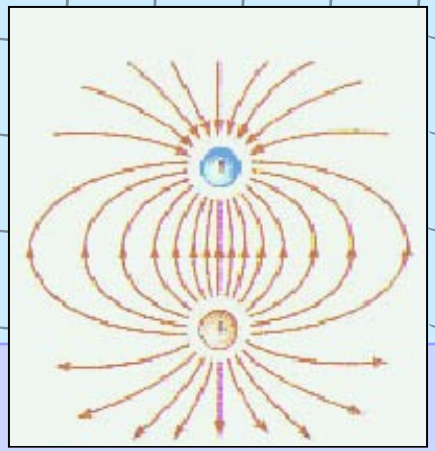
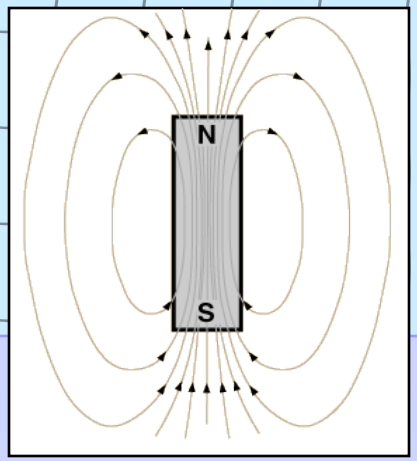




Electricity and Magnetism

Two sides of the same coin

NBSP Physical Science Institute

Thursday July 25, 2002

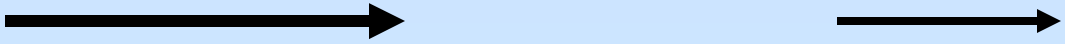
Standard Connections

- *Electricity and magnetism are related effects that have many useful applications in everyday life.*

- How are they related?
- How are they used everyday?

Key concepts: Fields

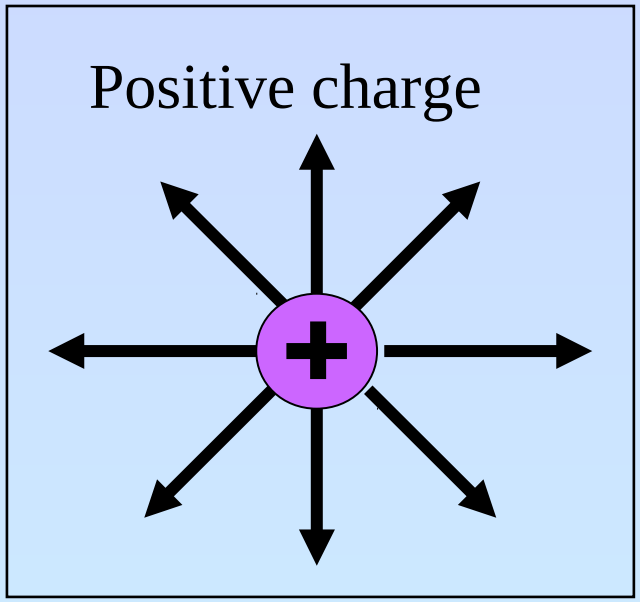
- Fields are a mathematical representation of the way that forces are transmitted between objects
- The mathematical representation is a vector which is graphically indicated as an arrow
- The length of the arrow indicates the strength of the field, and it points in the direction of the force
- Regions with stronger forces have more field lines

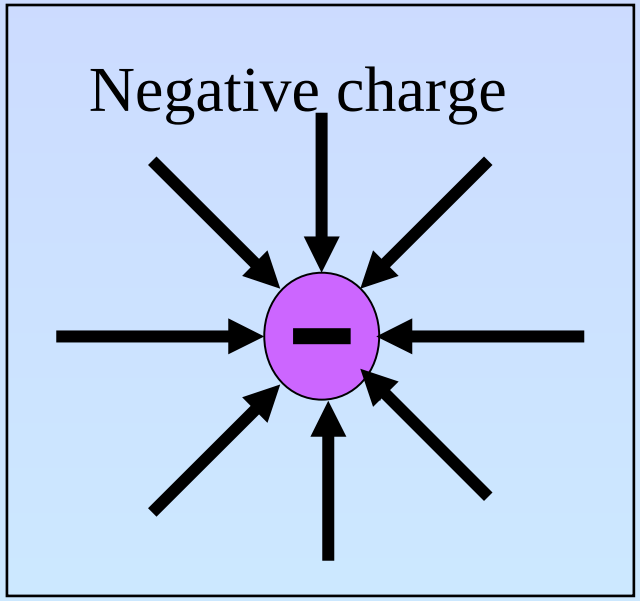


Stronger field Weaker field

Key concepts: Electric Fields

- The field of a positive charge is outward
- The field of a negative charge is inward
- Field lines start and end on charges

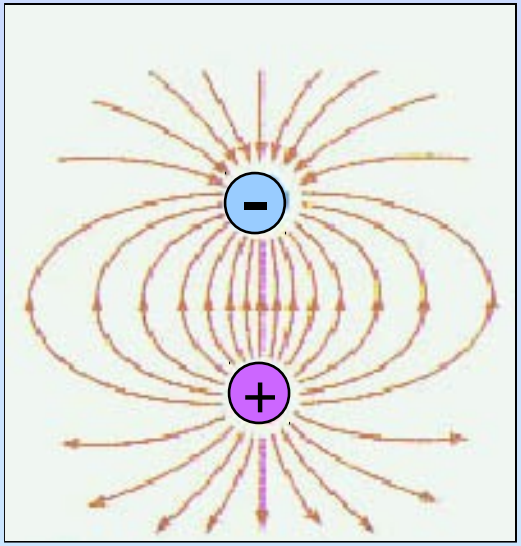




Key concepts: Electric dipole

- An electric dipole is a pair of charges: one positive and one negative
- The field pattern resembles that of a bar magnet, which is a magnetic dipole

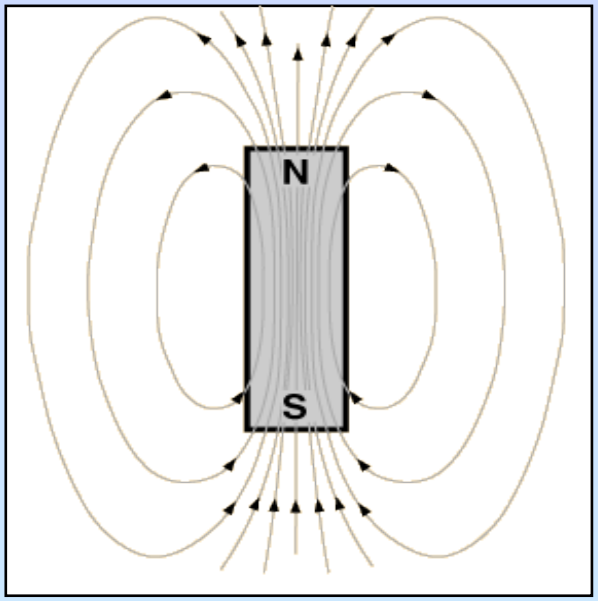
What is the direction of the field between the + and - charges (inside the dipole)?



Key concepts: Magnetic Fields

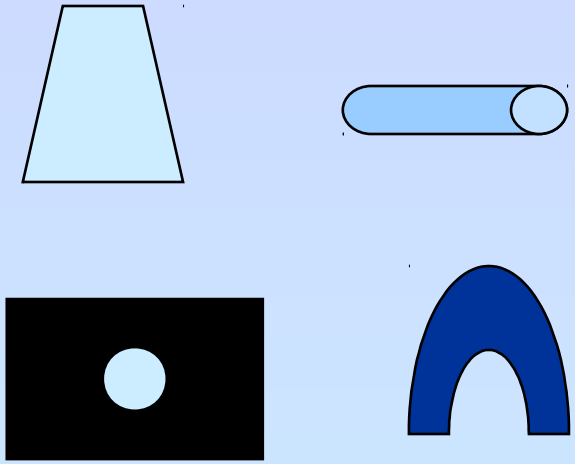
- The field of a North pole is outward
- The field of a South pole is inward
- Magnetic poles are always found in pairs, so field lines are always loops

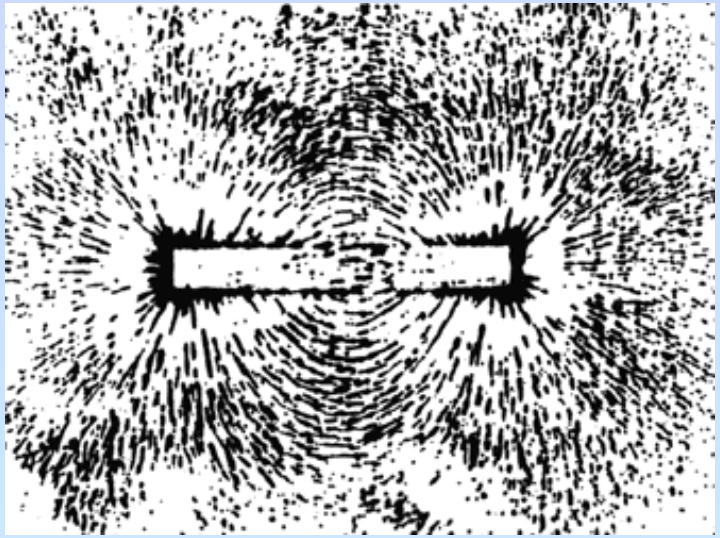
What is the direction of the field between the N and S poles (inside the magnet)?



Equipment for first activity

- Magnets of various types
- Iron filings, etc.
- Paper envelopes



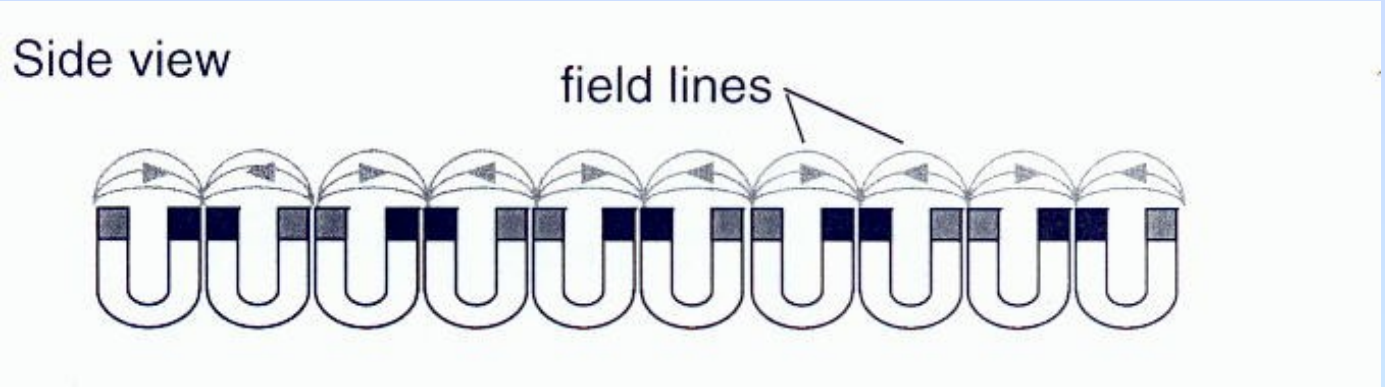


A few things to try:

- Put a magnet inside the envelope to keep it clean
- Sprinkle the iron filings on top of the envelope
- Take the compass and move it along the direction of the lines traced by the filings
- What do you notice about the compass needle?
- Put two bar magnets inside the envelope
- How do the field lines change when the 2 magnets are end to end? Side by side?
- A few things on your own

First Activity: See the magnetic field

- Are all the fields patterns dipoles?
- Can you find a magnet with more than two poles?
- What do the field lines look like for refrigerator magnets?

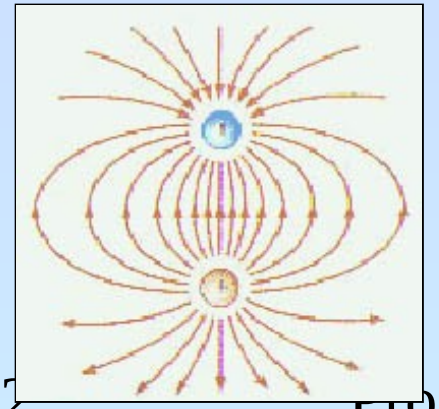


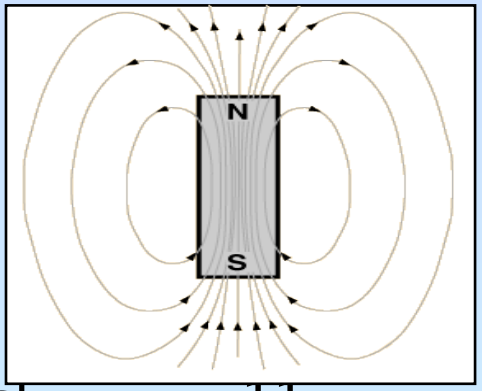
Key concepts

- Both magnetic and electric fields can be visualized by using field lines
- Electric and magnetic dipole fields have similar configurations
- Electric charges can be isolated; magnetic poles cannot
- Field lines show the direction of force

Vocabulary for ELL

- Electric field: a way to picture the effects that electric charges have on one another
- Magnetic field: a way to picture the effects that magnetic poles have on other magnets
- Dipole: the combined field of two charges of opposite signs or a pair of magnetic poles



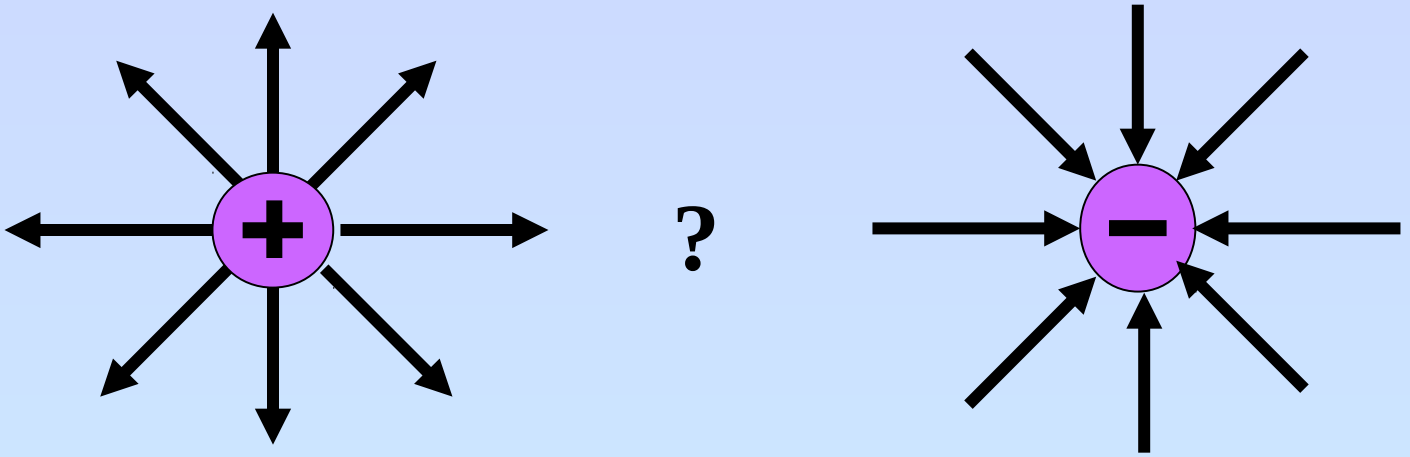


ELD Activities

- What other types of fields do you know?
- What do they have in common with electric and magnetic fields?

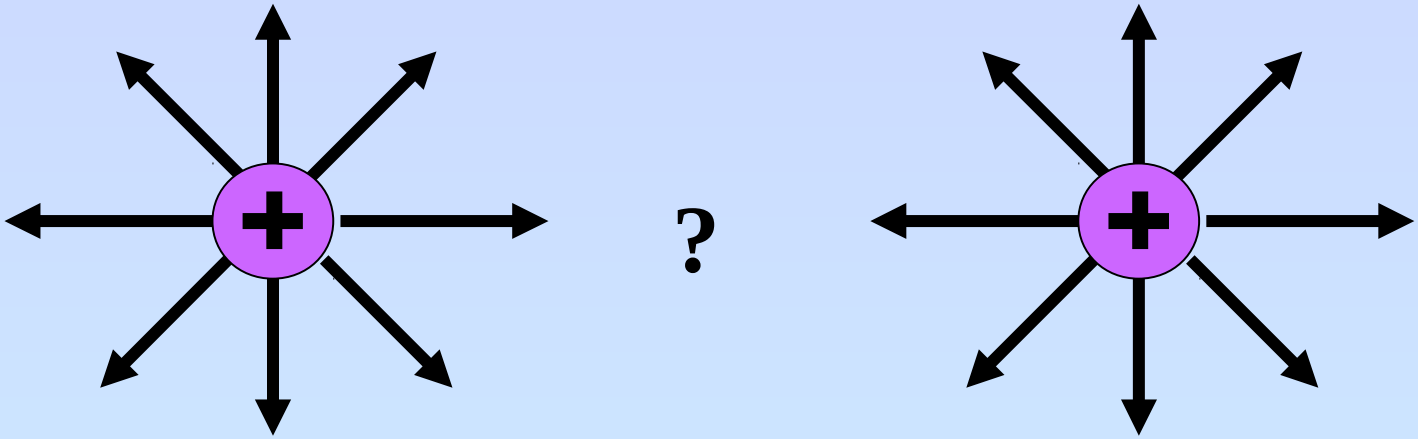
Break – some things to think about

- What is the electric field at the midpoint of two unlike charges (a dipole)?



Break – some things to think about

- What is the electric field at the midpoint of two like charges?



Standard Connections

- *Students know* electric currents produce magnetic fields and know how to build a simple electromagnet.

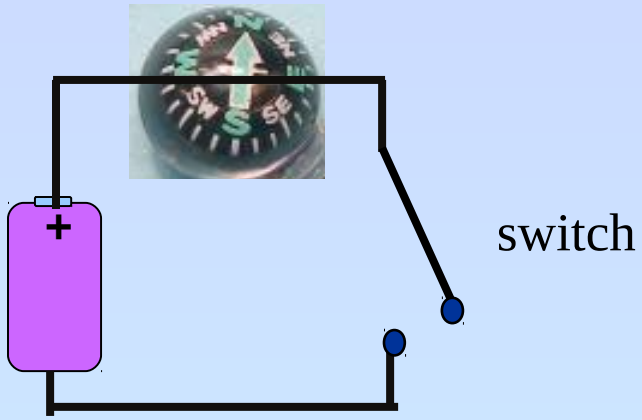
- How do we see electric currents produce a magnetic field?
- What does this field look like?

Key concepts

- Electric charges have a static electric field
- When electric charges move, they create a current
- Any current can create a magnetic field
- (A changing magnetic field can also create an electric field)

Second Activity:

- Build a circuit with a switch
- Put a compass underneath one of the wires
- What happens when you close the switch?
- Why?



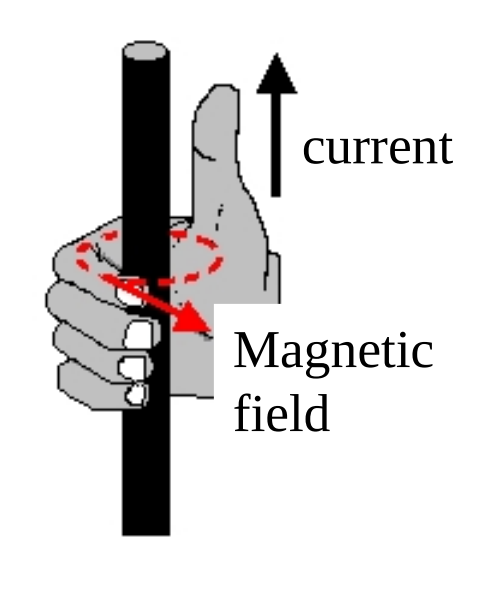
A few things to try:

- Move the compass to different places along the wire
- Does the same thing happen to the compass at each place?
- Flip the battery around
- How does the compass direction compare to the direction found with the battery in its original orientation?
- Some things on your own!

Key Concepts

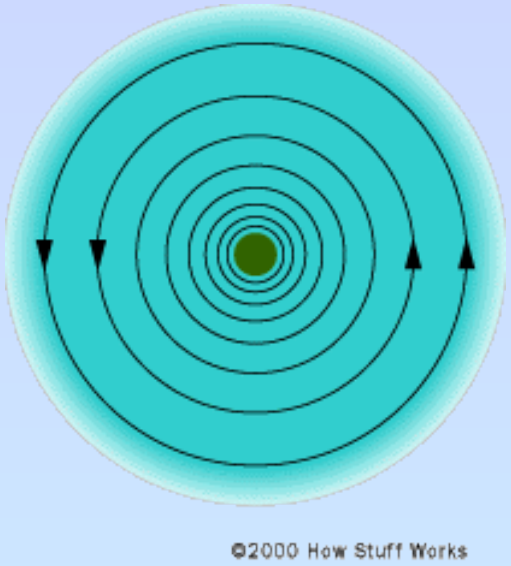
- The magnetic field encircles a current carrying wire, with the field lines curling around like the fingers of your right hand, if the current sticks up like your right thumb

- This is known as the **right hand rule**



Key Concepts

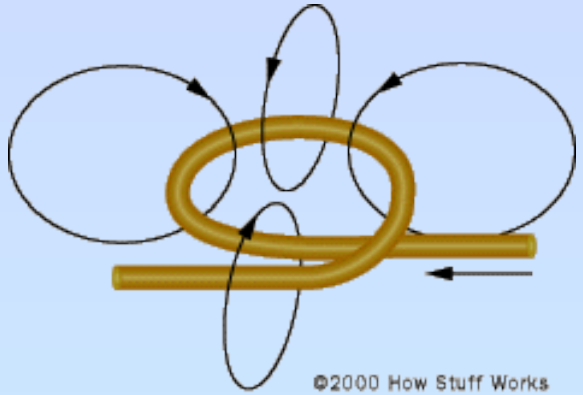
- If you reverse the direction of the current, the direction of the magnetic field reverses also



Which direction is the current flowing in the green circle in the center of these field lines?

Key Concepts

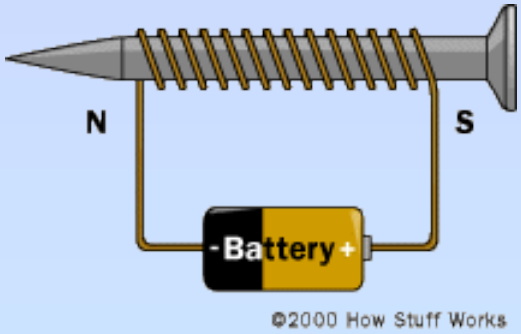
- A good way to increase the strength of the magnetic field is to coil the wire into a loop
- Then all the field lines point in the same direction in the center of the loop



- How would you verify this using your circuit and compass?
- What are other ways to make the magnetic field stronger?

Key Concepts

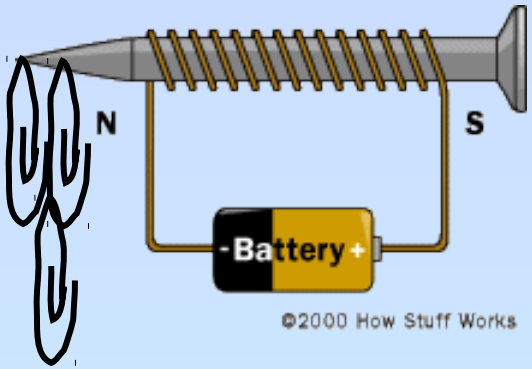
- More coiled loops → stronger magnetic field
- If you put an iron nail through the center of the loops, you can make an **electromagnet**



- Can you draw the magnetic field lines in this diagram?
- What do you think happens when the switch is opened again?

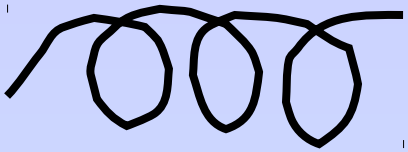
A few more things to try:

- How can you test the strength of an electromagnet?
- What happens to the strength of the electromagnet when you turn off the current?
- Can you turn the electromagnet off completely?

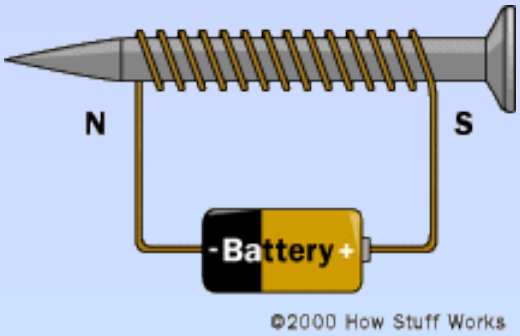


Vocabulary for ELL

- Coil – a loop of wire



- Electromagnet – a magnet made using electricity (current)



ELD Activities

- Make a list of things around your house that are found in coils
- What properties do these things have in common?

Publisher's Materials

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

Lunch break – brain teaser

An electric current is flowing through two parallel wires in the same direction. Do the wires tend to

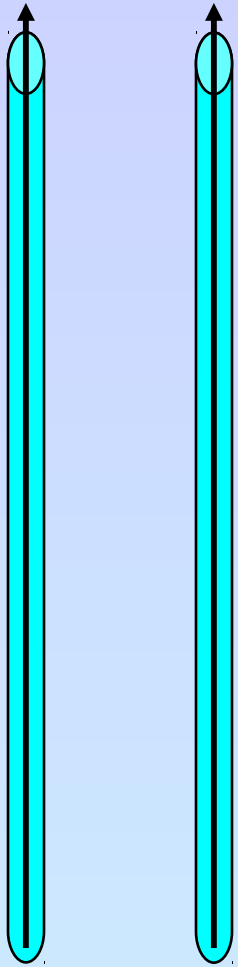
a) repel each other

b) Attract each other

c) Exert no force on each other

d) Twist at right angles to each other

e) Spin



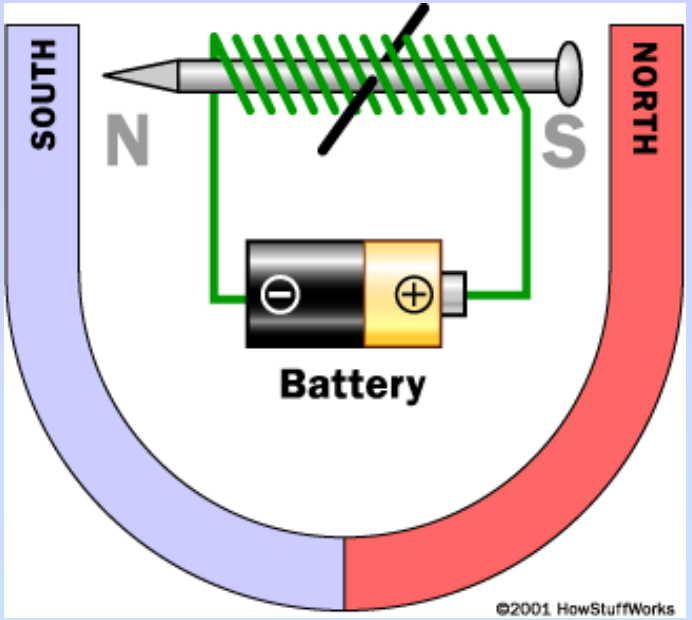
Standard Connections

- *Students know* the role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.
- *Students know* electrical energy can be converted to motion.

- How do motors and generators work?
- How do motors convert electrical energy into motion?

Key concepts – Start with an electromagnet

- If you put an electromagnet on a pivot and turned on the current, it would swing to align itself with the permanent magnetic field of a horseshoe magnet

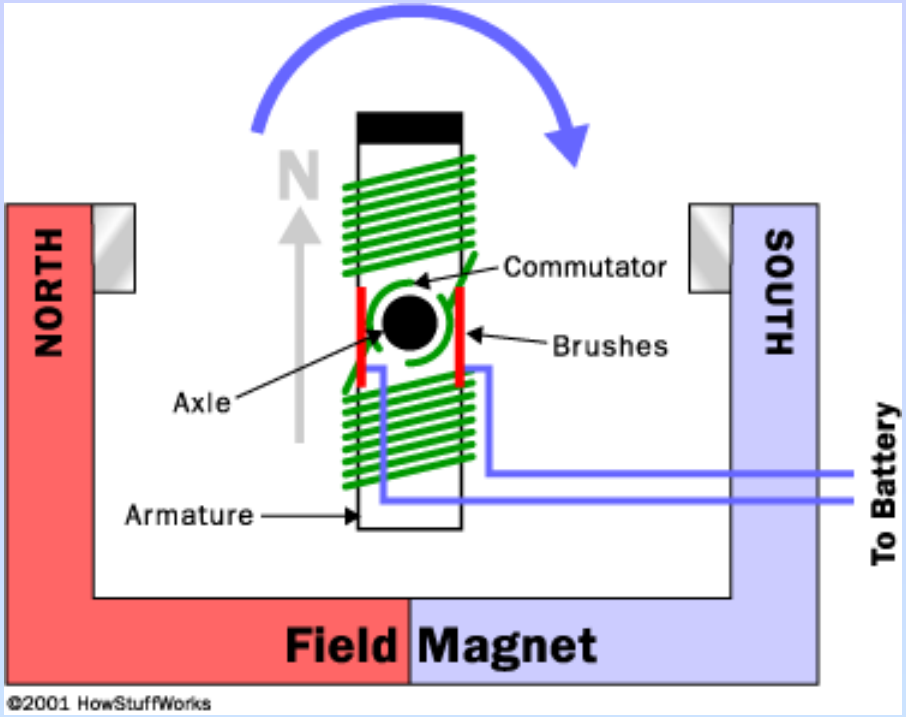


So, what do you have to do to keep the electromagnet spinning?

Key concepts – Parts of a DC motor

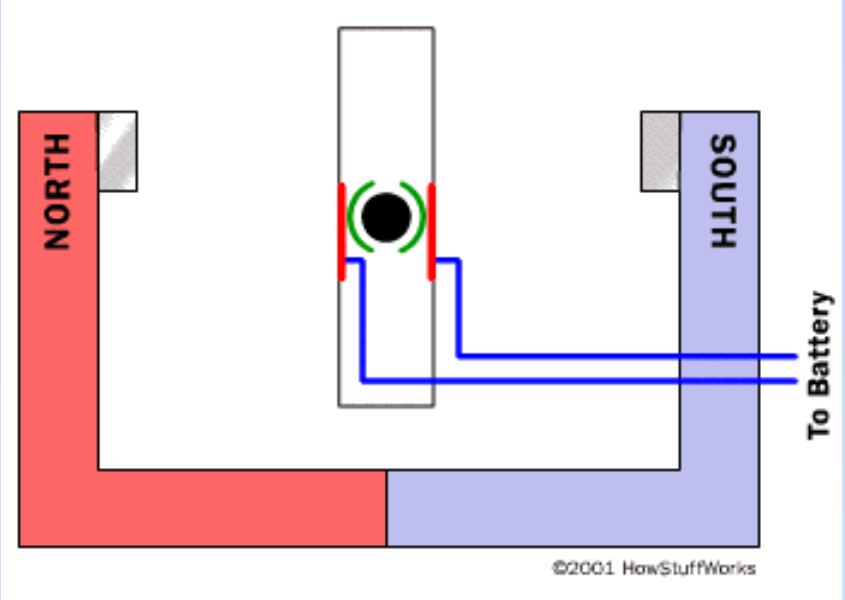
- Armature or rotor
- Commutator
- Brushes
- Axle
- Field magnet
- DC power supply

of some sort



Key concepts: Motor in action

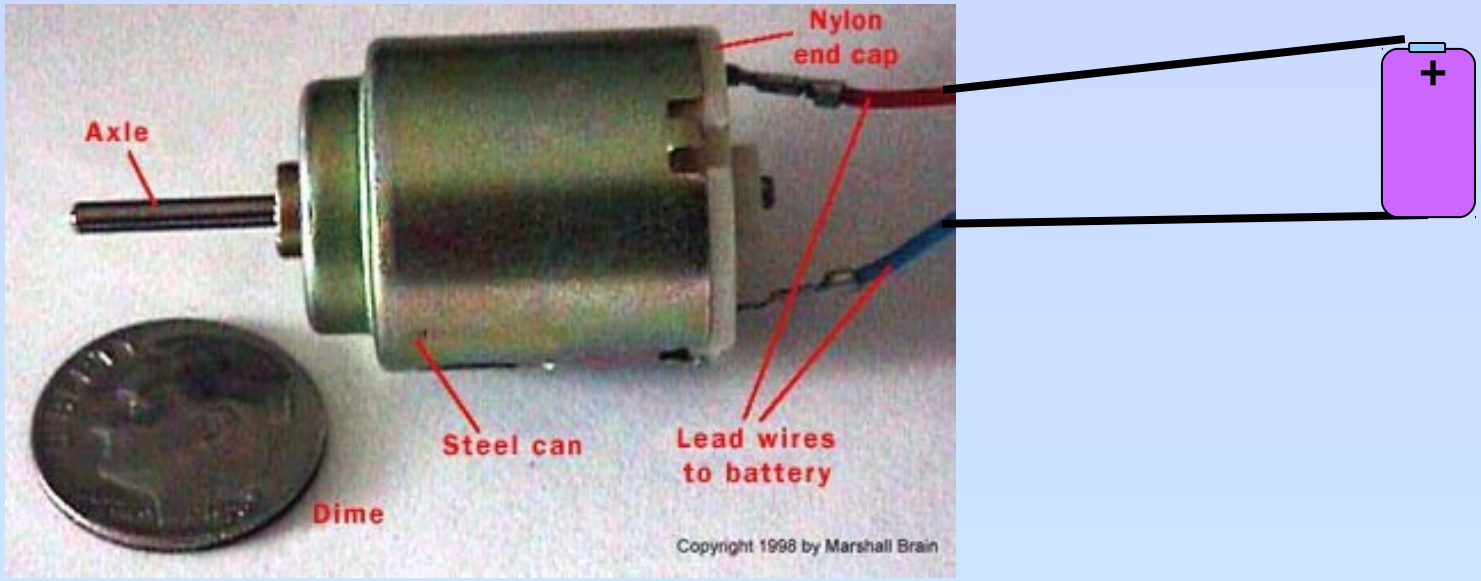
- The axle of the electromagnet is connected to commutators (green)
- Brushes (red) touch the commutators as axle spins around
- Poles flip as armature passes through horizontal position



- North pole always stays above the horizontal and is repelled from field magnet

Third Activity: Spin a DC motor

- Get a small DC motor and connect it to a battery



A few questions:

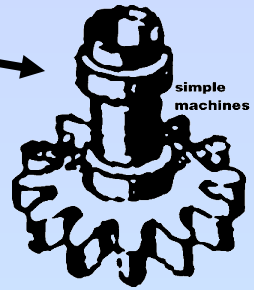
- How can you tell which way it is spinning?
- How can you reverse its spin direction?
- How can you slow down the motor?
- How can you use the motor to move something?

Vocabulary for ELL

- Armature or rotor - similar to the nail in the electromagnet, the armature forms its core while mounted on a spinning axle
- Commutator – attached to the spinning axle and to each end of the coil. Commutators spin, connecting to the brushes on each side, thereby flipping the pole of the electromagnet for each 180 degree rotation.

Vocabulary for ELL

- Brushes – connect the battery to the commutators. Usually made of springy metal.
- Axle – the part that the electromagnet spins around



ELD Activities

- Make a list of things in each room of your house that have motors
- How many motors does each device have?

Room	Device	Number of motors
Kitchen	Refrigerator	3 (with icemaker)

- What are some other things that have axles?

Publisher's Materials

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

Break – some things to think about

- How strong are permanent magnets?
- How strong are electromagnets?
- Why can't permanent magnets be used in all applications?
- What limits the strength of an electromagnet?

Publisher's Materials

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

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 (continued)

- http://solar.physics.montana.edu/YPOP/Spotlight/Magnetic/loi.html
- http://www.colorado.edu/physics/2000/waves_particles/wavpart3.html
- http://www.howstuffworks.com/electromagnet.htm
- http://purcell.phy.nau.edu/SeatExpts/resource/rhr/rhr.htm
- http://www.howstuffworks.com/motor.htm
- http://www.ed.uri.edu/SMART96/ELEMSC/SMARTmachines/wheel.html