Magnetism

(Chapter 9)

Student Learning Outcome: Compare and contrast electric and magnetic properties; recall and apply Faraday's law and Maxwell's law.

1. *How does a magnetic pole compare to an electric charge?*
2. *What are the properties of a magnetic field?*
3. *What makes a material magnetic?*
4. *How do magnetic properties affect electric current?*
5. *What are the applications of Faraday's law and Maxwell's law?*

How does a magnetic pole compare to an electric charge?

- All magnets have <u>two</u> poles; this is where the magnetic force is strongest.
  - A north-seeking pole
  - A south-seeking pole
- When poles interact they repel or attract each other, similar to how charges interact.

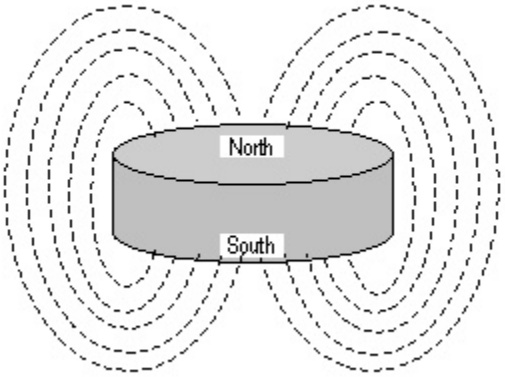
Like magnetic poles → repel
Opposite magnetic poles → attract

- While charges can exist individually, there are no magnets with only one magnetic pole.
- Magnets do not have charged ends! Each piece of the magnet has a north and a south pole.

What are the properties of the magnetic field?

- A magnetic field exists around a magnet, just as an electric field exists around a charge.
- Magnetic field lines always form closed loops (the field runs throughout the magnetic material).

Go To: http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/elemag.html



Question: Do electric field lines tend to form closed loops?

Go To: http://www.youtube.com/watch?v=nWTSzBWEsms

- The Earth is surrounded by a magnetic field which protects us from the solar wind. *Magnetic poles appear to switch!*

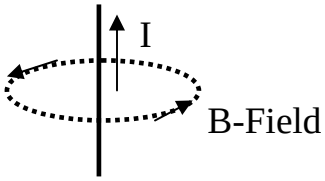
Go To: http://www.uaff.info/magnetic_field_changing.htm

What makes a material magnetic?

- A magnet is a material that produces a magnetic field, and is attracted to metals and other magnets.
- **The motion of electric charge is what makes a material magnetic.**
- Magnetic materials have all or most **electrons spinning in the same direction**!
- **Alignment of magnetic domains produces a magnetic field.**

Go To:
http://www.rpi.edu/dept/phys/ScIT/InformationStorage/faraday/magnetism_a.html

- **Electric current produces both an electric field and a magnetic field.**



- Electric current induces magnetism.

Go To: http://www.youtube.com/watch?v=yB0qYHkTWJ4

The wire becomes a magnet!

- **Convection currents in the Earth generate a magnetic field.** The motion of ionized particles inside the Earth coupled with Earth's rotation induces the magnetic field.

Go To: http://www.youtube.com/watch?v=CiCBrXKIH_0&feature=related

Question: What happens when solar particles interact with Earth's magnetic field?

Go To: http://borealis2000.com/
http://www.youtube.com/watch?v=sBWPCvdv8Bk

How do magnetic properties affect electric current?

- **A charge moving in a magnetic field may be deflected.**

$$F = qvB$$

- The magnetic force on a loop of current carrying wire will cause the wire to rotate. This is a simple electric motor.

Go To: http://www.miniscience.com/projects/magnet_motor_kit/index.html

- **Changing magnetic fields can induce electric current.**

Question: How is the magnetic field changed?

What are the applications of Faraday's law and Maxwell's law?

- **Faraday's Law: 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.**

More Loops + Turning Faster = More Voltage

Examples: Generators & Stop Lights

- In a **generator**, a coil of wire is turned within a magnetic field. The result is induced voltage in the coil (available electricity).

Go To:
http://new.wvic.com/index.php?option=com_content&task=view&id=9&Itemid=46

- Generators do not create energy, they convert it!

- **Maxwell's Law: A magnetic field is induced in any region of space in which an electric field is changing with time.**

- **Transformers** use two coils of wire and the connection between electricity and magnetism, to step-up or step-down the voltage supplied to a system.

Alternating current → ΔB → Induced voltage

Go To: http://www.electricityforum.com/products/trans-s.htm

Question: How does Faraday's law apply to transformers?

- The relative number of coils determines whether the secondary voltage is greater or less than the primary voltage.

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

Most Coils	Voltage	Transformer Type
Secondary	Increase	*step-up transformer*
Primary	Decrease	*step-down transformer*

Questions:

1) If a laptop needs only 12 volts and the wall outlet supplies 110 volts, what is the relative number of turns needed in each coil? What type of transformer is this?

2) Where are transformers located?
http://www.howstuffworks.com/inside-transformer.htm