AQA GCSE Physics

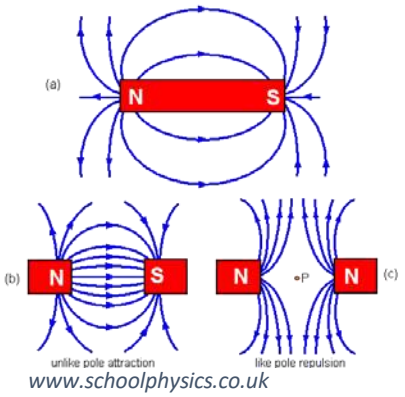
Topic 7: Magnetism and Electromagnetism

Notes

(Content in bold is for Higher Tier only)

Magnets

- North and South Poles
- Same Poles repel
- Opposite poles attract



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Permanent Magnets
- Always magnetic, always have poles

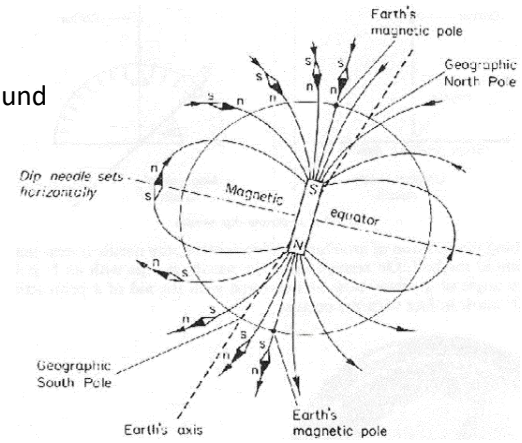
Induced Magnets
- Materials that are "magnetic" but do not have fixed poles
- These can be made into temporary magnets by 'stroking' them with a permanent magnet
  - These align the domains in the material all in the same direction, creating a temporary magnet
  - Iron, Nickel, Cobalt

Magnetic Fields

- Field Lines point from North to South
- Strength decreases with distance from the magnet
- Direction always points to south pole and away from north pole, at any point
- Use Plotting Compasses
  - Small compasses which show the direction of the magnetic field at a certain point

Earth's Core

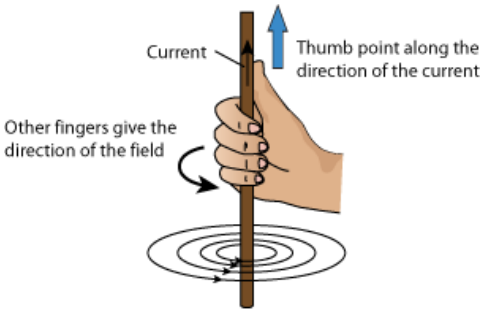
- The core is magnetic, and creates a large magnetic field around the Earth
- We know this because a freely suspended magnetic compass will align itself with the earth's field lines and point North
- It doesn't point to the Geographic North pole – it is over North Canada
- Also, the compass is effectively a suspended Bar Magnet, with its own north pole lining up with Earth's 'North pole'
  - However this cannot be right, as like poles repel
  - So in fact, Earth's magnetic pole above Canada is a magnetic South Pole! (and the geographic south pole is close to the Magnetic North Pole)



astarmathsandphysics.com

Current

- Current produces a magnetic field around the wire
- The direction is dictated by the "right hand grip rule"
- Plotting compasses on a piece of paper through which a wire is pierced shows this



Right Hand Grip Rule

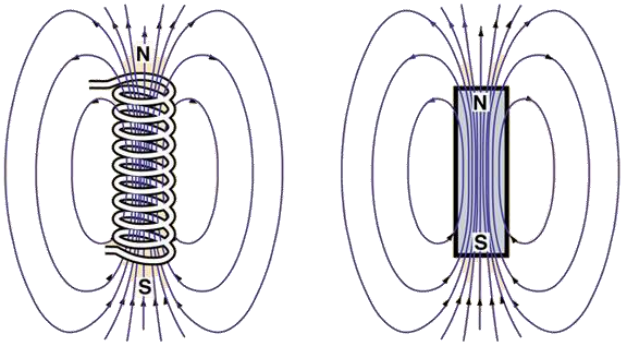
Strength of Magnetic Field

- Greater current, stronger magnetic field
- Greater distance from wire, weaker field

www.ibworldwideacademy.com

Solenoid

- Magnetic field shape is similar to a bar magnet
- It enhances the magnetic effect as coiling the wire causes the field to align and form a giant single field, rather than lots of them all perpendicular to the direction of the current
- Having an iron core in the centre increases its strength as it is easier for magnetic field lines to pass through than air
- Factors that affect the strength
    - Size of current
    - Length
    - Cross sectional area
    - Number of turns (coils)
    - Using a soft iron core



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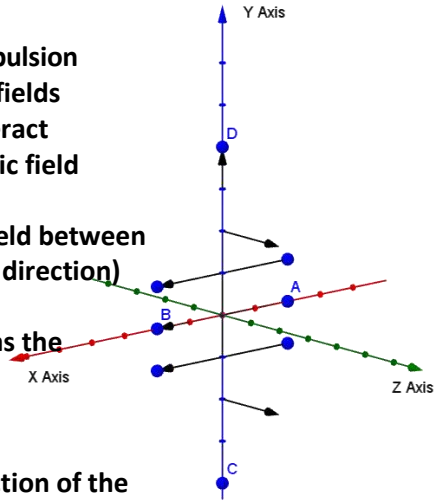
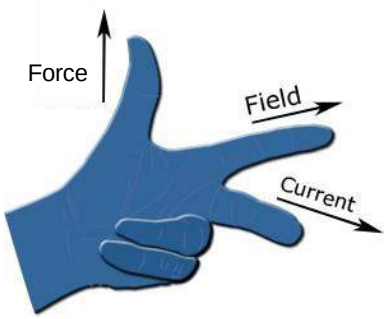
The Motor Effect

- **Two magnets will interact, feeling a magnetic force of attraction/repulsion**
- **So a magnet and a wire will also exert a force, as the two magnetic fields (generated by the magnet and the current in the wire) will also interact**
    - **The magnetic field around a wire is circular, but the magnetic field between two magnets is straight**
    - **When the two interact, the wire is pushed away from the field between the poles (at right angles to the wire direction and the field direction)**
- **To visualise**
    - **Fixed permanent magnets have field lines along the x axis, as the magnets are at A and B and the field lines are shown**
    - **Wire is along y axis, where current is moving up from C to D**
    - **The Force felt on the wire is at right angles to both the direction of the current and magnetic field lines**
        - **Along the z axis**



Fleming's Left Hand Rule

- **Each direction is 90° to each other**
- **Use this to work out the unknown factor out of the three (usually the direction of the force felt)**
- **Remember current is conventional current, which moves in opposite direction to the electrons**



en.wikipedia.org

$$Force = (magnetic\ flux\ density) \times (current) \times (length)$$
$$F = BIL$$

- **Where Magnetic Flux Density is measured in Tesla**
    - **And it is the number of flux lines per metre squared**

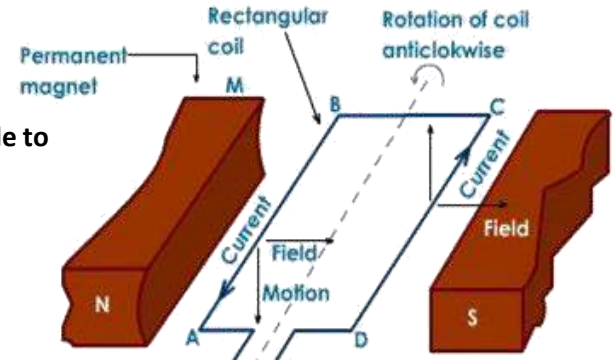
How Electric Motors work

- **Knowledge of structure is not expected**
- **Permanent Magnets lie in fixed positions**
- **In between, a coil of current-carrying wire lies on an axis**
    - **Force on one side moves that side up**
    - **Force on the other side (where current is flowing in opposite direction) moves down**
    - **This can be verified using Fleming's Left Hand Rule**
- **Hence it rotates**

Electromagnetic Induction (Physics only)

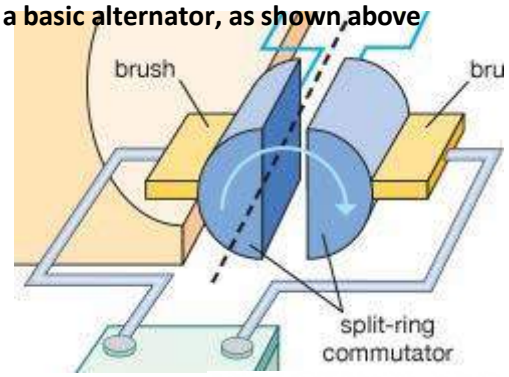
- **When there is a relative movement between a conductor and a magnetic field, a potential difference is induced across the conductor.**
- **This happens if the magnetic field changes as well**
- **A current flows if the conductor forms a complete circuit.**
- **This current will produce its own magnetic field, which oppose the change inducing it**

How Electric Generators (dynamos) work (Physics only)



tutorvista.com

- **Same setup as a motor, with a coil of wire able to rotate between two permanent magnets**
- **A turbine spins turning the coil of wire**
- **The movement of the wire causes the wire to cut through the magnetic field**
- **It experiences a change in magnetic field**
- **This creates a potential difference**
- **If the coil of wire is connected to a complete circuit, an alternating current (AC) will flow – this is a basic alternator, as shown above**
- **Direct current (DC) current is produced if the ends, A and D in diagram above, are connected to a split ring commutator**
- **This reverses the current each half-rotation so current remains positive – this system is called a dynamo**



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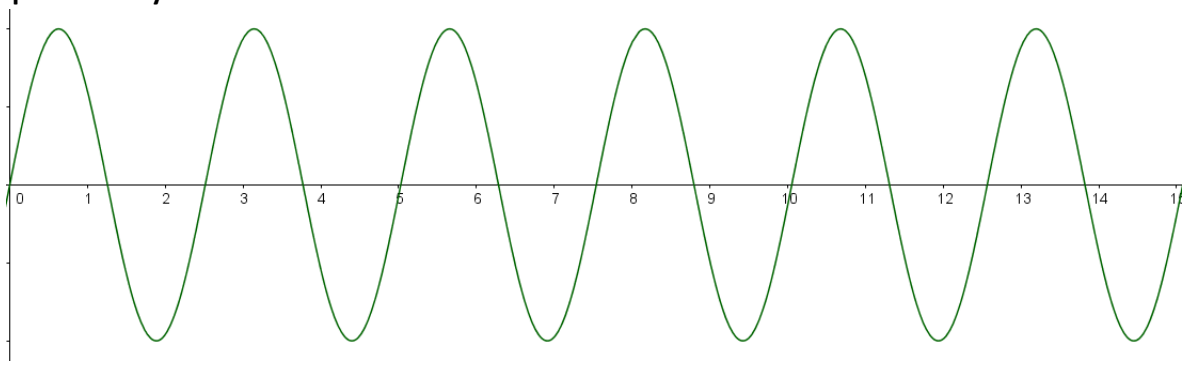
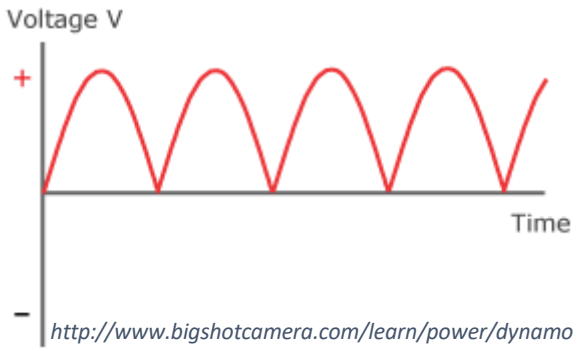
http://kids.britannica.com/eb/art-53254

AC produced by Alternator:



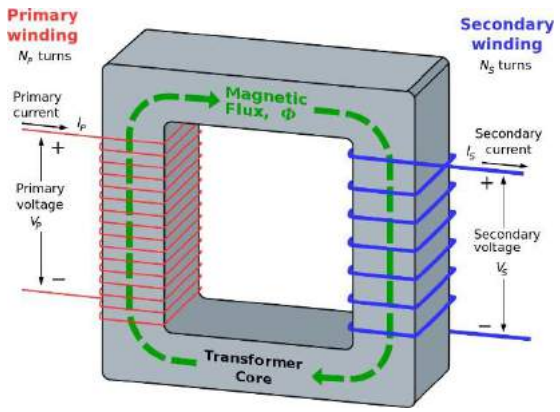
DC produced by Dynamo:



http://www.bigshotcamera.com/learn/power/dynamo

Transformers (Physics only)

- **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 it produces will be constant, not inducing anything in the secondary coil**
- **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**
- **Fewer coils on secondary: Step down transformer, as smaller pd forms on secondary**



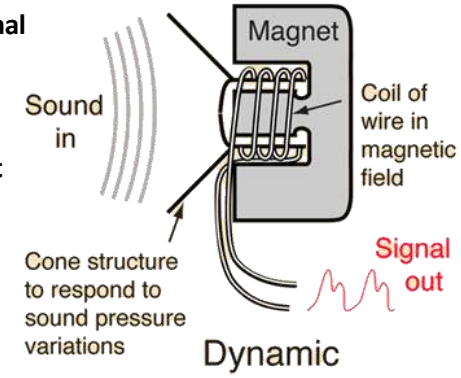
en.wikipedia.org - step down transformer

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

- **This only works with current too if the transformer is 100% efficient. Unless it states this, assume not and just use this to find voltage**

How Dynamic Microphones Work (Physics only)

- **They 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 cuts the magnetic field)**
- **This current is then sent to a loudspeaker**



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Loudspeakers (Physics only)

- **The setup is identical, working in reverse**
- **The 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**