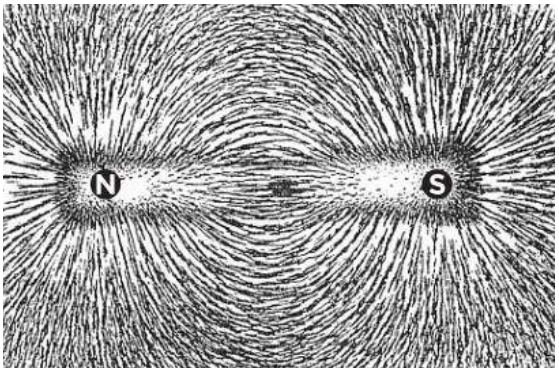


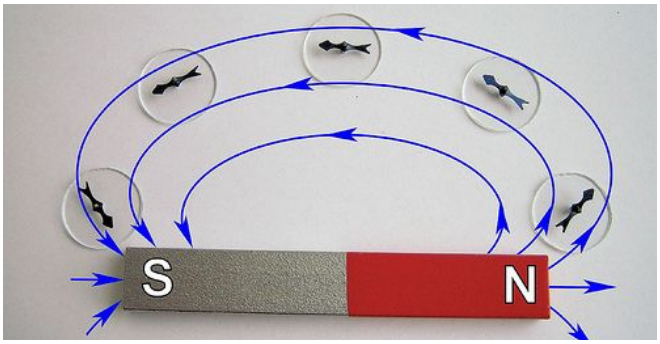
-The three magnetic materials are iron, cobalt and nickel

-Like poles on a magnet will repel, unlike poles will attract

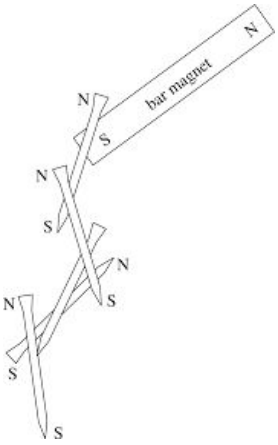
-To visualise the magnetic field of a magneti, either iron filings can be sprinkled around a magnet, or compasses can be used to show the direction of the field lines

-Using compasses is a better method as it shows the direction of the field lines

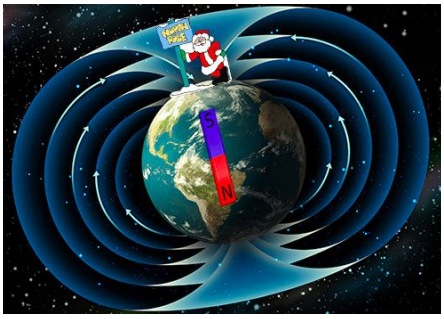




-A permanent magnet produces its own magnetic field, whereas an induced magnet is a material that becomes a magnet when placed inside a magnetic field

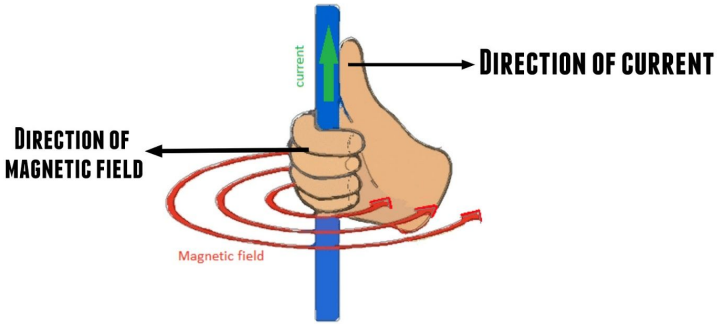


-The Earth has its own magnetic field, this acts as a giant bar magnet, meaning that a compass will be able to direct you towards geographical north (which is magnetic south)



-A wire with a current flowing through it produces a magnetic field, the direction of this field can be calculated using the **right hand grip rule**

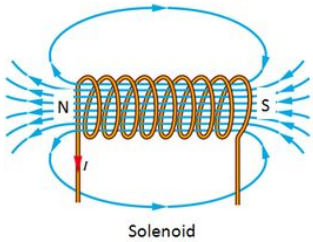
-If you reverse the direction of the current, the direction of the magnetic field lines will reverse



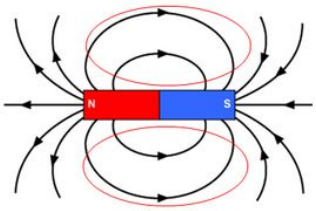
The magnetic effect of a solenoid

-A solenoid is a long straight coil of wire

-The magnetic field of a solenoid behaves like a bar magnet



Solenoid

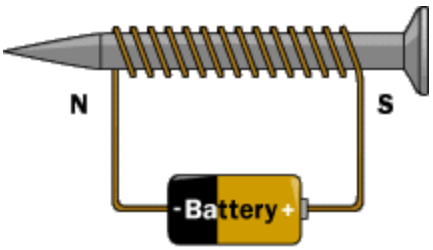


Magnet

-This occurs as all of the magnetic fields of each coil of wire combine to form the field similar to a bar magnet

Electromagnets

-An electromagnet is created as there is a magnetic field created when a current flows through a wire, this becomes stronger when there is more loops of wire.



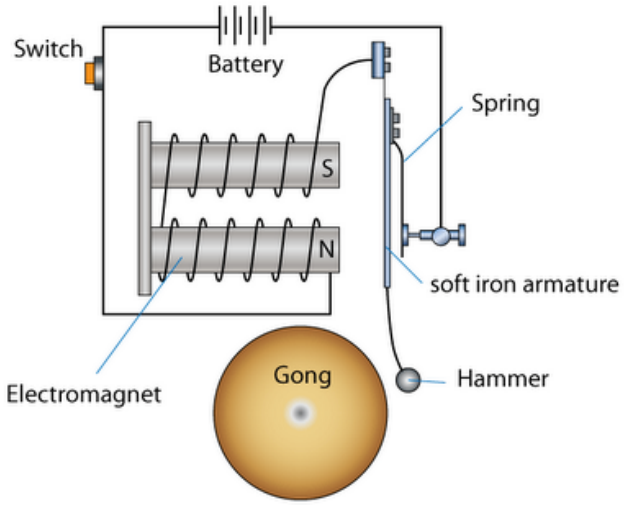
-An electromagnet needs a magnetic core such as iron or steel

-Electromagnets can be turned on and off and are stronger than permanent magnets

-To make an electromagnet stronger:

- Pass a higher current through the wire
- Create more loops of the wire
- Use a more magnetic material for the core

-Electromagnets can be used in an electric bell, pushing the switch of the bell completes the circuit, which will cause the electromagnet to attract the hammer which will hit a gong, once the gnog is hit, the circuit is broken due to this movement, the hammer returns to its original position and the process repeats



Calculating the force on a conductor

-When a current carrying wire is in a magnetic field it will experience a force

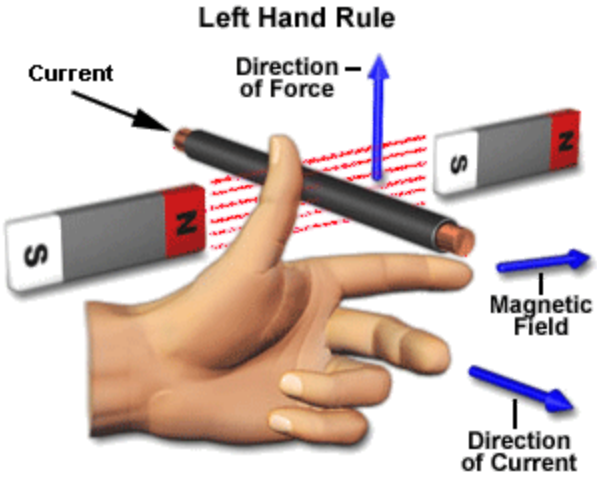
-This force is a result of the magnetic field from the current carrying wire and the permanent field interacting, this is known as the **motor effect**

-This field will be strongest when the field lines are at 90° to one another

-The strength of this force can is affected by:

- The size of the magnetic field
- The current passing through the wire
- The length of the wire in the magnetic field

-The direction of the force on the wire can be calculated using **Fleming's left hand rule:**



-Magnetic flux density is a measure of the strength of a magnetic field, it is measured in teslas

-As a current carrying wire in a magnetic field will experience a force, we can calculate this force with the equation:

F=BIL

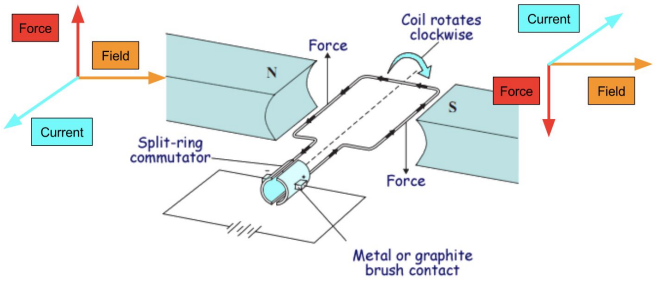
Force = magnetic flux density x current x length of wire

Electric motors

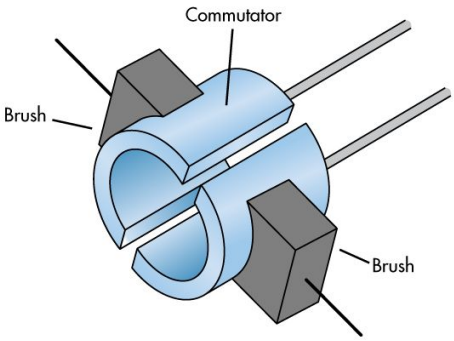
-The order of a motor turning (possible 6 mark question):

- The switch is turned on and current runs through the wire
- As the coil is in a magnetic field, one side of the coil will experience an upwards force, and the other a downwards force, causing the coil to spin
- When the commutator spins, the brushes break the circuit when they reach the split
- As this occurs, the momentum of the motion keeps the coil turning
- When the commutator has reconnected with the brushes, the current in each side of the wire is opposite to what it was before
- As a result of this, the forces allow the coil to continue to spin

- When the circuit is broken, the coil comes to rest in a vertical position

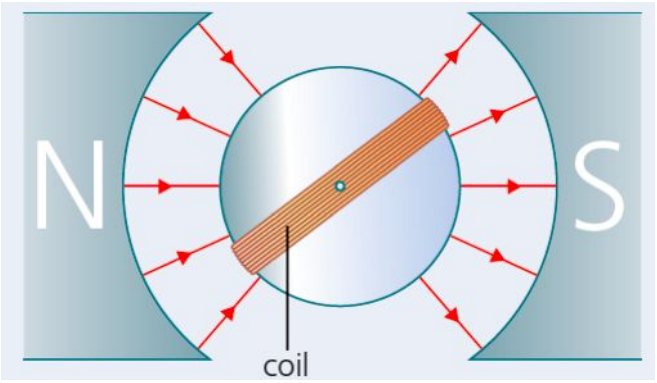


-**The split ring commutator** keeps the coil turning as it means that the direction of the current does not need to change every half turn
-Contact is lost at the split, momentum keeps the motor turning, meaning that the current is constantly in the same direction, meaning one side is constantly being forced down, and the other constantly being forced upwards
-The brushes are often made from carbon as it is a soft and slippery material that conducts electricity



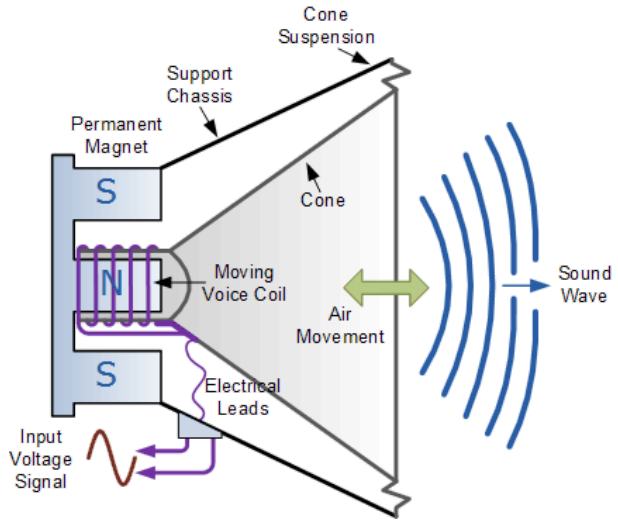
-To increase the strength of the turning motion:

- Curved magnets can be used to keep the field lines at 90° for as long as possible
- Higher current
- Stronger magnetic field
- More turns on the coil
- Put a soft iron core in the coil (this will make an electromagnet, increasing the magnetic force from the coil)



Loudspeakers

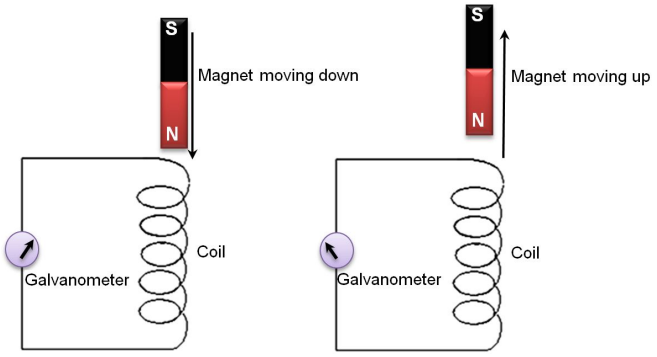
-A moving coil loudspeaker has a permanent magnet and an electromagnet
-The magnet is fixed, and the electromagnet is attached to the cone
-The permanent magnet produces a field that is at right angles to that in the coil, when the current flows through the coil, a change in the magnetic force occurs, causing the coil to move in and outwards
-This movement causes the coil to move, and hence the cone to move, setting up vibrations in the air



-Headphone work in the same way as loudspeakers, however less current and movement is needed in a headphone as it has to project the sound into your ear canal rather than the whole room

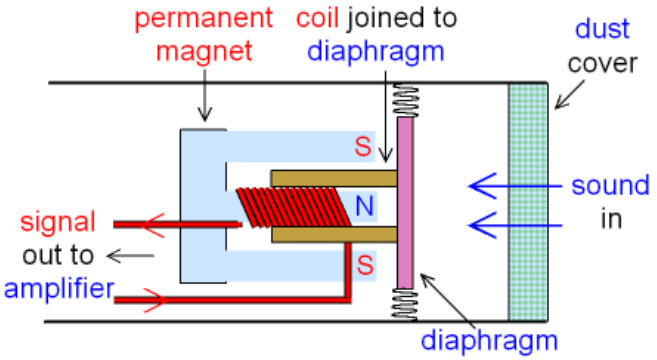
The generator effect

-**Electromagnetic induction** is caused when an electrical conductor (wire) cuts through a magnetic field, this produces a potential difference in the wire, this is only true when the wire or the magnet is moving
-When the magnet moves in one direction the potential difference induced is in one direction, however when the magnet moves in the opposite direction, the potential difference induced is in the other direction



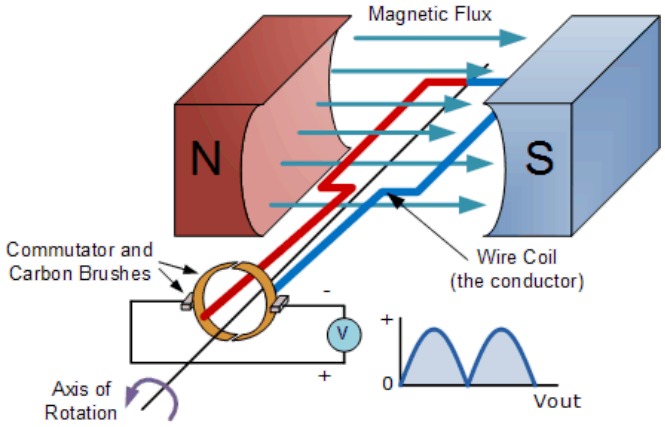
-The size of the potential difference is increased by increasing the speed of the movement, the strength of the magnetic field, or the number of turns on the coil

-**Moving coil microphones** work like loudspeakers but in reverse, energy is transferred from the moving air into the coil, causing a current to flow



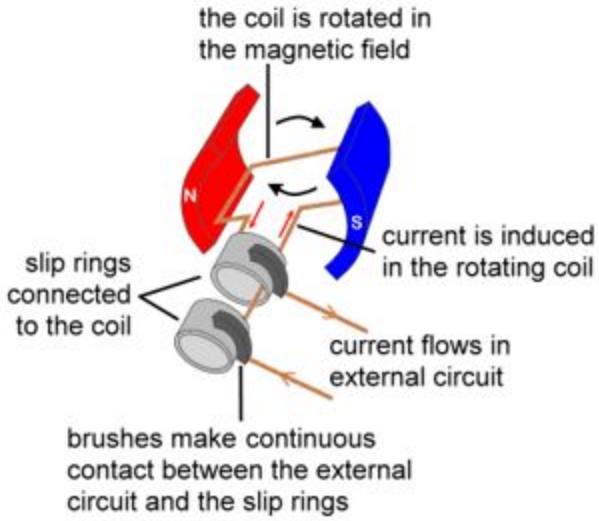
-**Dynamos** work by rotating a coil inside a magnetic field, as the coil turns, it cuts the magnetic field lines, inducing a potential difference

-A split ring commutator is used as this means that a direct current will be induced, the direction of the current in the field will not alternate



-**An alternator** works in the same way as a dynamo, however, as split rings are used, the potential difference induced alternates

-The potential difference induced is greatest when the coil is vertical, as this is where the coil is at 90° to the magnetic field lines



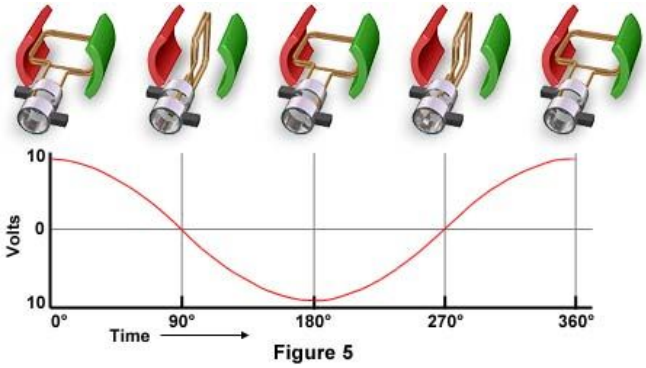
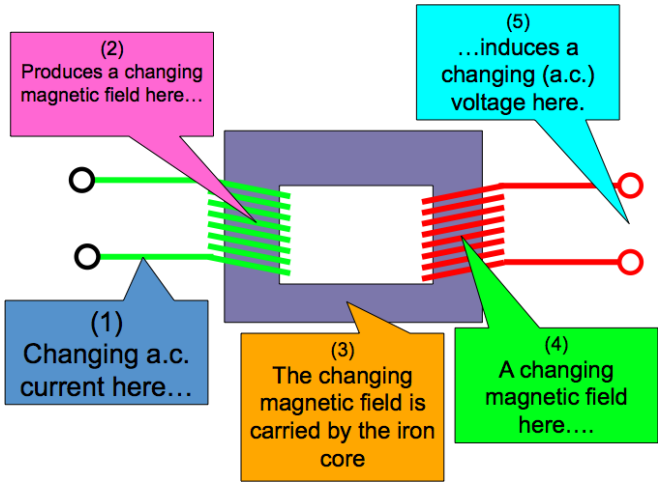


Figure 5

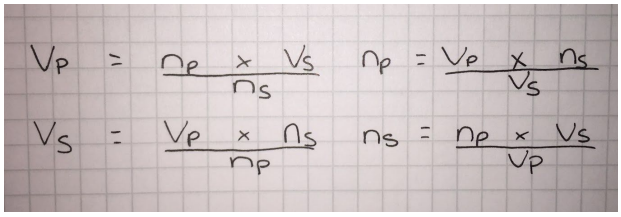
Transformers

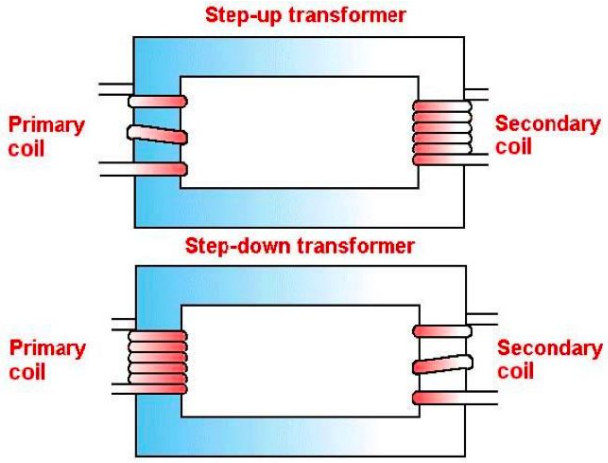
-Transformers consist of two coils of wire wrapped around an iron core

-A changing AC current in the primary coil causes a changing magnetic field, this is carried through the iron core which causes a changing magnetic field on the secondary coil, as a result of this a changing AC potential difference is induced in the secondary coil

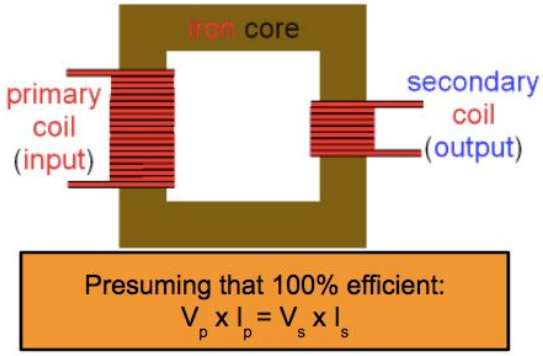


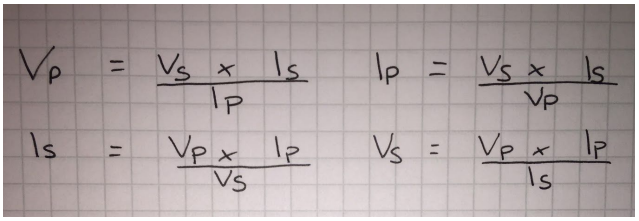
-Step up transformers have more turns on the secondary coil, increasing the potential difference
-Step down transformers have less turns on the secondary coil, reducing the potential difference





-If we presume that a transformer is 100% efficient, we can calculate potential difference and current in each coil with the equation:





-We can also relate the number of turns and the potential difference with the following equation: