Electromagnetism (Separate Physics)

1. Key Terms in this sub-unit

Permanent magnet	A permanent magnet produces its own magnetic force.
Induced magnet	A material that becomes a magnet when placed in a magnetic field, but quickly loses its magnetism when removed from the field.
Magnetic materials	Iron, steel, nickel, cobalt
Magnetic field	The region around a magnet where a force acts on another magnet or magnetic material. The field is strongest at the poles of the magnet.
Magnetic field lines	The direction of a magnetic field line is from the north pole of a magnet to the south pole of the magnet.
Compass	This contains a small bar magnet and the magnet aligns itself with the surrounding magnetic field.
Earth's magnetic field	The Earth has a magnetic field. The compass needle points in the direction of the Earth's magnetic field.
Magnetic field of a conductor	When a current flows through a conducting wire a magnetic field is produced around the wire. The strength of the magnetic field depends on the current through the wire and the distance from the wire.
Motor effect	When a conductor carrying a current is placed in a magnetic field the magnet producing the field and the conductor exert a force on each other.
Solenoid	A coil of wire which carries an electric current.
Soft iron core	A solenoid is wrapped around this to increase the strength of its magnetic field. The core is an induced magnet.
Electromagnet	A solenoid wrapped around an iron core, whose magnetism can be turned on an off by an electric current.
Magnetic flux density	A measure of how many field (flux) lines there are in a region – it shows the strength of the magnetic field.
Electric motor	A coil of wire placed between the poles of a magnet and able to spin.
Commutator	A split ring which allows current to flow through the coil of an electric motor as it spins.
Generator	Can produce a alternating or direct current.
Dynamo	Generate direct current.
Alternating current	Current where the direction is constantly changing direction.
Alternators	Generate Alternating current.
Direct current	Current is a flow of charge, and conventional current (direct current, d.c.) flows from positive to negative. Flows from **+** → **-**
Oscilloscope	Used to see the generated potential difference and how it changes over time.
transformers	Change the potential difference only in alternating current. Can increase or decrease the potential difference.

2. Quantities & Units

Force (F)	Newton (N)
Magnetic flux density (B)	Tesla (T)
Length (*l*)	Metre (m)
Potential difference (*V*)	Volt (V)
Number of turns (N)	-
Current (I)	Ampere (A)

3. Equations

HT: - Force on a conductor	$F = BIl$
Transformers	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$
	$V_s I_s = V_p I_p$

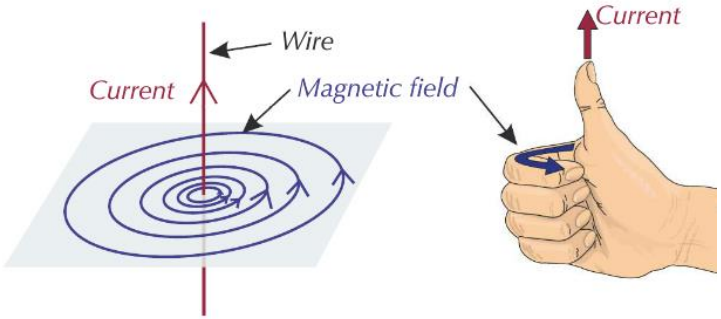
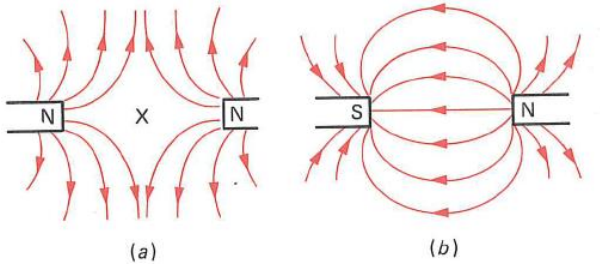
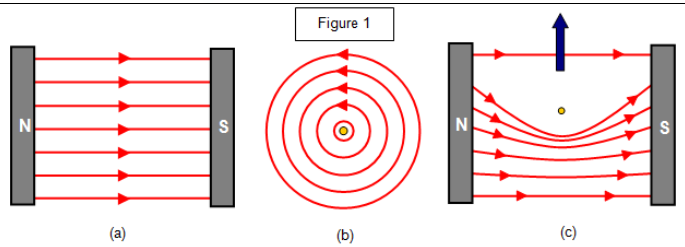
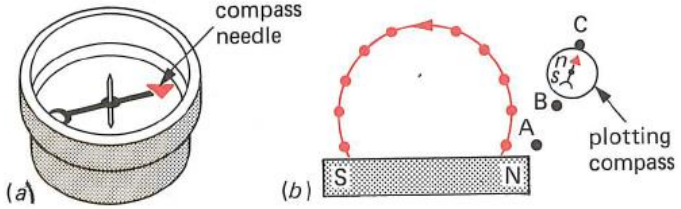
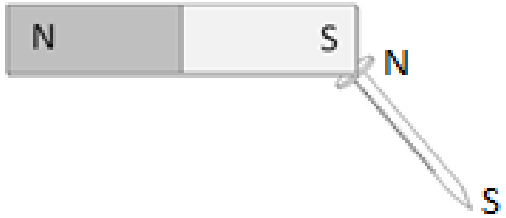
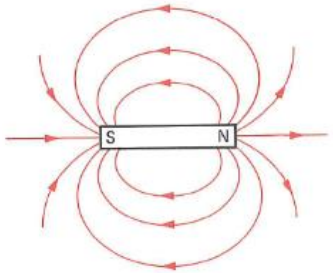
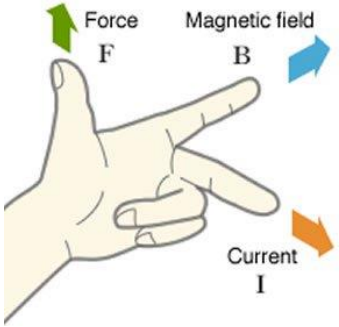
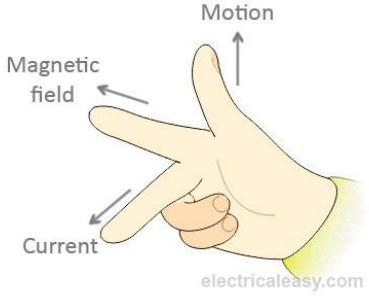
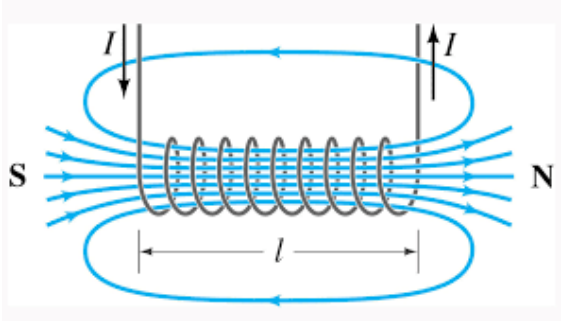
4. Electric Motors

Increase speed by	Increasing current
	Increasing the n^o of **turns**
	Increasing the field **strength**
Reverse direction	Reversing direction of current
	Swapping magnetic poles

5. Electromagnets

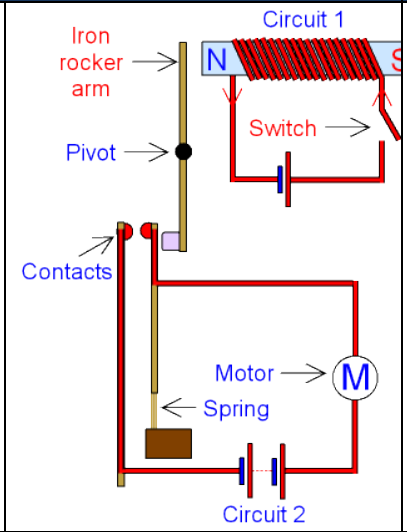
Increase the strength by	Adding more **turns** to the coil.
	Insert an iron coil into the centre of the coil.
	Increase the voltage.

6. Diagrams to interpret

Field around a conductor (Right-hand grip rule)		**Forces between magnets**	
Force on a conductor (you may have to draw diagrams a and b)		**Plotting a magnetic field pattern**	
Induced magnet poles		**Magnetic Field**	
HT: - Fleming's Left-hand rule: - to determine the direction of force in the motor effect		**HT: - Fleming's Right-hand rule: - to determine the direction of current a generator**	
Solenoid			

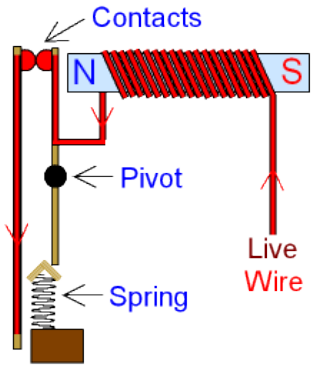
7. Uses of Electromagnets

Relay Switch



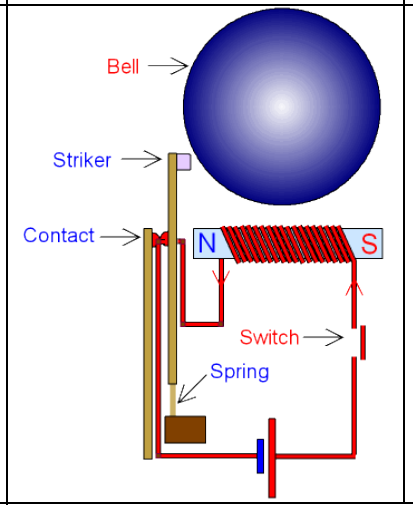
- Consists of 2 circuits
- Switch is closed, current flows and iron arm is attracted to the electromagnet.
- The arm pushes the contacts together.
- Circuit 2 is now switched on.

Circuit breaker



- If something goes wrong with the appliance and a large current flows.
- This increase the strength of the electromagnet and separates the contacts and breaks the circuit

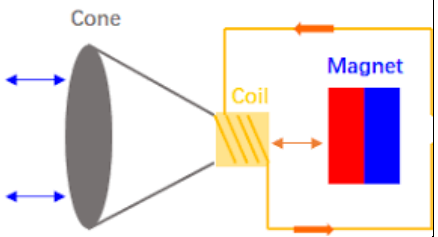
Electric bell



When the switch is pushed closed the electromagnet is switched on
1.The iron striker is attracted and strikes the bell.
2.As the striker moves towards the bell, the contact is broken. The electromagnet switches off.
3.The spring returns the striker to its original position which makes a new contact and so electricity flows again.

Speaker

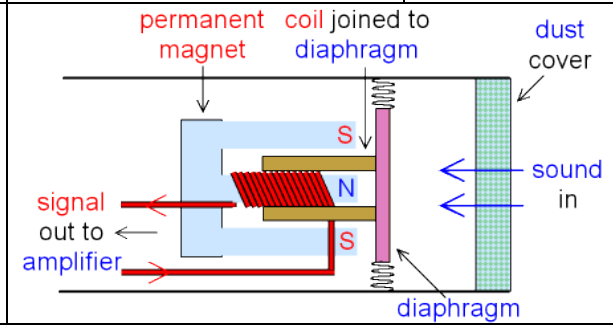
HT: -



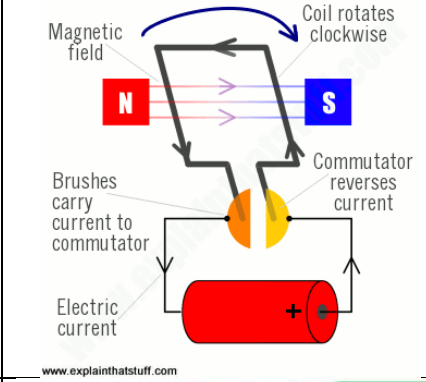
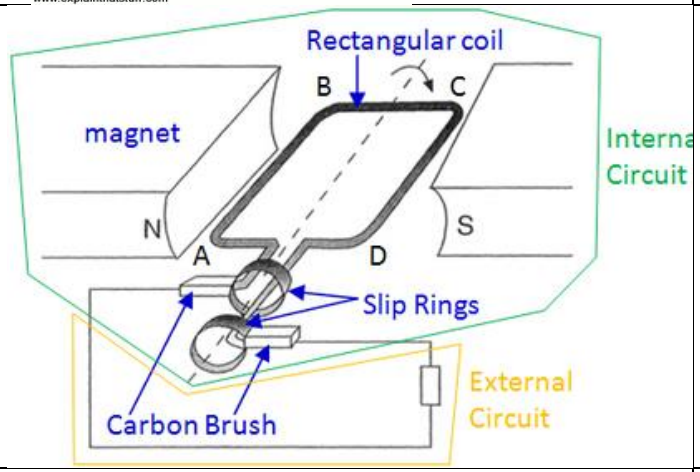
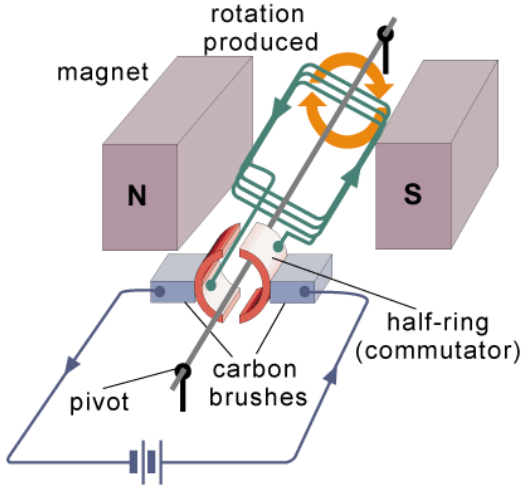
- When connected electrical current flows through wires.
- This turns the coil into a temporary magnet or **electromagnet**.
- As the electricity flows back and forth in the cables, the electromagnet either attracts or repels.
- This moves the coil back and forward, pulling and pushing the loudspeaker cone.
- This vibrates the air molecules creating a sound wave.

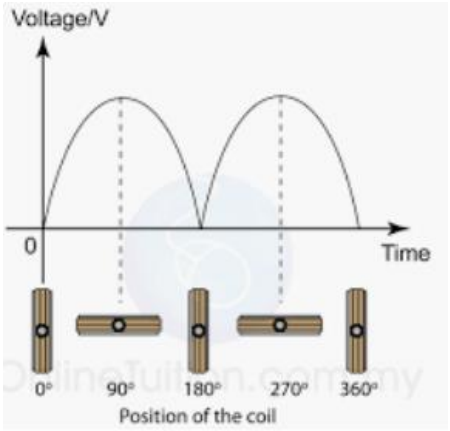
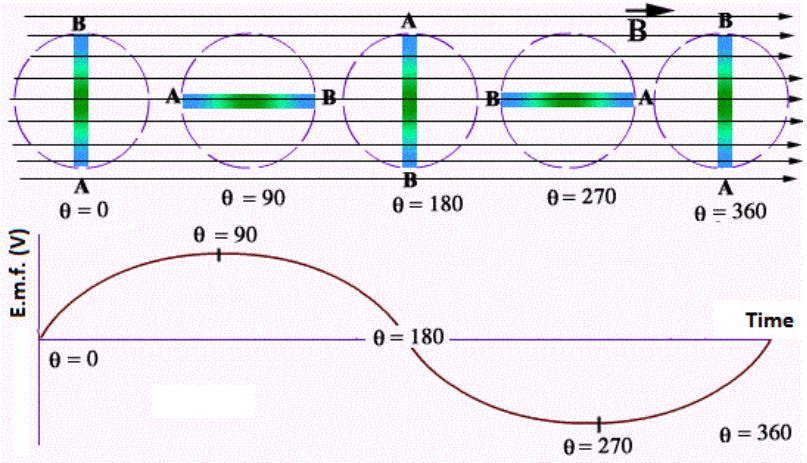
Micophone

HT: -



- Sound waves vibrate the diaphragm.
- The moves the coil of wire, wrapped around the permanent magnet, backwards and forwards.
- This generates a current which can be transmitted.

8. Motors and Generators : - Higher Tier		
Electric Motor- apply Flemings left hand rule for direction of force.		- The Current in the wire creates a magnetic field around the wire. - This interacts with the magnetic field of the permanent magnets - The sides of the coil (parallel to the magnet) experience a force (in opposite directions). - The forces cause moments that act in the same (clockwise / anticlockwise) direction **or** the moments cause the coil to rotate (clockwise / anticlockwise). - Each half-revolution, the two halves of the (rotating) commutator swap from one (carbon) brush to the other. - This reverses the direction of the current in the coil. - Keeping the forces in the same direction. - Keeping the coil rotating in the same direction.
Alternating Generators – apply Flemings right hand rule for direction of current.		- When a wire cuts through a magnetic field an electromagnetic force is exerted on the electrons on the wire. - This causes the electrons to move, creating a current. - The direction of the current depends on the direction the wire is moving in relation to the magnetic field. - As one side of the coil moves up in the magnetic field, electrons are pushed in one direction. - However as the coil rotates the wire starts to move down in the magnetic field, so the electrons are forced in the other direction. - This causes the current to constantly change direction, depending on the position of the coil in the EM field. - You can increase the size of the potential difference by having a stronger magnetic field or rotating the coil more quickly, having more turns on the coil, have an iron core. - The slip rings stop the wire from twisting together and provide a continuous connection to the circuit.
Dynamos (DC)		- In a generator the position of the coil in the magnetic field effects the direction of the current. - In whichever side of the coil is moving down the through the magnetic field, the current will move one way. - Whichever side is moving up through the field the current will move the other way. This creats alternating current. - To create a direct current, the external circuit needs to be connected so the current is always flowing in the same direction. - This is done with the split ring commutator. - Every half turn the coil connects with the opposite terminal on the external circuit, so despite the current in the coil changing direction, the current in the external circuit stays flowing in the same direction.

Oscilloscope trace	Direct Current  The faster the coil spins the greater the Potential difference so the greater the amplitude and higher frequency.	Alternating Current 

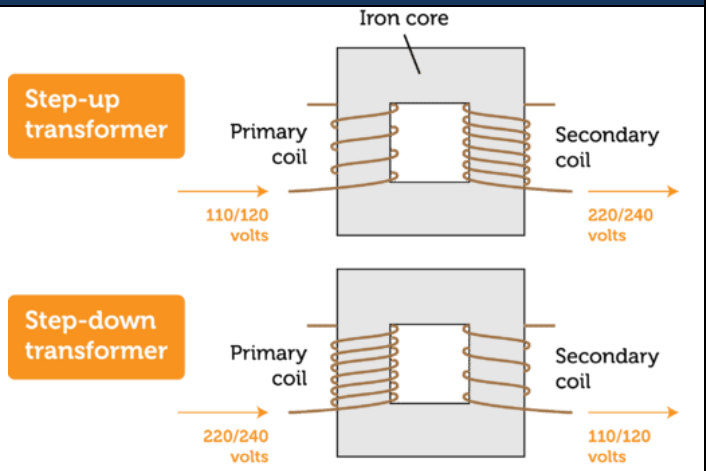
9. Transformers : - Higher Tier

What is a transformer?

Alter the potential difference but only for alternating current.

A transformer consists of a soft iron coil with two coils wound around it which are not connected to one another.

There are 2 types of transformer:
- step up – more coils on secondary - increase the P.D.
- step down – fewer coils on secondary - decrease the P.D.



Formula

1)

$$\frac{\text{Voltage in Secondary Coil}}{\text{Voltage in Primary Coil}} = \frac{\text{Turns on Secondary Coil}}{\text{Turns on Primary Coil}}$$

OR

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

2) Transformers are almost 100% efficient. Therefore **Power in primary coil = Power in secondary coil**

OR

Primary coil p.d. x primary coil current = Secondary coil p.d. x secondary coil current

$$V_P \times I_P = V_S \times I_S$$