Edexcel GCSE Physics

Topic 13: Electromagnetic induction

Notes

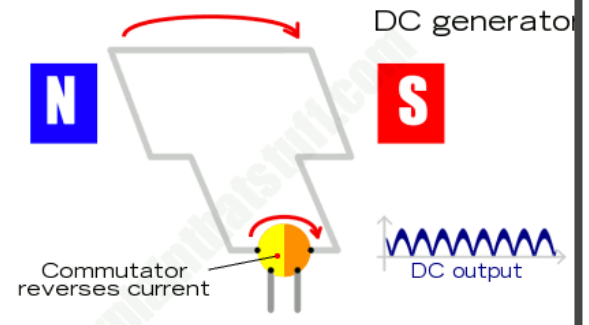
(Content in bold Higher Tier only)

Current Induction (Physics only)

- Current is induced if a wire is moved in a magnetic field
- The Conductor (wire) forms a potential difference (electrons move to one side of the conductor as the field changes)
- If the conductor is connected in a circuit, a current will flow
    - (This current will produce its own magnetic field)
    - (The direction of this new field is in the *opposite* direction to the first field)
        - (I.e. it opposes the original change)

Production (Physics only)

- Small-scale
    - Spinning a coil of wire in between two permanent magnets will cause a current to flow in the wire, which can be shown by a sensitive ammeter (only milliamps will be generated)
    - Passing a wire through a field will also show a deflection in an ammeter (a reading).
- Large-scale
    - In a thermal power station, water heats up and evaporates to form steam
        - Combustion of fossil fuels / nuclear fission may cause this
    - The steam is put under pressure and forced into a turbine
    - This causes the turbine to rotate, which is connected to a massive coil of wire in a strong magnetic field (the generator)
    - Current is generated in the coil by the spinning motion of the coil through the field.

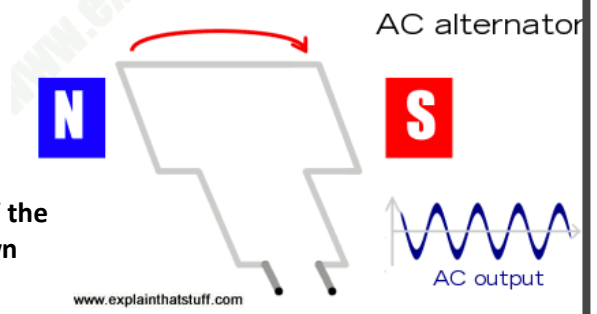


Factors that affect the size of the current/voltage produced:

- Number of coils of wire
- Speed of rotation
- Magnetic field strength

Alternator

- Every half turn, the current switches direction, as the wire will be in the opposite orientation compared to its starting position (see figure).
    - Use the Left Hand Rule to show the direction of the current induced switches as it moves up or down
- This produces AC.



Dynamo

- Same set up as an alternator.
- At end of the coil, there is a 'commutator'
    - A metal ring that reverses the sign of the current that flows from the coil – ensuring current output remains positive
    - Every half-turn the commutator switches the sign of the current, so it remains positive
- This produces DC.

Microphones and Loudspeakers

- **Produce a current which is proportional to the sound signal**
- **Fixed magnet is at the centre, and the coil of wire around the magnet is free to move**
- **Pressure variations in the sound waves cause the coil to move, and as it moves current is induced in the coil (because it passes through the magnetic field)**
- **This current is then sent to a loudspeaker**

- **The Loudspeaker setup is identical**
- **Current flows into the coil**
- **The magnetic field from magnet and from current interact, causing the coil to move**
- **The cone therefore moves**
- **Producing pressure variations, making sound**

Transformers

- **AC in first coil creates a changing magnetic field**
- **This changing magnetic field cuts through the secondary coil**
- **This induces a current in the secondary coil**
  - **Which is also AC**
  - **If primary current was DC, magnetic field produced will be constant, not inducing anything in the secondary coil**
- **(Physics only) More coils on secondary? Step up transformer, as voltage will be increased, as changing field will cut through more of the secondary wire inducing a larger pd**
- **(Physics only) Fewer coils on secondary? Step down transformer, as smaller pd forms on secondary**

$$\frac{number\ of\ coils\ on\ primary}{number\ of\ coils\ on\ secondary} = \frac{pd\ of\ primary}{pd\ of\ secondary}$$

$$\frac{N_{primary}}{N_{secondary}} = \frac{V_{primary}}{V_{secondary}}$$

National Grid

- Electrical energy is transferred at high voltages from power stations
- In domestic uses, electrical energy is transformed to lower voltages
  - This is done to improve the efficiency of the transmission
  - The larger the current, the greater the heating effect occurs in wires
  - So this means a large current means lots of energy is lost
  - So as P = IV and power is constant, increasing the voltage out of the power station and so reduces the current
    - However high voltages are very dangerous
  - So when it is close to towns (etc.) the voltage is decreased (and so current increases)
  - This means it is safer to use
    - As well as making sure less energy is lost as it is carried from power stations

Transformer Summary

- Step-up transformers increase the voltage
- Step-down transformers decrease the voltage

Power for a transformer with 100% efficiency: power of primary circuit = power in secondary

$$V \times I = V \times I$$

$$primary = secondary$$