Triple Science - Physics

SP12-13 Knowledge organiser

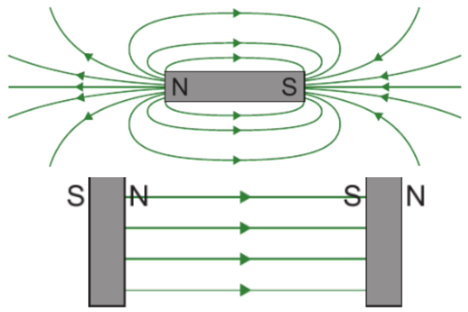
P12-13: Magnetism and electromagnetic induction

Lesson sequence

1. Magnets and magnetic fields
2. Electromagnetism
3. Magnetic forces
4. Electromagnetic induction
5. The national grid
6. Transformers and energy

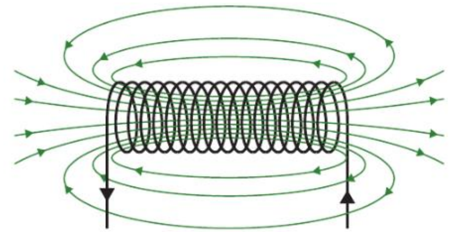
1. Magnets and magnetic fields

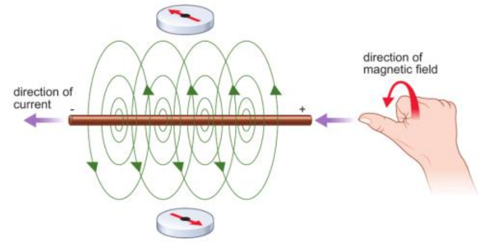
Permanent magnet	A magnet that is always magnetic.
Temporary magnet	A magnet that is not always magnetic.
Induced magnet	When something becomes temporarily magnetic when close to another magnet.
Uses of magnets	Motors, loud speakers, generators, door locks, knife holders.
Magnetic field	The area of magnetic force around a magnet.
Bar magnet field shape	Curved lines going from north to south
Uniform magnetic field shape	When the north of one magnet is near the south of another, straight field lines connect them.
Magnetic field direction	From north to south
Plotting a magnetic field	Draw around a magnet. Place a plotting compass on it and draw a small arrow to show needle direction. Move a cm in that direction and repeat. Connect arrows to form lines. Repeat.
Earth's magnetic field	The North Pole is a magnetic south pole (because it attracts the north of bar magnet).



2. Electromagnetism

Electromagnetism	Current flowing through a wire creates a magnetic field around it.
Wire magnetic field shape	Concentric circles.
Wire magnetic field strength	Stronger nearer the wire and with higher current.
Wire magnetic field direction	Right hand rule – thumb points towards negative, field in same direction as fingers.
Solenoid	A coil of wire with current running through it.
Solenoid magnetic field shape	Outside: similar to bar magnet. Inside: almost uniform
Solenoid magnetic field direction	From negative to positive.
Electromagnet	A temporary magnet made by placing an iron core inside a solenoid.



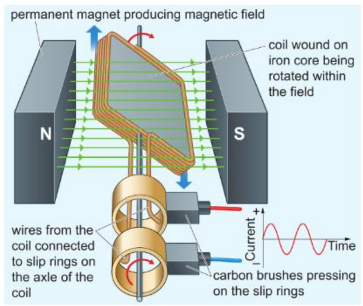


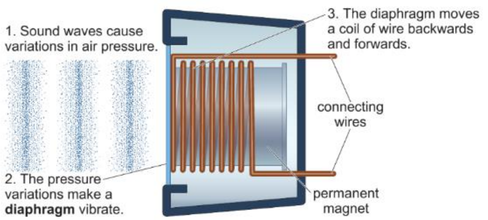
3. Magnetic forces

Motor effect	Force produced when the magnetic field from a permanent magnet pushes a magnetic field from a wire.
Direction of force from motor effect	Flemming's left-hand rule – index finger points in direction of magnetic field, middle finger points from + to – current, thumb points in direction of force.
Force from motor effect is greatest when…	Magnetic field and electric field are at right angles, wire is longer, current is greater, magnet is stronger.
Magnetic flux density, B	The strength of a magnetic field.
Newtons per amp metre (N / A m)	Units of magnetic flux density.
Tesla, T	Same as newtons per amp metre.
Calculating forces from the motor effect	Force = magnetic flux density x current x length F = B x I x L Force = newtons Magnetic flux density = teslas Current = amps Length = metres

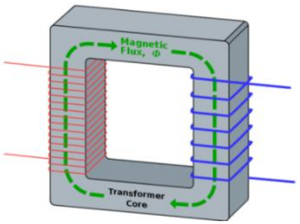
4. Electromagnetic induction

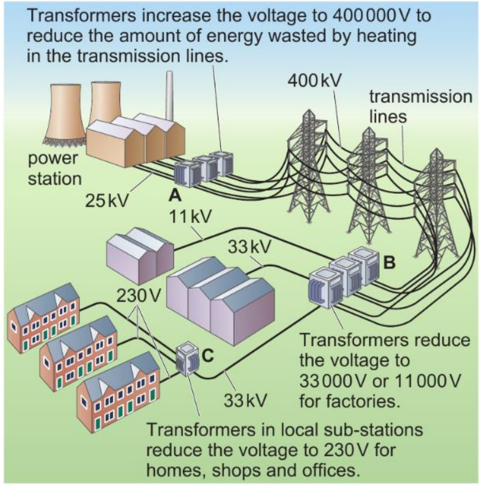
Electromagnetic induction	The production of an electromotive force (i.e., voltage) across an electrical conductor in a changing magnetic field.
Potential difference	The difference of electrical potential between two points.
Generators	Consists of a coil of wire that is rotated inside a magnetic field. A the coil turns , a voltage is induce in the wire.
Dynamo	A generator with a commutator is often called a dynamo
Split rings	A small steel ring with two spiral turns, such as a key ring.
Commutator	Switches over the connections every half-turn of the coil, an so produce a form of direct current.
Carbon brushes	Allows electrical contact with an external circuit
Alternating current	An electric current that reverses its direction many times a second at regular intervals.
Alternator	A dynamo that generates an alternating current.
Direct current	An electric current flowing in one direction only.
Microphones	Convert the pressure variations in sound waves into variations in current in electrical circuits.
Loudspeakers	Convert variations in an electrical current into sound waves.





5. The national grid	
Transformer	A device that changes the potential difference of a an electricity supply.
Electromagnetic induction	When voltage in one coil of wire causes a voltage in another.
Transformer structure	Two coils of wire wrapped around an iron core. Current goes in the primary coil and comes out from the secondary coil.
How transformers work	Current passing through the primary coil induces a current in the secondary coil of higher voltage and lower current 9or vice versa).
Conservation of energy in transformers	If the voltage increases, the current decreases, so energy is conserved since: Power = current x voltage
Transformer calculations	Primary current x primary voltage = secondary current x secondary voltage $V_p \times I_p = V_s \times I_s$ Voltage = volts Current = amps





6. Transformers and energy	
National grid	The system of cables and transformers that transfers electricity from power stations to homes and businesses.
Voltage in the national grid	Power station = 25 kV Overhead cables = 400 kV Factories = 33 kV Homes = 230 V
Step-up transformer	Increase voltage and decreases current.
Step-down transformer	Decrease voltage and increases current.
Factors affecting the potential difference induced in a transformer	Coils: more coils → higher voltage Frequency: how many times the magnetic field changes or moves past the wire
Transformers and current	Transformers only work with alternating current.

Worked example W2

An electricity substation supplies 2 MW of power to a small housing estate. Electricity is sent to the substation along cables with a resistance of 0.08 Ω. The supply is at 230 V. Calculate the energy wasted every hour.

Current required: $I = \frac{P}{V}$

$= \frac{2 \times 10^6\,W}{230\,V}$

$= 8.7 \times 10^3\,A$

Power transferred by heating in the wires to the substation: $P = I^2 \times R$

$= (8.7 \times 10^3\,A)^2 \times 0.08\,\Omega$

$= 6.05 \times 10^6\,W$

Energy transferred per hour: $E = P \times t$

$= 6.05 \times 10^6\,W \times 3600\,s$

Energy wasted $= 2.18 \times 10^{10}\,J$