

Magnetism

Chapter 21 – Prentice Hall
Physical Science



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Magnetic Force



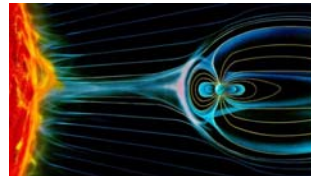
- **Magnetic Force:** the force a magnet exerts on either
 - another magnet
 - on iron (or similar metal)
 - on moving charges
- **Magnetic poles:** regions in a magnet where the magnetic force is strongest
 - All magnets have two poles: **north** and **south**.
 - Like poles repel; Unlike poles attract.

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Magnetic Fields



- **Magnetic field:** the direction and strength of magnetic forces in a region around a magnet
 - Strongest around the poles of a magnet
 - Field lines point FROM the north pole TO the south pole
- **Magnetosphere:** Area surrounding Earth affected by Earth's magnetic field



Iron filings and compasses show the shape and direction of the magnetic field. (Source: http://www.school-for-champions.com/science/magnetic_detection.htm)

Bill Allan, Katja Riedel, Richard McKenzie, Sylvia Nichol and Tom Clarkson.
'Atmosphere', Te Ara - the Encyclopedia of New Zealand, updated 21-Sep-2007
URL: <http://www.TeAra.govt.nz/EarthSeaAndSky/ClimateAndAtmosphere/Atmosphere/en>

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Electrons and Magnetism



- Moving charges cause magnetic fields.
- Magnetic fields in materials are caused by:
 - Electrons moving around the nuclei of atoms
 - “Spin” of electrons (e^- are not actually spinning, but “spin” describes a property of e^- that makes them act like tiny magnets)
- Most electrons in materials are paired with other electrons of opposite spin.
 - Magnetic caused by these electrons **cancel out**.
- Other materials have one or more unpaired electrons, giving rise to magnetic fields.

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Magnetic Materials

- **Weak magnetic materials:** the fields of unpaired electrons don't combine very well
- **Strong magnetic materials:** magnetic fields of unpaired electrons align to produce strong total fields. Examples include:
 - Iron
 - Cobalt
 - Nickel
- **Magnetic domain:** region in a material with a large number of atoms with aligned magnetic fields

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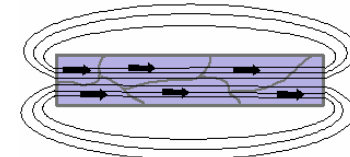
Magnetic Materials (cont'd)

- **Ferromagnetic:** material that can be magnetized because it contains magnetic domains



Unmagnetized

In an **unmagnetized** material, the magnetic domains are randomly aligned.



Magnetized

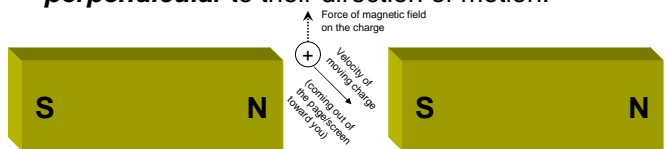
In a **magnetized** material, the domains have been aligned by placing the material in a magnetic field.

Source: <http://www.audiomasterclass.com/arc.cfm?=&noise-the-curse-of-analog-recording>

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Electricity and Magnetism

- **Electromagnetic force:** force associated with charged particles
 - Discovered by Hans Oersted in 1820
 - Electric force results from charged particles.
 - Magnetic force results from electrons moving in atoms.
- Charges moving in a magnetic field feel a force **perpendicular** to their direction of motion.



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Solenoids and Electromagnets

- **Solenoid:** a coil of current carrying wire
 - The inside of a solenoid coil has a magnetic field like a bar magnet: straight lines through the middle of the coil.
 - If you place a ferromagnetic material in the center of the coil, it will become magnetized. This is called an **electromagnet**.
- Electromagnet strength depends on:
 - # of coils
 - Current (controlled by voltage and resistance of wires in circuit)
 - Type of ferromagnetic material (iron vs. nickel, etc...)
- Recall the electromagnet quick lab we did in class...

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Electromagnetic Devices

- Electromagnetic devices change electrical energy into mechanical energy.
 - **Galvanometers:** use a solenoid to measure small amounts of current (fuel gauges, for example)
 - **Electric Motors:** use an electromagnet to turn an axle
 - **Loudspeakers:** use a solenoid around one pole of a magnet; current representing a sound signal changes as the sound changes, causing the magnet to deflect back and forth and move a membrane which reproduces the sound waves

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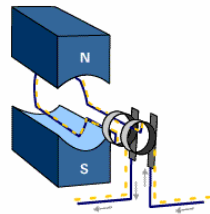
Electromagnetic Induction

- Just as electric currents cause magnetic fields, *changing magnetic fields can cause currents in conducting materials.*
- **Electromagnetic Induction:** process of generating a current by moving an electrical conductor relative to an electric field
 - Discovered by Faraday (1831)
 - Used in generators to convert mechanical energy to electrical energy

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AC Generators

- Produce alternating current: charge flows first in one direction, then in another
- Used by most power plants today



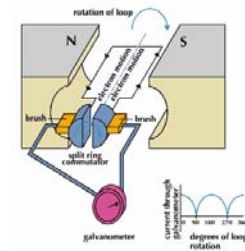
A loop of wire spinning through a magnetic field will create an alternating current. Note: current will flow only if the circuit connected to the generator is complete.

Source:
http://www.pbs.org/wgbh/amex/edison/sfeature/acdc_insideacgenerator.html

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DC Generators

- Produce direct current: charge flows in only one direction out of the generator
- Used in smaller applications



Electric current in the loop of a DC generator alternates—that is, it changes directions—but in the outer circuit it travels in only **one** direction, and drops to zero twice with each rotation of the loop. By arranging more loops, a steadier direct current can be obtained.

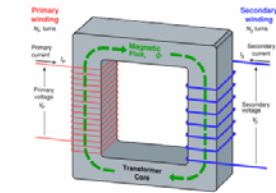
Source: "direct-current motor; electric current alternation." Online. Britannica Student Encyclopedia. 24 Mar. 2009 <<http://student.britannica.com/eb/art-53255>>.

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Transformers



- **Transformer.** device that increases or decreases the voltage and current of two linked AC circuits
 - Used because electrical energy transmitted over large distances must travel at high voltages in order to reduce energy losses
 - Changes voltage and current with 2 solenoids (or coils) that have different numbers of turns



Source: <http://www.electricityforum.com/products/trans-s.htm>

Types of Transformers



- Named by what the transformer does to the **voltage**
- **Step-up transformer.**
 - INCREASES voltage
 - Decreases current
- **Step-down transformer.**
 - DECREASES voltage
 - Increases current

