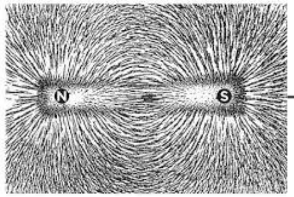
# Physics 7: Magnetism & electromagnetism

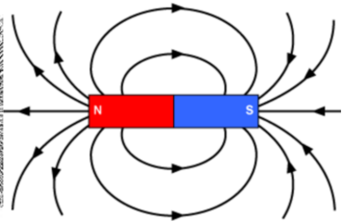
## Section 1: Permanent Magnets & Electromagnets

| Key term | Definition |
|---|---|
| Permanent magnet | A magnet that is magnetic all the time, e.g. a bar magnet or a horseshoe magnet or a fridge magnet |
| Electromagnet | A magnet that can be turned on and off. Needs an electric current in a coil (called a solenoid) to work |
| Magnetic field | An area around a magnet where a magnetic material will be attracted |
| Magnetic field lines | These show the shape of a magnetic field. You can show magnetic field lines with iron filings. |
| Magnetic material | A material that is attracted to a magnet: iron, steel, cobalt & nickel |

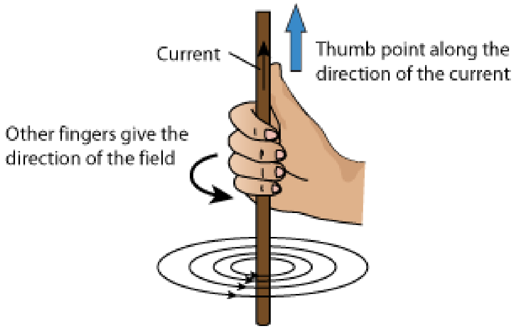
## Section 2: Magnetic Fields

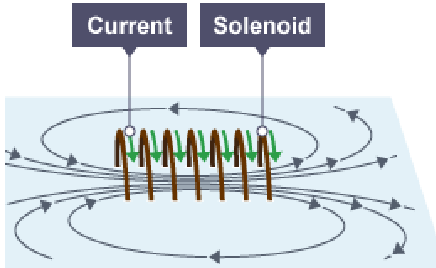
We can show magnetic fields by placing paper over a magnet and sprinkling iron filings on it. Tap the paper to show the magnetic field lines.



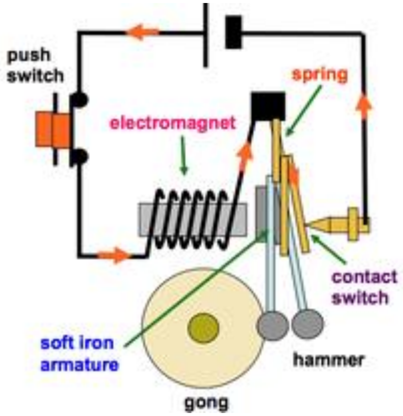

The magnetic field around a straight wire is concentric circles.
The magnetic field of a solenoid (electromagnet) looks the same as around a permanent bar magnet.



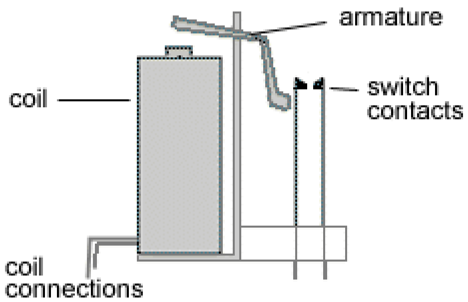




## Section 3: Uses of electromagnets

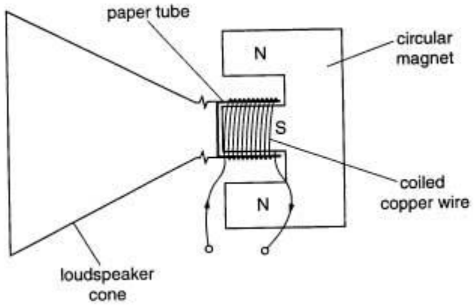
**Scrapyard electromagnet**: Electromagnets can be made much stronger than permanent magnets and they can be switched on and off. In a scrapyard, an electromagnet picks up scrap metals that contain iron or steel and does not pick up any other metals.




**Electric bell**: When you push the switch, the current flows in the coil of wire, the electromagnet turns on and attracts the iron armature. The hammer hits the gong and the contact switch opens. This stops the current and the electromagnet turns off. The iron armature springs back and the whole process repeats.

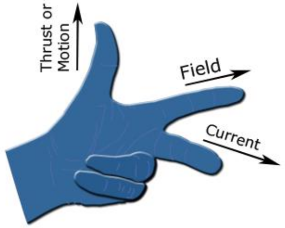


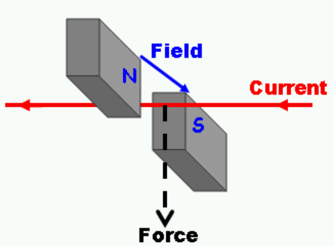

**Relay switch**: A small current in the coil turns it into an electromagnet. The iron armature is attracted to the electromagnet and pivots to push the switch contacts closed. This turns on a separate circuit that can have a much larger current. Used in electronic devices and car ignition circuits.




**Loudspeaker**: Uses the motor effect.
An alternating current in the coil of wire makes it into an electromagnet. The electromagnet is attracted and repelled by the circular permanent magnet. The coil is free to move so it vibrates and makes the cone vibrate with the same frequency as the alternating current.

## Section 4: The Motor Effect



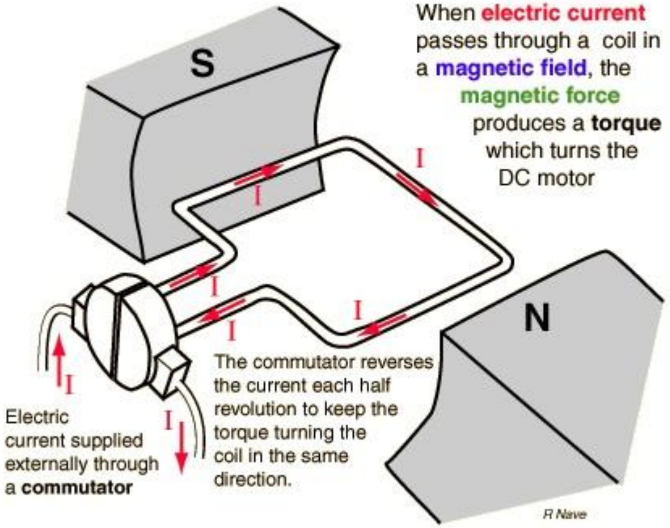




**The Motor Effect & Fleming's Left Hand Rule:**
A wire with a current in it put in a magnetic field will experience a force because the magnetic field around the wire is repelled by the magnetic field of the permanent magnet.
Fleming's LH rule tells you the direction of the force.
You can increase the force by:
→ increasing the current
→ using a stronger magnet
→ coiling the wire into loops

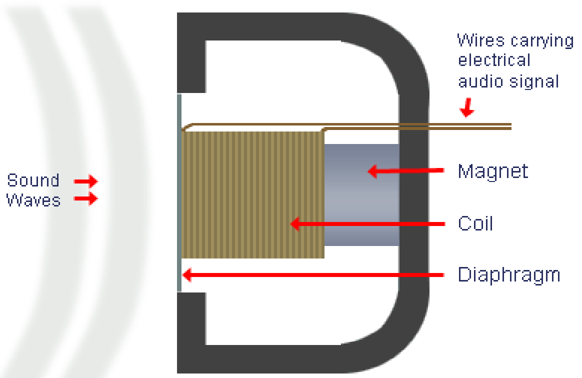
## Section 4: The Motor Effect – in more detail

**DC Motor**: uses this effect.
The split ring commutator keeps the current in the correct direction around the loop. You can speed it up by using a stronger magnet, increasing the current, or having more loops of wire on the coil.

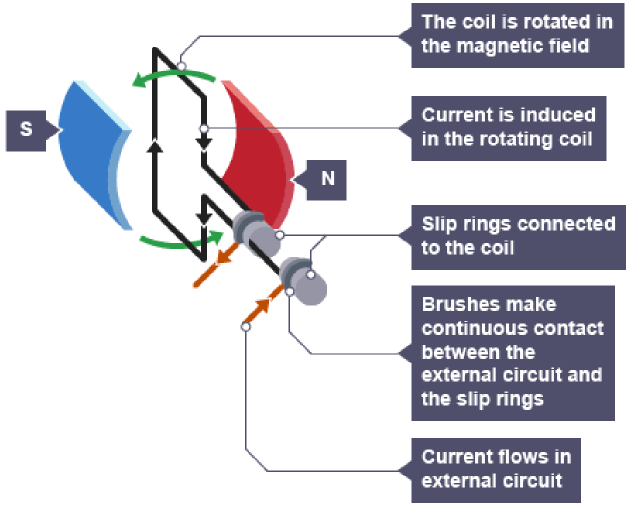
Practical motors have many sets of coils at different angles to make their rotation smoother




Cross-Section of Dynamic Microphone




## Section 5: Electromagnetic Induction (Generating Electricity)

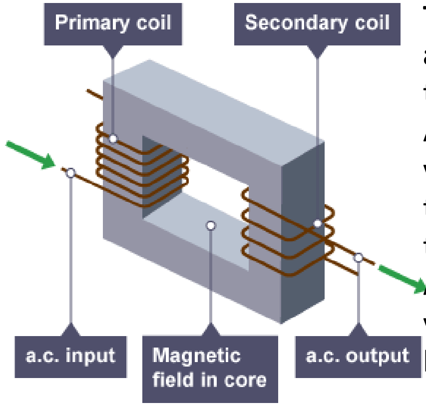



**The Generator Effect:** If you move a wire across magnetic field lines, a voltage is induced. To get a bigger voltage: use a stronger magnet, loop the wire into a coil, move it faster.
**AC Generator / Dynamo**: When you make a coil spin in a magnetic field, the wire cuts across the magnetic field lines. A potential difference (p.d. / voltage) is induced. If the coil is connected to a complete circuit, a current is induced too. The p.d. (and therefore the current) is alternating. Slip rings and brush contacts stop the wires from tangling up.
**To increase the voltage:**
→ Use a stronger magnet
→ Wind more loops(turns) of wire on the coil
→ Spin it faster
The generator in a power station uses electromagnets instead of permanent magnets, and has many more coils of wire.

**microphone**: Uses the generator effect.

- A sound wave makes the diaphragm vibrate.
- This pushes on the coil and moves it forwards and backwards over the permanent magnet.
- This movement between the coil and the magnet induces an alternating current in the wire…
- …that has the same frequency as the sound wave.

## Section 6: Transformers




**Transformers change the size of alternating voltages.** They are used in the National Grid.
A step-up transformer increases the voltage and decreases the current so that less energy is wasted by heating the power lines.
A step-down transformer reduces the voltage to a safe level for us to use at home.

Whatever happens to the number of turns, the same happens to the voltage. If the secondary coil has twice as many turns as the primary coil, the output (secondary) voltage will be twice the input (primary) voltage.

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

- An alternating current in the primary coil
- makes an alternating magnetic field in the iron core
- The magnetic field is moving and cuts across the secondary coil
- This induces a voltage in the secondary coil
- The induced secondary (output) voltage is at the same frequency as the primary (input) voltage

A step up transformer has more turns on the secondary coil than on the primary. A step down transformer has fewer turns on the secondary than the primary. The iron core is laminated (made of layers) to reduce energy loss.

**Power = current x voltage (P = IV)**

The power at the secondary coil has to be the same as the power at the primary coil (assuming the transformer is 100% efficient). This means that if the voltage increases, the current must decrease by the same factor – e.g. if the voltage doubles, the current is halved.
In reality, the secondary current will be a bit less than we calculate because transformers are not 100% efficient and lose energy as heat.