A Deeper Look at Electricity
A First Look at Magnets

NBSP Physical Science Institute

Tuesday July 23, 2002

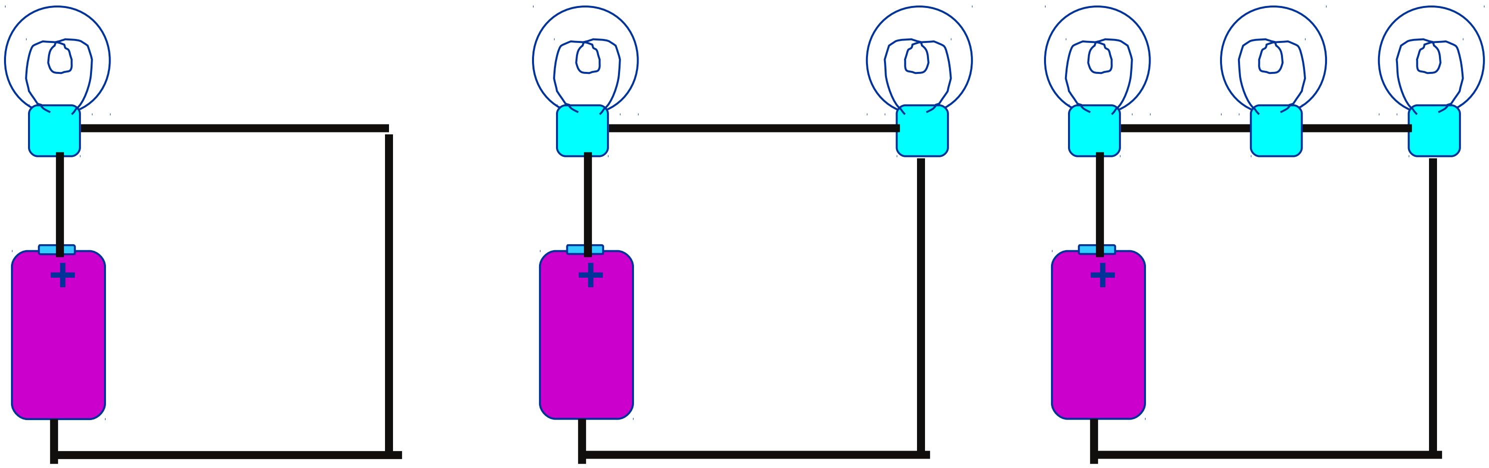
Currents: Thinking Deeper

- *Our model for current so far:*

  - The current in a circuit depends on the number of bulbs in the circuit and on the arrangement of the bulbs (series vs. parallel)
  - The brightness of the bulbs indicates the amount of current flowing through the bulb

Predict, Test and Explain

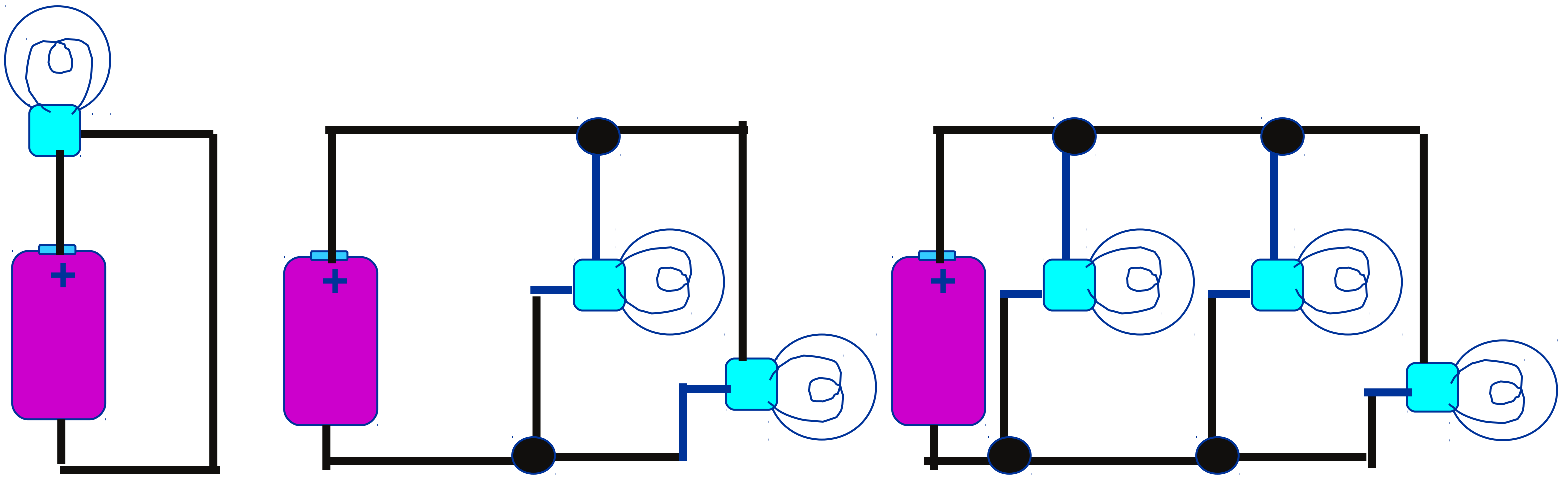
- How will the brightness of the bulbs change as we add more in series?



- What does this imply about the current in the circuit?

Predict, Test and Explain

- How will the brightness of the bulbs change as we add more in parallel?



- What does this imply about the current in the circuit?

Key Concepts

- Bulbs in series represent a source of resistance to current flow, similar to boulders in a stream which can block the flow of water
- Bulbs in parallel offer additional pathways for current flow, similar to branches of a stream which can carry more water.

Key Concepts

- A battery is a source of constant voltage, for example 1.5 volts or 12 volts (labeled on the battery)
- The current flowing from the battery depends on its (unchanging) voltage and the total resistance in the circuit
- More bulbs in series = more resistance
- More parallel pathways = less resistance

Key Concepts: Ohm's Law

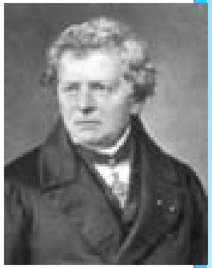
- V=IR where V=battery voltage, I=current and R=resistance
- Resistance is measured in Ohms (Ω)
- Current is measured in Amperes (A)
- Example: 12 V = I (1 Ω) so I = 12 A
- For two bulbs in series, R = 2 Ω therefore I = 6 A (and each bulb is dimmer as it has less current through it)

Key Concepts

- For two bulbs in parallel, R = ½ Ω (since there are 2 pathways), so I = 24 A total
- The total current then splits into two pathways: half the current goes down each pathway. So the current in each pathway = (24/2) A = 12 A
- The bulbs in the parallel circuit are therefore each as bright as the bulb in the single bulb circuit.

Historical Notes:

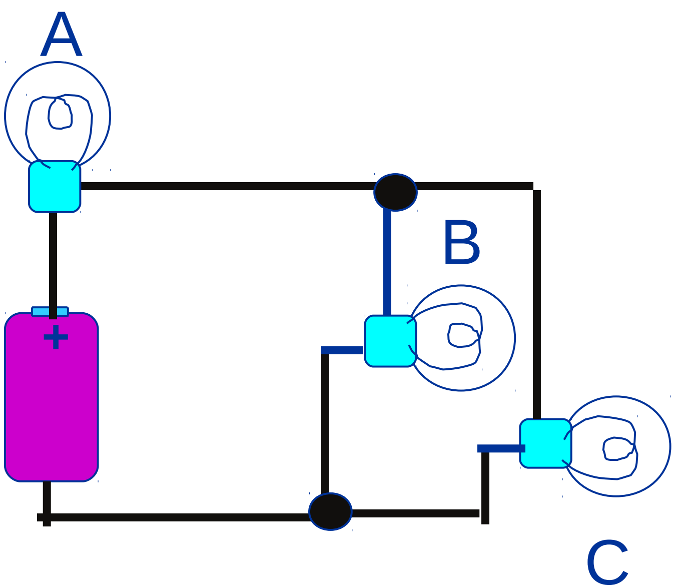
- Alessandro Volta was an Italian physicist who invented the battery in 1800; hence “Volt”
- Georg Simon Ohm was a German physicist who did the experiments that resulted in Ohm’s Law in 1827



- Andre Marie Ampere was a French mathematician and physicist who made many contributions to our understanding of electricity in the 1820s

Predict, Test and Explain

- How do the the bulbs compare in brightness?
- Is this circuit series or parallel?
- How will the brightness of A and B change if bulb C is removed?
- How will B and C change if A is removed?



Break – consider this discussion:

- Student 1: Unscrewing bulb C removes a path for the current. Thus the resistance of the circuit increases and the current through the battery and remaining bulb decreases. So bulbs A and B both will dim.

Break – consider this discussion:

- Student 2: I agree that bulb A will dim, but I disagree about bulb B. Before you unscrew bulb C, only part of the current through bulb A goes through bulb B. Afterward, all the current through bulb A goes through bulb B. So bulb B should get brighter.
- Has either student given a complete answer? Explain.

Key Concepts

- Bulbs B and C form a *network*
- This network is in series with Bulb A
- Within the network, B and C are in parallel with each other
- Total resistance of the network = ½ Ω
- Total resistance of the circuit = 1½ Ω
- All the current flows through A, then it splits in half to flow through B and C
- Can you calculate how much current flows through each bulb? (Assume 12 V battery)

Deeper Connections to the Standards

- *Potential Differences*
- The voltage rating of a battery is really the difference in electric potential between the two terminals.
- We say: “The positive terminal is at a higher electric potential by 1.5 V than the negative terminal.”
- This is similar to saying that a ball is at a higher gravitational potential on top of a hill than at the bottom.

Deeper Connections to the Standards

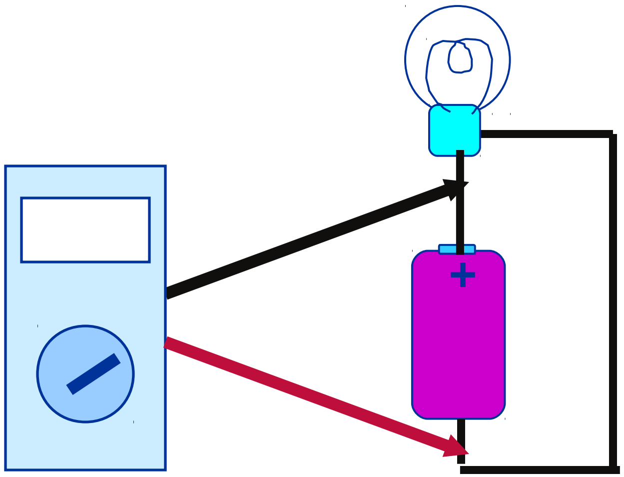
- The higher potential (energy) of the positive terminal is what provides the “push” that drives electrons through the circuit.
- The electrons lose energy along the way, as they encounter sources of resistance, such as lightbulbs.
- The energy goes into heating the filaments in the bulbs, producing light.

Equipment for second activity

- Voltmeters are usually also ammeters (measure current) and ohmmeters (measure resistance) – so they are called “multimeters”
- There is a dial to choose which quantity you would like to measure
- There is usually also a choice of measuring DC or AC circuits
- In your classes, you will only work with DC circuits and low voltages and currents, in order to ensure safety

Using a multimeter

- Measure voltage or resistance in parallel

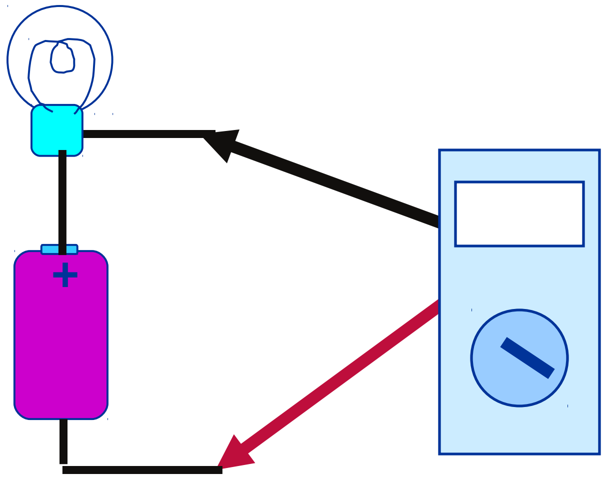


Predict, test and explain what happens when you reverse the position of the red and black leads while measuring voltage.

- Does the same thing happen when you reverse the leads while measuring resistance?

Using a multimeter

- Measure current in series



Predict, test and explain what happens when you reverse the position of the red and black leads while measuring current

- Does it matter where you put the ammeter in the circuit? Why or why not?

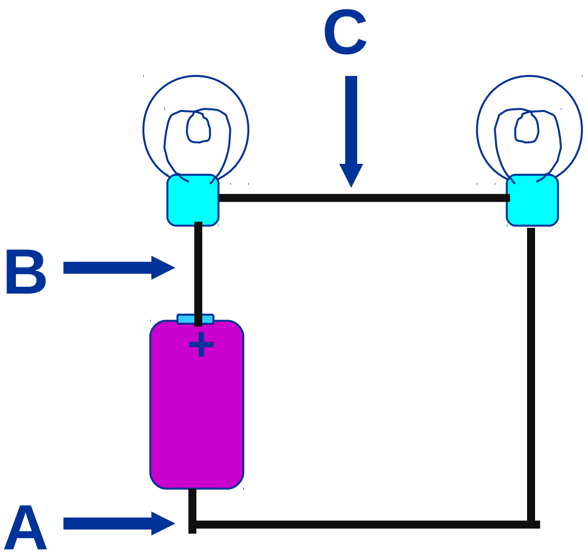
A few things to try:

- Build a two bulb series circuit.
- Take a multimeter and use it to measure the potential difference between several different places in the circuit

•What do you measure between points A and B?

•Between B and C?

•Between C and A?



A few more things to try:

- Now measure the resistance in the circuit between the same locations
- And measure the current in the circuit at any convenient location
- Do the values that you measure obey Ohm's Law (V=IR)?
- Why or why not?
- What do you think are possible sources of error in this experiment?

Key concepts

- A lightbulb is a source of *resistance* to current because when current flows through a lightbulb, it loses energy which is used to heat the filament in the bulb
- The amount of current is not changed when it flows through the bulb
- The amount of energy in the electrons is changed when they flow through the bulb, producing a *potential difference* (or voltage change) across the bulb
- The potential difference, resistance and current are related by Ohm's Law (V=IR)

Key concepts

- Voltage provides the "push" that drives the electrons through the circuit
- Without voltage (*potential differences*), there would be no current flow
- Electrons will flow from regions of higher potential to lower potential (just like water flowing down hill)
- Batteries are constant voltage sources (until they run out of "juice") which produce different amounts of current in response to the total resistance of the circuit.

Lunch with Two Birds

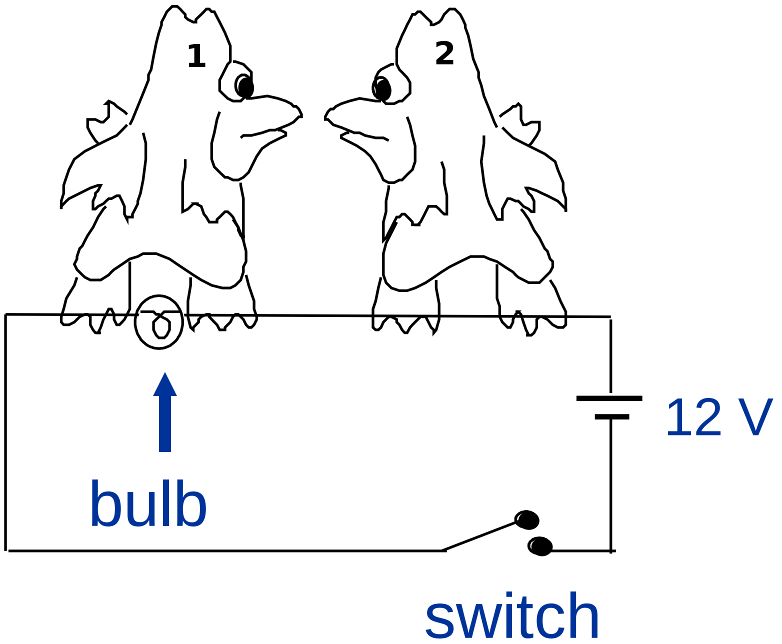
When the switch is closed, what happens to the birds?

a) Bird 1 gets a shock and bird 2 does not

b) Bird 2 gets a shock and bird 1 does not

c) They both get a shock

d) Neither gets a shock



Explain your answer!

Standards Connections

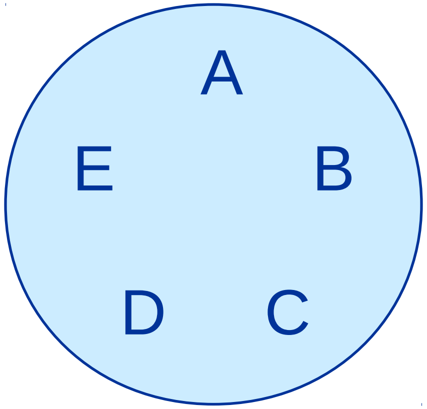
- *Students know* magnets can be used to make some objects move without being touched. *(Grade 2)*
- *Students know* that magnets have two poles (north and south) and that like poles repel each other while unlike poles attract each other.

Third activity: Exploring magnets

- How can you show that there are two types of magnetic poles?
- Do all magnets have exactly two poles?
- How can you figure out whether like or unlike poles attract each other?
- What types of materials are attracted to magnets?
- Are any materials repelled from magnets?

Equipment for third activity

- Magnets of various sizes and shapes
- Some pieces of non-magnetized metal
- Other things like rubber, wood, glass, plastic, aluminum, paper clips, etc.
- Compasses
- Mystery plates



A few things to try:

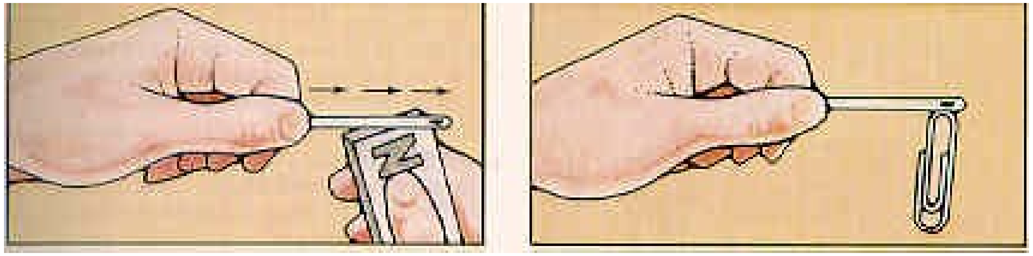
- Bring pairs of like and unlike magnets together at different locations
- Play with magnets and pieces of metal like paper clips
- Play with magnets and other materials
- Move a compass around all sides of different types of magnets
- Explore the mystery plate with a cylindrical test magnet and/or with a compass
- Some things on your own!

More questions for third activity

- What is located at each labeled spot on the Mystery plates?
- Are all metals attracted to magnets?
- Are metals attracted to all parts of a magnet?
- How can you tell the difference between a magnet and a metal?
- Where are the poles in a bar magnet?
- Where are the poles in a horseshoe magnet?
- Where are the poles in a refrigerator magnet? How are they arranged?

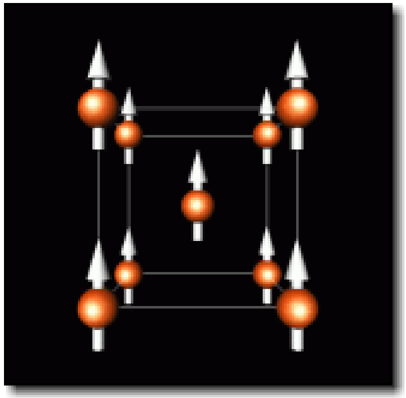
Making and Breaking Magnets

- In most materials, if you add energy to the electrons, you can get them to move and realign
- Can you think of ways to add energy to electrons?
- How can you make a magnet?
- How can you demagnetize a magnet?
- What happens when you break a magnet?



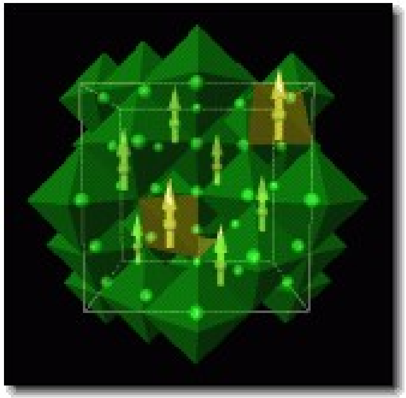
Magnetic elements: A deeper look

- Individual electrons can act as magnets
- In Iron, it is easier to make the electrons line up than in other materials. When electrons line up, they make a stronger magnet.



Iron

Lodestone (Magnetite)

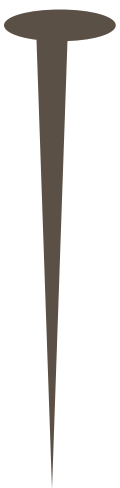


Key concepts

- Magnets have two types of poles: opposites attract and like poles repel
- Magnets may have more than one pole of each type
- Magnets are both attracted and repelled from other magnets
- Metals are always attracted to magnets
- Magnets can be used to magnetize metals
- If you add energy, it is easier to magnetize or demagnetize a metal

Vocabulary for ELL

- Magnet: material that can both attract and repel other magnets. Iron is most common.
- Pole: Part of the magnet where the force is the strongest



- Metal: material that is often attracted to magnets and a good electrical conductor
- Horseshoe magnet:

U-shaped magnet

ELD Activities

- Take a cylindrical or bar magnet around your house and try sticking it to different things. First predict whether or not the magnet will stick to the object. Then fill in the table below with the names of the things you have tested and write the result.

Object	Prediction?	Result

Publisher's Materials

- Take some time to look through the state-adopted texts to find activities relating to magnets and magnetic poles that could be used in your classroom.

Break – brain teaser

- Someone gives you 2 bars of identical shape, weight and appearance
- One is a magnet and the other one is metal
- How can you tell which is which? (You can't use any other equipment, you can't touch the bars to anything but each other and you don't know which way North is located.)

Standard Connections

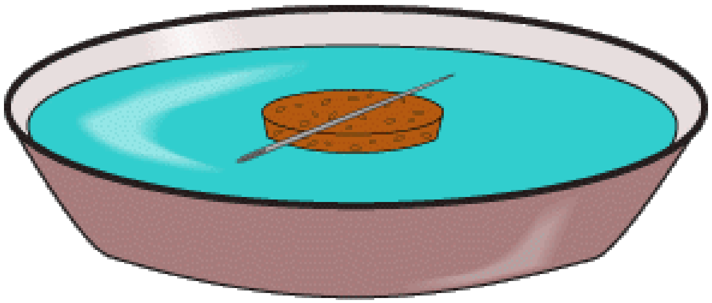
- *Students know* how to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field.
- Where is the Earth's magnetic north pole?
- What is the orientation of the big magnet inside the Earth that makes its magnetic poles?

Fourth Activity:

- Make your own compass
- Use it to determine the direction of North in this classroom
- Does your compass agree with those made by the other groups?
- How can you tell which direction is North?

Equipment for fourth activity

- Permanent magnets
- Paper clips or needles
- Flat piece of cork or styrofoam
- Pie plates
- Water

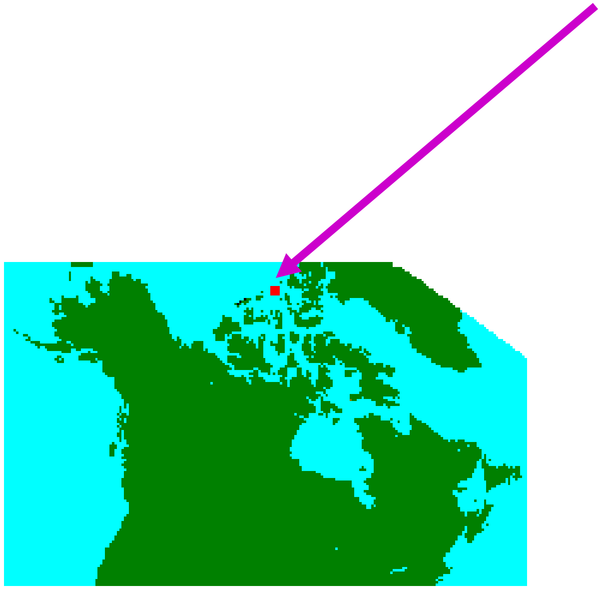


A few other things to try:

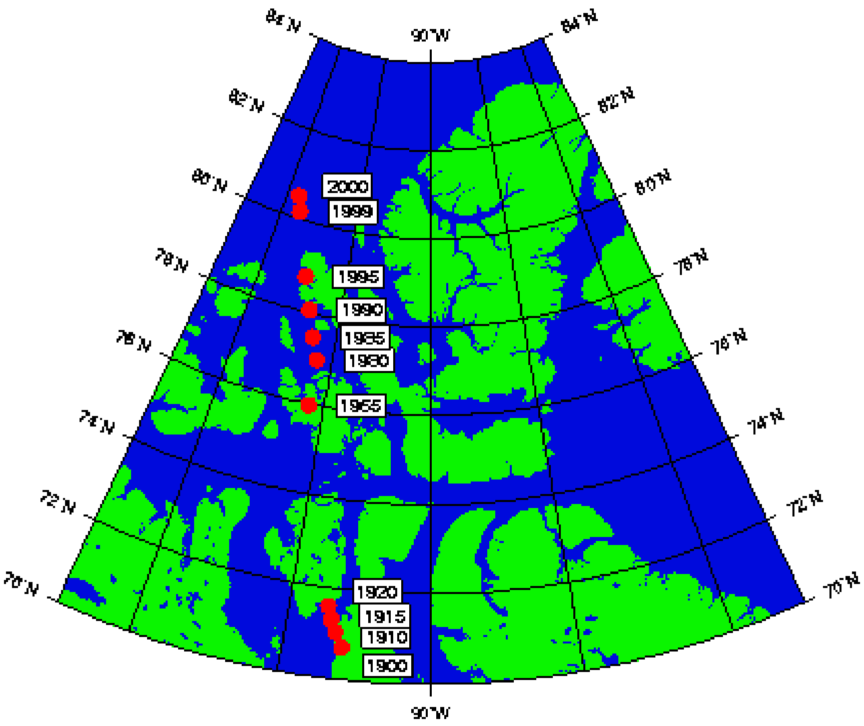
- Take a few cylindrical magnets, tie strings around them and hang them from the table tops around the classroom
- Do they all point the same way?
- If not, why not?
- Move the permanent compass near your floating compass. What happens? Why?

The Magnetic North Pole

- Position of pole in 1995



Predicted Magnetic North Pole



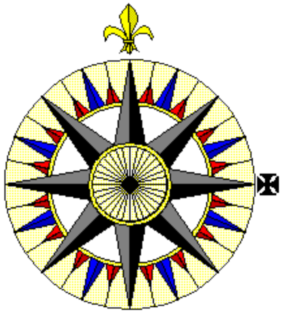
Key concepts

- The Earth's magnetic north pole and its geographic north pole are about 800 miles apart
- The Earth's magnetic north pole is really a SOUTH pole of the imaginary bar magnet that is located inside the Earth
- The Earth's magnetic poles have changed location throughout the ages

Vocabulary for ELL

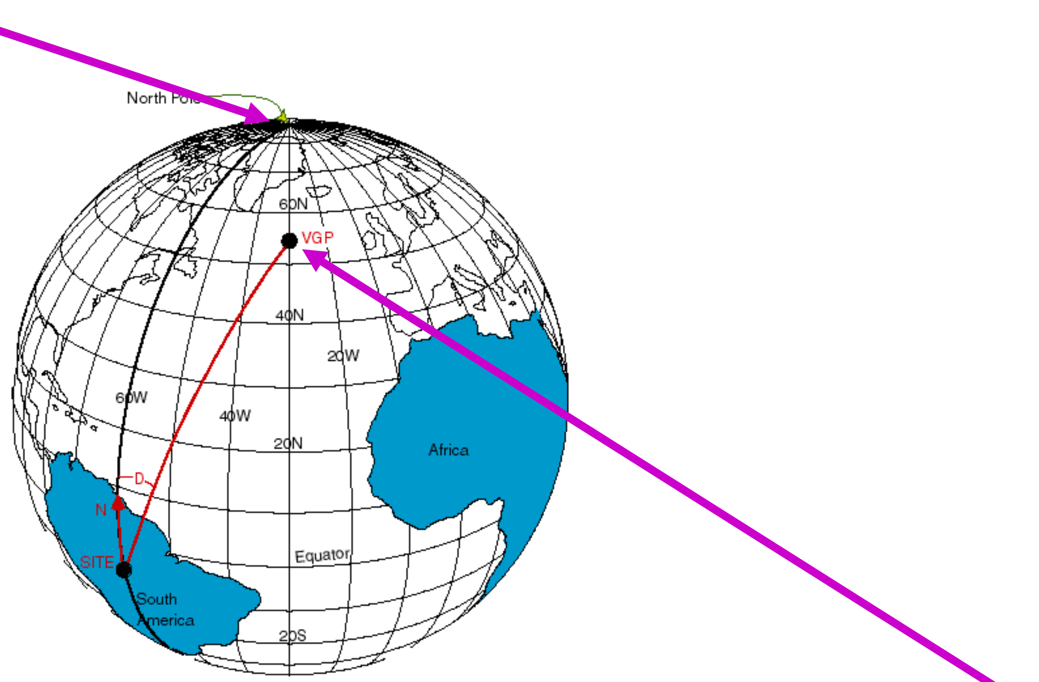
- Compass: a device used for determining direction that consists of a small magnetized needle free to pivot on a point

- Needle: the pointer in the compass
- Compass rose: the face of the compass that shows the directions



Vocabulary for ELL

- Geographic North pole: the north end of the axis around which the Earth rotates



- Magnetic North pole: the point on the Earth to which a compass needle points

ELD Activities

- Draw a compass rose and label the primary directions (N, S, E and W)
- Now label the sub-primary directions (NE, SE, SW and NW)
- Walk outside with a compass, face north and raise your arms to shoulder height
- What direction is on your right? Left?
- What direction is behind you?

Lesson Study Activities

- Identify a key concept from today's lecture for further development
- Review the publisher's materials about this key concept
- Discuss the best way to present this key concept in your classroom

Resources

- Physics by Inquiry – L. McDermott and the PEG at U Washington
- http://www.execpc.com/~rhoadley/magindex.htm
- http://www.igpp.lanl.gov/Geodynamo.html
- http://gamma.mhpcc.edu/schools/hoala/magnets/what.htm
- http://www.howstuffworks.com/compass.htm

Resources (continued)

- http://www.ill.fr/dif/3D-crystals/magnets.html
- http://www.lessonplanspage.com/ScienceMagnetismUnit3MakeUseCompass2.htm (second grade lesson plan)
- http://www.askeric.org/Virtual/Lessons/Science/Earth_Science/EAR0071.html (fourth-fifth lesson plan)
- http://www.geo.cornell.edu/geology/classes/isacks/mag_99/finals/mag_pole.html
- http://www.gisnet.com/notebook/comprose.html
- http://www.geolab.nrcan.gc.ca/geomag/e_nmpole.html