WJEC (Eduqas) Physics GCSE

8.3: Induced Potential and Transformers

Detailed Notes

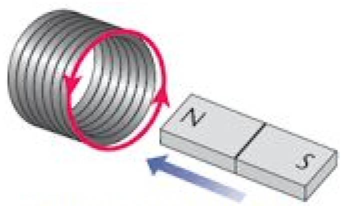
(Content in **bold** is for higher tier **only**)

Electromagnetic Induction

Magnetic fields can be used to generate (induce) a current in a coil of wire. When a magnet is moved into the centre of the coil of wire, a voltage is produced. When the magnet is removed and moved out of the wire coil, a reverse voltage is produced. It can also be reversed when the magnet direction is reversed so that the other pole is moved into the coil.

Connecting the coil as part of a circuit means a current is able to be induced and flow in the circuit.

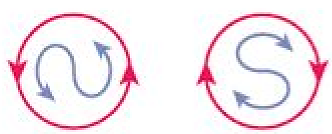
It is important to understand that there is no voltage induced when the magnet is not moving, even when inside the coil.



Electromagnetic induction (revisionworld.com).

The size of the induced voltage can be increased by moving the magnet faster, increasing the number of turns on the wire coil or by increasing the strength of the magnet.

The direction of the current flow and magnetic field relative to the direction of rotation of the wire coil can be found using the following method:



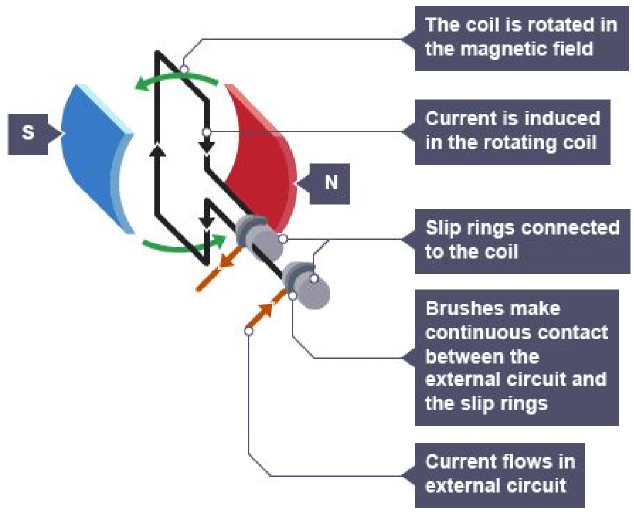
Using arrows to indicate the rotation of the coil can identify the pole (N or S) and indicate the flow of current (revisionworld.com).

Generators

A generator uses a magnetic field and a moving wire to generate a current in a circuit. The movement of the wire, magnetic field and induced current all occur at right angles to one another. Therefore if the direction of the wire movement is reversed, the current induced will be in the opposite direction.

AC Generators

AC generators use a coil of wire meaning that for each half turn, one side of the coil moves upwards and the other side of the coil moves downwards. Therefore as the coil is rotated in the magnetic field, the current induced changes direction for every half turn of the wire. This is an alternating current (AC) where current and voltage are continually changing direction around a circuit.



Electromagnetic AC generator (bbc.co.uk).

The induced voltage can be increased by rotating the coil faster, including more turns of wire on the coil or by using stronger magnets. An iron core can also be added inside the coil to help increase the size of voltage induced.

DC Generators

DC generators are also sometimes called dynamos. They use the same setup as a basic motor, with a coil of wire able to rotate between two permanent magnetic poles. A turbine spins, turning the coil of wire.

The movement of the wire causes the wire to cut through the magnetic field so it experiences a change in magnetic field. A commutator ring is required to allow the current and p.d. output be supplied in a constant direction.

Transformers

A transformer is a device used to **increase or decrease the voltage** in a circuit. **Two coils** of wire around a **soft iron core** use the concepts of electromagnetic induction to do this.

An alternating voltage is supplied to the first coil creating a changing magnetic field. This field is transferred through the soft iron core to the secondary coil. An alternating voltage is then induced in the secondary coil by this alternating magnetic field.

If there are more turns on the secondary coil, a greater voltage will be induced in that coil, creating a step-up transformer. If there are fewer coils on the secondary coil, a step-down transformer is produced, as a smaller voltage is induced on the secondary coil. This shows how the induced voltage depends on the number of turns on the coil and the input voltage.

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

V_1 is the voltage in the primary coil (V), V_2 voltage in the secondary coil (V), N_1 the turns on the primary coil and N_2 the turns on the secondary coils.

This equation is only accurate when the transformer has **100% efficiency**.

Power Output

Electrical **power output** for a transformer can be found using the relationship of power, p.d. and current.

$$P = IV$$

P is power (W), I is current (A) and V is potential different (V).

Assuming the transformer is **100% efficient**, the **power output** from the transformer can be calculated by considering both coils involved.

$$V_1 I_1 = V_2 I_2$$

V_1 is the primary potential difference, I_1 is the primary current, V_2 is the secondary potential difference and I_2 is the secondary current.

National Grid Transformers

The National Grid is a system of **power lines** and **transformers** linking **power stations** to consumers across the UK. It allows electricity to be transferred for domestic use. Transformers are used in the National Grid network to make this domestic energy transfer **safer** and **more efficient**.

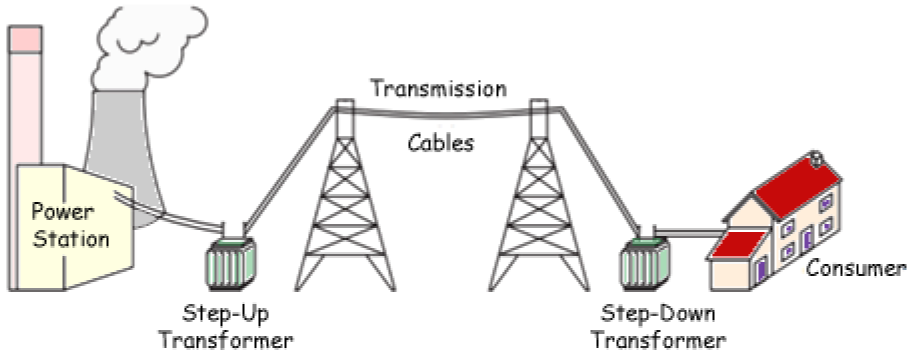


Diagram showing the components of The National Grid (cyberphysics.co.uk)

Power stations produce electricity at **25,000 V**. This power station voltage needs to be transformed to a **higher** power line voltage to **reduce the current** ($P=IV$). Reducing the current will **reduce the amount of energy lost** through heat in the power lines. Step-up transformers can increase the voltage to up to **132,000 V**.

Step-down transformers then **reduce** the voltage back to a **safe level** ready for domestic use. Household electricity has a voltage around **230 V**.