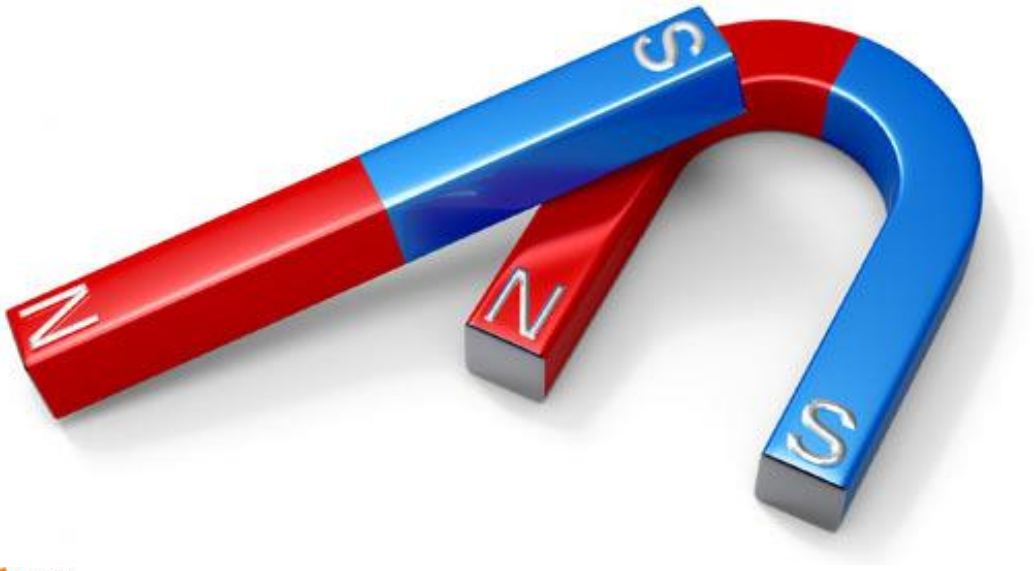
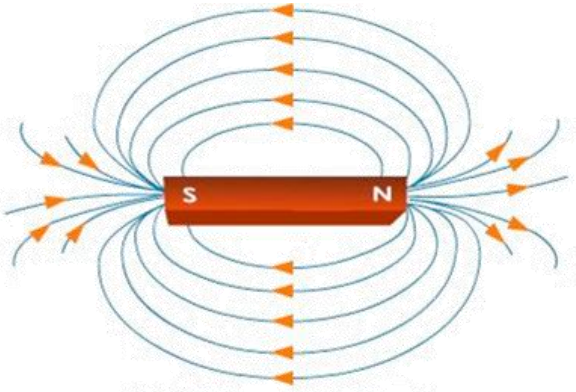
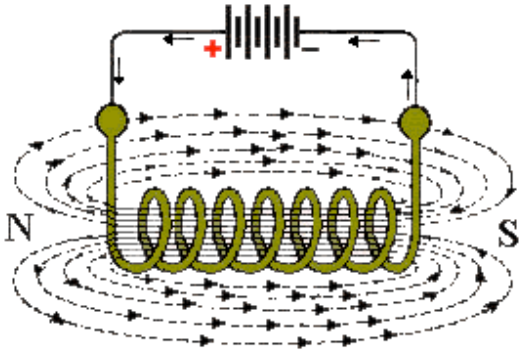
Magnetism

Magnetism





Ferromagnetism

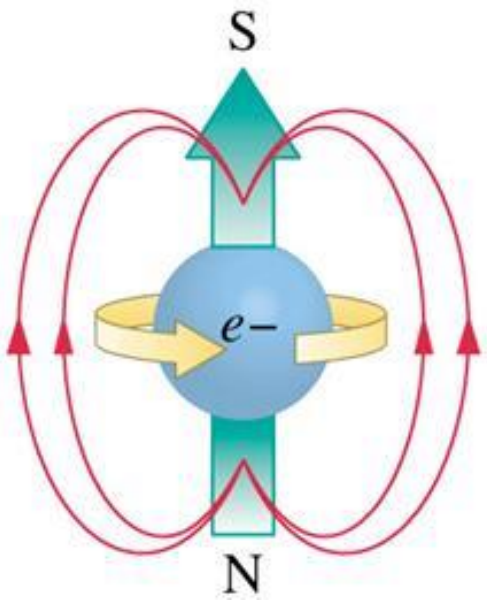


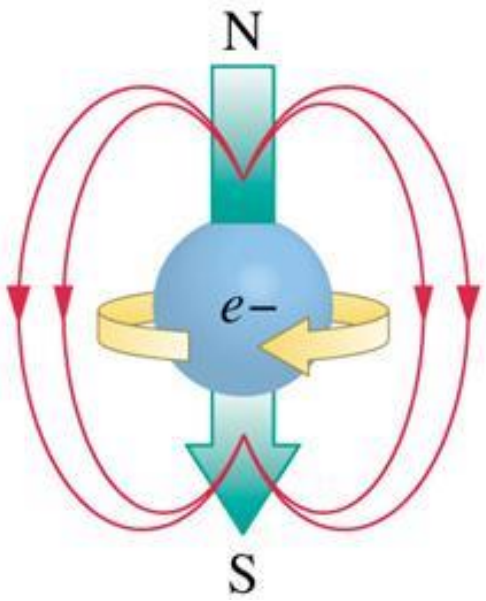
Electromagnetism

Ferromagnetism

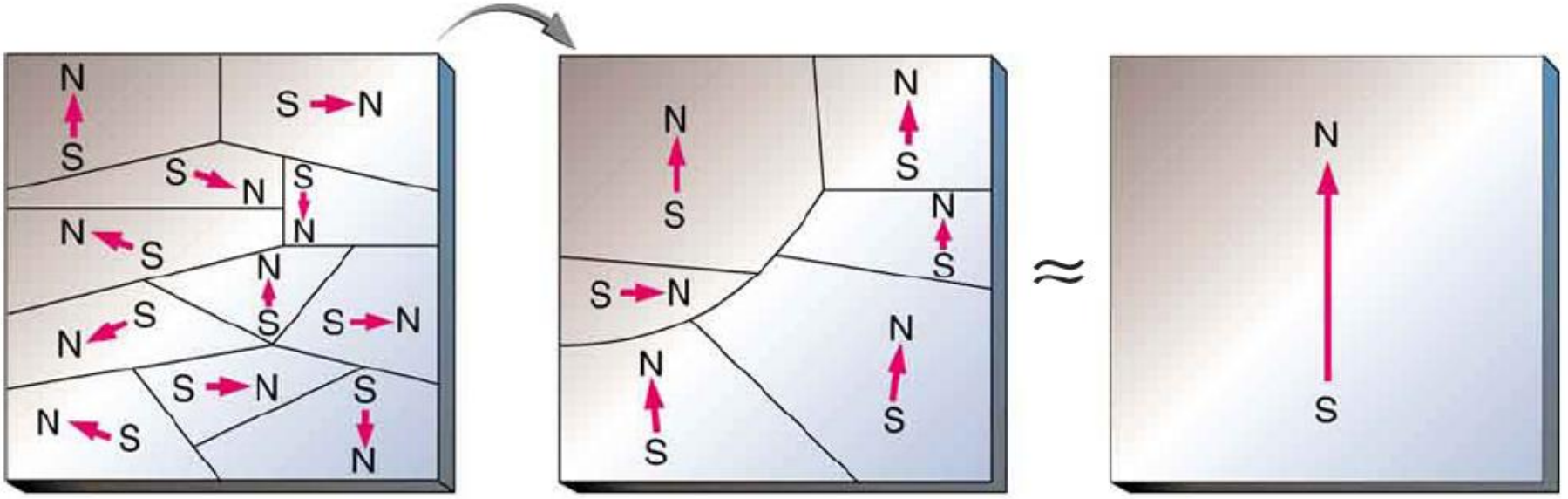
Ferromagnetic materials are those that can become strongly magnetized, such as iron, nickel & cobalt.

These materials are made up of tiny regions called domains; the magnetic field in each domain is in a single direction.





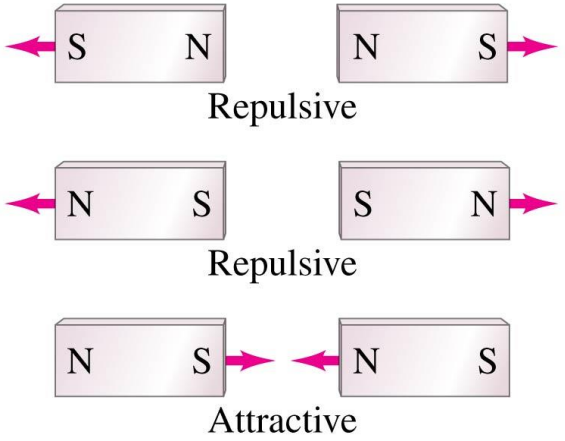
Permanent Magnets



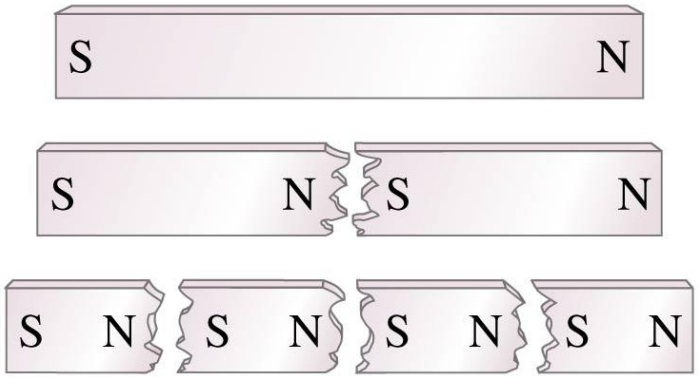
- Ferromagnetic materials
- Atomic magnetic moment
- Clusters of atomic moments align in domains
- Not magnetized - domains randomly oriented
- Magnetized - domains aligned

Magnetic Poles

Magnets have two ends—poles—called north and south.



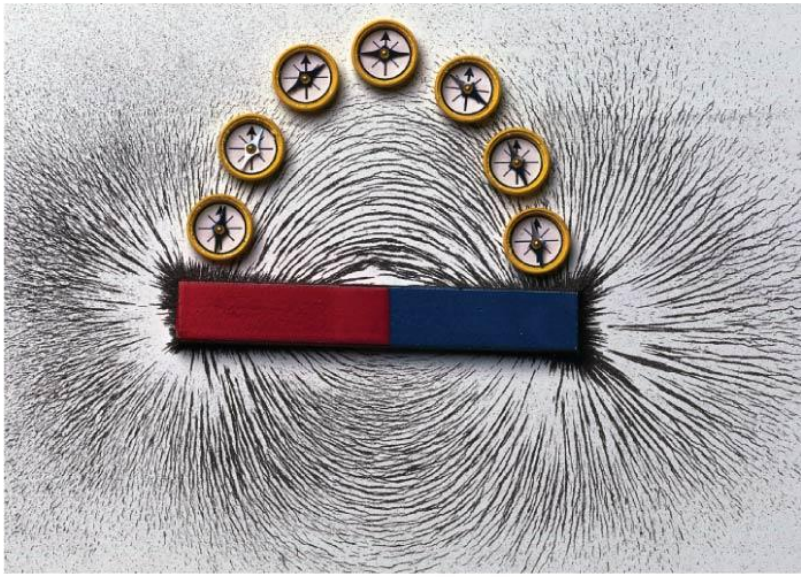
Like poles repel; unlike poles attract.

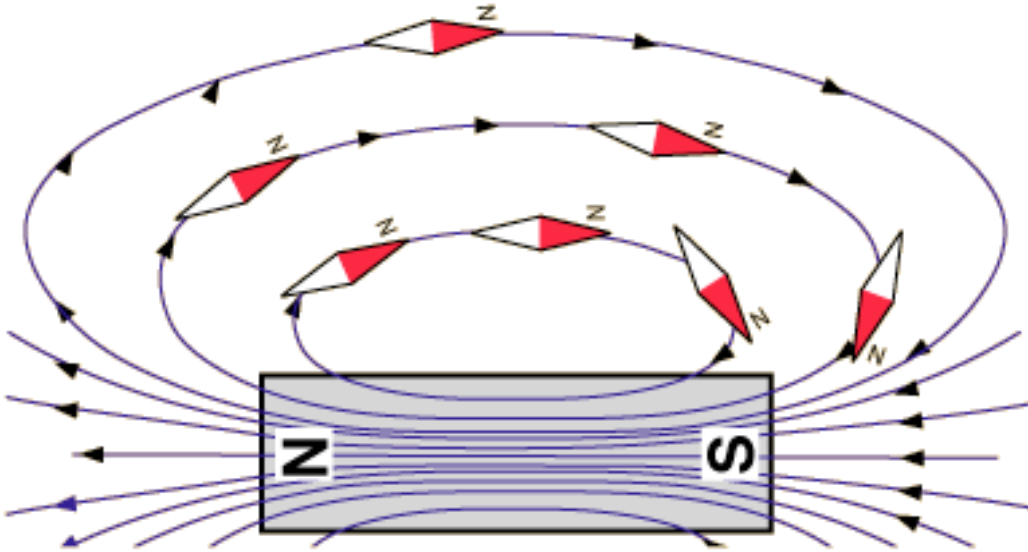


If you cut a magnet in half — get two smaller magnets.

Magnets and Magnetic Fields

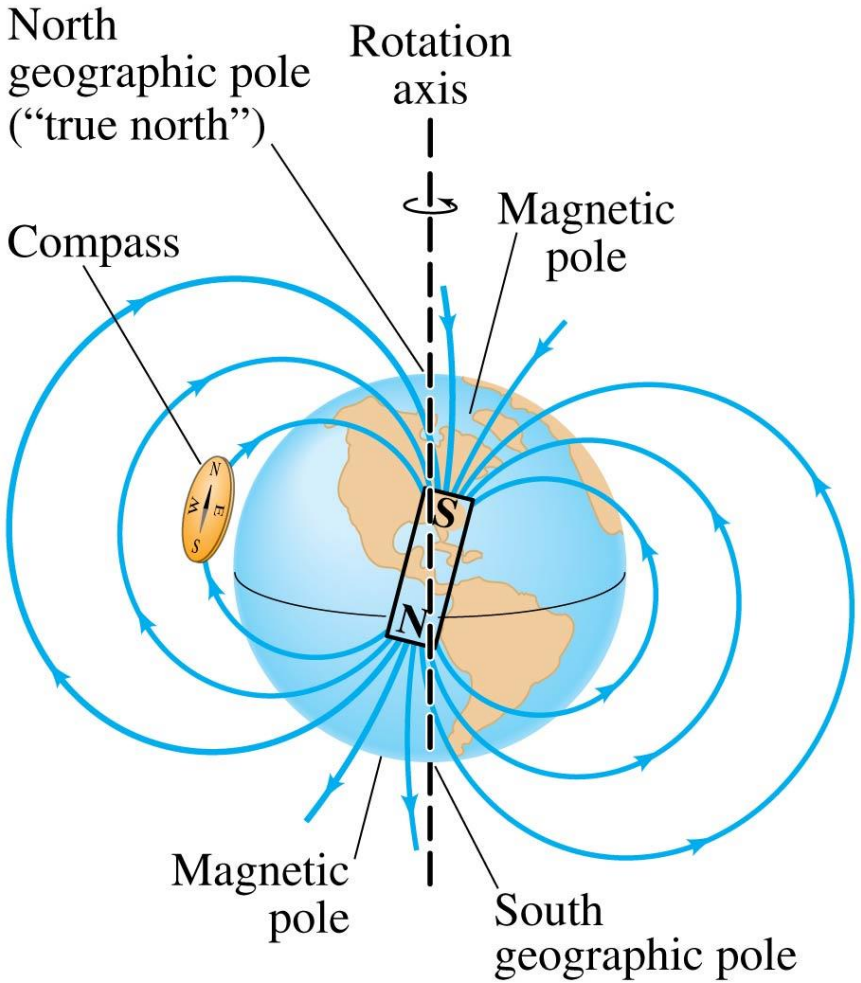
Magnetic fields can be visualized using magnetic field lines, which are always closed loops.



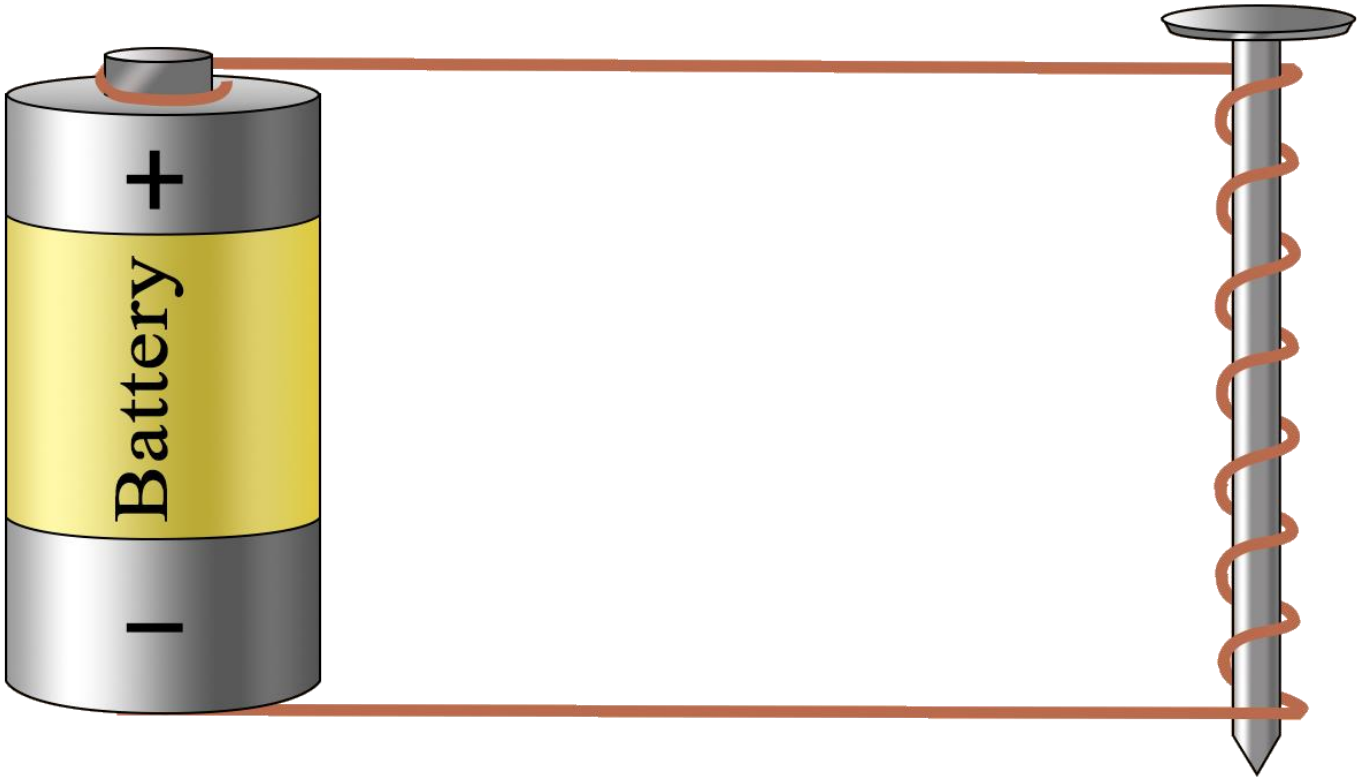


Earth's Magnetic Field

- Originates deep beneath the surface from currents in molten core
- Magnetic "north" pole = south pole of Earth's magnetic field
- Magnetic declination = offset
- Direction of field periodically reverses
  - Deposits of magnetized material
  - Last reversal - 780,000 yrs. ago

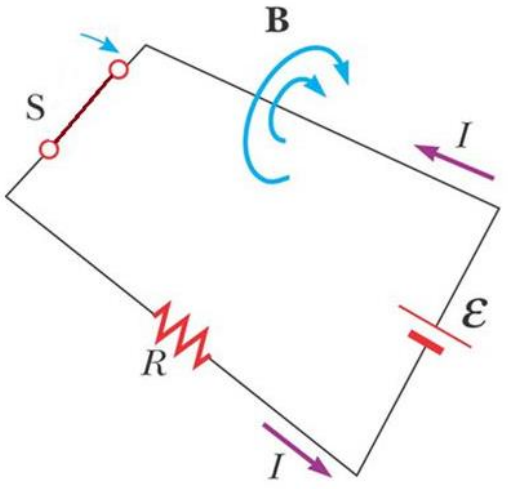


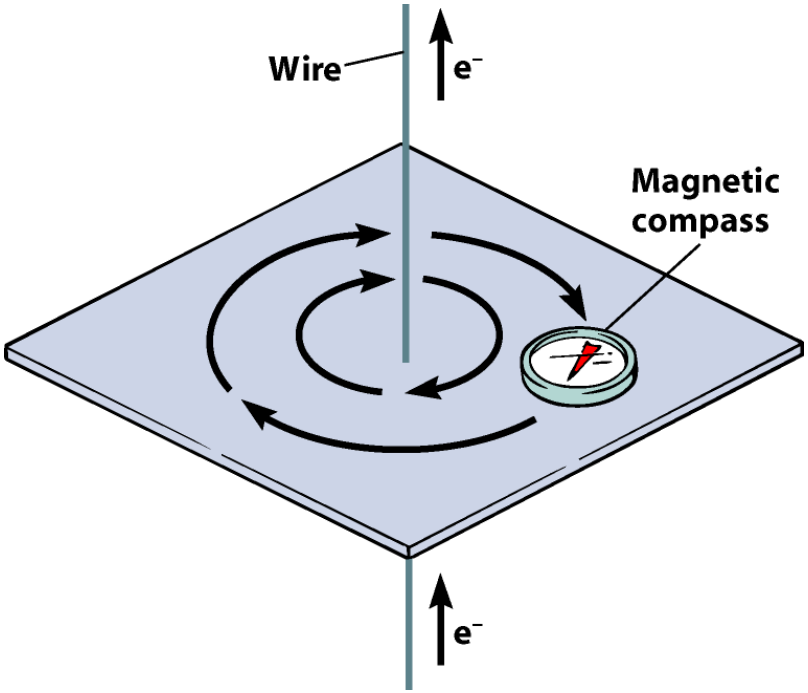
Making a magnet



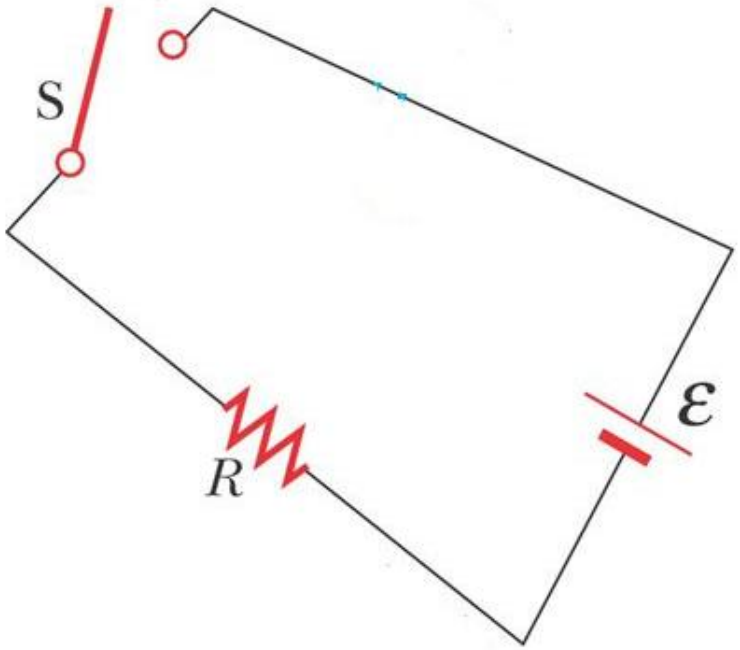
Electric Currents and Magnetism

- Moving charges (currents) produce magnetic fields

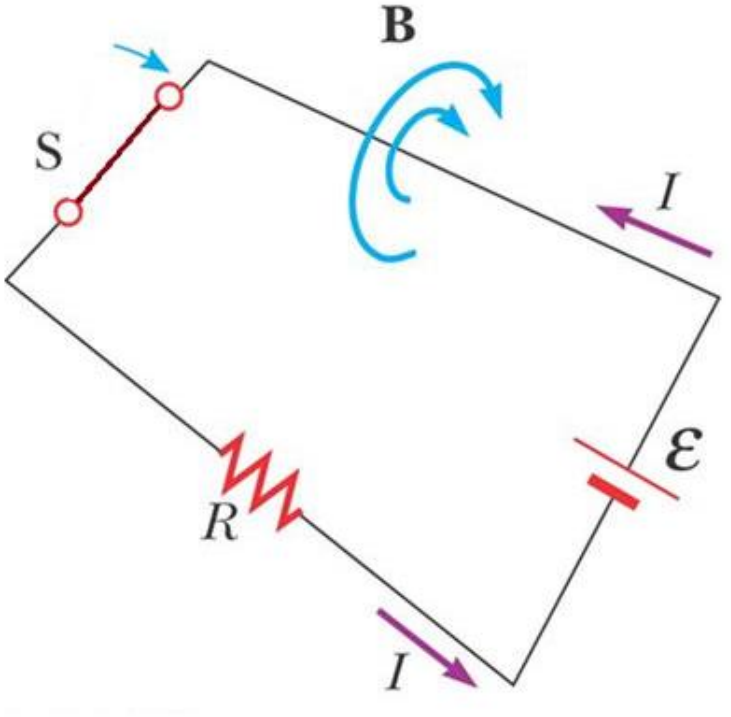




Electricity and Magnetism-EMF



Switch Open: No current
And no magnetic field

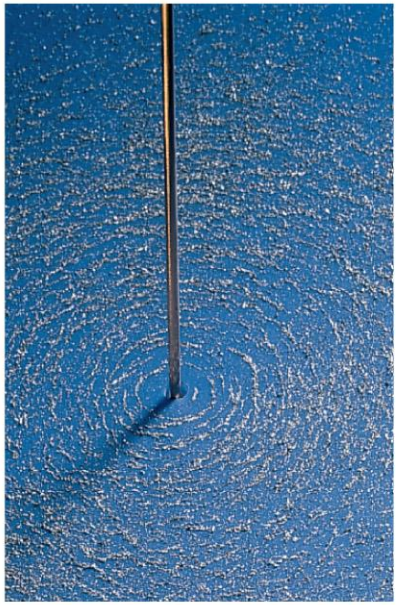


Switch Closed: Current increases, creates and magnetic field or electromagnetic field (EMF)

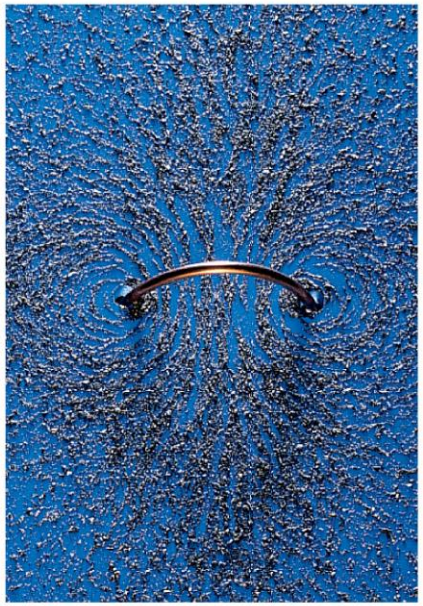
Electric Currents and Magnetic Fields

Magnetic field intensity

- increases as the number of loops increase in a current-carrying coil



(a)



(b)

(c)

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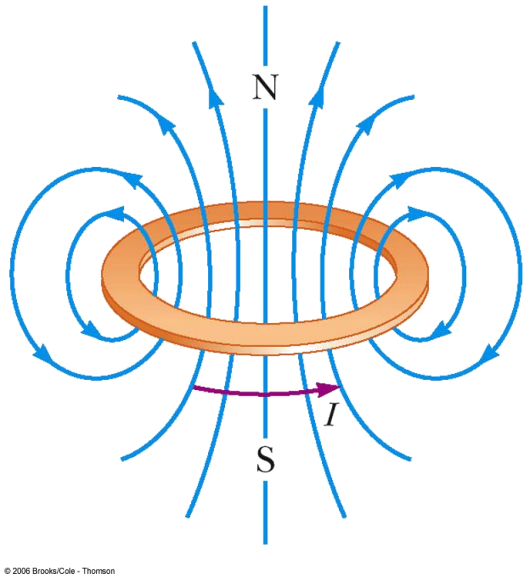

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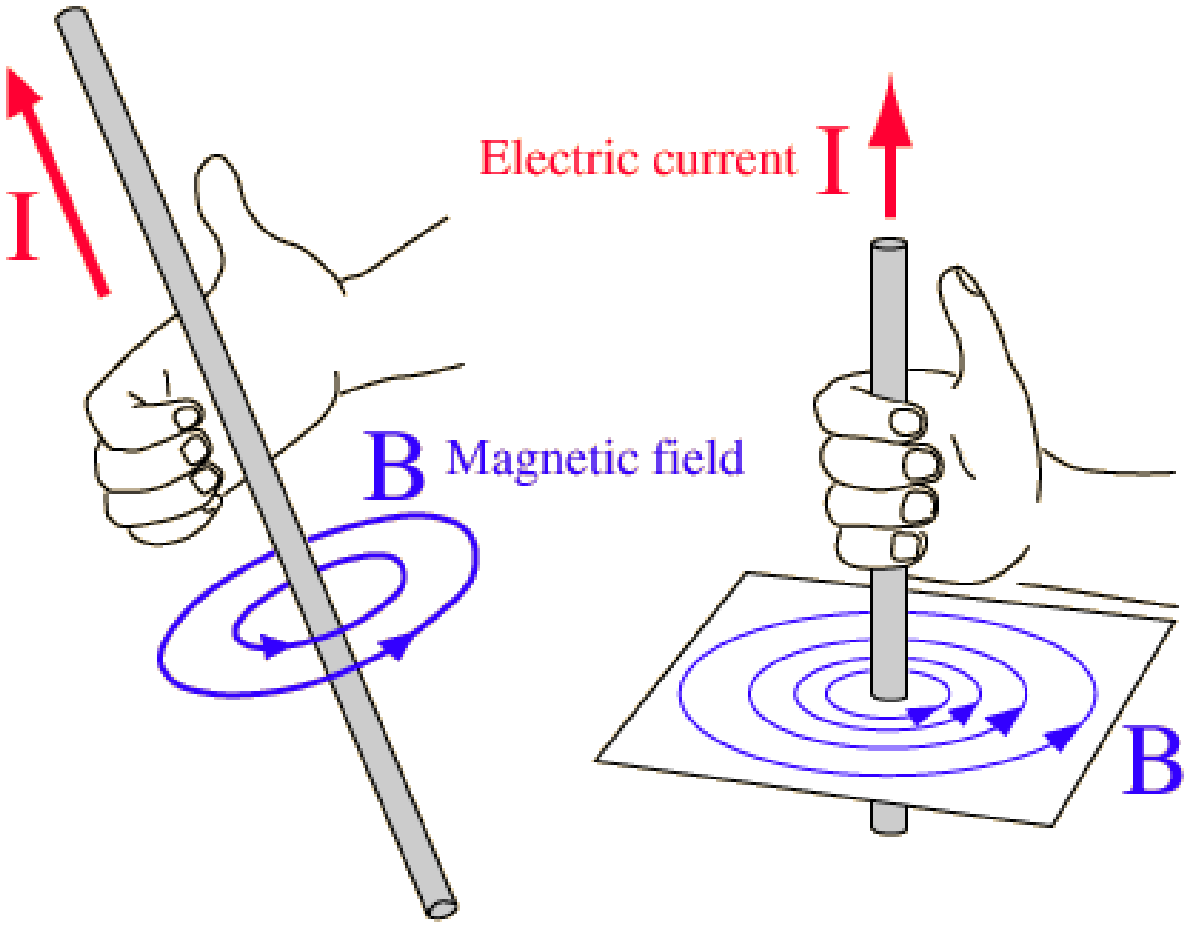
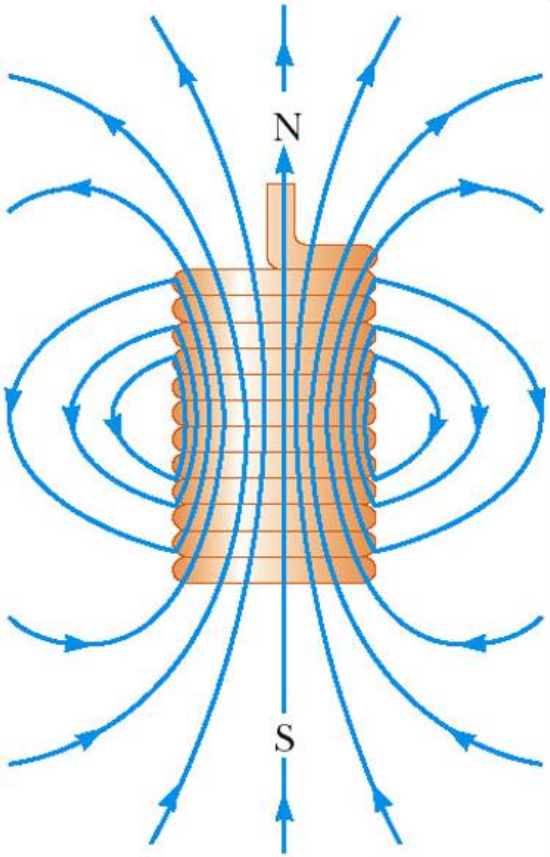
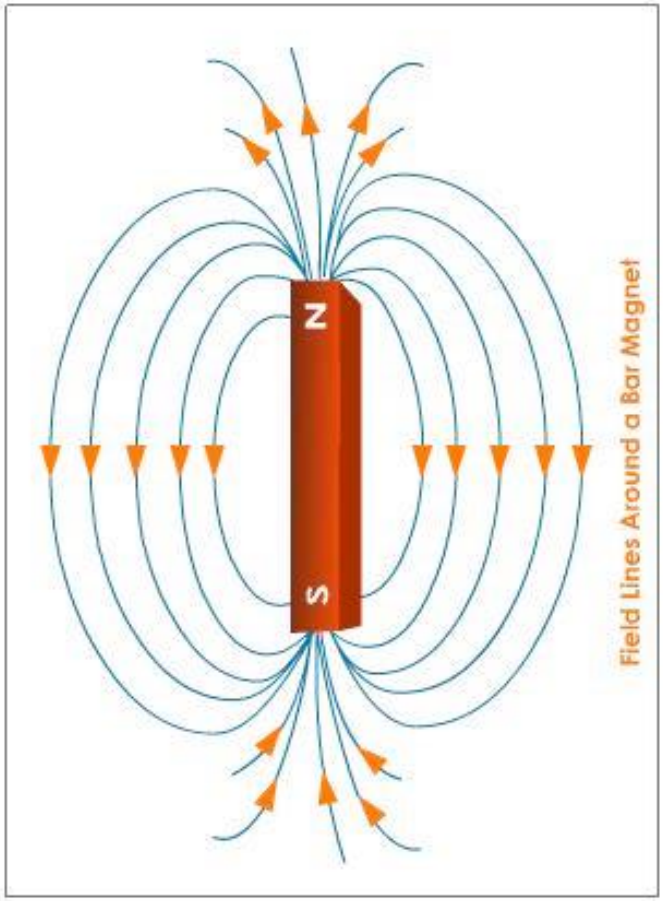
Magnetic Field of Straight Wire
RHR



Solenoid Behaves Like a Magnet

Electromagnet – Magnetism from Electricity

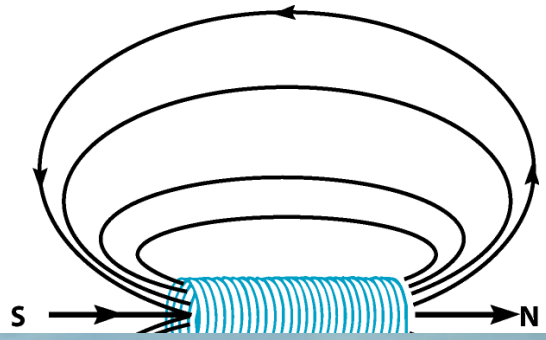




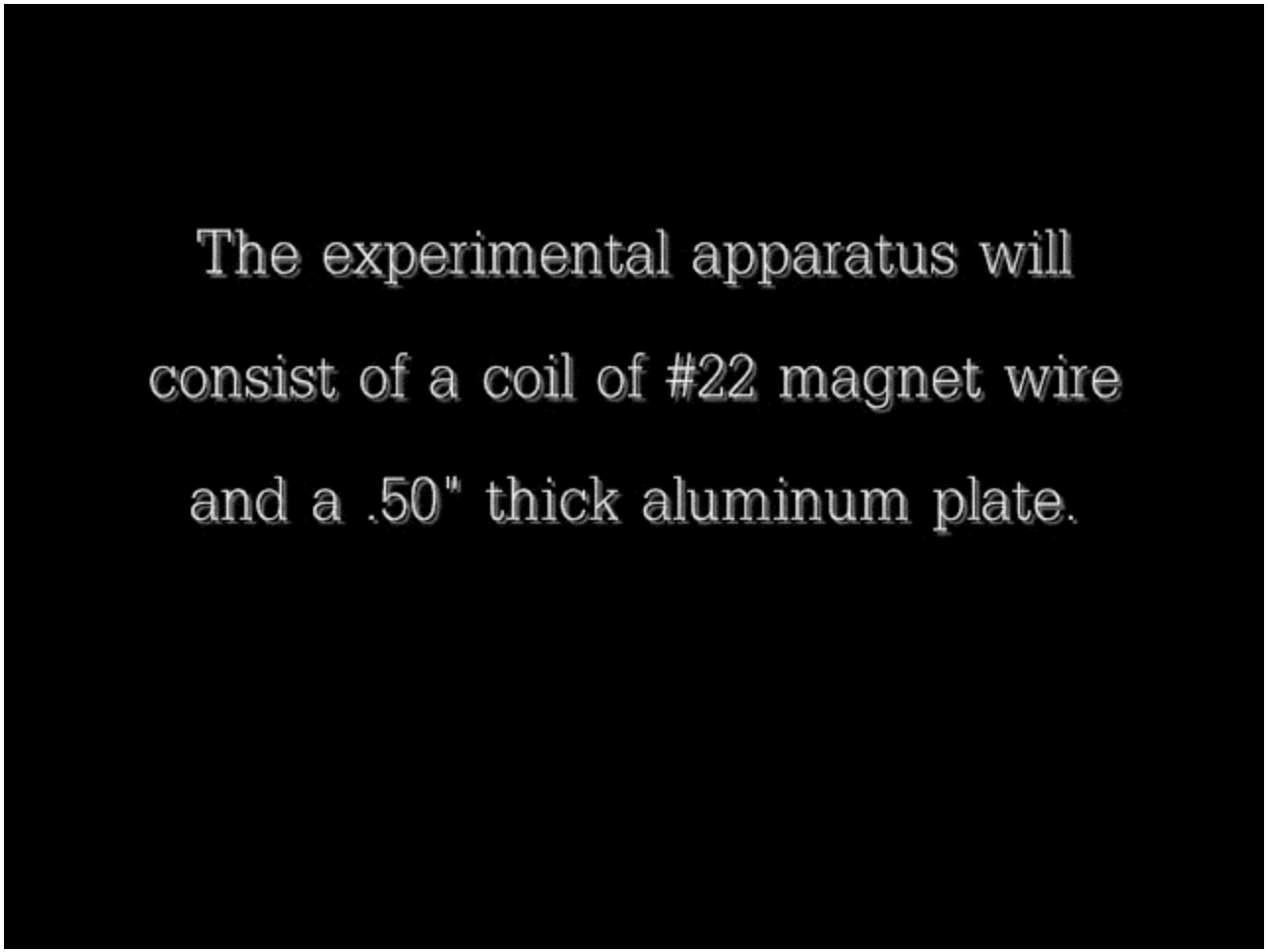
Can be turned on/off

Electromagnets

- Structure
  - Ferromagnetic core
  - Current carrying wire wrapped around core
- Field enhanced by the combination
- Can be turned on/off
- Used in many applications: meters, switches, speakers, motors …



Magnet Levitation



Magnetic Force and Levitation

- When an upward magnetic force is greater than gravity, then an object can levitate.
- A magnetically levitated vehicle is shown in the figure to the right – a magplane.
- No friction, no vibrations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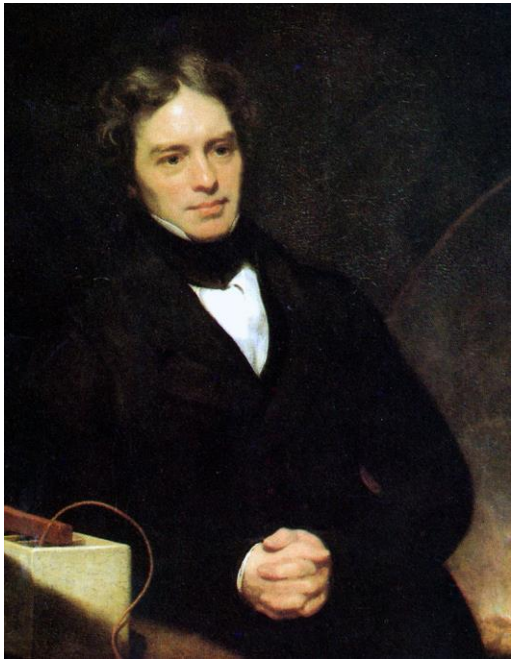
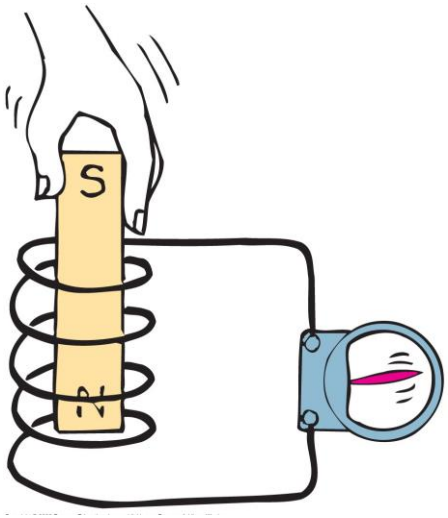
Electromagnetic Induction and Faraday's Law



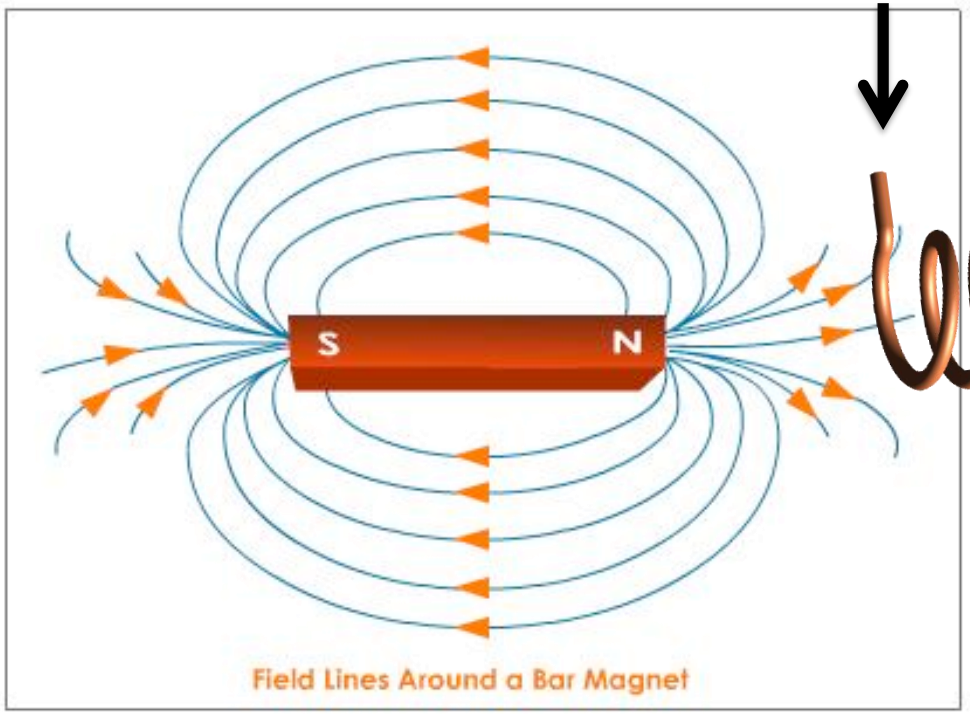
Michael Faraday
1791- 1867

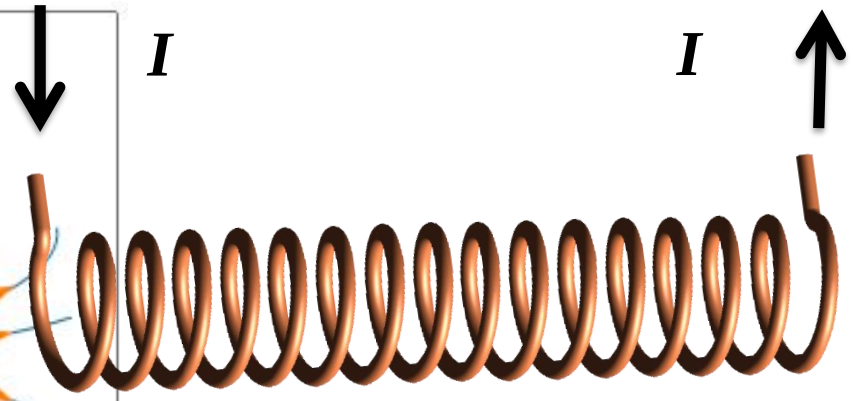
Electromagnetic Induction and Faraday's Law

Electromagnetic induction



- discovered by Faraday and Henry
- voltage is induced with change of magnetic field strength in a coil of wire


S
N
Field Lines Around a Bar Magnet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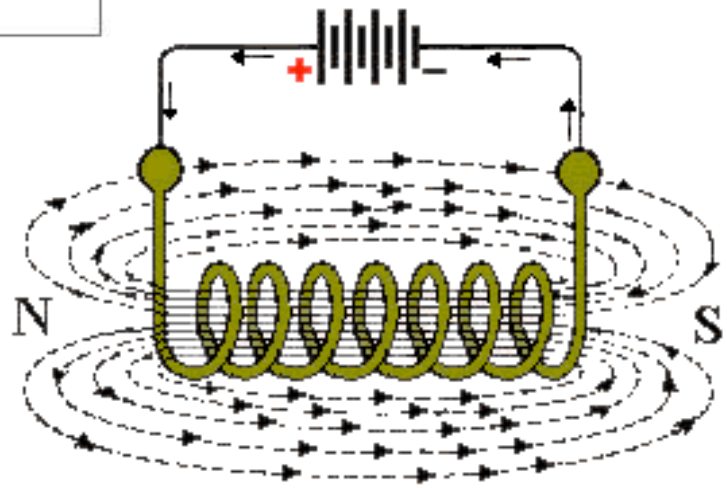

+
–
N
S

Electromagnetic Induction

Causes:

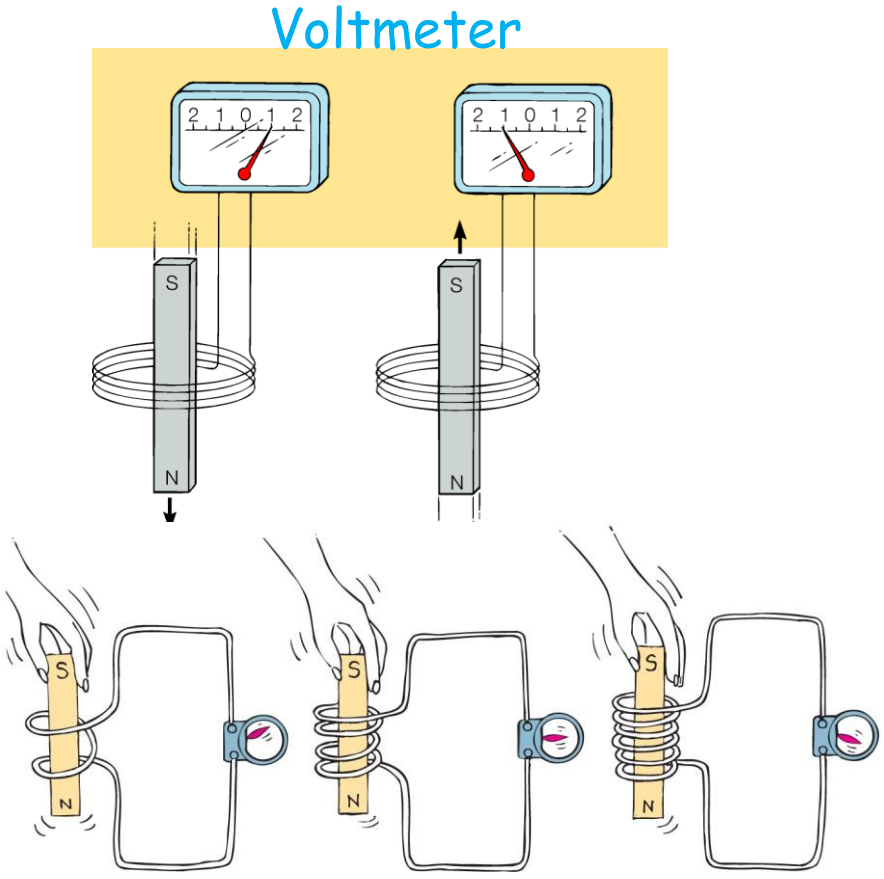
- Relative motion between magnetic fields and conductors
- Changing magnetic fields near conductors

Effect:

- Induced voltages and currents

Induced voltage depends on:

- Number of loops
- Strength of magnetic field
- Rate of magnetic field change



More loops; more induction

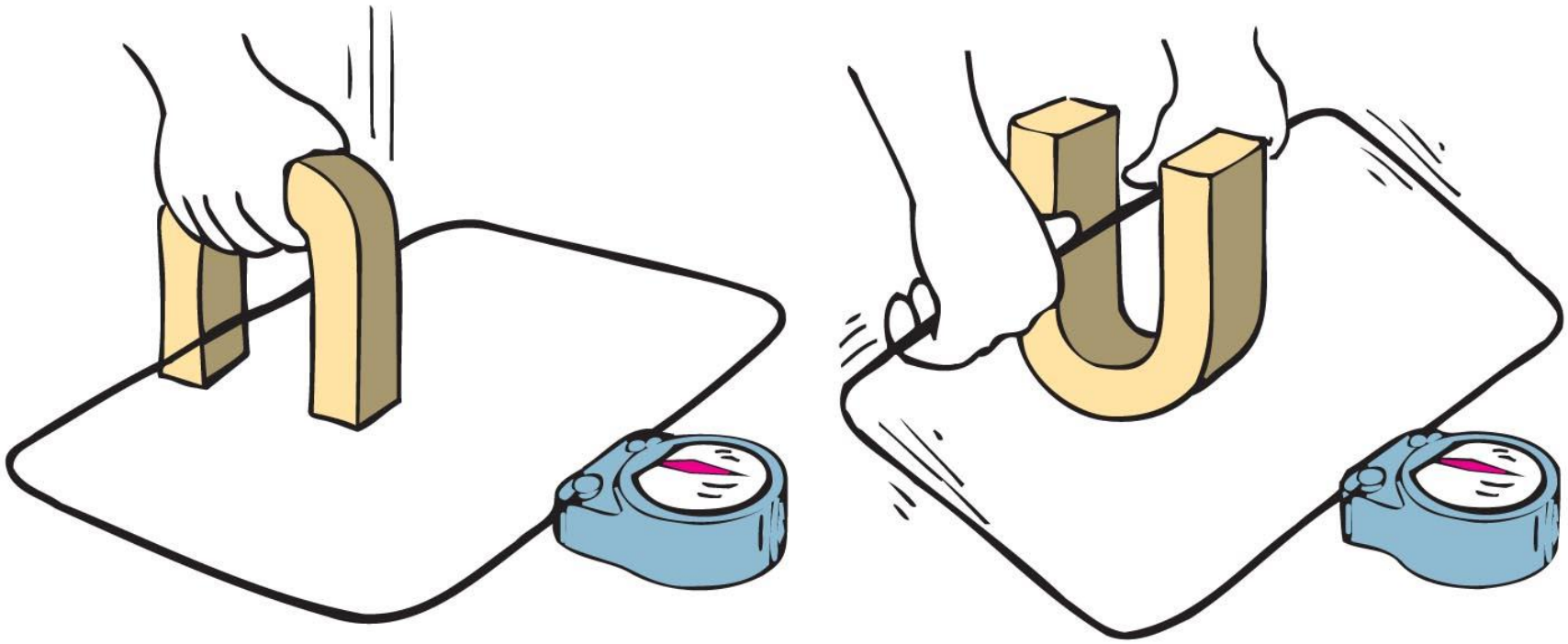
Electromagnetic Induction

More difficult to push the magnet into a coil with many loops because the magnetic field of each current loop resists the motion of the magnet.

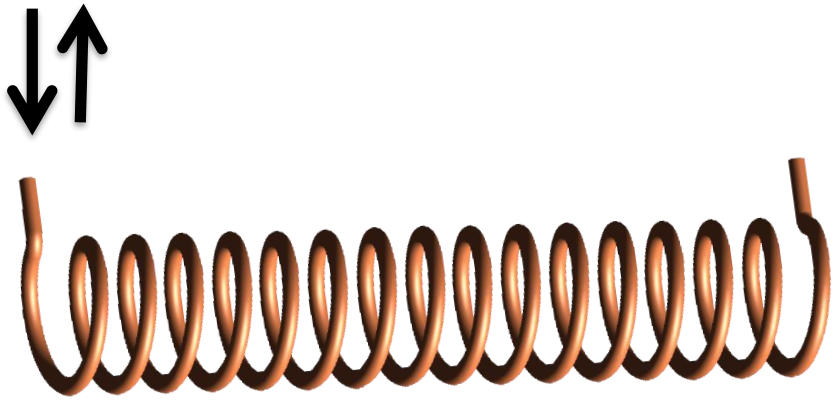
Faraday's law

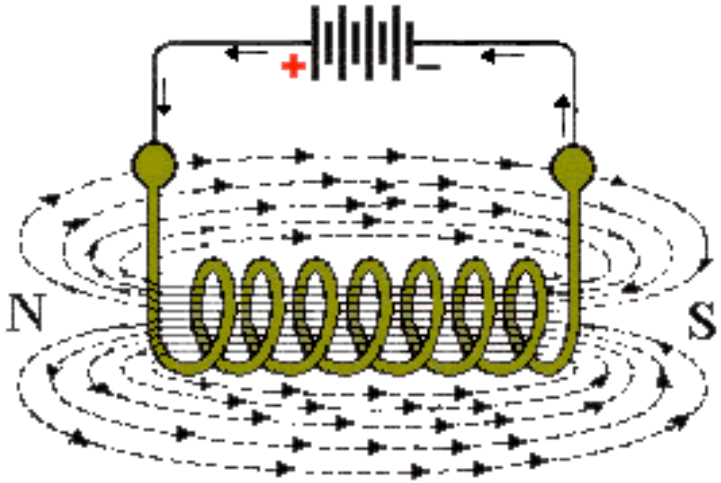
the induced voltage in a coil is proportional to the number of loops, multiplied by the rate at which the magnetic field changes within those loops

Electromagnetic Induction



Induction occurs whether the magnetic field moves past the wire or the wire moves through the magnetic field.

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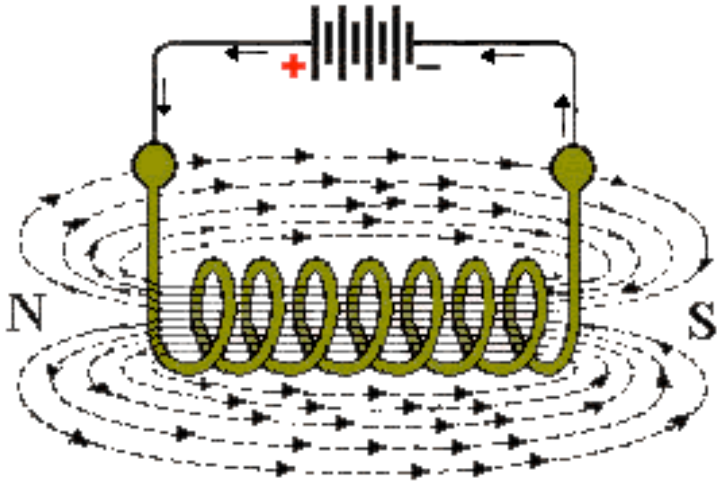
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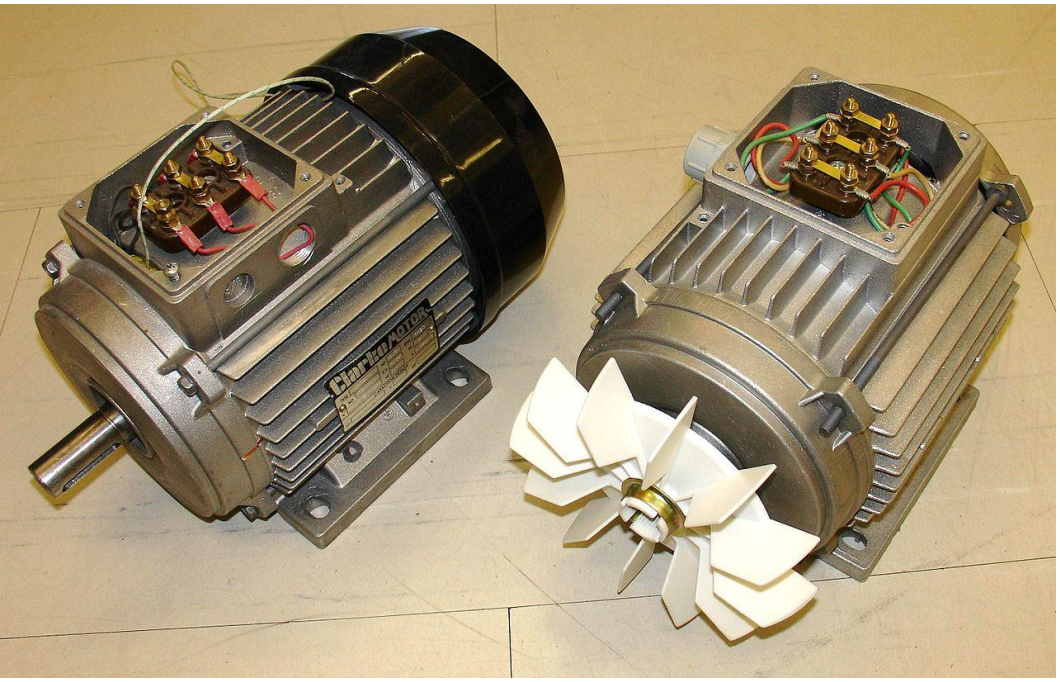
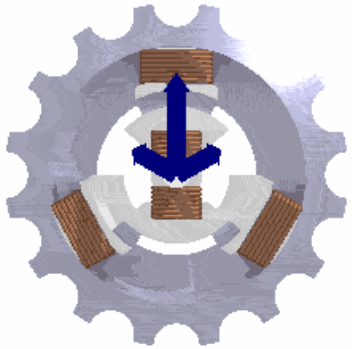
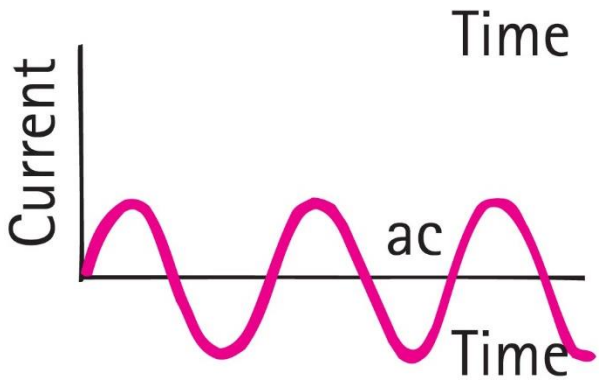
Power Production

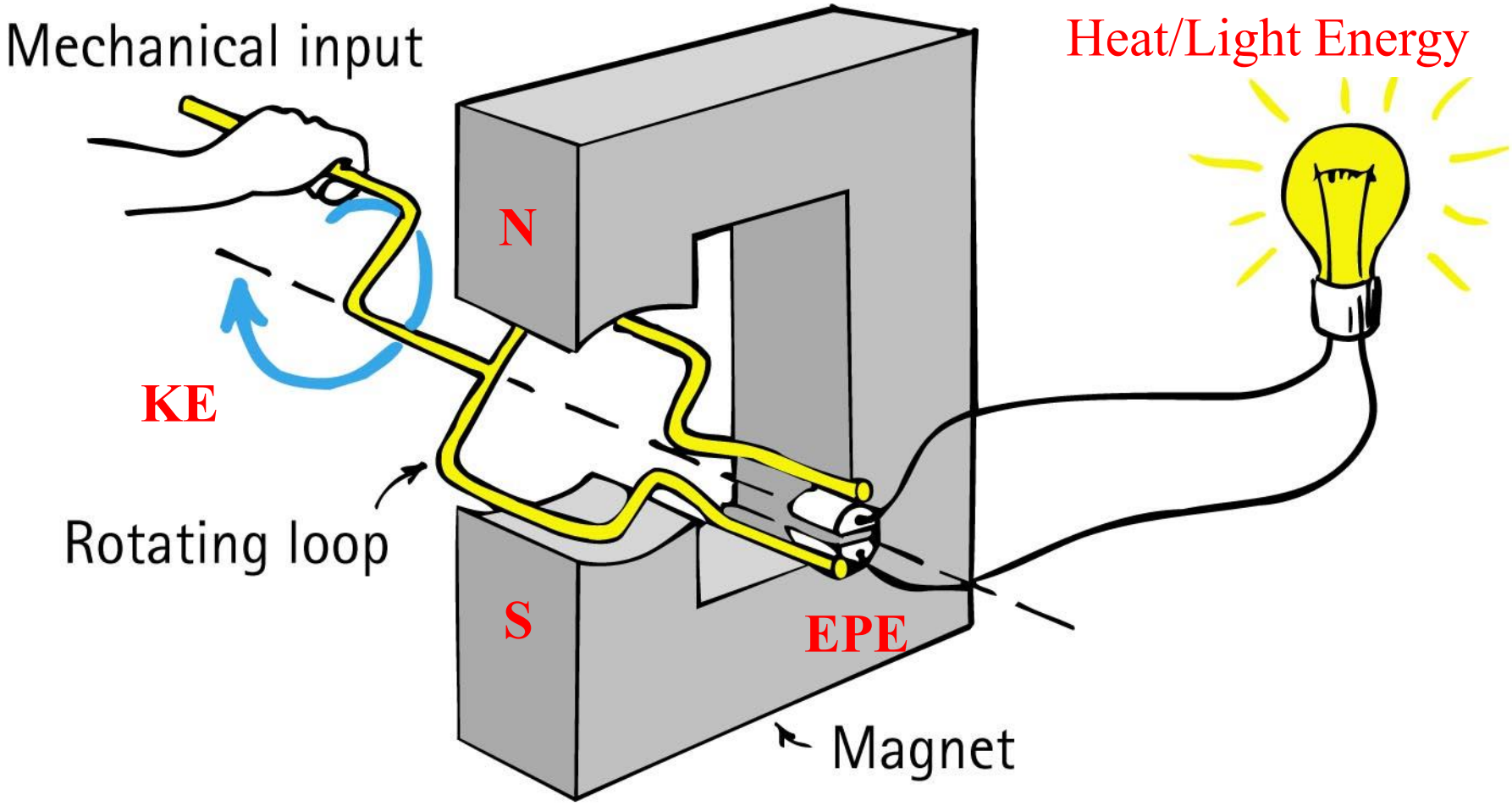
Using Faraday and Henry's discovery of electromagnetic induction, Nikola Tesla and George Westinghouse showed that electricity could be generated in sufficient quantities to light cities.







Generator: KE to EPE to Heat/Light Energy



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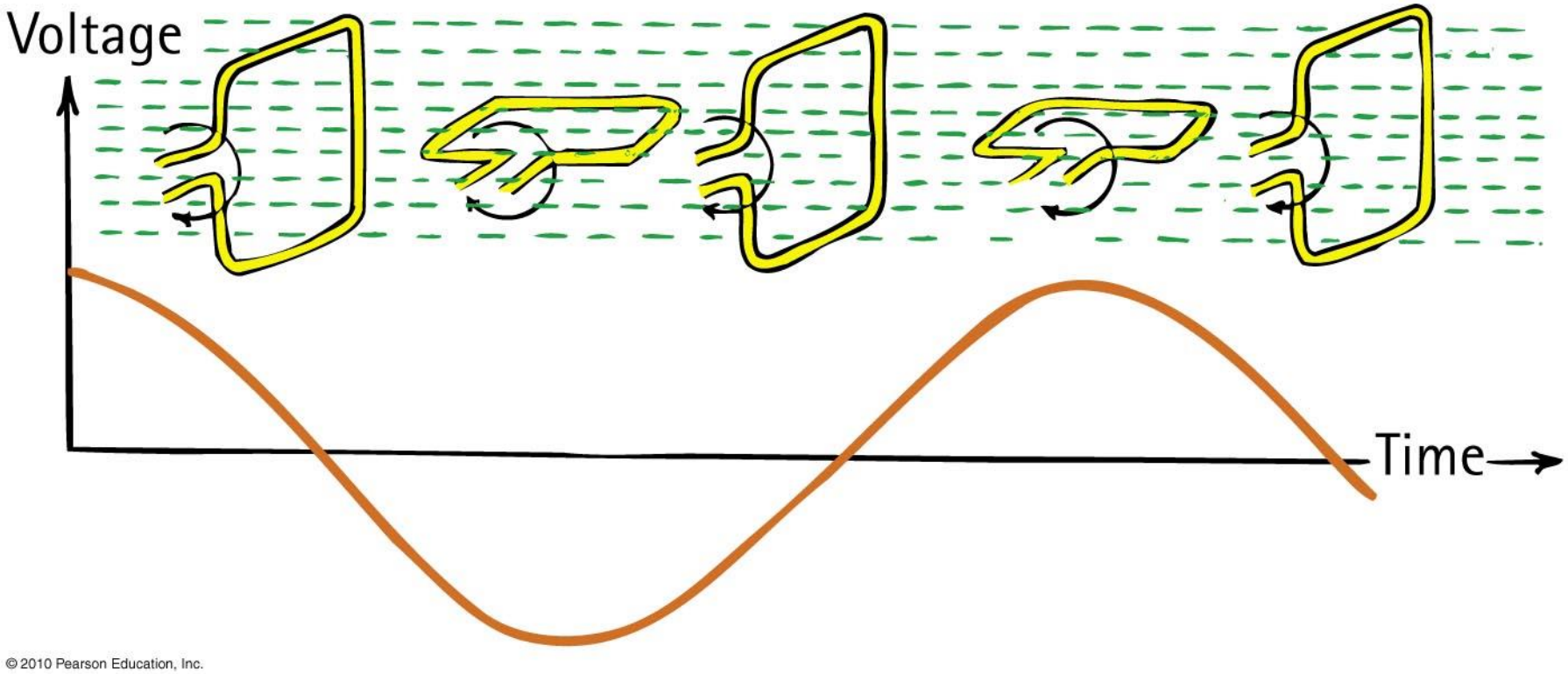
Generators = Alternating Voltage and Alternating Current (AC)



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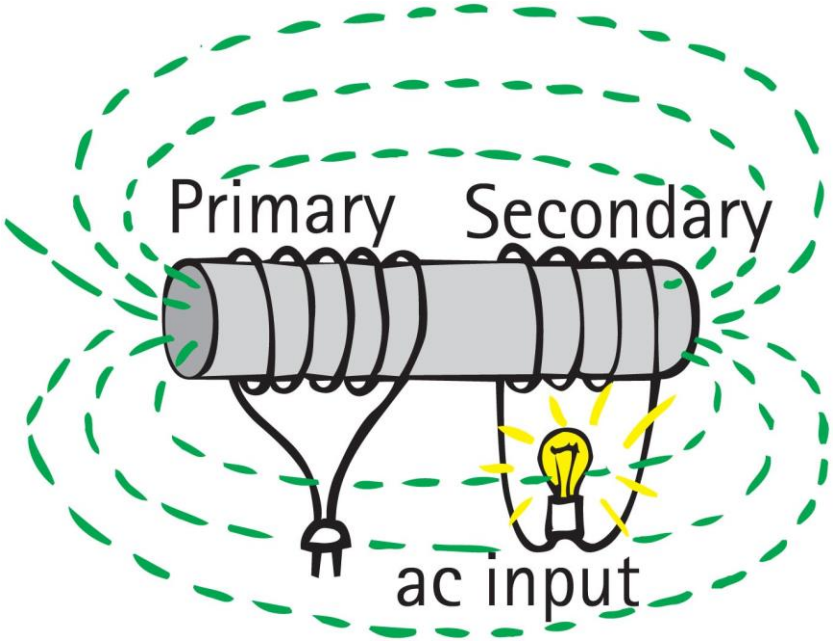
AC is equivalent to a spinning magnet

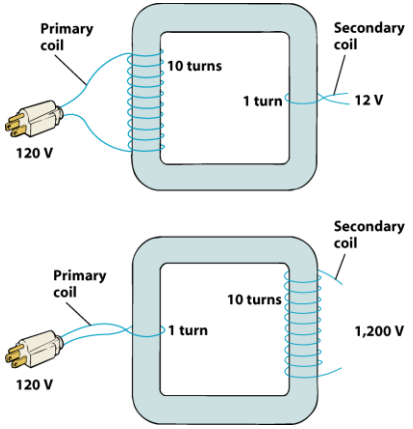
The Transformer—Boosting or Lowering Voltage



- input coil of wire —primary powered by AC voltage source
- output coil of wire —secondary connected to external circuit

Transformers

- Problems in power transmission
  - High currents - large resistive losses
  - High voltages - dangerous potential differences
- Solution: transformers boost/lower AC currents and voltages
- Basic relationships
  - Power in = power out
  - Number of coils to voltage



Voltages in primary/secondary coils

$$\frac{V_p}{N_p} = \frac{V_s}{N_s}$$

Number of turns in primary/secondary coils

The Transformer

- Transformer relationship:

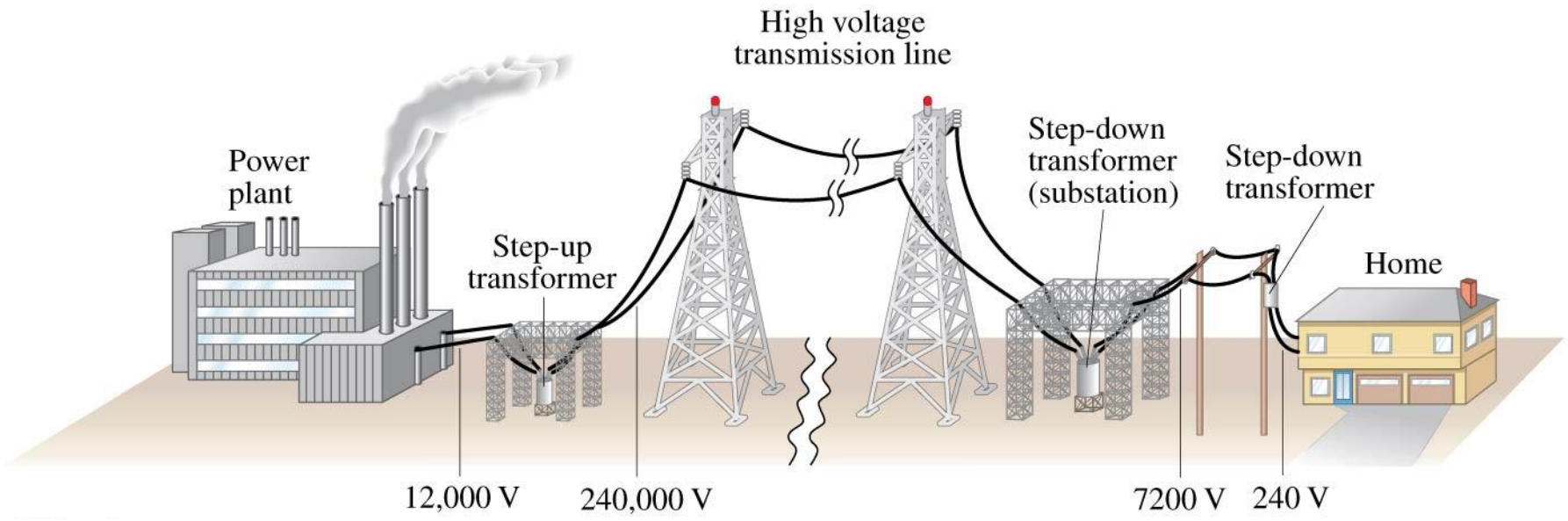
$$\frac{\text{primary voltage}}{\text{number of primary turns}} = \frac{\text{secondary voltage}}{\text{number of secondary turns}}$$

$$\frac{V_p}{N_p} = \frac{V_s}{N_s}$$

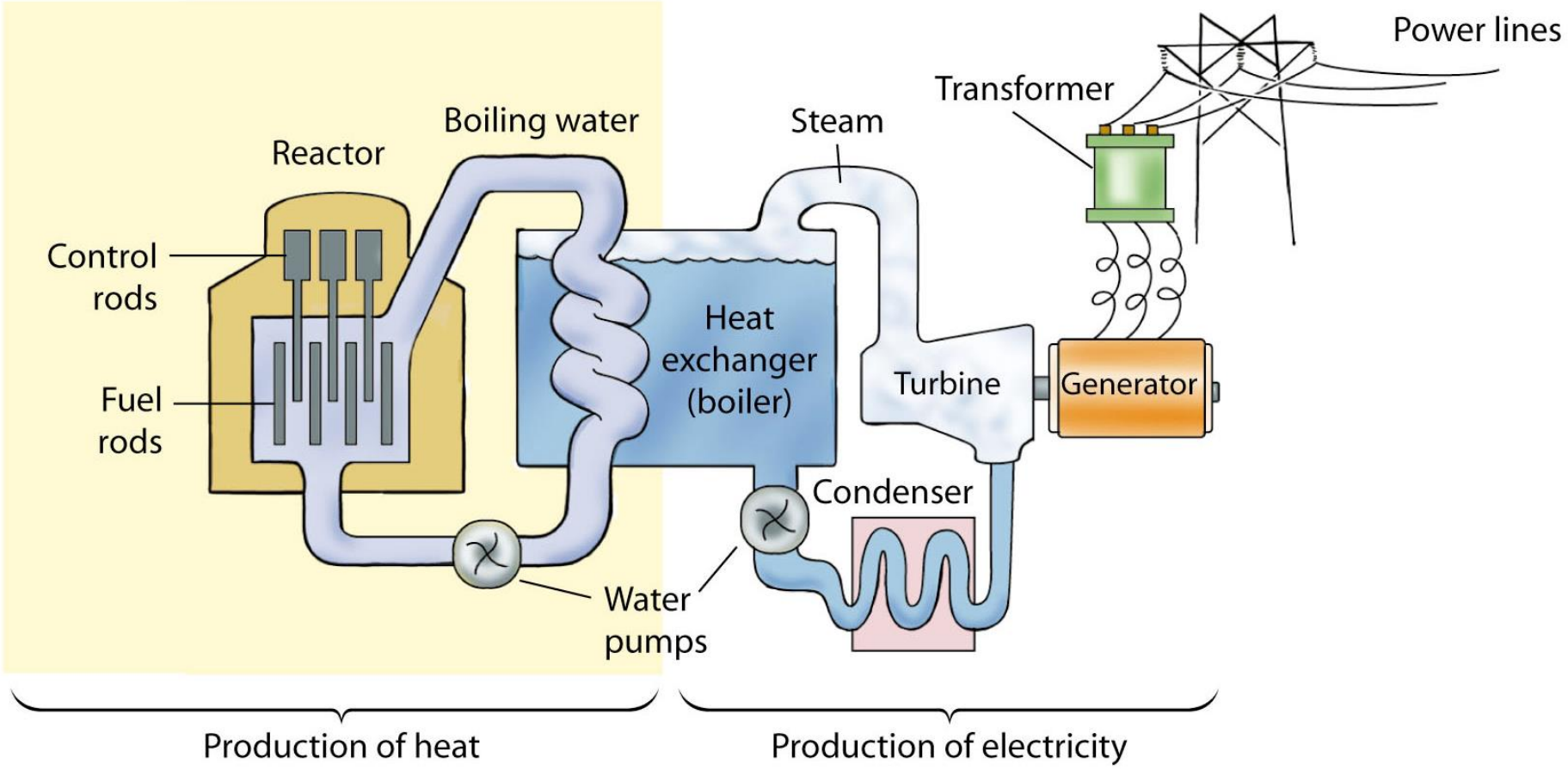
- This common transformer lowers 120V to 6V or 9V. It also converts AC to DC by means of a diode inside.

Transformers and Transmission of Power

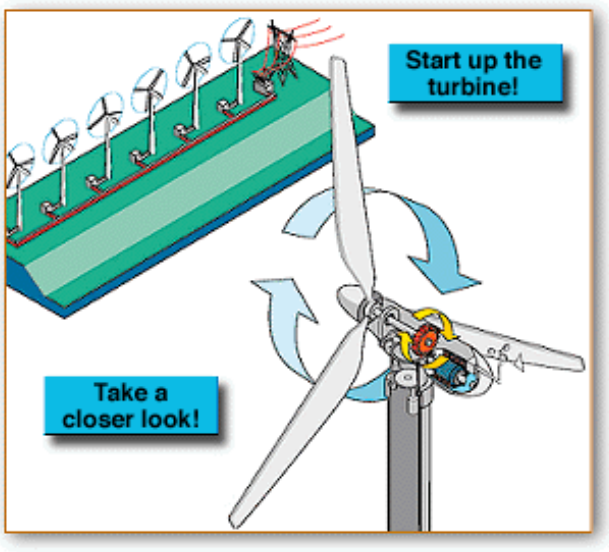
Transformers work only if the current is changing; this is one reason why electricity is transmitted as ac.

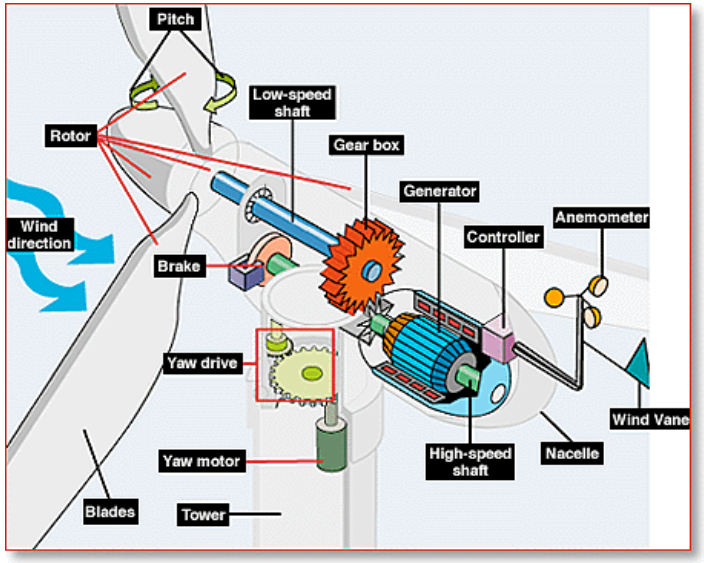


Nuclear Power Plant

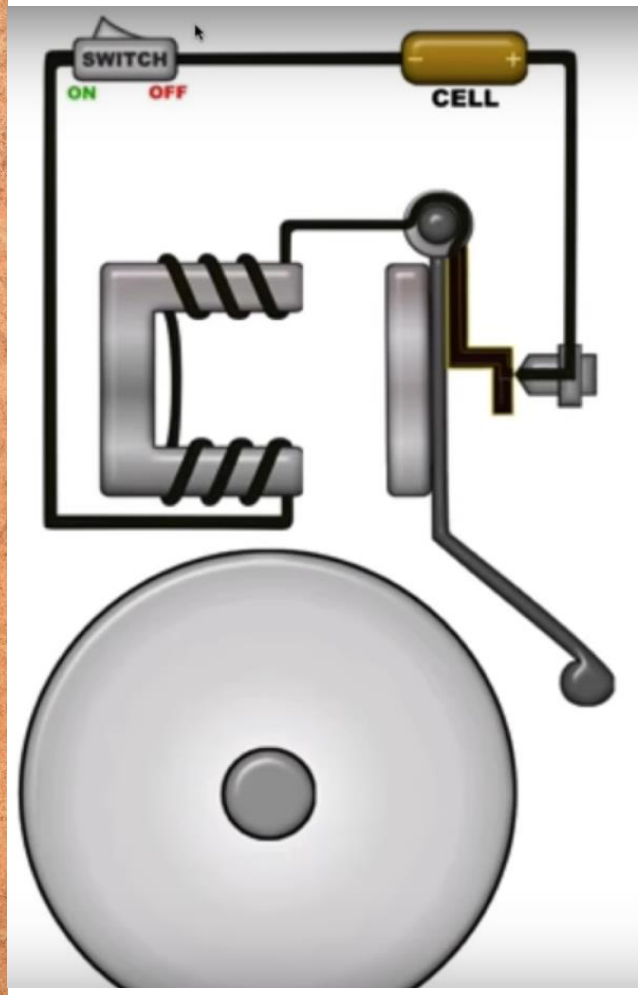


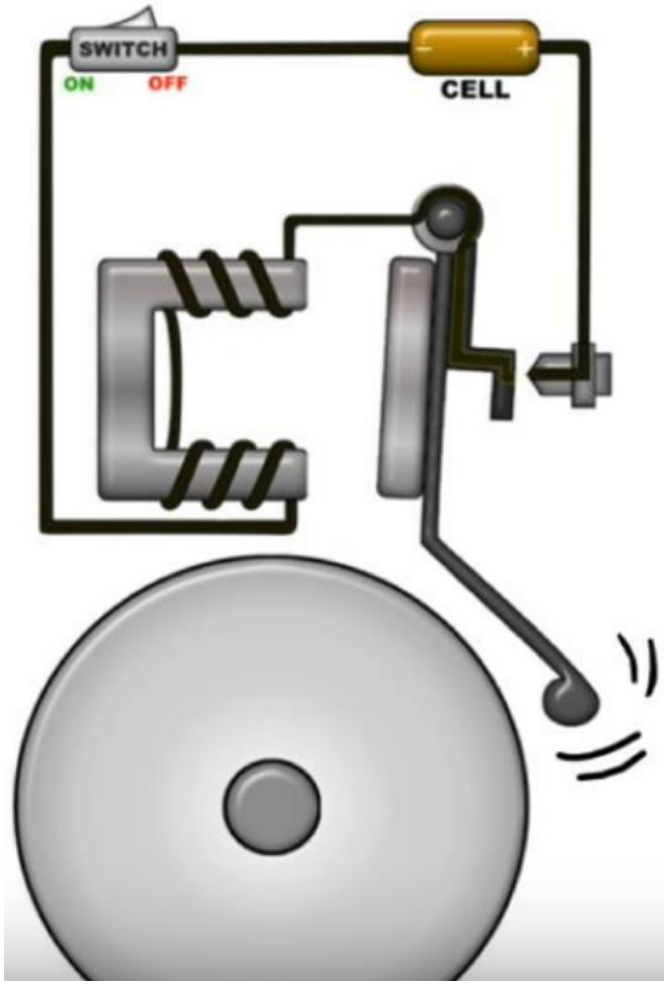
Wind Power


Start up the turbine!
Take a closer look!

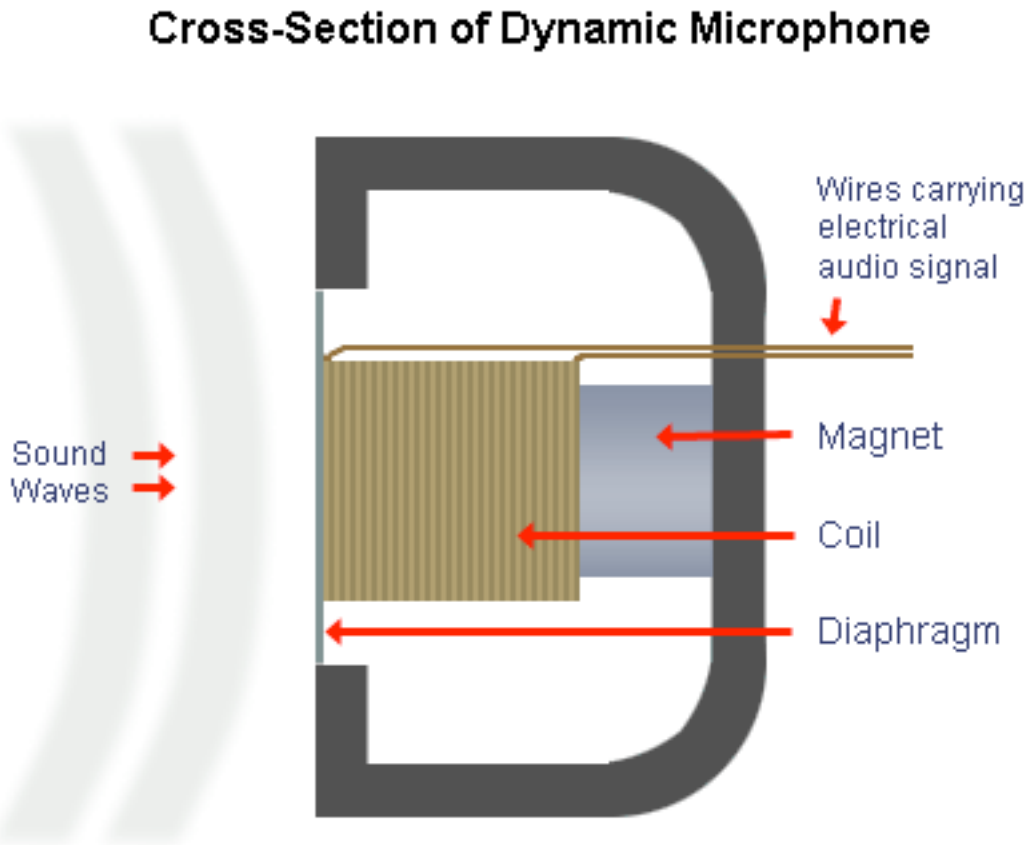

Pitch
Low-speed shaft
Rotor
Gear box
Generator
Anemometer
Wind direction
Controller
Brake
Yaw drive
Wind Vane
Nacelle
High-speed shaft
Yaw motor
Blades
Tower

Applications: The bell



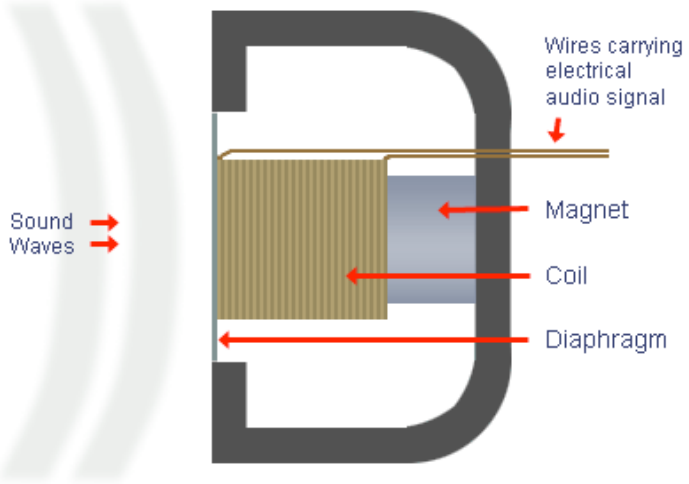


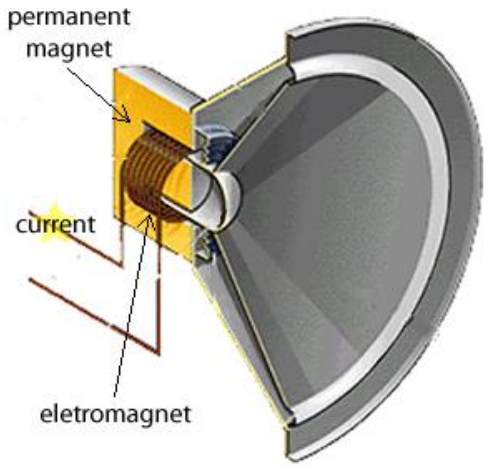
Applications: Microphone



Applications: Telephones and Loudspeakers

Coupling Acoustic Waves to Electric Currents





Telephone

- Sound vibrates membrane
- The moving coil generates a changing current

Speaker

- Varying current changes field of electromagnet.
- Perpendicular force (product of magnet and electromagnet) vibrates spring attached to paper cone producing sound