Developed by: Sabrina L. Cales 9/30/08 9:07 PM

Grade Level: Introductory College

Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)

Topics Covered: Electrostatics and Magnetism

Standards and Benchmarks:

CONTENT STANDARD

1. CONCEPTS AND PROCESSES

In the context of unifying concepts and processes, students develop an understanding of scientific content through inquiry. Science is a dynamic process; concepts and content are best learned through inquiry and investigation.

BENCHMARK

GRADE 11

UNIFYING CONCEPTS AND PROCESSES

Concepts in LIFE SYSTEMS and EARTH, SPACE, and PHYSICAL SYSTEMS are taught within the context of the following Unifying Concepts and Processes of Science:

Systems, classification, order and organization

Evidence, models, and explanations

Change, constancy, and measurement

Evolution and equilibrium

Form and function

EARTH, SPACE, AND PHYSICAL SYSTEMS

10. Structure and Properties of Matter: Students describe the atomic structure of matter including subatomic particles, their properties, and interactions. They recognize that elements are organized into groups in the periodic table based on their outermost electrons and these groups have similar properties. They explain chemical bonding in terms of the transfer or sharing of electrons between atoms. Students describe physical states of matter and phase changes. Students differentiate between chemical and physical properties, and chemical and physical changes.

12. Conservation of Energy and Increase in Disorder: Students demonstrate an understanding of the laws of conservation of mass and energy within the context of physical and chemical changes. They realize the tendency for systems to increase in disorder.

13. Energy and Matter: Students demonstrate an understanding of types of energy, energy transfer and transformations, and the relationship between energy and matter.

14. Force and Motion: Students develop a conceptual understanding of Newton's Laws of Motion, gravity, electricity, and magnetism.

PERFORMANCE STANDARDS

LEVEL DESCRIPTORS

GRADE 11

ADVANCED PERFORMANCE

11th grade students at the advanced level, in addition to demonstrating the proficient level, make connections among unifying concepts and processes to explain the natural world and the dynamic nature of science. The cognitive complexity for students at this level reaches into a higher level of thinking, requiring frequent responses citing evidence, drawing conclusions, explaining phenomena, and using concepts to solve problems. Students extend many of the higher level thinking skills over a period of time, such as making connections

CONTENT STANDARD

2. SCIENCE AS INQUIRY

Students demonstrate knowledge, skills, and habits of mind necessary to safely perform scientific inquiry. Inquiry is the foundation for the development of content, teaching students the use of processes of science that enable them to construct and develop their own knowledge. Inquiry requires appropriate field, classroom, and laboratory experiences with suitable facilities and equipment.

BENCHMARK

Developed by: Sabrina L. Cales 9/30/08 9:07 PM
Grade Level: Introductory College
Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
Topics Covered: Electrostatics and Magnetism

GRADE 11
1. Students research scientific information and present findings through appropriate means.
2. Students use inquiry to conduct scientific investigations.
• Pose problems and identify questions and concepts to design and conduct an investigation.
• Collect, organize, analyze and appropriately represent data.
• Give priority to evidence in drawing conclusions and making connections to scientific concepts.
• Clearly and accurately communicate the result of the investigation.
3. Students clearly and accurately communicate the result of their own work as well as information from other sources.
4. Students investigate the relationships between science and technology and the role of technological design in meeting human needs.
5. Students properly use appropriate scientific and safety equipment, recognize hazards and safety symbols, and observe standard safety procedures.

PERFORMANCE STANDARDS
LEVEL DESCRIPTORS
GRADE 11
ADVANCED PERFORMANCE
11th grade students at the advanced level, in addition to demonstrating the proficient level, are able to propose new problems and questions based on experimental results or research. Students analyze information to provide new insight and draw logical conclusions that are not immediately obvious.

Objectives (Enduring Ideas):

Electric charge – Like forces repel, opposites attract
Electric force – Inverse square law like gravitation
Current – Flow of charge
Voltage – The pump, moving charge from higher to lower potential
Resistance – Difficulty of flow, heating up
Magnets – N and S poles, like poles repel and opposites attract, cause by physical/fundamental characteristics of atoms
Poles – Always come in pairs, no monopoles unlike single charges
Current and magnetism – Currents (moving charge) cause magnetic fields

Vocabulary: (Bri)

Chapter 22 *Electrostatics*

Electricity – General term for electrical phenomena, much like gravity has to do with gravitational phenomena, or sociology has to do with social phenomena.
Electrostatics – The study of electric charge at rest (not in motion, as in electric currents).
Conservation of charge – Electric charge is neither created nor destroyed. The total charge before an interaction equals the total charge after.
Coulomb's law – The relationship between electrical force, charge, and distance:

$$F=kq_1q_2/d^2$$

If the charges are alike in sign, the force is repulsive; if the charges are unlike, the force is attractive.

Grade Level: Introductory College
Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
Topics Covered: Electrostatics and Magnetism

Coulomb – The SI unit of electrical charge. One coulomb (symbol C) is equal to the total charge of 6.25 x 10^{18} electrons.
Conductor – Any material having free charged particles that easily flow through it when an electric force acts on them.
Insulator – A material without free charged particles and through which charge does not easily flow.
Semiconductor – A material that is a perfect conductor with zero resistance to the flow of electric charge.
Charging by contact – Transfer of electric charge between objects by rubbing or simple touching.
Charging by induction – Redistribution of electric charges in and on objects caused by the electrical influence of a charged object close by but not in contact.
Electrically polarized – Term applied to an atom or molecule in which the charges are aligned so that one side has a slight excess of positive charge and the other side a slight excess of negative charge.
Electric field – Defined as force per unit charge, it can be considered to be an "aura" surrounding charged objects and is a storehouse of electric energy. About a charged point, the field decreases with distance according to the inverse-square law, like a gravitational field. Between oppositely charged parallel plates, the electric field is uniform.
Electric potential energy – The energy a charged object possesses by virtue of its location in an electric field.
Electric potential – The electric potential energy per unit of charge, measure in volts, and often called *voltage*:
Voltage = electric potential energy/amount of charge
Capacitor – An electrical device, in its simplest form, a pair of parallel conducting plates separated by a small distance, that stores electric charge and energy.

Chapter 23 *Electric Current*
Potential difference – The difference in electric potential between two points, measure in volts. When two points of different electric potential are connected by a conductor, charge flows so long as a potential difference exists. (Synonymous with *voltage difference*.)
Electric current – The flow of electric charge that transports energy from one place to another. Measured in amperes, where 1 A is the flow of 6.25 x 10^{18} electrons per second, or 1 coulomb per second.
Electrical resistance – The property of a material that resists electric current. Measured in ohms (Ω).
Ohm's law – The statement that the current in a circuit varies in direct proportion to the potential difference or voltage across the circuit and inversely with the current's resistance.

Current = voltage/resistance

A potential difference of 1 V across a resistance of 1 Ω produces a current of 1 A.
Direct current (dc) – Electrically charged particles flowing in one direction only.
Alternating current (ac) – Electrically charged particles that repeatedly reverse direction, vibration about relatively fixed positions. In the United States, the vibrational rate is commonly 60 Hz.

Electric power – The rate of energy transfer, or the rate of doing work; the amount of energy per unit time, which electrically can be measured by the product of current and voltage.

Power = current x voltage

Electric power is measured in watts (or kilowatts), where 1 A x 1 V = 1 W.
Series circuit – An electric circuit in which electrical devices are connected along a single wire such that the same electric current exists in all of them.
Parallel circuit – An electric circuit in which electrical devices are connected in such a way that the same voltage acts across each one and any single one completes the circuit independently of all the others.

Chapter 24 *Magnetism*
Magnetic force – (1) Between magnets, it is the attraction of unlike magnetic poles for each other and the repulsion between like magnetic poles. (2) Between a magnetic field and a moving charged particle, it is a deflecting force due to the motion of the particle: The deflecting force is perpendicular to the velocity of the particle and perpendicular to the magnetic field lines. This force is greatest when the charged particle moves perpendicular to the field lines and is smallest (zero) when it moves parallel to the field lines.
Magnetic field – The region of magnetic influence around a magnetic pole or a moving charged particle.
Magnetic domains – Clustered regions of aligned magnetic atoms. When these regions themselves are aligned with one another, the substance containing them is a magnet.
Electromagnet – A magnet whose field is produced by an electric current. It is usually in the form of a wire coil with a piece of iron inside the coil.
Cosmic rays – Various high-speed particles that travel throughout the universe and originate in violent events in stars.

Chapter 25 *Electromagnetic Induction*
Electromagnetic induction – The induction of voltage when a magnetic field changes with time. If the magnetic field within a closed loop changes in any way, a voltage is induced in the loop:

Voltage induced ~ no. of loops x Δ magnetic field / Δ time

This is a statement of Faraday's law. The induction of voltage is actually the result of a more fundamental phenomenon: the induction of an electric *field*, as defined for the more general case below.
Faraday's law – An electric field is created in any region of space in which a magnetic field is changing with time. The magnitude of the induced electric filed is proportional to the rate at which the magnetic field changes. The direction of the induced field is at right angles to the changing magnetic field.
Generator – An electromagnetic induction device that produces electric current by rotating a coil within a stationary magnetic field. A generator converts mechanical energy to electrical energy.
Transformer – A device for transferring electric power from one coil of wire to another, by means of electromagnetic induction, for the purpose of transforming one value of voltage to another.
Maxwell's counterpart to Faraday's law – A magnetic field is created in any region of space in which and electric field is changing with time. The magnitude of the induced magnetic field is

proportional to the rate at which the electric field changes. The direction of the induced magnetic field is at right angles to the changing electric field.

Materials and Preparation:

Activities DAY 1	**Science**	**Write Up?**	**Materials?**	**Check Works?**
Van de Graff Generator (Class)	Electric Energy Storage (Build high Voltages)	From Travis (429)	Apparatus	✓
Wimshurst Generator	Electrostatic Induction	Online	Apparatus	✓
Explaining Lightning	Same as above	From Me	N/A	✓
Hanging Straws	Charge by Friction/Contact	From Book (182)	Wool, 2 straws, string, hanging app, silk, plastic rod	✓
Combs and Paper Bits	Charge Polarization	From Book/Travis (420)	Comb, paper bits	✓
Light a Bulb (Using 5 Scenarios)	Current	From Travis (454)	Battery, 2 wire, light bulb	✓ Pic
Crank Demo	Effects of Current on Body	From Book (440)	Generator crank	Extra ✓ Table
Lemon Battery	Creating a Voltage Source	From Book (453)	Lemon, copper wire, paper clip	✓
Suspend Bar Magnet	Earth's Magnetic Field	From Book (210, 469)	Bar magnet, string	✓
Iron Filings	Magnetic Fields	From Travis	Magnets, paper, filings	✓
Compass w/ Magnets	Compasses and Magnets	From Me	Magnets, compasses	✓
Make a Magnet	Magnetic Induction	From Travis	Bar magnet, paper clips	✓
Make Your Own Compass	Surviving Physics	Use the materials provided to make a compass	Magnetized steel needle/wire, cork, plastic container of water, 2 pins	✓
Science or Science Fiction	Energy, Current,	From Book (440, 446, 466,	N/A	✓

	Magnetic Induction, BioMagnetism	online)		
Activities Day 2				
Same as above				

Background Information: (see vocab and outlines)

5E Procedures:

i) Engage – Van de Graff and Wimshurst Generators demos (Day 1)
ii) Explore – Discovery activities (Both days)
iii) Explain – Answers to discovery activities (Day 2)
iv) Elaborate – Scientific background and vocabulary for answers to discovery activities (Day 2)
v) Evaluate – Class participation, exam, possible (Both days)

Step-by-Step:

i) Do Van de Graff and Wimshurst Generators demos (Day 1)
ii) Do discovery activities (12 lab style activities, 3 min ea) (Day 1)
iii) Finish discovery activities (Day 2)
iv) Lecture: Incoporate answers to the activities in with the scientific background to explain phenomenon (Day 2)
v) Go over Van de Graff and Wimshurst Generators again (Day 2)

References:

4th and 10th ed of Conceptual physics by Hewitt

Appendix:

Developed by: Sabrina L. Cales 9/30/08 9:07 PM
Grade Level: Introductory College
Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
Topics Covered: Electrostatics and Magnetism

Outline: (Travis)

Objectives:

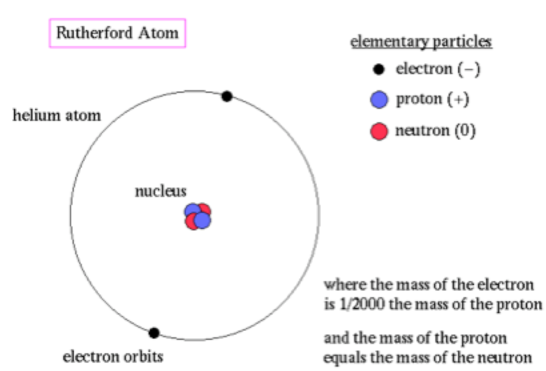
- Understand electric force, relate to gravity, '-' attractive
- Like and opposite charges
- Current – Voltage allows charge to flow
- Resistance – Heating up

Electric Force and Current:

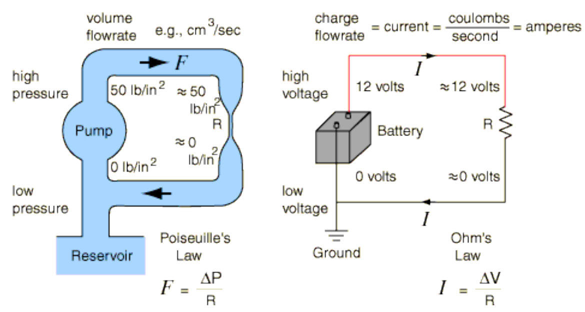
- Electric Force
    - Recall Newton's Law of Universal Gravitation => $F_G=GM_1M_2/d^2$
    - For Electric Force we have => $F_E=kq_1q_2/d^2$, where k is a constant and q are charges
    - Gravity depends on mass and distance
    - Electric Force depends on charge and distance
    - Electric Force is ~10^{36} times stronger than gravity for two protons
    - Gravity attracts, Electric force repels like charges and attracts opposite

Newton's Law of Universal Gravitation	**Electric Force**
$F_G=GM_1M_2/d^2$	$F_E=kq_1q_2/d^2$
Gravity depends on mass and distance	Electric Force depends on charge and distance
	~10^{36} times stronger than gravity for two protons
Gravity attracts	Electric force repels like charges and attracts opposite

- Atomic Model
    - Electron "orbits" nucleus '-1' charge
    - Nucleus
        - Neutrons have no charge
        - Protons have '+1' charge, and are 1800 times more massive than e^-
    - Neutral atoms have equal number of protons and electrons. However, electrons can be "freed" from atoms thus changing neutral objects into charged objects. => Example of us building up charge from carpet
    - Note: Electrons are never created or destroyed only transferred (Conservation of charge)



- Current: Flow of charges (typically electrons). For metals such as copper and aluminum the electrons are very loosely bound to the atoms, thus there are lots of electrons that are available to flow.
  - Kinks/pinch – harder to push water through
  - Resistor – harder to push electrons through
  - Voltage is not used up, like a pump it provides a steady constant "push" (electrons are not used up only recalculated).
  - A battery is a voltage source. A voltage is a difference in electron charge, thus causing electrons to flow (current).
  - Electric resistance describes how "difficult" it is for electrons to flow. Resistors increase electric resistance like kinks in a water pipe increasing the difficulty of water to flow. Note that resistors do not decrease flow, only make it more difficult.
  - Example: The filament in a light bulb is a resistor. As filament heats up the ease at which electrons pass through decreases. The increased temperature causes the filament to glow.



Pipes	Circuits
Pressure, force per unit area	Voltage, a difference in electron charge
Pump, push from low to high pressure	Battery, voltage source causing e^- to flow
Flowrate in mass per second	Current in charge per second
Reservoir	Ground
Kink/pinch, harder to push water through	Resistor, harder to push electrons through

Objectives:

- Where magnets come from, atoms
- No monopole, continuous
- Currents create magnetic fields

Magnetism:

- Force of gravity – force felt by masses
- Electric Force – force felt by charges
- Magnetic Force – force felt by magnetic poles
- Magnets have both North and South poles (N and S are simply designations, like poles repel, opposite poles attract)
- What causes magnetism? Why are magnets made of iron and not wood?

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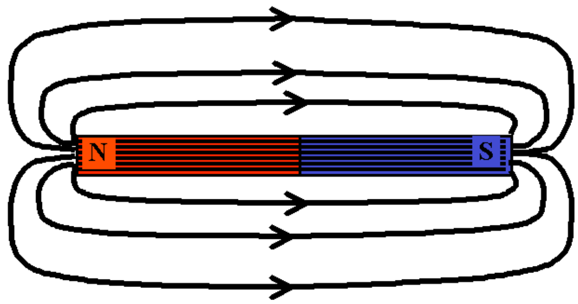
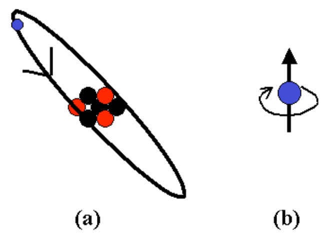
Grade Level: Introductory College
Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
Topics Covered: Electrostatics and Magnetism

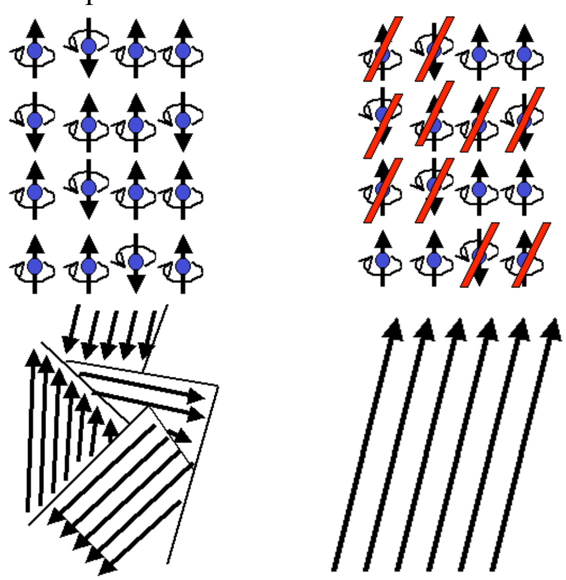
- Magnetic Fields
  - The magnetic field describes the shape of the magnetism.
  - Magnetic field lines describe how another magnet will react (direction of pole, strength, N to S)



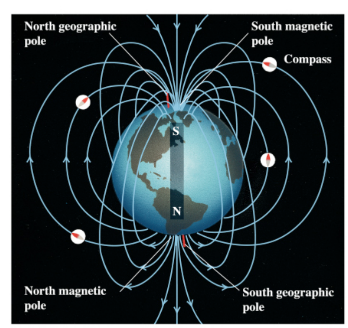
  - A magnetic field is created by a current (flow of charge), a moving charge is created by a current (flow of charge).
  - Does that mean current if flowing through a magnet?



    - (a) shows electron orbit (around nucleus)
    - (b) shows electron spin (like a top)
    - Spinning motion (moving charge) is responsible for most magnets
    - In non-magnetic materials the spins cancel
      - (a) electron spins in a material, (b) add up spins, red lines show those that cancel each other out, (c) domains, lines show net magnetization, (d) total net magnetization seen in magnets



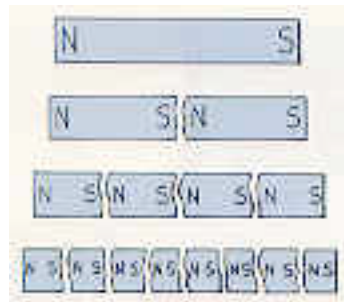
    - All magnets have a north and a south pole, there are no magnetic monopoles. Can't have a N without a S and vice versa. An object can be negatively or positively charged…



      - Example: Earth acts like a bar

magnet
  - N Geographic pole: S magnetic pole
  - S Geographic pole: N magnetic pole

- Example: Break a magnet



- Example: Junkyard cranes use giant magnets to pick up metal cars. How do they release? Remember current (current creates a magnetic field) turn it off => no more magnet.

图8.2-8 电磁起重机

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Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
Topics Covered: Electrostatics and Magnetism

Electric Force and Magnets Experiments

Electric Force and Current

The purpose of these activities is to see some effects of electric force and to better understand current (electron flow).

Experiment I: Electric Force

Take a piece of paper and rip it into small pieces. Using either a plastic comb or a plastic writing pen, rub the object against your hair. Next place the plastic object next to the paper and see what happens.

Electrons in plastic are more tightly bound than those in your hair. Also, electrons in the bits of paper can flow somewhat easily from one end o the paper to the other. Using these pacts and what you observed, explain why the paper moved when the plastic was brought close to it.

Experiment II: Electric Force

Go over to the sink and turn it on until you get a steady light flow. Again take a plastic comb or plastic pen and rub it against your hair. Move the plastic object close to the water flow and see what happens.

Water is a polar molecule, meaning that one end is slightly more negative than the other end. In light of this, explain why the stream of water moved when the plastic object was broth close.

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Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
Topics Covered: Electrostatics and Magnetism

Outline: (Me)

Day 1 – Lab Style Discovery

Activities	**Science**	**Write Up?**	**Materials?**	**Check Works?**
Van de Graff Generator (Class)	Electric Energy Storage (Build high Voltages)	From Travis (429)	Apparatus	✓
Wimshurst Generator	Electrostatic Induction	Online	Apparatus	✓
Explaining Lightning	Same as above	From Me	N/A	✓
Hanging Straws	Charge by Friction/Contact	From Book (182)	Wool, 2 straws, string, hanging app, silk, plastic rod	✓
Combs and Paper Bits	Charge Polarization	From Book/Travis (420)	Comb, paper bits	✓
Light a Bulb (Using 5 Scenarios)	Current	From Travis (454)	Battery, 2 wire, light bulb	✓ Pic
Crank Demo	Effects of Current on Body	From Book (440)	Generator crank	Extra ✓ Table
Lemon Battery	Creating a Voltage Source	From Book (453)	Lemon, copper wire, paper clip	✓
Suspend Bar Magnet	Earth's Magnetic Field	From Book (210, 469)	Bar magnet, string	✓
Iron Filings	Magnetic Fields	From Travis	Magnets, paper, filings	✓
Compass w/ Magnets	Compasses and Magnets	From Me	Magnets, compasses	✓
Make a Magnet	Magnetic Induction	From Travis	Bar magnet, paper clips	✓
Make Your Own Compass	Surviving Physics	Use the materials provided to make a compass	Magnetized steel needle/wire, cork, plastic container of water, 2 pins	✓
Science or Science Fiction	Energy, Current, Magnetic	From Book (440, 446, 466, online)	N/A	✓

	Induction, BioMagnetism			

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Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
Topics Covered: Electrostatics and Magnetism

Intro

About Me: Sabrina Cales (Bri), PhD Candidate in P&A department, Last Year Science Posse – science outreach for middle school aged kids (classrooms do demos, a lot like this…)

Plan: Backwards, start off with discovery (lab style get into 8 groups, ~4 each), 3 min, easy button, then next time do lecture, working the answers into the lecture.

What I expect: Are we elementary education or all? Remember I said I did middle school demos? Would middle school be easiest or hardest, do you think? Why's that? So I actually loved the middle school kids the best because although they might not be the most well behaved, the reason for that (lack of inhibition) is really great for class participation. In general I really love class participation! I will be asking lots of questions. Feel free to blurt out the answer. Just try to stay on topic and give me your attention when I speak. To get you to lessen your inhibition you can always add 'Just kidding' to the end of your answer if I give you a funny look. So let's try it. Travis why is the sky blue? (*Give me a BS answer*, make funny face, *you're supposed to say 'Just kidding'*, …, *Phew, that was hard*). OK, let's get to the demo.

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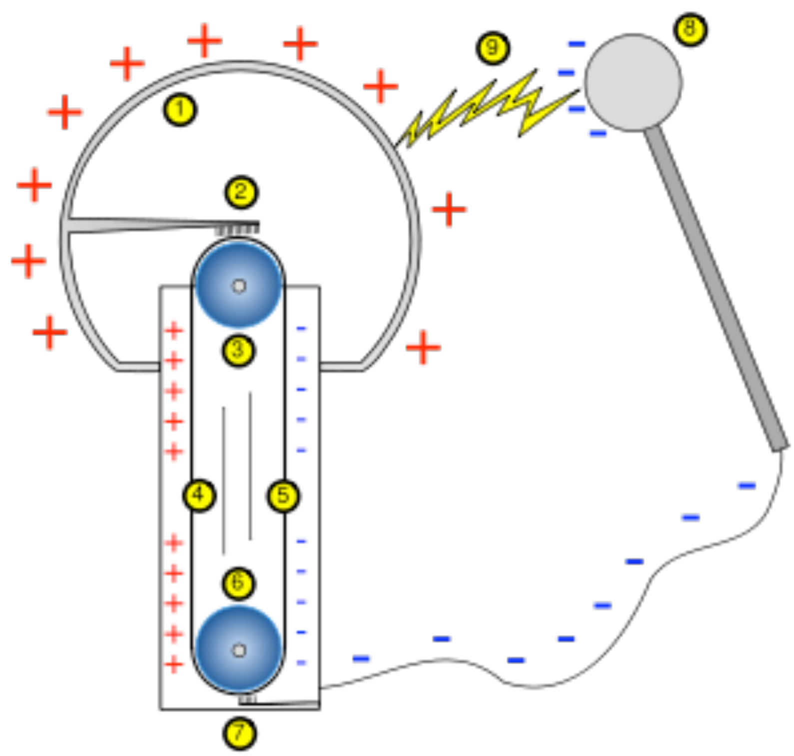
Topics Covered: Electrostatics and Magnetism

Activities

Van de Graff Generator – Electric Energy Storage (Build high Voltages)
Question: I need two volunteers. Name please? Does anyone know what this is? How it works? (Draw diagram). Just start shouting out E&M vocab.

A common laboratory device for building up high voltages is the Van de Graff Generator. This is one of the lightning machines that mad scientists used in old science-fiction movies. A simple model of the Van de Graff generator is shown in the figure below. A large, hollow metal sphere is supported by a cylindrical insulating stand. A motor-driven rubber belt inside the support stand passes a comb-like set of metal needles (**brush**) that are maintained at a large **negative** potential relative to ground. **Discharge** by the points deposits a continuous supply of electrons on the belt, which are **carried up** into the hollow conducting sphere. Since the electric field inside the sphere is zero, the charge **leaks** onto metal points (tiny lightning rods) and is deposited on the inside of the sphere. The electrons repel each other to the outer surface of the sphere. Static charge always lies on the **outside** surface of any conductor. This leaves the inside uncharged and able to receive more electrons as they are brought up by the belt. The process is continuous and the charge **builds up** until the negative potential on the sphere is much greater than at the voltage source at the bottom – on the order millions of volts… then **zap**.



Schematic view of a classical Van de Graaff generator.
1) hollow metal sphere
2) upper electrode
3) upper roller (for example in acrylic glass)
4) side of the belt with positive charges
5) opposite side of the belt with negative charges
6) lower roller (metal)
7) lower electrode (ground)
8) spherical device with negative charges, used to discharge the main sphere
9) spark produced by the difference of potentials

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Topics Covered: Electrostatics and Magnetism

Wimshurst Generator – Electrostatic Inductance

Question: I need another volunteer. Name please? Before or after Van de Graff? Does anyone know what this is? How it works? (Draw diagram) Just start shouting out vocab?

In a Wimshurst machine, the two insulated **disks** and their metal sectors **rotate** in **opposite** directions passing the crossed metal **neutralizer** bars and their **brushes**. An imbalance of **charges** is **induced**, **amplified**, and **collected** by two pairs of metal combs with points placed **near** the surfaces of each disk. These collectors are mounted on insulating supports and connected to the **output** terminals. The positive feedback increases the accumulating charges exponentially until the dielectric **breakdown** voltage of the air is reached and a **spark** jumps across the gap**.**

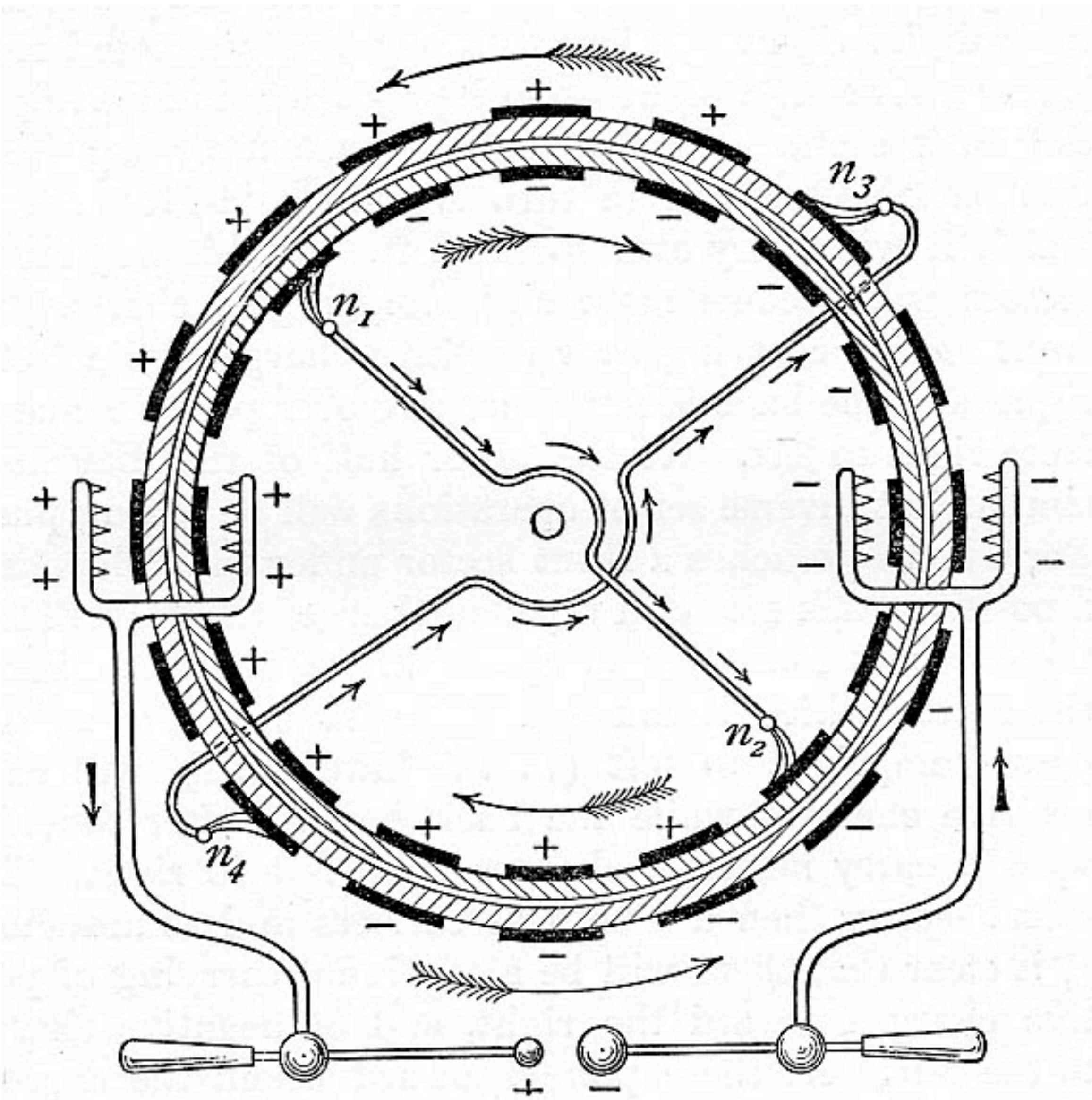

Fig. 40.

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Grade Level: Introductory College

Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)

Topics Covered: Electrostatics and Magnetism

Explaining Lightning

Use any method (research, yours or others' current knowledge…) to explain the lightning phenomenon. Is lightning anything like the spark outputs from the Wimshurst and Van de Graff Generators?

Hanging Straws – Charge by Friction/Contact

Tie a thread around the middle of a plastic drinking straw and then hang the straw by the thread. Rub half of the hanging straw with a piece of wool. If you rub another straw with wool and bring the rubbed ends of the straws near each other, what do the two straws do?

If instead you rub a plastic rod with silk and bring the plastic rod near the hanging straw, what do the two straws do?

Predict what would happen if you replace the hanging straw with a plastic rod and rub it and another plastic rod with silk. What would the two plastic rods do?

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Topics Covered: Electrostatics and Magnetism

Combs and Paper Bits – Charge Polarization

Take a piece of paper and rip it into small pieces. Using either a plastic comb or a plastic writing pen, rub the object against your hair. Next place the plastic object next to the paper and see what happens. Explain.

Light a Bulb – Current

i) You have a battery, two wires and a bulb. Play around with these until you can get the bulb to light. Sketch the configuration.

ii) Try these configurations. Which configuration matches best with what you found in part i.

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Topics Covered: Electrostatics and Magnetism

Crank Demo – Effects of Current on Body (@ Your Own Risk)

This is not a demo for the faint of heart. This demo is for groups that have at least one of each: a particularly brave member and a particularly sadistic member. This brave member should be free of major health conditions, have a reasonably high threshold for pain and have dry hands (not sweaty). The sadistic member should be willing to (and be OK with) causing your brave team member a little bit of pain.

Have your brave member touch the left lead of the generator with his/her left hand and the right lead with his/her right hand (make sure the light bulb is screwed in). Have your sadistic member slowly turn the crank (the light should flicker and barely glow a faint red). If at anytime your brave member feels discomfort he/she should simply let go of the leads. Write down your brave members description of the experience. If you have another brave member have him/her grab a hold of the first brave members right hand with his/her left hand and touch the right lead with his/her right hand. Again write down your brave members' description of the experience.

Look at the table below. What amount of current do you think your sadistic member was able to produce with the crank.

Developed by: Sabrina L. Cales 9/30/08 9:07 PM
Grade Level: Introductory College
Estimated Time: ~1 hour (Demo) 1.5 hr (Lecture/Discussion)
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Lemon Battery – Creating a Voltage Source

This is another demo for your brave member. Stick a straightened paper clip and a piece of copper wire into a lemon. Sanitize the ends wire ends protruding from the lemon with the wipe provided (or if you like you can use new wires if provided). Hold the ends of the wire close together, but not touching and place the ends on your tongue. Write down your brave members description of the experience. What do we call a contraption of this sort?

Suspend Bar Magnet – Earth's Magnetic Field

Suspend a bar magnet at its center by a piece of string. Either have a group member suspend the magnet or find a place to hand it away from any metallic/magnetic objects. What do you have?

One end, called the north-seeking pole, points northward. The opposite end, called the south-seeking pole, points southward. Look at your magnet which end points north? Which end points south?

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Iron Filings – Magnetic Fields

Place a sheet of paper on your table and put a magnet over it. On another sheet of paper scatter the iron filings as uniform as you can and in a very thin layer. Carefully take the sheet of paper with the iron filings and place it on top of the magnet. Gently shake the paper with iron filings. You should see a pattern forming that describes the magnetic field.

Sketch the magnetic field for both the horseshoe magnet and the bar magnet below. In your sketch include how you think the magnetic field lines look inside the magnet (are they continuous or do they stop?).

Compass with Magnets – Magnetic Fields

Experiment with a compass and each of the different magnets. Note which direction the compass points when the magnet is far away. Bring the magnet close to the compass. Note the direction that the compass points at different locations around and distances from the magnet. Is there a noticeable pattern? If so what is the significance of this pattern?

Make a Magnet – Magnetic Induction

Use a bar magnet and stick a paperclip to it. Separate out more paperclips and see how many you can “hang” from the bar magnet. Try to keep the paperclips aligned (do not let them bunch together. How many paperclips were you able to string together? Does each paperclip act like a magnet? Explain.

Make a Compass – Surviving Physics

You’re stranded in the Physical Sciences building and you need to make a compass to find your way out. Use the provided materials (cork, various metallic needle-like objects, plastic bin with water) to fashion a compass. Is your compass accurate. Compare it to the suspended bar magnet activity (do they point in the same/correct direction?)

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Science or Science Fiction

Science or Sci-Fi? The space shuttle uses hydrogen fuel cells to meet its electrical needs. (Its hydrogen and oxygen are both brought on board in pressurized containers.) The cells also produce more than 100 gallons of drinking water for the astronauts during a typical week-long mission.

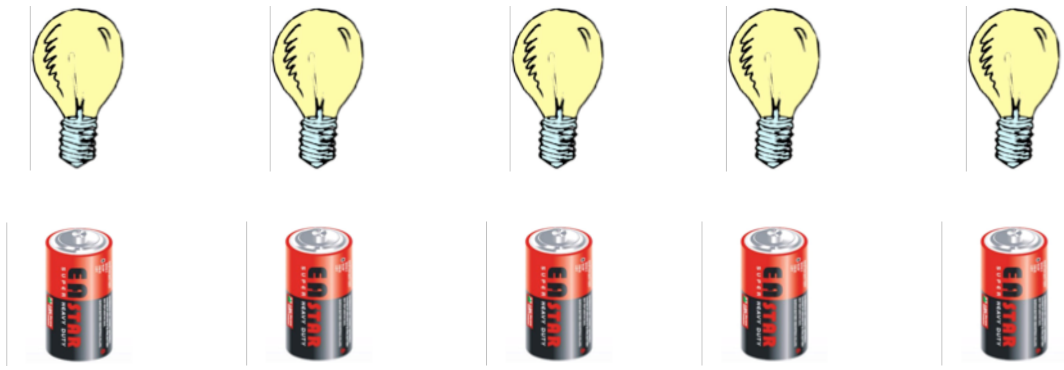
Science or Sci-Fi? I (Bri) inevitably cause a power outage at the 'in-laws' house each Christmas by using my blow dryer while the Christmas lights are on. AND… I once cause a power outage at a hotel in India by plugging in a small battery charger while the TV was on.

Science or Sci-Fi? Watch for magnetically levitated, or 'maglev', transportation. The vehicle, called a magplane, carries superconducting coils on its underside. Moving along an aluminum trough, these coils generate currents in the aluminum that act as mirror-image magnets and repel the magplane. It floats a few centimeters above the guideway, and its speed is limited only by air friction and passenger comfort.

Science or Sci-Fi? They could be the world's smelliest magnets. Grazing cows tend to face the North and South Poles, claims a new study of 308 herds made using Google Earth satellite photos. The ungulate's orientation suggests that they, like migratory birds, sea turtles and monarch butterflies, tune into Earth's magnetic fields, says Hynek Burda, a biologist at the University of Duisburg-Essen, Germany.

Science or Sci-Fi? It is interesting to note that MRI was formerly called NMRI (nuclear magnetic resonance imaging), because hydrogen nuclei resonate with the applied fields. Because of public phobia of anything "nuclear," the devices are now called MRI scanners. Tell phobic friends that every atom in their body contains a nucleus!

Light a Bulb (configurations)



1 2 3 4 5

Effects of Current on Body

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0.001	Can be felt
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Day 2 – Lecture (explain labs)

Ch 8 *Static and Current Electricity*
8.1 *Electric Charge*

Let's start off with the…
Hanging straws activity

Hanging Straws – Charge by Friction/Contact

Tie a thread around the middle of a plastic drinking straw and then hang the straw by the thread. Rub half of the hanging straw with a piece of wool. If you rub another straw with wool and bring the rubbed ends of the straws near each other, what do the two straws do? Repel (why are they charged the same or opposite)

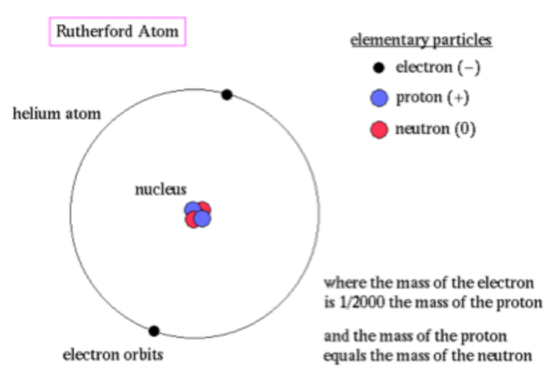
If instead you rub a plastic rod with silk and bring the plastic rod near the hanging straw, what do the two straws do? Attract (why are they charged the same or opposite)

Predict what would happen if you replace the hanging straw with a plastic rod and rub it and another plastic rod with silk. What would the two plastic rods do? Repel (why are they charged the same or opposite)

This informs us of the most fundamental rule of electrical behavior: Like charges repel; opposite charges attract.

Now on to the…
Atomic model

- Atomic Model
    - Electron "orbits" nucleus '-1' charge
    - Nucleus
        - Neutrons have no charge
        - Protons have '+1' charge, and are 1800 times more massive than e^-
    - Neutral atoms have equal number of protons and electrons. However, electrons can be "freed" from atoms thus changing neutral objects into charged objects. => Example of us building up charge from carpet or hanging straws experiment
    - Note: Electrons are never created or destroyed only transferred (Conservation of charge)



So when you rub the straws what happens? (You charge the object.) Some materials hold on to their electrons more firmly than others, so when you rub two materials together that material becomes negatively charged because the other material gave up its electrons to it. Here is a table that I made from the different materials in the book:

Electron transfer:	
From (becomes positive)	**To (becomes negative)**
Wool	Plastic/Rubber
Glass	Silk
Carpet	Rubber
Hair	Balloon
Hair	Comb

From the book:
An object that has an unequal number of electrons and protons is electrically charged. If it has more electrons than protons, the object is negatively charged. If it has fewer electrons than protons, then it is positively charged.

So if I rub plastic with wool, negative charges transfer from wool to the plastic. The wool becomes positive and the plastic becomes negative. If 5 electrons were rubbed off of the wool, how many rubbed onto the plastic? 5 This demonstrates conservation of charge. Conservation of charge – Electric charge is neither created nor destroyed. The total charge before an interaction equals the total charge after.

8.2 *Coulomb's Law*

Electric Force:

- Electric Force
    - Recall Newton's Law of Universal Gravitation => $F_G=GM_1M_2/d^2$
    - For Electric Force we have => $F_E=kq_1q_2/d^2$, where k is a constant and q are charges
    - Inverse square law (Travis asked me to pound this into you): twice the charge (F?), twice the distance (F?) Make a chart
    - Gravity depends on mass and distance
    - Electric Force depends on charge and distance
    - Electric Force is ~10^{36} times stronger than gravity for two protons
    - Gravity attracts, Electric force repels like charges and attracts opposite

Newton's Law of Universal Gravitation	Electric Force
$F_G=GM_1M_2/d^2$	$F_E=kq_1q_2/d^2$
Gravity depends on mass and distance	Electric Force depends on charge and distance
~10^{36} times stronger than gravity for two protons	
Gravity attracts	Electric force repels like charges and attracts opposite

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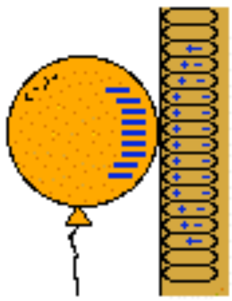
Now a comment on…
Combs and Paper Bits – Charge Polarization

Take a piece of paper and rip it into small pieces. Using either a plastic comb or a plastic writing pen, rub the object against your hair. Next place the plastic object next to the paper and see what happens. Explain.

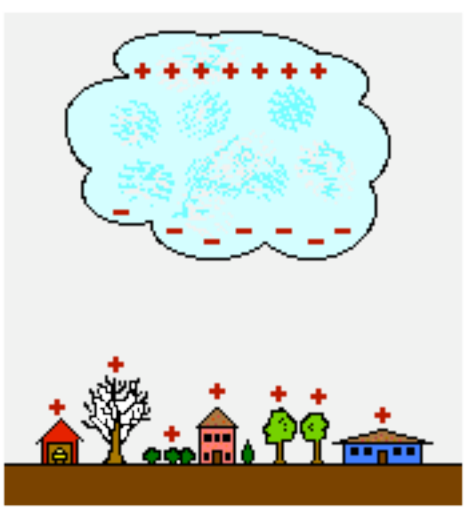


The charged balloon causes the wood molecules to become polarized. Attraction is then possible.

Hint: Polarization. This is actually the same as when you rub a balloon against your hair and then it sticks to the wall. Wasn't there a presentation on this? What was the reason for the sticking? Well, when you rub the balloon against your hair you are charging by contact, right? Hair is more positive and balloon is more negative. Then by polarization the excess negative charges on the balloon push away the negative charges in the molecules of the wall and attract the positive charges. Electrically polarized – Term applied to an atom or molecule in which the charges are aligned so that one side has a slight excess of positive charge and the other side a light excess of negative charge.

Who got the lightning question…?... (Saw a good picture)
Explaining Lightning

Use any method (research, yours or others' current knowledge…) to explain the lightning phenomenon. Is lightning anything like the spark outputs from the Wimshurst and Van de Graff Generators?



The negative charge at the bottom of the cloud induces a positive charge at the surface of the ground below.

Ice? Forces separation of positive and negative charges

Story about woman with raised hair, lightning strikes minutes later.

Lightning is a discharge, the sound and light are caused by billions and billions of electrons (in a column) bombarding air molecules on their way down from the cloud (take the path of least resistance, like water downhill, not necessarily straight).

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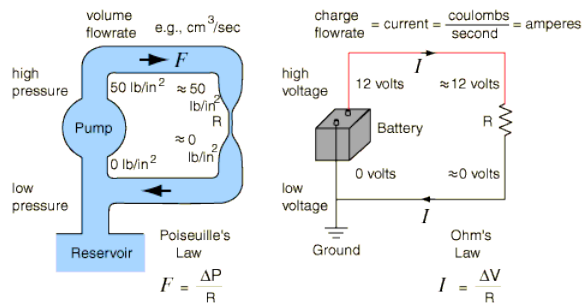
8.6 *Electric Current*

- Current: Flow of charges (typically electrons). For metals such as copper and aluminum the electrons are very loosely bound to the atoms, thus there are lots of electrons that are available to flow.
  - Voltage is not used up, like a pump it provides a steady constant "push" (electrons are not used up only re-circulated).
  - A battery is a voltage source. A voltage is a difference in electron charge, thus causing electrons to flow (current).
  - Electric resistance describes how "difficult" it is for electrons to flow. Resistors increase electric resistance like kinks in a water pipe increasing the difficulty of water to flow. Note that resistors do not decrease flow, only make it more difficult.
  - Example: The filament in a light bulb is a resistor. As filament heats up the ease at which electrons pass through decreases. (What was the connection between motion and temperature? Electrons are moving around faster.) The increased temperature causes the filament to glow.

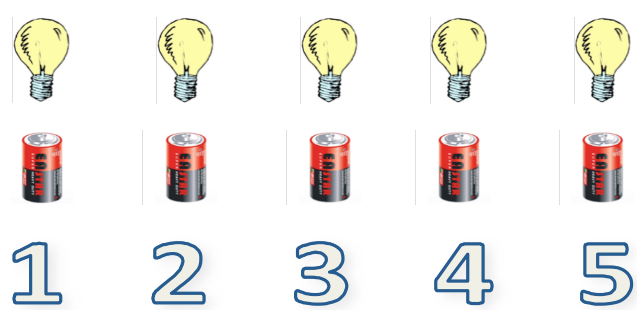


Water Pipes	Electrical Circuits
Pressure, force per unit area	Voltage, a difference in electron charge
Pump, push from low to high pressure	Battery, voltage source causing e^- to flow
Flowrate in mass per second	Current in charge per second
Reservoir	Ground
Kink/pinch, harder to push water through	Resistor, harder to push electrons through

We can use this concept to…
<u>Light a Bulb – Current</u>

i) You have a battery, two wires and a bulb. Play around with these until you can get the bulb to light. Sketch the configuration.

ii) Try these configurations. Which configuration matches best with what you found in part i.



What number configuration did it look like? 5 Could you do it with just one wire? Yes just get ride of the one in the middle. Why does this configuration work? Complete the circuit, the bulb is the resistor.

Lemon Battery – Creating a Voltage Source

This is another demo for your brave member. Stick a straightened paper clip and a piece of copper wire into a lemon. Sanitize the ends wire ends protruding from the lemon with the wipe provided (or if you like you can use new wires if provided). Hold the ends of the wire close together, but not touching and place the ends on your tongue. Write down your brave members description of the experience. What do we call a contraption of this sort?

What does your tongue have to do with feeling the tingle? Tingle means current, your tongue completes the circuit. Would you be able to feel it on your hand? No the water lessens the resistance.

Direct and alternating current
AC/DC converters? What are the wall plugs? AC What are batteries? DC Figure.

8.7 *Electric Resistance*

Electrical resistance – The property of a material that resists electric current. Measured in ohms (Ω).

Lemon Battery – Creating a Voltage Source

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Look at the table below. What amount of current do you think your sadistic member was able to produce with the crank?

Current (A)	Effect of Current on Body
0.001	Can be felt
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0.015	Causes loss of muscle control
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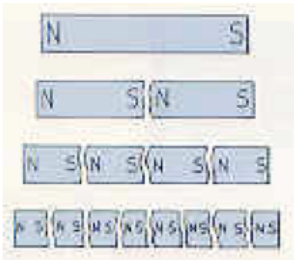
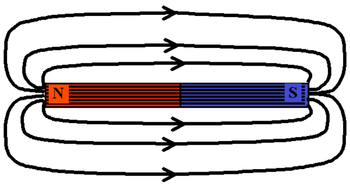
Mythbusters (Don't try this at home): I don't want you taking apart machines at home touching the positive and negative ends. Who are the brave ones and who are sadistic?

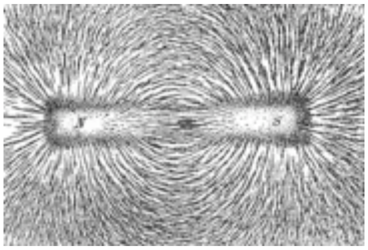
Ch 9 *Magnetic and Electromagnet Induction*
9.1 *Magnetic Poles*



- Force of gravity – force felt by masses
- Electric Force – force felt by charges
- Magnetic Force – force felt by magnetic poles
- Magnets have both North and South poles (N and S are simply designations, like poles repel, opposite poles attract)
- What causes magnetism? Why are magnets made of iron and not wood?
- Can't have individual poles, i.e., can't even make poles by breaking a magnet

9.2 *Magnetic Fields*





- Magnetic Fields
  - The magnetic field describes the shape of the magnetism.
  - Magnetic field lines describe how another magnet will react (direction of pole, strength, N to S)

<u>Iron Filings – Magnetic Fields</u>

Place a sheet of paper on your table and put a magnet over it. On another sheet of paper scatter the iron filings as uniform as you can and in a very thin layer. Carefully take the sheet of paper with the iron filings and place it on top of the magnet. Gently shake the paper with iron filings. You should see a pattern forming that describes the magnetic field.

Sketch the magnetic field for both the horseshoe magnet and the bar magnet below. In your sketch include how you think the magnetic field lines look inside the magnet (are they continuous or do they stop?). Outside – N to S, Inside – S to N

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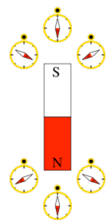
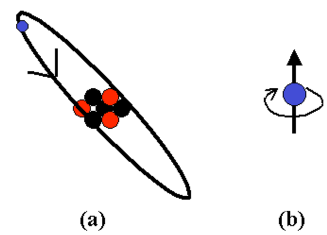
Compass with Magnets – Magnetic Fields

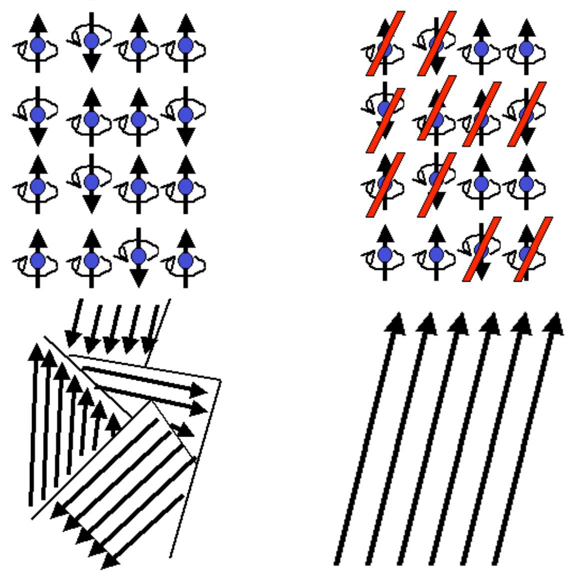


Experiment with a compass and each of the different magnets. Note which direction the compass points when the magnet is far away. Bring the magnet close to the compass. Note the direction that the compass points at different locations around and distances from the magnet. Is there a noticeable pattern? If so what is the significance of this pattern? Opposites attract (N points to S and S to N)

9.3 *Magnetic Domains*

- A magnetic field is created by a current (flow of charge), a moving charge is created by a current (flow of charge).
- Does that mean current is flowing through a magnet? Not necessarily
  - (a) shows electron orbit (around nucleus)
  - (b) shows electron spin (like a top)
  - Spinning motion (moving charge) is responsible for most magnets
  - In non-magnetic materials the spins cancel
    - (a) electron spins in a material, (b) add up spins, red lines show those that cancel each other out, (c) domains, lines show net magnetization, (d) total net magnetization seen in magnets





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- Example: Junkyard cranes use giant magnets to pick up metal cars. How do they release? Remember current (current creates a magnetic field) turn it off => no more magnet.

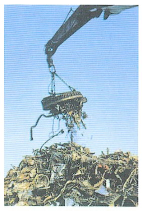
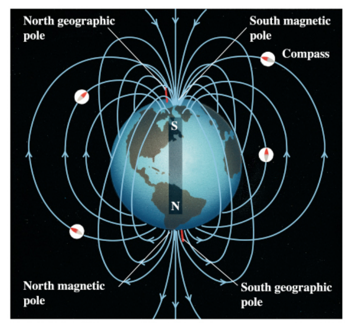


图8.2−8 电磁起重机

9.? *Earth as a Magnet*

- All magnets have a north and a south pole, there are no magnetic monopoles. Can't have a N without a S and vice versa. An object can be negatively or positively charged…

- Example: Earth acts like a bar magnet
  - N Geographic pole: S magnetic pole
  - S Geographic pole: N magnetic pole



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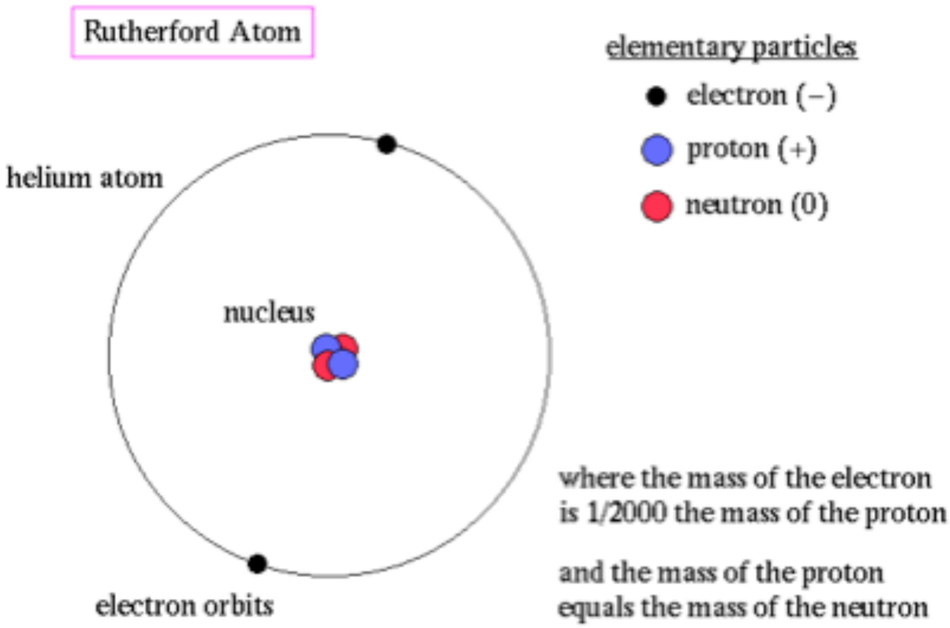
Transparencies



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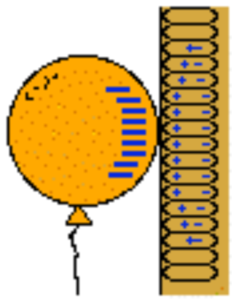

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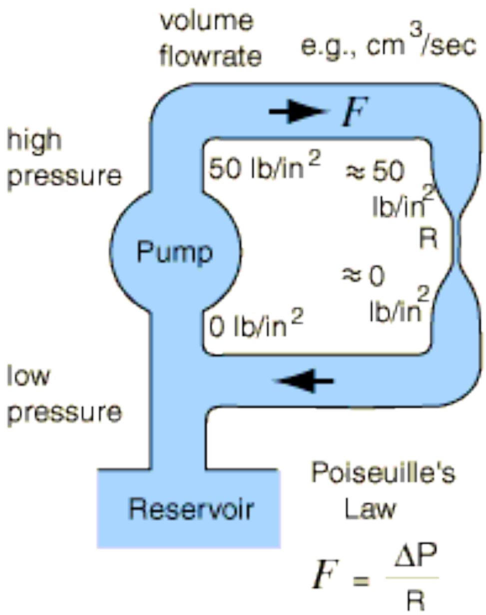

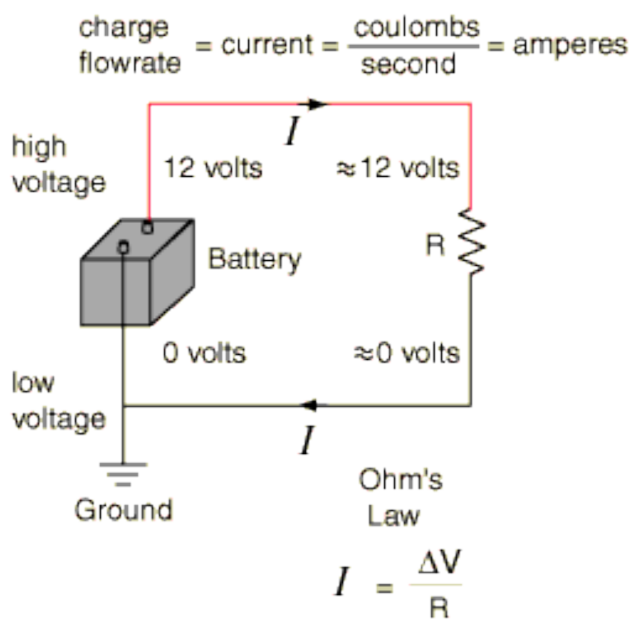

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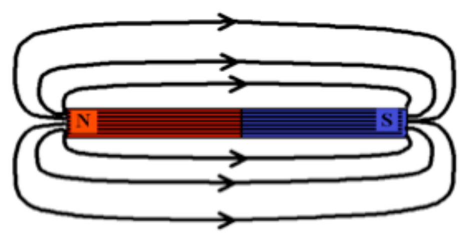
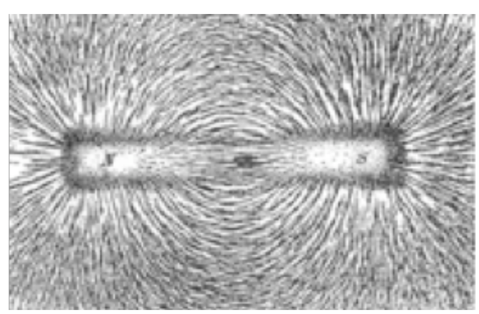
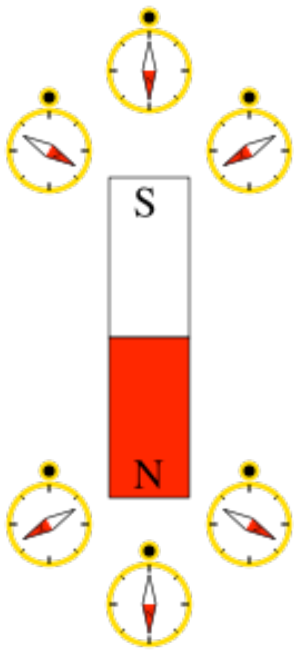
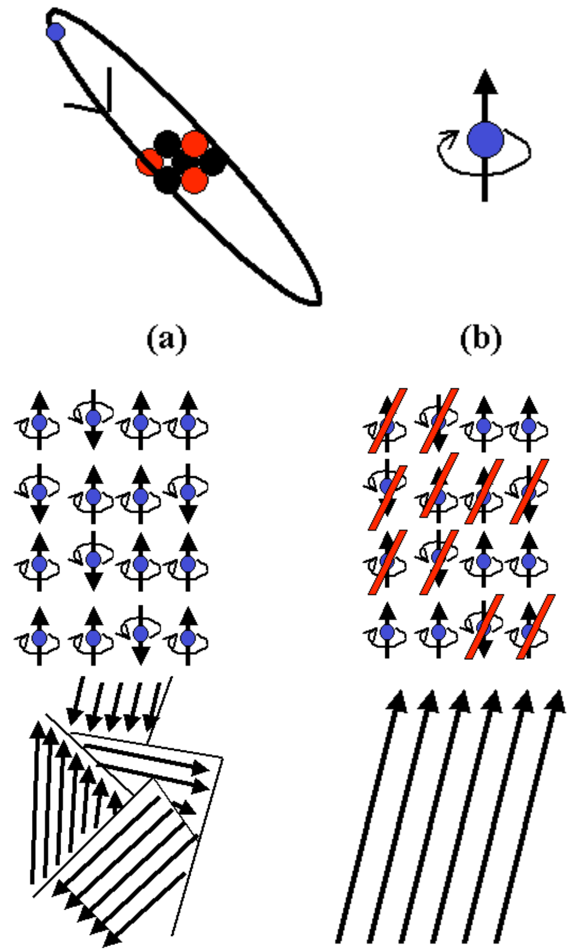
0.015	Causes loss of muscle control
0.070	If through the heart, causes serious disruption; probably fatal if current lasts for that 1s









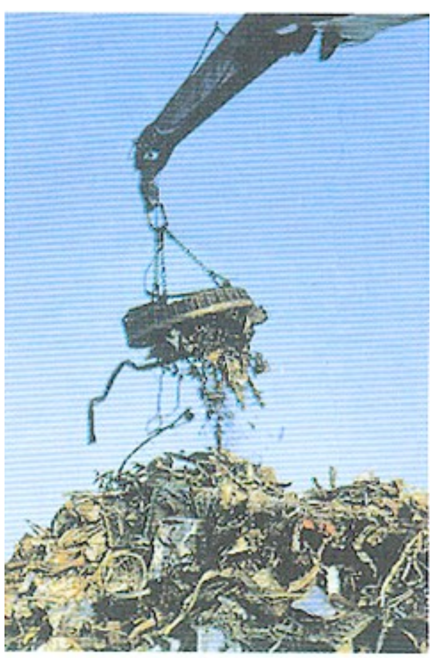
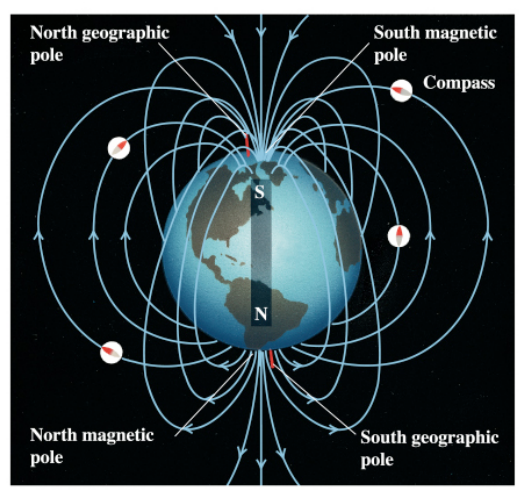


图8.2-8 电磁起重机



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