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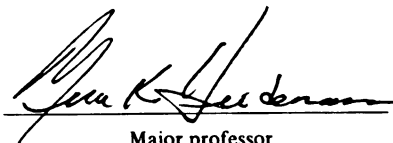
Electricity and Magnetism for Freshmen
Physical Science

presented by

David N. Dean

has been accepted towards fulfillment
of the requirements for

Master of Science degree in Physical Science-
Interdepartmental



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ELECTRICITY AND MAGNETISM FOR FRESHMEN PHYSICAL SCIENCE

By

David N. Dean

A THESIS

**Submitted to
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ABSTRACT

ELECTRICITY AND MAGNETISM FOR FRESHMEN PHYSICAL SCIENCE

By

David N. Dean

The goal of this unit was to implement engaging lessons and activities relating electricity and magnetism in order to enhance the learning environment for these topics. Students taking Physical Science did not appear to have a good understanding of the basic concepts of electricity and magnetism, such as the relationships between current, voltage and resistance, the different types of circuits, or the relationship between magnetism, motors, generators and transformers. Altering the curriculum to offer students investigative experiences in order to help them understand the principles of electricity and magnetism became the focus of this research. By way of hands-on activities and experimentation, students would be able to directly observe and determine properties relating current, voltage and resistance within circuits and the interactions between magnets and electricity using motors, generators and transformers.

TABLE OF CONTENTS

List of Tables.....	v
List of Figures.....	vi
Introduction.....	1
Scientific Background.....	5
Demographics.....	9
Implementation of the Electricity and Magnetism Unit.....	11
Summary of Activities.....	16
Evaluation	
Overview from Journal Entries.....	20
Qualitative Data.....	25
Quantitative Data.....	26
Discussion.....	32
Appendices A: Learning Styles Information	
1. Multiple Intelligence: Seven Styles of Learning.....	35
2. Multiple Intelligence Evaluation Questions: What Kind of Learner M.I?..	36
3. The Multiple Intelligence Inventory: Student Score Sheet.....	38
4. Multiple Intelligence: Classroom Strategies.....	39
5. Multiple Intelligence Assessment Menu.....	40
Appendices B: Electricity and Magnetism Unit Student Work	
1. Activity 1: Creating a Circuit.....	42
2. Activity 2: Drawing a Circuit.....	44
3. Activity 3: Circuits - Relating Voltage & Current.....	46
4. Homework #1 Drawing Series Circuits.....	48
5. Class Warm-up 1: Circuits & Ohm's Law	49
6. Activity 4: Series Circuits - Ohm's Law Calc.....	50
7. Class Warm-up 2: The Light Bulb as a Circuit.....	54
8. Activity 5: Drawing a Parallel Circuit.....	55

9. Class Warm-up 3: Drawing Parallel Circuits.....	57
10 Activity 6: Draw & Wire Parallel Circuits.....	58
11. Activity 7: Resistance.....	63
12. Activity 8: Drawing Circuits & Using Ohm's Law.....	64
13. Homework #2: Circuits & Ohm's Laws.....	67
14. Activity 9: Magnets.....	70
15. Activity 10: Strength of Magnets.....	72
16. Activity 11: Magnetic Materials.....	73
17. Activity 12: Magnets & Magnetic Fields.....	77
18. Activity 13: Electromagnets.....	81
19. Activity 14: How a Motor Works.....	83
20. Class Warm-up 4: Rotating Motors.....	88
21. Activity 15: How Fast Does a Motor Turn.....	89
22. Activity 16: Introduction to Transformers.....	92
23. Activity 17: Transforms & Voltage.....	93
24. Homework #3: Unit Review.....	95
25. Unit 4 TEST.....	99
26. Student Survey.....	105
References.....	107
General References.....	108

LIST OF TABLES

Table 1: Percentage of students ranked in each learning style category.....	3
Table 2: Number of Students Per Class Period.....	10
Table 3: Average Test Score and Percent by Class Period and Gender.....	24
Table 4: Electricity and Magnetism Unit Test Scores for Physical Science classes in 2000 to 2002.....	27

LIST OF FIGURES

Figure 1: Drawing of student circuit board.....	11
Figure 2: Circuit diagram symbols.....	14
Figure 3: Circuit diagram and drawn circuit on student circuit board.....	14
Figure 4: Bar graph comparing percentage test scores over three years for the electricity and magnetism unit test.....	27
Figure 5: Bar graph showing the total score for each hour and the average score on each objective on the Electricity and Magnetism Test.....	28
Figure 6: Bar graph showing the percentage of students scoring correct responses on objective 1 questions.....	29
Figure 7: Bar graph showing the percentage of students scoring correct responses objective 2 questions.....	30
Figure 8: Bar graph showing the percentage of students scoring correct responses objective 3 questions.....	31

Introduction

Physical Science classes at Mattawan High School have mainly utilized the textbook and a few standard laboratory activities to show students, in a very short unit, the basics of electricity and magnetism. This creates a challenge for both the students and teachers, since electricity and magnetism tend to be topics covered at the end of the semester with very little emphasis placed on student comprehension or the relationship between the aforementioned phenomena. The students are “shutting down”, allowing their grades to slip, while the teachers are desperately attempting to hold each student’s attention, keep them engaged and cover as much material as possible. With this in mind, it seemed advantageous to implement an electricity and magnetism unit with more engaging lessons and activities in order to enhance the learning environment.

The implementation of an activity-based science curriculum engages students and challenges them to construct scientific knowledge and understanding through experimentation and inquiry. Problem solving, experimentation and investigation empower students with greater freedom while providing a process that teachers can use to guide and lead students. This transfers the active role in the classroom to the students through problems and situations that connect to their lives (Delisle, R. 1997). Through recent brain research and studies conducted by Howard Gardner pertaining to various learning styles, it has been determined that individual students perceive and process information differently. The old paradigm of how students acquire knowledge has changed. Gardner’s theory of multiple intelligences gives educators an understanding of how the learning process differs from one student to another. Traditional views of intelligence offered only the two basic categories of analytical and verbal learning. Governed only by these two categories of information processing, students were thought to be able to learn all the different types of

subject matter. Gardner challenges this idea of most students fitting neatly into only two modes of intelligence and instead has identified as many as nine different intelligences or learning styles. Gardner further speculates that there will be more learning styles identified in the future (Gardner, H. 2000).

Over the seven years that I have evaluated the learning styles or multiple intelligences of my students, I have identified only the seven original learning styles outlined by Gardner, as found in Appendices A. As we change students at the beginning of each semester, students entering my Physical Science classes are asked to complete a learning style inventory to determine each individual's learning style or styles. Thirty-five statements are read outlining Gardner's seven different intelligences or learning styles, five statements describing some attribute of each learning style. The students are asked to respond by noting the statements that they feel best describe them. During the class discussion that follows the students share their ideas and questions about the individual tendencies that are common for each learning style. Over the seven years that I have used an evaluation of learning styles, the vast majority of my students have expressed a positive sense of agreement with the outcome of the evaluation and have seemed to appreciate the insight it offers them about themselves as a learner.

Frequently throughout the semester students are reminded to look back at the analysis of their learning styles to reemphasize the manner in which they interact during learning opportunities. Active involvement during class activities allows students to draw upon their natural learning strengths. Since a majority of students show a strong tendency toward the visual/spacial and bodily/kinesthetic learning styles, active hands-on assignments and small group interaction should greatly improve the understanding and retention of information. Table 1 shows the results of the learning styles inventory for the sixty-two Physical Science

students that took part in this study.

Table 1: Percentage of students identifying with each learning style category.			
<u>Learning Style</u>	High ranking: 4 or 5	Medium ranking: 2 or 3	Low ranking: 0 or 1
Verbal/Linguistic	12.9%	50.0%	37.1%
Mathematical/Logical	11.3%	35.5%	53.2%
Visual/Spatial	54.8%	29.1%	16.1%
Bodily/Kinesthetic	66.1%	22.6%	11.3%
Musical/Rhythmic	79.0%	19.4%	1.6%
Interpersonal	35.5%	32.2%	32.3%
Intrapersonal	29.0%	33.9%	37.1%

As an educator, I feel it is important for students to actively participate in their education and take responsibility for acquiring the knowledge and understanding deemed necessary to be scientifically literate in today's society. In my class, approximately 80 percent of a student's grade is determined from tests and assessments. It is my feeling that a list of objectives offers each student a target with which to focus their efforts toward learning what is expected and what will be tested. It is my general policy, and in this study, that most activities are not graded but serve as the means for student to gain the knowledge, experience and understanding that is expected. Homework assignments are given in order for each student, along with me, to evaluate their level of comprehension of the topic covered and whether or not extra assistance is needed.

Activities are either chosen or designed to be the means by which students can experience and construct knowledge about the topics we cover in Physical Science. Through a constructive approach, students are given multiple opportunities during class activities to

use laboratory equipment that allows them to test and explore the concepts outlined in the objectives. Many of the activities have been designed or chosen in order for students to work in small groups or individually and raise questions that can be tested by the students in order to construct knowledge and understanding of magnetism and electricity. Students often need to refocus and emphasize to them the purpose of completing the activities is to learn and understand the science concepts rather than just a “play time” with the lab equipment. Dale Parnell (1995) notes that many secondary classrooms are filled with students and labeled as to the different subjects which will be “taught” within these walls. Teachers attempt to fill each student’s head with bits of knowledge by way of lecture and textbooks with the idea that they “might need it someday”. The process of solving problems, testing ideas and discovering how things work is much more vital to a student’s education and understanding than is note taking and remembering facts.

Multiple activities increase the retention of the information through repeated experiences that help to focus the students on specific topics related to the objectives. Class warm-ups are handouts used at the beginning of the class period to reinforce and review terms and concepts correlated with the unit objectives in order to improve learning and retention. The warm-up sheets give students an opportunity to take a few minutes to focus on the terms or concepts that they have been working on during previous days activities. As students complete the warm-ups, there is some class discussion in order to address any new questions students may have before moving on with that day’s activities. Understanding and applying scientific terminology and concepts are necessary for the retention of new and existing information. Repeated rehearsals assist in this knowledge and application process by ensuring students’ understanding of the unit concepts. In order for new learning to have meaning and make sense, the learner must have time in order to process and reprocess new

information. In order for students to communicate scientifically, they must be able to properly apply terminology and concepts. This *rehearsal* of information is the crucial part of a continuous processing that is necessary for transfer learning to occur and for information to be shifted from working memory to long-term storage (Sousa, D. A. 2001).

Constructing a solid understanding of the concepts being taught and forming relationships between various concepts involves using a wide variety of methodology and challenging students at the appropriate level with realistic expectations. For this to occur it is important to maximize the efforts of both educators and students. The thought of holding the attention of each student throughout the entire class period is unrealistic and has even been proven to be less beneficial than having periods of high and low levels of attention through peak interest activities and downtime reflection and processing (Jensen, E. 1998).

Scientific Background

Static electricity is a build up of electrons on the surface on an object. Electrons can be deposited on objects such as a friction rod or Styrofoam cup when the surface is rubbed over materials such as animal fur, wool or silk. As the rod or cup is rubbed on the fur, loosely held electrons are picked up by the object causing its surface becomes “charged” due to the accumulation of electrons on the object’s surface. When the negatively charged object is brought near a foil leaf electroscope a positive charge is induced at the knob as the electrons migrate away from the knob and downward into the foil leaves. This creates the repulsion observed between the foil leaves suspended in the electroscope flask. When a negatively charged Styrofoam cup is brought near to a second uncharged Styrofoam cup, the second cup is repelled with enough force that the negatively charged cup is able to push the other cup across the table without making contact.

Due to high humidity situations, the surface of objects can become more conductive

and will not allow a buildup of electrons. The water molecules in the air make the surfaces conductive enough so that the moisture creates a "short" on surfaces that would normally collect electrons. Under high-humidity conditions, insulating surfaces can behave as a dead short, almost like metal (Beaty, W. J., 1994).

Electrical current is the flow of charges through a conducting material and is measured in amperes (amps). The force causing the charges to move is potential difference or voltage measured in volts. Flow of charge can be regulated by the resistance, a property of materials that resists or opposes the flow of charge through a material. Resistance is measured in units of ohms. Metals are generally known to act as conductors and are used to complete electrical circuits. Nonmetal materials commonly act as insulators due to the fact that they block the flow of current. Among the three quantities of current, voltage, and resistance, the relationship can be expressed mathematically using Ohm's law which states that the current through a conductor is directly proportional to the potential difference and inversely proportional to the resistance. Different materials have different values for resistance.

A circuit is a closed path allowing current to flow from place to place. Circuits can be closed or open and classified as series or parallel. When a circuit is complete and permits electric current to flow it is called a closed circuit. Closed circuits are commonly attributed to situations that have a closed switch, referring to when the switch is in the "on" position. An open circuit is a condition that does not allow the flow of current to occur and frequently is attributed to when the switch is in an open or "off" position. Series circuits have a single path in which current flows through each individual part within the circuit. When any part of a series circuit is removed or disabled the entire circuit is opened and the flow of electricity stops. Parallel circuits have more than one path available for current to flow

through. The multiple paths in a parallel circuit allow different parts of the circuit to act independently of each other. For instance, light switches in different rooms of a house or switches within the same room are generally wired parallel. If a part of a parallel circuit is removed or disabled, the parts of the circuit that are parallel to the removed or disabled parts are still closed and the electricity flow is not altered. Most circuits used in household wiring situations are combinations of series segments wired parallel to each other allowing each segment of a circuit to act independently from other segments, such as the different circuits observed in a fuse box.

The phenomenon of magnetism has been observed for centuries. More than 2000 years ago the invisible magnetic fields of natural magnets, or loadstones, were observed creating a force of attraction and repulsion making magnetism a puzzle. Magnetism is a property of matter that produces a force of attraction or repulsion between objects that are considered to be magnets. In order for magnetism to occur within a substance, groups of atoms, called domains, align their magnetic poles with each pointing in the same direction. Magnetic substances, such as iron, cobalt and nickel are attracted to a permanent magnet due to the ability of their domains to line up when in the close proximity to a magnet. So, when a permanent magnet is brought close to a magnetic substance the domains in the object align and the substance is attracted to either end of the magnet and the magnetic substance becomes a temporary magnet. When the permanent magnet is removed from the magnetic field around one of the magnetic substances, the arrangement of the domains within the object return to their previous random order and the substance no longer acts as a magnet. The law of magnetism says that opposite poles of a magnet will be attracted to each other and similar poles repel each other. A substance that is magnetic will be attracted to either pole of a magnet. Magnets are strongest at their poles showing a greater attraction at their

poles than anywhere else along the magnet.

The property of magnetism can be used to do work by using the attraction and repulsion properties of magnets to cause motion. When magnets are aligned in such a way that their attraction and repulsion cause rotation; we call this a motor. A motor uses electrical energy to create electromagnets that have the ability to alternate the direction of their poles. A coil of wire that is wrapped around an iron core creates an electromagnet, or temporary magnet, when current flows through the wire. The magnetic fields of the electromagnets interact with alternately aligned magnets attached to the rotor or rotating axle within the motor. When the electromagnet and a permanent magnet on the rotor align so that like poles are facing each other, the repelling force causes the rotor to rotate and the next magnet, oriented with its poles in an opposite direction to the previous magnet, will then be attracted to the electromagnet. The electromagnet is therefore repelling one magnet and attracting the next. When the second magnet aligns with the electromagnet the current is reversed and the poles of the electromagnet reverse their direction and the electromagnet now repel the magnet that it was previously attracting. This repeated cycle within the motor is the conversion of electrical energy to mechanical energy that can be used to do work.

Generators act opposite to motors and are turned mechanically to produce an electrical current. Using electromagnets, a generator produces a magnetic field around the rotating coil of wire found inside the generator that exerts a force on the electrons within the wires, thus inducing a current to flow within the wire. Attaching a generator to a circuit allows the current to flow to areas where electrical energy is needed.

The properties of electromagnetism and electromagnetic induction are used in transformers to change the voltage of alternating current. A transformer is made of an iron core with two coils of wire wrapped around it at two different locations. One side has an

incoming current and the opposite side has the resulting outgoing current. The coil of wire carrying the incoming current on a transformer is called the primary coil, and the outgoing coil is called the secondary coil. Electric current passing through the wire of the primary coil induces the iron core to become an electromagnet which puts a force on the electrons in the secondary coil causing current to flow in the wire of the secondary coil. Transformers have the ability to increase voltage in what is called a step-up transformer, or to decrease voltage in a step-down transformer. Step-up transformers are commonly used at power plants to increase the voltage to high values and step-down transformers are located near homes where the voltage needs to be decreased to lower values. Step-down transformers are commonly used to reduce the voltage for portable CD players and small battery powered devices around the home.

Demographics

This study conducted at Mattawan High School with freshman students enrolled in Physical Science. Mattawan High School is a Class A high school having a student population of roughly 1050 students, and a staff of teachers, administrators, and support staff totaling 88 people located in Mattawan, Michigan. The school district encompasses Mattawan, a small rural village, and the surrounding suburban areas located southwest of Kalamazoo. Most residents work outside the general area of the school district and commute to and from work. Of the sixty-two students participating in this study, sixty-one were freshmen and one was a sophomore; thirty-one were boys and thirty-one were girls; three were Hispanic students, one was an Asian student and one an African-American student. There is very little ethnic diversity in the Mattawan school system and the majority of the students come from middle to upper-class homes with parents having a professional background and higher education. The Physical Science course is the first of two science

courses required to graduate from Mattawan High School. Other than students who successfully test out of Physical Science, all incoming ninth grade students are enrolled in the course for their freshman year in high school. Students are varied in their academic abilities and their motivation to do well in school. For example, the mathematics experiences of the students in this study ranged from Pre-Algebra 1+, the lowest level math course offered at Mattawan High School, all the way up to Advanced Algebra for the few students that excelled in math. The sixty-two students involved in this study were split up into three different sections throughout the school day as shown in Table 2.

Table 2 - Number of Students Per Class Period

1st Hour		3rd Hour		6th Hour	
19		24		19	
Girls	Boys	Girls	Boys	Girls	Boys
12	7	12	12	7	12

Implementation of the Electricity and Magnetism Unit

When the Mattawan science staff analyzed proficiency test scores for 1997 through 1999, the electricity and magnetism cluster questions had a lower percentage of correct responses than the motion and mechanics cluster questions. Students showed a lack of understanding regarding the fundamental properties of electricity. With these things in mind, I chose to design a unit on electricity and magnetism utilizing hands-on activities and experiences which allowed students to observe and encounter properties of circuits, magnets, motors, generators and transformers in situations that would be part of their everyday lives. At the completion of the unit, students should recognize that common appliances around their homes use the same principles and devices as those studied in class.

Through activities and demonstrations developed and planned during and since my research in the summer of 1997, students experienced static and current electricity, circuits, motors and generators. The electricity and magnetism unit was introduced fourteen weeks into the second semester and completed over the last four weeks of the school year. The previous units covered in the Physical Science course were motion, mechanics and energy. During my research, my colleagues and I determined that we all had experiences with different circuit activities that caused frustration for students. Too often students would struggle to organize simple circuits using battery holders, miniature light fixtures and switches. Using loose, individual circuit pieces tended to create a confusing situation for students. Loose parts became spread out and mixed up, as well as wires getting twisted up or clumped together making it almost impossible for students to recognize the circuits they were wiring. If it was important for students to learn by observing and manipulating circuits, then it was also important for them to have a set of circuit parts that were organized

in a way that would allow them to more easily wire and experiment with different circuits. Circuit boards, as seen in Figure 1, were assembled which worked very well for the students.

There was less confusion as students connected and disconnected wires to create different circuit configurations.

In preparing to teach the electricity and magnetism unit, I decided to keep a journal, allowing me to address issues brought up by students during activities and/or make

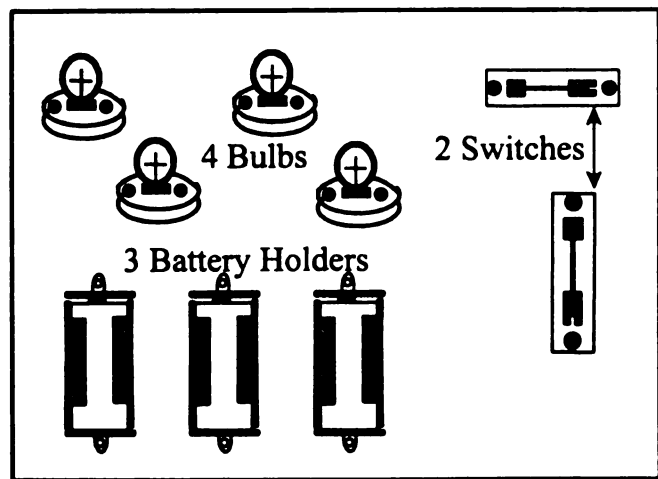


Figure 1: Drawing of student circuit board

improvements or changes. I have found the journal to be personally gratifying and helpful, making me more aware of each student's abilities, questions and concerns. Keeping a journal was something different for me and I hoped it would offer some insight into ways that lessons might be changed and improved due to the student responses and interactions. As a teacher, I generally found myself making "mental" notes (without writing them down) about how activities went, or comments that were overheard among students as they worked through an activity. These frequently were forgotten. Occasionally, I would remember comments or my thoughts that occurred during class, then I would sit at the computer and make corresponding changes to the activities. When making journal entries, I frequently noted students' comments, their attempts and reactions to the challenges they faced during the various activities and comments they brought up during class discussions. Repeatedly, I recorded my own insights, recognizing different ways that I could approach the same topic with different groups of students. Changes that would improve the students' comprehension of concepts or the communication of the lessons were also noted. Not only did the journal

entries prove to be very interesting, it was also informative as I worked with three different class periods throughout each day.

At the start of the electricity and magnetism unit a list of objectives was given to each student. It is my practice, and my educational philosophy, to lay out the objectives for students at the beginning of each unit. It is important for students to be cognizant of the material that will be covered and the knowledge they are expected to acquire as they work through the different activities and assignments. Students use the list of objectives as an introduction to the material as they begin learning the information and as a study guide to focus their learning. As the unit is completed, students return to the list of objectives to review and summarize their ideas and experiences for the unit test.

In the electricity and magnetism unit, students are given the following objectives based on the Michigan Curriculum Framework Science Benchmarks:

Objective #1: The student will be able to define electricity, in terms of circuits, and discuss the relationship among voltage, current, and resistance within different circuits and calculating values within a circuit using Ohm's law.

Objective #2: The student will be able to identify parts within an electrical circuit, diagram and construct circuits, and identify properties associated with series and parallel circuits.

Objective #3: The student will be able to describe how magnetism, magnetic fields and magnetic poles interact and how they relate to motors, generators, and transformers.

Actively involved in small groups, students had opportunities to experiment and observe properties of multiple circuit configurations making measurements utilizing batteries, bulbs and switches, experimenting with magnets and relating their properties with

working motors, generators and transformers. Throughout the electricity portion of the unit, students investigated series and parallel circuits, making measurements and observations in order to determine the properties of current electricity for both types of circuits. Students were expected to draw both series and parallel circuit diagrams using the standard symbols shown in Figure 2. Using Ohm's law, students were given values for various parts within a circuit and would then have to calculate the unknown value. It would be expected that students be able to wire circuits on the circuit boards from a circuit diagram, as shown in Figure 3. Once wired, the current and voltage would be measured. The observed difference in the brightness of the light bulbs would offer students a visual relationship between current, voltage and resistance. Students would have the opportunity to observe properties associated with series and parallel circuits by wiring different circuit configurations on the circuit boards. Each student would be expected to apply Ohm's law to the circuits they had wired on the circuit boards.

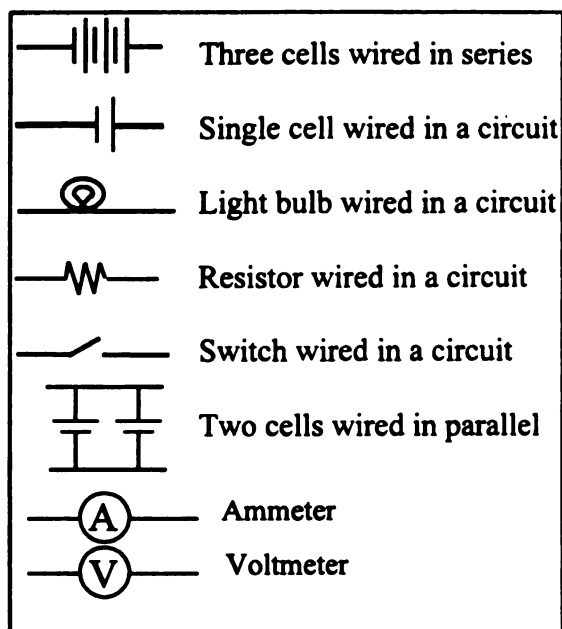


Figure 2: Circuit diagram symbols

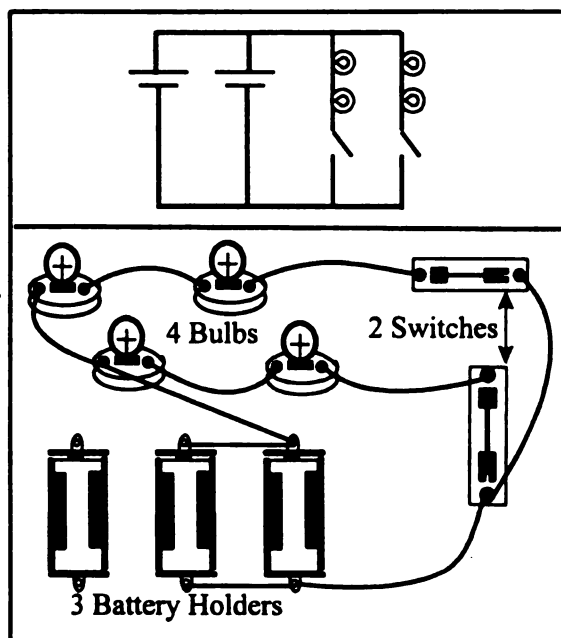


Figure 3: Circuit diagram and drawn circuit on student circuit board

The magnetism and motor activities, found in appendix B, were modified from activities in Electricity, Magnets, and Motors Teacher's Guide (Cambridge Physics Outlet 1997). Students investigated the interaction between magnets and determining the relationship between the poles of magnets and their magnetic fields through three different investigations. The first investigation had students experimenting with magnets of different sizes and strengths to determine the distance over which the two magnetic fields would interact, either repelling or attracting each other. The second investigation measured the distance of interaction between a magnet and other magnetic matter (pieces of metal containing iron, nickel and cobalt). The final magnet investigation asks students to determine whether shielding a magnet with a non-magnetic material has any influence on the distance at which the magnetic field affects another magnet.

Most of the students previously had some experiences "playing" with magnets in middle school science courses but were not familiar with how magnets interacted with wires to induce electrical currents. Once students have an understanding of how magnets interact they are asked to determine how magnets interact with electric currents to make an electric motor work. Hands-on experimentation for students to learn how a motor works is provided using the Cambridge Physics Outlet (CPO) Electric Motor <<http://www.cpo.com>>. Once students have figured out how a motor works, they are then asked to apply what they have learned in order to build and test motors with different magnet configurations. Use of a photogate timer provides precise time measurements allowing students to calculate the rotation speed and compare individual motor designs.

A Genecon hand-held generator clearly demonstrates the relationship between motors and generators as the same piece of equipment can act as both a motor and a generator. Students witness that electric motors and electric generators are based on the principle of

induction. By turning the handle of the generator students observe an electrical current being generated as the lights on the circuit board light up. This provided students an opportunity to see their motion, as mechanical energy, being converted to electrical energy. Magnetic induction is also investigated through electrical transformers. Students observe several different transformers in order to relate the number of turns of wire wrapped on the primary and secondary coils of the transformer. Students are expected to calculate the ratio of turns of wire and the resulting voltage for different examples of step-up and step-down transformers.

Summary of Activities

The activities and assignments listed in Appendices B are cataloged in the order they were assigned. The 17 different activities were designed so that students construct their knowledge and experience the concepts relating electricity and magnetism. The book *Targeting Students' Science Misconceptions* (Stepans, J. 1996) was helpful in designing some of the hands-on activities to either dispel previous misconceptions or help students avoid the development of misconceptions by allowing them to hypothesize and test their ideas as they began learning about current electricity.

The introduction to current electricity and circuits began with Activity 1: Creating a Circuit. Students work in their groups to discover a variety of different ways to illuminate a light bulb given one battery, two pennies, one light bulb and a wire. After discussing what students determined about conductors and circuits from finding ways to light their light bulb, two questions were posed to them: 1: How does a light bulb work? 2: How is a light bulb considered a circuit? Each group was given a full sized light bulb to be “dissected” so the internal parts that carry a current could be viewed. Current was demonstrated using a conductivity indicator. The light bulb shines brighter as more salt is added to the water

creating a more concentrated electrolytic solution that conducts a current across the electrodes. After the demonstrations, classes were divided into groups, given lists of terms and phases relating to current electricity. Groups were asked to discuss definitions of each term and to recall examples of two different circumstances observed throughout class activities and demonstrations that exemplify each situation. Each group then shared their responses with the entire class.

Activities 2, 3 and 4: These activities laid the basic groundwork for drawing, wiring, and testing circuits and student activities centered on the discovery of series circuit properties. Students used bulbs, wires, switches and batteries in drawing diagrams and wiring circuits on the circuit boards. Two days were devoted to drawing, wiring, and testing series circuits before beginning parallel circuits. Once students had a good foundation regarding series circuits, and circuits in general, activities 5 and 6 introduced parallel circuits. Students worked several days drawing and wiring parallel circuits and completing the parallel circuit activities. As a freshman level course, the students were applying Ohm's law only within the individual series portions of the parallel circuits. The combination of drawing each circuit diagram and then planning out where each wire would be attached gave students a visual image of their circuit would look like. The benefit of planning and seeing where the connections were to be made was evident (Hyerle, D. 1996).

The light bulb was used as an example of a circuit and how insulators and conductors must be separated in order to maintain a constant current of electricity. In activity 7: Resistance, students were exposed to different physical properties of wire that affect the wire's resistance. The students wired circuits using five different spools of wire mounted on a board. The length and gauge of wire varied and one spool of wire was made of material other than copper, giving students a situation to examine varying degrees of resistance.

Several magnet activities gave students a quantitative look at magnets interacting. Students measured the distance over which magnetic fields interact with other magnets and also with magnetic substances. Observing how magnets interact with an invisible magnetic field between the magnets and magnetic substances, showed students that magnets apply forces and that force strength relates to measurable distances of attraction or repulsion. In activity eight, students were able to observe magnetic fields by using compasses, iron filings and paper clips. In activity 13, the students applied current around an iron nail to develop and test electromagnets. Through experimentation, students determined the relationship between the strength of an electromagnet and both the amount of current and number of times the wire was coiled around the iron nail.

In activities 14 and 15, hands-on experimentation using the CPO Electric Motor offered students the opportunity to observe the interaction of permanent magnets and electromagnets to determine how a motor works. By realigning the magnets, students then developed different motor configurations that were tested using a photogate and timer to determine the speed at which the different motors rotated and the reliability of the motor to start rotating under its own interacting forces.

The common use of transformers was introduced using the Internet and the article: "Inside a Power-Cube Transformer" from How Stuff Works located at: <http://www.howstuffworks.com/inside-transformer.htm>. Students looked inside a transformer and were able to read a description of how they work. The activity that followed had the students observing three different transformers that have been disassembled in order to show the windings of wire. From their observations and reading, students are asked to identify the type of transformer by looking at the windings along with the incoming and outgoing wires. Students were also responsible for correlating the known ratio of voltage

or turns of wire in order to calculate an unknown quantity of voltage or turns of wire within a coil.

Evaluation

Overview from Teacher Journal Entries

I found keeping a journal to be very helpful and rewarding. It was a new experience for me and I definitely gained a greater insight into my own teaching and the interactions with students. Recording my comments and observations, it was common to find myself returning to student groups the next day to follow up with help or questions about the topics that their group had either struggled with the day before or not yet completed. I felt much more aware of student questions and misconceptions due to rereading my journal entries each day. This unit started off unlike most other units; the students began raising questions about electricity and magnetism as the objective list was handed out. Several students in each hour made similar remarks about “wondering what made a motor go ‘round.” I wheeled out a cart with a Van de Graaff generator on it and prepared to begin my introductory demonstration and discussion of static electricity. As soon as students saw the Van de Graaff generator they began asking “is that the “thing” that makes your hair stand up.” Students were very attentive as I turned on the Van de Graaff generator and turned out the lights so they could get a better view of the spark jumping from the dome to the discharge rod. The room soon filled with oohs, aahs and wows! Placing the ribbon plume on the dome of the generator produced many questions as the ribbons began to separate and float effortlessly upward away from the dome and one another. Students were asked then to think about what they had just observed and discuss their observations within their groups.

While students continued their discussions, a box containing a foil leaf electroscope, a friction rod, two Styrofoam cups and a piece of fur was placed at their table. Right away the questions began: “What are these for?” “Is this real animal fur?” “What are we going to do with this stuff?” Then came the best lead in you could ask for, student “1AB6” remarked:

“I thought we were going to be learning about electricity, what do these things have to do with electricity?” Students were asked to rub the friction rod with the fur and then to move the rod near to the electroscope without touching the metal knob at the top. At this point the reality that it had been raining all morning sunk in. This being the first hour of the day, the humidity was so high that there was minimal reaction between the electroscope and the friction rod. Students tried rubbing the fur on a Styrofoam cup and moving the “charged” cup slowly toward the second cup that had been placed upside down on the table. NO REACTION! The students were intrigued enough to ask what they were supposed to be observing. Since the activity was not cooperating, an explanation would have to do. Objects can become charged by picking up or giving up electrons. An object that has picked up electrons will have a negative charge. Given enough time, particles in the air, specifically water molecules, will pick up the electrons from the surface of an object leaving it neutrally charged. This would explain why when it is humid (moist) we have less trouble with static electricity or static shock. There are more water molecules in the air to quickly pick up the electrons and neutralize the charge (Wirt, S. 2002). By the beginning of third hour class, the sun was out, the humidity had decreased and the activities worked fine for the other two classes that day. The first hour class was able to successfully complete and observe the activity the following day.

The introduction to current electricity and circuits began with an activity asking students to figure out different ways to illuminate a light bulb given one battery, two pennies, one light bulb and a wire. Observing groups in each of the three classes, I saw a variety of attempts and a lack of desire to try numerous configurations. As the students shared their discoveries, it was evident that they were comprehending the difference between conductors and insulators as they related to the parts of the light bulb and the positioning required to

light them.

The discussion quickly shifted to the light bulb parts and how those parts interact to convert electrical energy to radiant energy. The resistance of the filament seemed evident as I lowered the electrodes into a beaker of distilled water and began to slowly pour in a solution of salt water. The students were asked to discuss how or why the light given off by the bulb changed as I poured more salt solution into the beaker. I was pleased with their responses as they replied using terms such as conductivity, current, flow of current, resistance. All three class periods were divided into groups and asked to define each term on their list, then describe an example or two that they had observed during class activities.

The focus then shifted to address circuits. Students would be drawing circuits, wiring circuits, and discovering the properties of circuits. It became clear that students were interested in the activities they were working on and many times I observed students express such joy when the circuits they had wired illuminated the bulb. I believe it was the instant feedback that brought about this reaction. As soon as students completed each circuit they could throw the switch and see immediate results. Several groups took some coaxing to work with their wires and solve the problem when the light did not light up. I was constantly asking them to determine: "Is it the bulb?" "Is it the batteries?" "Have you checked all your connections?" As I circulated between groups during the beginning activities, it became apparent that many students were not correlating what we had defined as a series circuit and the circuit diagram they had drawn. I frequently saw multiple wires coming out of the same clip on the circuit board and had to remind them of the reason I had them first drawing the diagram of the circuit then referring to their diagram, they were to draw the wiring on the picture of the circuit board before beginning to actually wire the circuit board. After pointing out my reasoning the several students "had the light go on!" Student 1PS13 commented,

“Now that makes sense to me! The definition actually tells you how to draw the circuit and the circuit diagram shows how to attach the wires when you do the circuit.” In another class the same day student 19P3 remarked, “This is much easier when you use all the parts to end up with a circuit that actually works.”

As the students progressed to wiring parallel circuits, it became clear that it was not always as simple to wire a parallel circuit as it was to draw a parallel circuit. In activity 4 it was again made evident that students were more successful wiring their circuits if they had first drawn the diagram and then drew in where they would attach their wires on the picture. As I observed groups working, I constantly had to remind them to look at the diagrams they drew and transfer the circuits to the picture and circuit board.

Several times I heard comments such as: “Now I see”, “I figured there had to be some way for each part to act on its own”, and “That makes sense why there’s more than one switch in each room.” The most frequent journal entry was, “They got it!” I also wrote: “The circuit boards have worked great, they have allowed students to construct various circuits with much less hassle and frustration than previous labs using loose parts.”

As each of the classes started into the magnetism section of the unit, I allowed them some “experience” time with the magnets. This gave me a perspective on what they already knew about magnets before starting the activity. I was surprised at how few students had an idea of how a magnetic compass worked. Working with compasses gave me an opportunity to interact with small groups and give some students more individualized attention in order to help them comprehend the interactions they were observing between magnets and their magnetic fields. As noted in my journal: “Magnets intrigue the students.” “They are fascinated by what they can’t see yet they observe that there is something there around each magnet.” “Many of these students could play with these magnets for hours at a time and

never get bored with them.”

I was very pleased with the activities involving the CPO Electric Motor. Student 6PS03 made the comment, “I liked getting to work with the motors, they REALLY helped me to understand how they work. It was a lot of fun.” Student 1106P stated, “Building the motor was a very good way to see and learn what is going on inside of a motor. I never had any idea that it was actually so simple.” “Using the CPO Motor made it much easier to understand what I was looking at when I took apart the motors in my remote-controlled car” remarked student 17S01.

Most of the students were unfamiliar with the function of transformers even though most of them used a transformer repeatedly with their CD player. Student 12PS06 remarked, “I often wondered how my CD player could work with just two little batteries and also use regular electricity.” “This makes sense to me now that I understand how electricity can make an electromagnet. The word transformer describes what it does, it transforms the push on the current so the electricity can be used for different things.” said student 08P3. It was obvious when discussing transformers that students were familiar with the term but never had a concept of what a transformer did. With the use of small battery powered appliances, like CD players, becoming more and more common, students were aware of transformers being used but without knowing what they actually were or “how” they worked. The example of the CD player was the model which most students were able to identify.

Other than the few students that had made a conscious decision not to participate in the activities, students enjoyed the unit and seemed to have learned what was expected of them. There were three students in my third hour class that did not take an active part to actually learn as they were attempting the activities and seldom completed an activity or assignment during this and previous units. These students chose failure rather than making

any attempt to discover and learn what is expected in the class.

Qualitative Data

I would consider the student achievement to be satisfactory over the course of the electricity and magnetism unit. Students were asked to complete a final survey, Appendix B-26, after the unit was completed, students overwhelmingly wrote positive comments relating they had a significant increase in their understanding of the topics covered. Student 16P01 made the statement: "I didn't know anything about electricity when we started, but I now feel that I have a good understanding of it and look forward to taking Physics and learning more." "When I first read through the objectives, I thought this was going to be a real tough unit. But as we started into the labs I thought it was very easy to learn this stuff because of all the examples and hands-on activities" stated student 22S03. "I learned a lot about electrical currents which I thought was very interesting" was noted by student 3P23. Student 6SP3 wrote the following comments "the labs that we did with the motors helped me a lot, I never knew that motors were so simple. It was a big help to be able to make different motors and test them so that we could see the differences. Without the motor activities I don't think that I would have understood them." 15SP3 wrote "I knew most of the stuff about magnets and magnetic fields but I never knew magnets were used in motors and generators and so important."

Question number five on the student survey ask students to offer input that would help me improve the electricity and magnetism unit. More than two thirds of the surveys had comments stating that I should continue using hands-on activities and that the students feel they learn so much more and better by doing the activities.

Of the 61 students that completed the unit survey, 45 students, 74%, rated their understanding of electricity and magnetism at a five or six on a scale from one to six, with

one being no understanding and five and six a good understanding.

Quantitative Data

The final student evaluation for the electricity and magnetism unit was a 39-question multiple choice test, found in appendix B. The test consisted of 14 questions related to objective 1 information, 10 questions for objective 2 and 15 questions that pertained to objective 3. The test scores were very close from one class period to another as shown in Table 3.

**Table 3: Average Test Score and Percent Listed
by Class Period and Gender**

1st Hour		3rd Hour		6th Hour	
32 / 39 82%		29.4 / 39 75%		31.4 / 39 81%	
Girls	Boys	Girls	Boys	Girls	Boys
31/39 80%	33.6/39 86%	29.2/39 75%	29.7/39 76%	26.9/39 69%	34/39 87%

The scores were also broken down into categories of boys and girls. The third hour class period showed very little difference in scores between girls and boys unlike the other two class periods. Sixth hour showed a dramatic range difference between the girls and the boys. I would attribute that difference to the fact that the boys in sixth hour were very involved in the activities and interested in learning about electricity and magnetism. The majority of the girls in the same class tended to be very passive when it came to taking an active part during the investigations. From previous discussions with their parents and other teachers, these girls had a reputation for their lack of motivation in all their classes.

Since I have been teaching the same subject over the past three years, I feel that I can justifiably state that the hands-on lessons and activities were the main factor in improving the understanding of electricity and magnetism by this study group. The activities were more

effective in engaging the students and helping them to gain an understanding of electricity and magnetism as outlined in the objectives. From my observations, the Physical Science class of 2001 was much more motivated and had a higher caliber academic record in most of their courses than did this years class. Yet this year's students scored 3.6% higher on the unit test than last year's students. Scores for the same unit compared to student scores from two years previous were 5.5% higher for the study group, as shown in Table 4 and Figure 4.

**Table 4: Electricity and Magnetism Unit Test Scores
for Physical Science classes in 2000 to 2002**

2000	2001	2002
73.0%	74.9%	78.5%

The test scores were consistent from one class period to another for all three of the objectives, ranging from a low of 77% for objective 3 and a high of 82% for objective 2. Figure 5 shows a comparison between each of the objective scores and the overall percentage for each class. The third hour class was had the lowest scores for two of the three objectives and the lowest average test score for the three classes. This has not been the trend since the class as a whole had out performed the other two classes throughout most of the semester. From my observations, the main reason for the lower third hour scores was due to an apathetic attitude as the end of the school year we got closer. I frequently found more students in third hour off task and inattentive than in the other two classes.

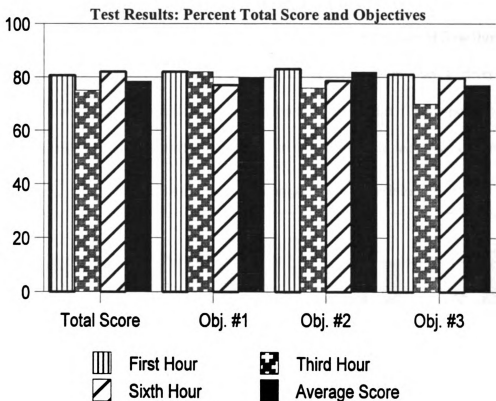


Figure 4: Bar graph showing the total score for each hour and the average score on each objective on the Electricity and Magnetism Test

Each test question was evaluated to determine how frequently each question had incorrect responses. The 14 questions relating to objective 1: The student will be able to define electricity, in terms of circuits, and discuss the relationship among voltage, current, and resistance within different circuits and calculating values within a circuit using Ohm's law, are shown in Figure 5. Four of the questions had less than 75% of the students choosing the correct answer. Three of these four questions, numbers 2, 12 and 13, required students to calculate the amount of current flowing in a circuit. There were two different circuit diagrams that apply to the three questions, one of them showing three batteries wired in series and the other with three batteries wired in parallel. Before the students could calculate the current, they had to correctly apply the concept of voltage to batteries wired in parallel and in series. Students also had to determine which path the current would flow through and then calculate the total resistance within that path and applying Ohm's law to determine the value for the current that would flow through that part of the circuit. This type of multi-step problem has several possibilities for mistakes that would result in incorrect answers.

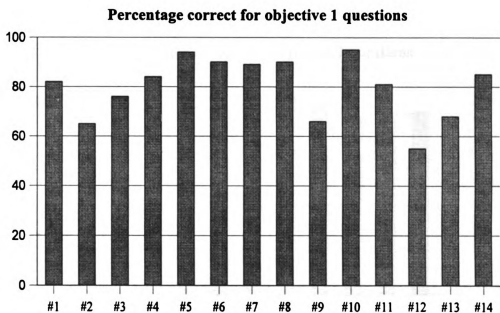


Figure 5: Bar graph showing the percentage of students scoring correct responses on objective 1 questions.

Questions from objective 2: The student will be able to identify parts within an electrical circuit, diagram and construct circuits, and identify properties associated with series and parallel circuits, averaging 82% correct responses, the highest scoring objective on the unit test. As shown in Figure 7, there were 10 questions relating the information for objective 2, with only one question having below 79% correct responses. Question number 18 was answered correctly by only 55% of the students. The question asked them to identify the total voltage of the cells in a circuit. The circuit was pictured having three parallel cells with quantitative information listed below the figure, each cell is rated at 1.5 volts. This question tested the student's knowledge of voltage adding when cells are wired in series but not adding when wired in parallel. Of those students that answered question 18 incorrectly, 23 of the students, or 37% had added the voltage for the three cells and given that as their answer. The knowledge application of this question relates directly to two of the questions students scored low on for objective 1 since the same circuit diagram was used for those two questions. The property difference between series and parallel circuits was consistently reinforced

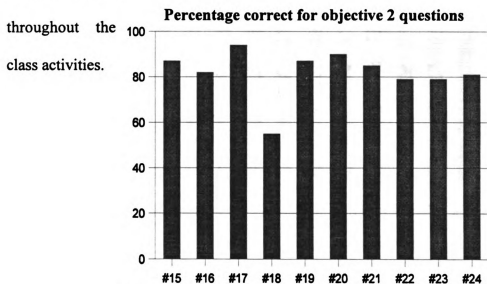


Figure 6: Bar graph showing the percentage of students scoring correct responses objective 2 questions.

Of the last 14 questions pertaining to objective 3: The student will be able to describe how magnetism, magnetic fields and magnetic poles interact and how they relate to motors, generators, and transformers, only two questions had less than 70% correct responses. For questions 28 and 29, students scored correctly 60% and 68% respectively. I'm not certain there is an explanation as to why question 28 was marked incorrect more frequently than question 26 since they were basically questions of an opposite nature. Question 28 asks the student to identify the type of transformer that would be found outside their home and question 26 relates the type of transformer that would increase AC voltage as it leaves an electrical power plant. Question 29 is a straightforward question about the energy conversion that occurs in a motor. Energy and energy conversions were also covered in a previous unit.

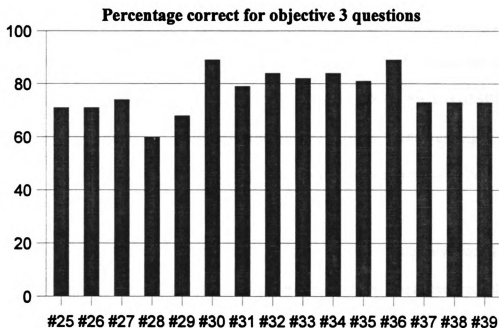


Figure 7: Bar graph showing the percentage of students scoring correct responses objective 3 questions.

Discussion

The goal of this new unit was to implement an electricity and magnetism unit with more engaging lessons and activities that would enhance the learning environment in my Physical Science classroom. After looking over the test data and reading through the journal I kept, it appears to me the goal has been met. From everyday observations it was obvious to me that students were actively involved in the learning process through meaningful activities that raised good interactive questions from the students. I was told by students repeatedly that the class period went by so quickly due to “doing” things instead of just sitting through lectures or doing book work. One remark written on the student surveys stood out from all the others and made the student’s point very clear. “Thank you for making this a hands-on class. The stuff about electricity and magnetism seemed so easy to learn because of all the things that we did to help us learn. I thought the activities were fun and interesting and I can’t imagine having to learn from just reading a book or having a teacher lecture. This was my favorite class and it always seems to go so fast because we are doing things and not just sitting there. Thanks again.” wrote student 22PS3. Student 01SP11 wrote “Doing the hands-on stuff is so much better than using the book.” After reading comments like these, I was sure it had been worth the effort I put into changing how this unit was taught.

I clearly observed a situation where the diversity of educational background had less to do with a student’s success than did the interest and motivation to be actively involved and making attempts to discover answers. Autonomy, involvement and the activities had a positive impact on student interest throughout this unit, allowing students to work with more independence to discover answers to the questions that were posed to them. During the

teaching of this unit I have seen how active involvement and hands-on manipulation by students allows teachers to give them greater responsibility, in their role as a student, to become educated and gain understanding of concepts necessary to be considered scientifically literate. The interaction with lab equipment and cooperation among students during group activities offers each student an opportunity to employ their own personal strengths and learning styles in order to learn successfully. It is likely that this approach will not work for all students, but has increased the participation and understanding for most students I have observed. It takes a certain amount of training and/or conditioning to develop feelings of confidence and comfort so students will ask questions (form hypotheses) that can be tested through experimentation in order for them to arrive at meaningful conclusions and comprehend the essential concepts and skills.

Reflecting on the preparation and teaching of this unit, I feel it has refreshed my teaching and given me a clearer vision of the direction I want to go with my teaching. I will to continue to use the multiple intelligence and brain research data to enhance the hands-on active approach to educating students in the areas of Physical Science. I plan to make improvements in the activities that address generators and transformers and add some new activities relating to capacitors. The purchase of some additional equipment would require fewer students per group so that more students have the opportunity to interact and discover information for themselves. Too often students get caught up in letting others “do” the activity and then they seem to lose interest. The more exposure each student has to interact to quality, hands-on, engaging activities the greater their chance of learning. I look forward to continuing to expand and improve this unit by making changes and additions that will facilitate the development, interest and understanding of electricity and magnetism.

APPENDICES

Appendices A: Learning Styles Information

A 1 Multiple Intelligence: Seven Styles of Learning

Linguistic Learner

- Tends to like to: read, write, and tell stories.
- Tends to be good at: memorizing names, places, dates, and trivia.
- Tends to learn best by: saying, hearing, and seeing words.

Logical/Mathematical Learner

- Tends to like to: do experiments, figure things out, work with numbers, ask questions, and explore patterns and relationships.
- Tends to be good at: math, reasoning, logic, and problem solving.
- Tends to learn best by: categorizing, classifying and working with abstract patterns/ relationships.

Spatial Learner

- Tends to like to: draw, build, design and create things, daydream, look at pictures/slides, watch movies and play with machines.
- Tends to be good at: imagining things, sensing changes, mazes/puzzles, reading maps & charts.
- Tends to learn best by: visualizing, dreaming, using the mind's eye and working with colors/pictures.

Bodily/Kinesthetic Learner

- Tends to like to: move around, touch, and talk and use body language.
- Tends to be good at: physical activities (sports/dance/acting), and crafts.
- Tends to learn best by: touching, moving, interacting with space and processing knowledge through bodily sensations.

Musical Learner

- Tends to like to: sing, hum tunes, listen to music, play an instrument, and respond to music.
- Tends to be good at: picking up sounds, remembering melodies, noticing pitches/rhythms, and keeping time.
- Tends to learn best by: rhythm, melody, and music.

Interpersonal Learner

- Tends to like to: have lots of friends, talk to people, and join groups.
- Tends to be good at: understanding people, leading others, organizing, communicating, manipulating, and mediating conflicts.
- Tends to learn best by: sharing, comparing, relating, cooperating, interviewing.

Intrapersonal Learner

- Tends to like to: work alone and pursue own interests.
- Tends to be good at: understanding self, focusing inward on feelings/dreams, following instincts, pursuing interests/goals, and being original.
- Tends to learn best by: working alone, individualized projects, self-paced instruction, and having own space.

A 2 Multiple Intelligence Evaluation Questions:

WHAT KIND OF LEARNER M. I.?

1. I can hear words in my head before I read, speak, or write them down.
2. I can easily compute or calculate numbers in my head.
3. I often see clear visual images when I close my eyes.
4. My best ideas often come to me when I'm out for a long walk or a jog or when I'm busy doing some other kind of physical activity.
5. I can tell when a musical note is off key.
6. I am the sort of person that people come to for advice at my job or here in school.
7. I regularly spend time alone meditating, reflecting, or thinking about important questions.
8. I show an ability for word games like Scrabble, Anagrams, or Password.
9. I enjoy playing games or solving brain teasers that require logical thinking.
10. I enjoy doing jigsaw puzzles, mazes, and other visual puzzles.
11. I need to touch things in order to learn more about them.
12. My life would be poorer if there were no music in it.
13. When I have a problem, I'm more likely to seek out another person to help me rather than work it out on my own.
14. I have opinions that set me apart from the crowd.
15. English, social studies, and history are easier for me in school than math and science.
16. My mind searches for patterns, regularities, or logical sequences in things.
17. I have clear, vivid dreams at night.
18. I frequently use hand gestures and body language when talking with someone.
19. I sometimes find myself walking along with a television jingle or other tune running through my mind.

20. I consider myself a leader (or others have called me a leader).
21. I have some important goals for my life that I think about on a regular basis.
22. My conversation includes frequent references to things that I've read or heard about.
23. I believe that almost everything has a rational explanation.
24. I can generally find my way around unfamiliar territory.
25. I would describe myself as coordinated.
26. I often make tapping sounds or sing little melodies while working, studying,
or learning something new.
27. I feel comfortable in the midst of a crowd.
28. I consider myself to be strong willed or independent minded.
29. I've written something recently that I was very proud of or that earned me
recognition from others.
30. I sometimes think in clear, abstract, wordless, image less concepts.
31. Geometry is easier for me than algebra in school.
32. I need to practice a new skill rather than simply reading about it or seeing a video
that describes it.
33. If I hear a musical piece once or twice, I am usually able to sing it back fairly accurately.
34. I like to get involved in social activities connected with my school,
church, or community.
35. I keep a personal diary or journal to record the events of my inner life.

A 3 The Multiple Intelligence Inventory

Student Score Sheet

WHAT KIND OF LEARNER M. I.?

Circle the number for each statement that describes you.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35

After you have responded to all of the statements, add up the number of items you circled in each column. The number of items you circled in each column represents your score for that learning style. The columns match up with the seven learning styles listed below.

1. Linguistic

2. Math/Logical

3. Spatial

4. Bodily/Kinesthetic

5. Musical

6. Interpersonal

7. Intrapersonal

A 4 The Multiple Intelligence: Classroom Strategies
The Multiple Intelligences: Checklist for Teachers Regarding Lesson Balance
 Consider the following descriptors.

Logical/Mathematical

- problem solving
- tangrams
- coding
- geometry
- measuring
- classifying
- predicting
- logic games
- data collecting
- serialing
- attributes
- experimenting
- puzzles
- manipulatives
- scientific model
- money
- time
- sequencing
- critical thinking

Musical/Rhythmic

- singing
- humming
- rhythms
- rap
- background music
- music appreciation
- mood music
- patterns
- form
- rhythm
- playing instruments

Visual/Spatial

- charts
- graphs
- photography
- visual awareness
- organizers
- visual metaphors
- visual analogies
- visual puzzles
- 3D experiences
- painting
- illustrations
- story maps
- visualizing
- sketching
- patterning
- mind maps
- color
- symbols

Verbal/Linguistic

- stories
- retelling
- journals
- process writing
- reader's theater
- story telling
- choral speaking
- rehearsed reading
- book making
- speaking
- nonfiction reading
- research
- speeches
- presentations
- listening

Intrapersonal

- individual study
- goal setting
- individual projects
- journal log keeping
- personal response
- personal choice
- individual reading
- self-esteem activities

Interpersonal

- learning groups
- sharing
- group work
- peer teaching
- social awareness
- conflict mediation
- discussion
- peer editing
- cross age tutoring
- social gathering
- study group
- clubs
- brainstorming

Bodily Kinesthetic

- drama
- field trips
- activities
- creative movement
- hands on experiments
- body language
- using manipulatives
- phys. ed. activities
- crafts

A 5 Multiple Intelligence Assessment Menu

A 5 Multiple Intelligence Assessment Menu

Verbal-Linguistic Intelligence (Language Arts-Based Assessment Instruments)

- written essays
- vocabulary quizzes
- recall of verbal information
- audio cassette recordings
- poetry writing
- linguistic humor
- formal speech
- cognitive debates
- listening and reporting
- learning logs and journals

Logical-Mathematical Intelligence (Cognitive Patterns - Based Assessment Instruments)

- cognitive organizers
- higher-order reasoning
- pattern games
- outlining
- logic & rationality exercises
- mental menus and formulas
- deductive reasoning
- inductive reasoning
- calculation processes
- logical analysis and critique

Visual-Spatial Intelligence (Imaginal-Based Assessment Instruments)

- murals and montages
- graphs and illustrations
- visualization & imagination
- read, understand, create maps
- flowcharts and graphs
- sculpting and building
- imaginary conversations
- mind mapping
- video recording, photography
- manipulative demonstration

Musical-Rhythmic Intelligence (Auditory-Based Assessment Instruments)

- creating concept songs
- illustrating with sound
- discerning rhythmic patterns
- composing music
- poetry writing
- linguistic humor
- formal speech
- cognitive debates
- listening and reporting

Interpersonal Intelligence (Relational - Based Assessment Instruments)

- cognitive organizers
- higher-order reasoning
- pattern games
- outlining
- logic & rationality exercises
- mental menus and formulas
- deductive reasoning
- inductive reasoning
- calculation processes

Intrapersonal Intelligence (Psychological-Based Assessment Instruments)

- murals and montages
- graphs and illustrations
- visualization & imagination
- read, understand, create maps
- flowcharts and graphs
- sculpting and building
- imaginary conversations
- mind mapping
- video recording, photography

APPENDICES

Appendices B: Electricity and Magnetism Unit Student Work

Physical Science: Physics

Electricity

B1 Activity 1: Creating a Circuit

Hour _____ Number _____

Name _____

Date _____

What is current electricity?

Current electricity is electrons in motion. Electricity is a kind of energy. Electricity can be sent through a system or path of wires that are commonly called a **circuit**. The electrons must be able to flow in order to complete a circuit.

Use problem solving! Use only the materials specified!

Draw a clear, simple sketch of each solution.

1.) Using only 1 dry cell, 1 wire and 2 pennies:

Make the wire warm without touching the wire directly to the dry cell.

(Disconnect as soon as you feel heat to save your dry cell from an energy-draining short circuit).

Sketch

What does this tell you about the pennies?

2.) Using only 1 dry cell and 1 wire and 1 bulb:

Make the lightbulb light up.

Avoid connections that make the wire warm.

The bulb will never light in a short circuit.

Sketch

3. Using only 1 dry cell and 1 wire and 1 bulb:

Make the bulb light up in as many different ways as you can.

Make a sketch of the different ways that you can light the bulb.

(Hint: There are 4 different ways.)

Sketches

4. Using only 1 dry cell and 1 wire and 1 bulb and 1 penny:
Light the bulb without touching the bulb to the dry cell.

Sketch

5. Light up the bulb using 2 dry cells and 1 wire and 1 bulb.

Sketch

How would you compare the difference you see using a single dry cell versus 2 dry cells?

6. Draw lines matching the parts with the correct position of identification on the bulb picture. Trace the path current flows through to light the bulb.

Ceramic Insulation Material

End Metal Contact Point

Filament Wire - Tungsten

Glass envelope - Bulb

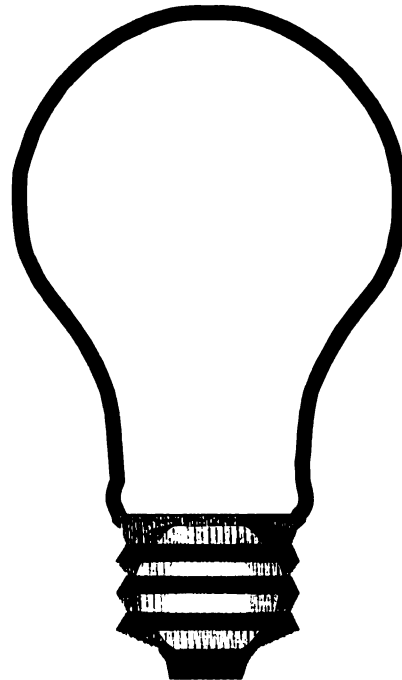
Glass Support Mount

Screw Threaded Metal Base

Solder Dot

Support Wires

Vacuum or Inert Gas



Physical Science: Physics

Electricity

B2 Activity 2: Drawing a Circuit

Hour _____ Number _____

Name _____

Date _____

1. Define a circuit:

2. Define a series circuit:

3. Define a parallel circuit:

Neatly draw each of the parts that will be used in drawing circuit diagrams.

Wire:

Lightbulb:

Resistor:

Switch:

Battery (Cells):

Three series cells:

Ammeter:

Voltmeter:

Three series bulbs:

Draw 2 bulbs, 1 switch and 2 cells in a series.

Diagram each circuit in the boxes below.

A. Draw 3 cells, 2 bulbs, 1 switch, and 2 resistors in series.	B. Draw 1 cell, 4 bulbs, 1 switch, 2 resistors, 1 ammeter, 2 bulbs in series.
C. Draw 4 cells, 3 bulbs, 1 switch, 2 bulbs and 1 switch in series.	D. Draw 3 cells, 3 bulbs, 1 resistor, 2 bulbs and 1 switch in series.
E. Draw 2 cells, 1 bulb, 1 ammeter, 1 switch, 2 bulbs, and 1 resistor in series.	F. Draw 1 cell, 2 bulbs, 1 ammeter, 2 bulbs, and 1 resistor in series.

Physical Science: Physics

Electricity

B 3 Activity 3: Circuits -

Hour _____ Number _____

Name _____

Date _____

Relating Voltage & Current

1. Look at one of your batteries (cells), what is the voltage printed on the cell? _____

Measure the voltage of each cell.

Does the measurement match the voltage printed on the cell? _____

2. If you wire two cells in series,
how much voltage will you have? _____ Voltage of three cells? _____

3. If you wire two cells in parallel,
how much voltage will you have? _____ Voltage of three cells? _____

4. Some bulbs in your kit are given a rating of 1.3 volts, 0.3 amps.

Measure the current through each bulb and then calculate the resistance of the light bulbs.

Givens

Formula

Calculation

Bulb Resistance = _____

5. There are also some bulbs that are rated at 3.8 volts, 0.3 amps.

Measure the current through each bulb and then calculate the resistance of the light bulbs.

Givens

Formula

Calculation

Bulb Resistance = _____

6. Measure each cell's voltage and the resistance of each bulb above then calculate the current that will flow through each circuit in the situations below.

- A. One cell and one bulb from #4:

Givens

Formula

Calculation

Current = _____

- B. Two cells and one bulb from #4:

Givens

Formula

Calculation

Current = _____

- C. One cell and one bulb from #5:

Givens

Formula

Calculation

Current = _____

- D. Two cells and one bulb from #5:

Givens

Formula

Calculation

Current = _____

Draw the circuits described below in the order they are given.
 Show your circuit drawings to Mr. Dean to have them checked.
 When your drawings have been checked, you are to wire each circuit a circuit board.
MAKE NEAT, CLEAR DRAWINGS USING CORRECT SYMBOLS!

<u>Circuit A:</u> A series circuit consisting of 1 cell, 1 switch and 1 bulb. Checked: _____	<u>Circuit B:</u> A series circuit consisting of 1 cell, 1 switch, 1 bulb and 1 switch. Checked: _____
<u>Circuit C:</u> A series circuit consisting of 2 cells, 1 switch, 1 bulb and 1 switch. Checked: _____	<u>Circuit D:</u> A series circuit consisting of 2 cells, 1 switch, 2 bulbs and 1 switch. Checked: _____

1. Could you observe a difference in the brightness of the bulbs in the four circuits?

Explain your observation: _____

2. Rank the circuits in order of the brightness of the bulbs.

Circuit A: _____

Circuit B: _____

Circuit C: _____

Circuit D: _____

Physical Science: Physics

Unit: Electricity

B4 Homework #1 Drawing Series Circuits

Hour _____ Number _____

Name _____

Date _____

Ohm's law Formulas: $I = V \div R$

Diagram each circuit in the boxes below.

Use the proper symbols for each of the parts of the circuit.

Circuit A: Draw a series circuit with 3 cells, 4 bulbs, 1 switch, one resistor, 2 bulbs, 1 ammeter and 1 resistor.

Show the direction of flow in your circuit.

What would the ammeter reading be in this circuit when:

Each cell = 1.5 V

Each bulb = 2.8 ohms

Each resistor = 11 ohms

Show your work!!

Current = _____

Circuit B: Draw a series circuit with 3 cells, 3 bulbs, 1 switch, 3 bulbs, 2 resistors and 1 ammeter.

Show the direction of flow in your circuit.

What would the ammeter reading be in this circuit when:

Each cell = 1.3 V

Each bulb = 1.6 ohms

Each resistor = 5 ohms

Show your work!!

Current = _____

Physical Science: Physics

Electricity

B 5 Class Starter 1: Circuits & Ohm's Law

Hour _____ Number _____

Name _____

Date _____

1. What is current? _____

What is the **symbol** for current? _____ What is the **unit of current**? _____

2. What is voltage? _____

What is the **symbol** for voltage? _____ What is the **unit of voltage**? _____

3. What is resistance? _____

What is the **symbol** for resistance? _____ What is the **unit of resistance**? _____

4. State Ohm's law. How does it relate current, voltage, and resistance?

5. Identify which of the following items describes current, voltage, or resistance.

Write the symbol for each quantity on the line.

For current use **I**; for voltage use **V**; for resistance use **R**.

_____ 1. The quantity that is measured in amperes or commonly called amps.

_____ 2. Quantity that is measured in units of ohms.

_____ 3. The flow of charge past a certain point within a circuit.

_____ 4. A property of wire that depends on the length and gauge of a wire.

_____ 5. The rate at which charges pass a given point in a circuit.

_____ 6. A quantity that is measured with an ammeter.

_____ 7. A property of wire that depends on the material that makes up the wire.

_____ 8. Describes a potential difference between two different positions.

_____ 9. Opposes the flow of electric charge.

_____ 10. Quantity that is measured in volts.

_____ 11. Property of wire depending to some extent on the temperature of wire.

_____ 12. Quantity that flows from positive to negative.

Physical Science: Physics
Electricity
B 6 Activity 4: Series Circuits
- Ohm's Law Calc.

Hour _____ Number _____
Name _____
Date _____

Ohm's law states that **current** (I) is proportional to **voltage** (V). That means that as current increases voltage increases, they both increase or they both decrease. **Resistance** (R) is related to current (I) in the opposite way. As **current** increases, **resistance** decreases, and as **resistance** increases, **current** will decrease. **Current** is measured in amperes (A or **amps**), **voltage** is measured in **volts** (V), and **resistance** is measured in **ohms** (Ω).

Apply Ohm's law to the problems below.

Ohm's law Formula: $I = V \div R$

Power (in Watts) is equal to voltage times current. $P = V \times I$

1. How many **amps** of current are supplied by a force of 12 **volts** through a wire that has a resistance of 6 **ohms**? What power is produced?

Givens

Formula

Calculations

Current _____

Power _____

2. Double the voltage with the same wire, calculate this change in current and power.

Givens

Formula

Calculations

Current _____

Power _____

3. How many volts are required to force 4 amps of current through a wire with a resistance of 5 ohms?

Givens

Formula

Calculations

Volts _____

Power _____

4. If you double the resistance in question 3, keeping the voltage constant, how does this change the current and power?

Givens

Formula

Calculations

Current _____

Power _____

5. A light bulb draws 0.2 amps of current when it is connected to a source of 2 volts. What is the resistance of the light bulb? What is the power produced?

Givens

Formula

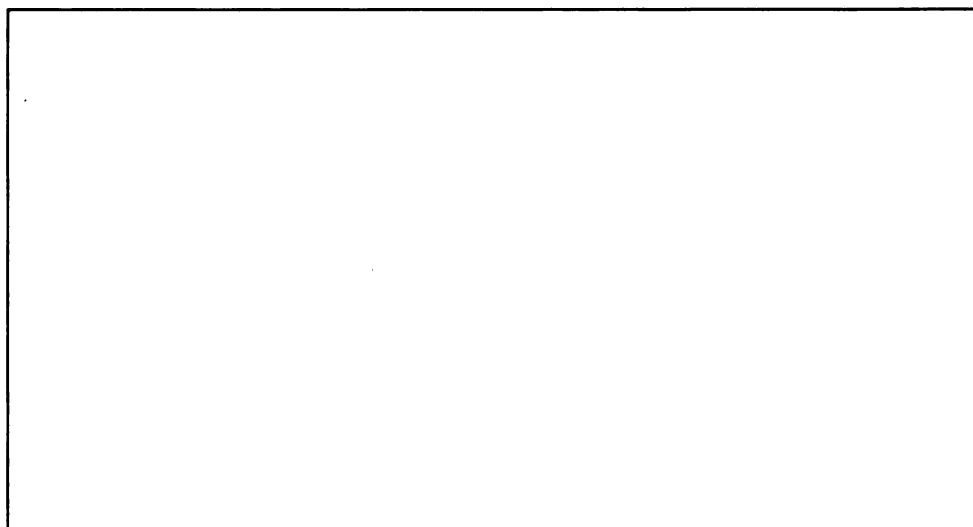
Calculations

Resistance _____

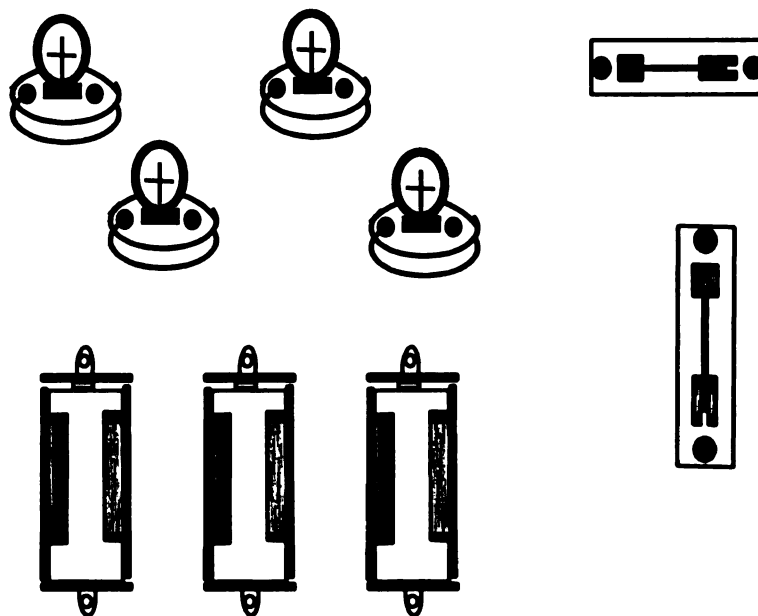
Power _____

Drawing and Wiring Series Circuits

Circuit A: Draw a series circuit with 2 cells, 2 bulbs and 1 switch in a series.



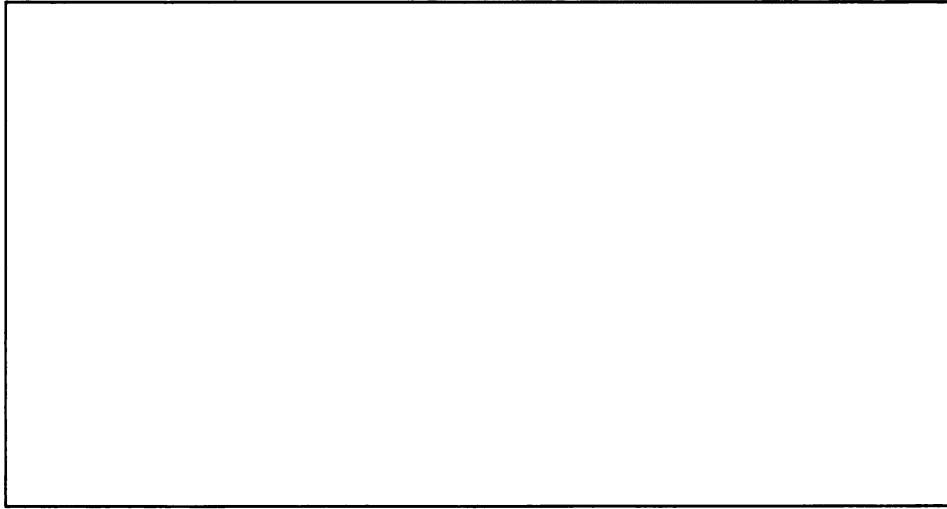
Checked _____



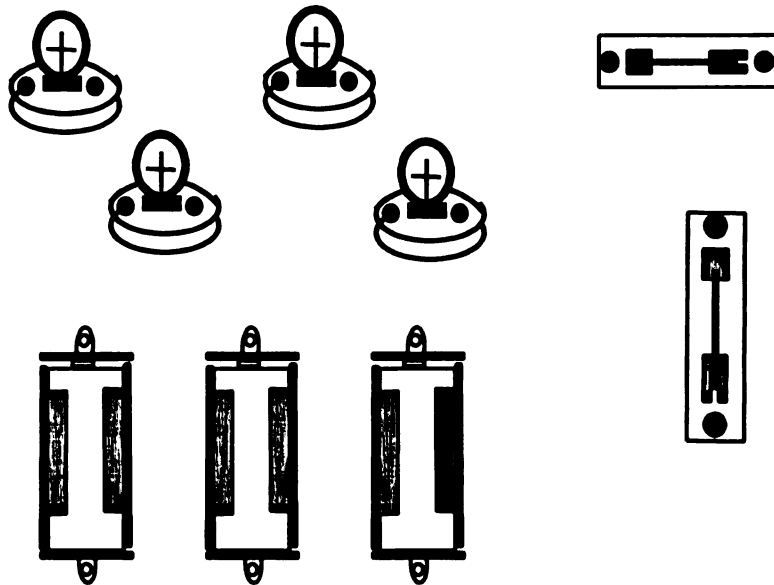
Checked _____

Circuit B:

Draw a circuit with 3 cells, 2 bulbs, 1 switch, 1 bulb, 1 bulb, 1 ammeter in series.



Checked _____

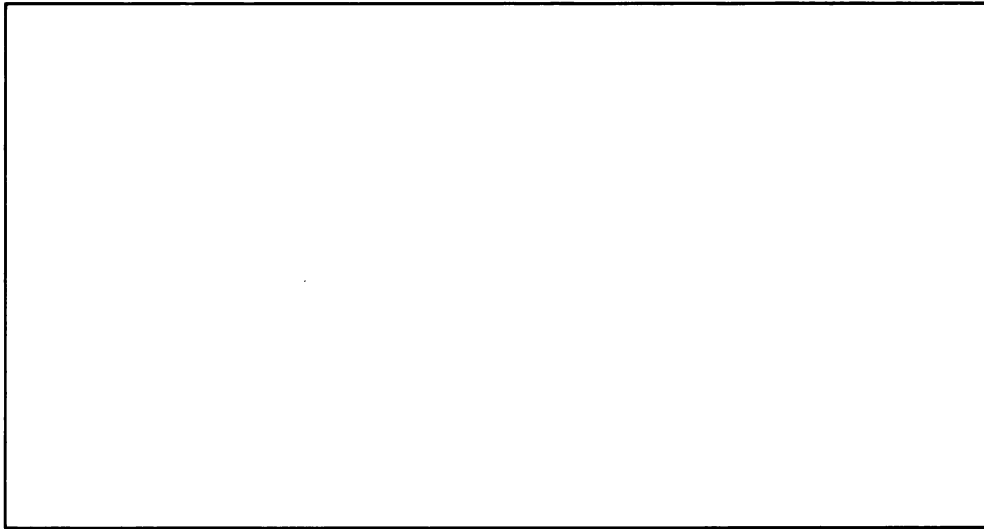


Checked _____

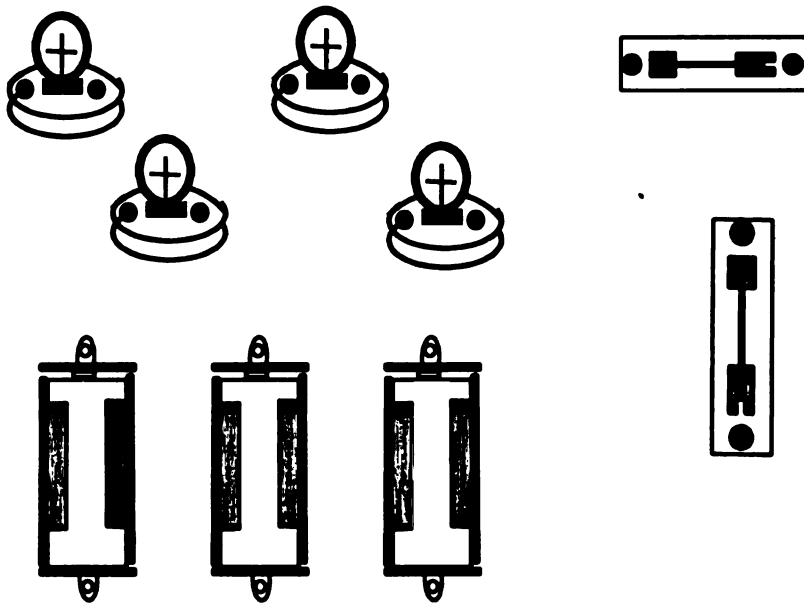
Ammeter Reading _____

Circuit C:

Draw a circuit with 2 cells in series, 1 switch, 2 bulbs and 1 ammeter in series.



Checked _____



Checked _____

Ammeter Reading _____

1. Identify the locations of the following parts that make up the common light bulb.

Glass envelope - Bulb

Screw Thread Metal Base

End Metal Contact Point

Ceramic - Insulation Material

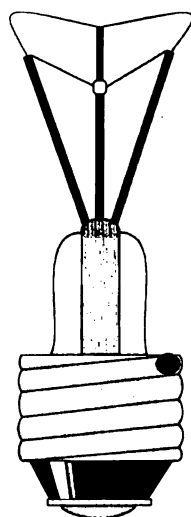
Filament Wire - Tungsten

Glass Support - Mount

Vacuum or Inert Gas

Solder Dot

Support Wires



2. How or why is a light bulb considered a circuit? _____

3. What type of circuit is the light bulb, series or parallel? EXPLAIN!! _____

4. What keeps a light bulb from shorting out? _____

Why is that important? _____

Physical Science: Physics
Electricity
B 8 Activity 5: Drawing a Parallel Circuit

Hour _____ Number _____
Name _____
Date _____

1. Define a circuit: _____
2. Define a parallel circuit: _____
3. Neatly draw each of the parts that will be used in drawing circuit diagrams.

// = parallel

Three parallel cells:

Three parallel bulbs:

Two // cells // 1 bulb and 1 ammeter:

Three // cells// 2 bulbs in series //
1 voltmeter:

Draw a neat diagram of each circuit below.

Circuit A. A circuit with 3 series cells // 1 switch, 1 resistor and 2 bulbs
// 1 switch, 3 bulbs and 1 switch // 2 bulbs, 1 resistor and 1 switch.

Number the circuits 1, 2 and 3 from left to right and answer the following questions.
All resistors are 6 ohms and all bulbs have a resistance of 0.2 ohms.

- A. If all switches are closed,
which segment of the entire circuit would have the greatest resistance? _____
- B. If all switches are closed,
which segment of the entire circuit would have the least resistance? _____
- C. Which segment of the entire circuit would have the brightest bulbs? _____

Circuit B. A circuit with 3 // cells // 1 bulb, 1 switch, 1 bulb // 2 bulbs, 1 switch, 1 resistor

Number the circuits 1 and 2 from left to right and answer the following questions.
All resistors are 5 ohms and all bulbs have a resistance of 0.3 ohms.

- A. If all switches are closed,
which segment of the entire circuit would have the greatest resistance? _____
- B. Which segment of the entire circuit would have the brightest bulbs? _____
- C. What segment do the switches have on the resistance in a circuit? _____

Circuit C. A circuit with 4 // cells // 4 bulbs and 1 switch // 1 switch and 3 bulbs
// 1 switch and 2 bulbs // 1 switch and 1 bulb.

Number the circuits 1, 2, 3 and 4 from left to right and answer the following questions.
All bulbs have a resistance of 0.23 ohms.

- A. If all switches are closed,
which segment of the entire circuit would have the greatest resistance? _____
- B. If all switches are closed,
which segment of the entire circuit would have the least resistance? _____
- C. Which segment of the entire circuit would have the brightest bulbs? _____
- D. Which segment of the entire circuit would have the dimmest bulbs? _____

Physical Science: Physics**Electricity****B 9 Class Starter 3: Drawing Parallel Circuits**

Hour _____ Number _____

Name _____

Date _____

Diagram each circuit below then have each one checked by a different student.

A. 2 // cells // 1 bulb and 1 switch
// 1 bulb and 1 switch.

Person Checking: _____

B. 3 // cells // 2 bulbs // 1 switch,
1 resistor and 1 bulb // 1 switch and 3
bulbs.

Person Checking: _____

C. 2 //cells // 2 bulbs // 1 switch and
3 bulbs in series.

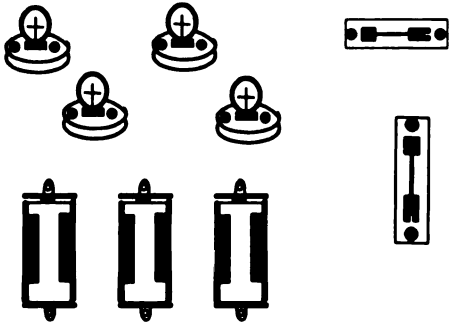
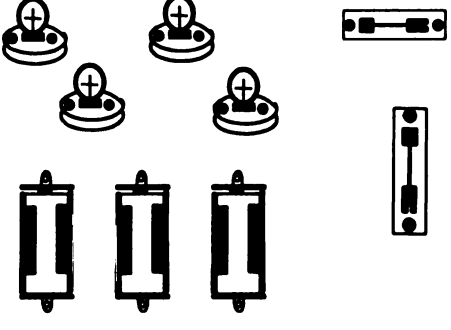
Person Checking: _____

D. 2 series cells in series // 1 switch
3 bulbs // 1 switch and 4 bulbs in series.

Person Checking: _____

Drawing and Wiring Series Circuits

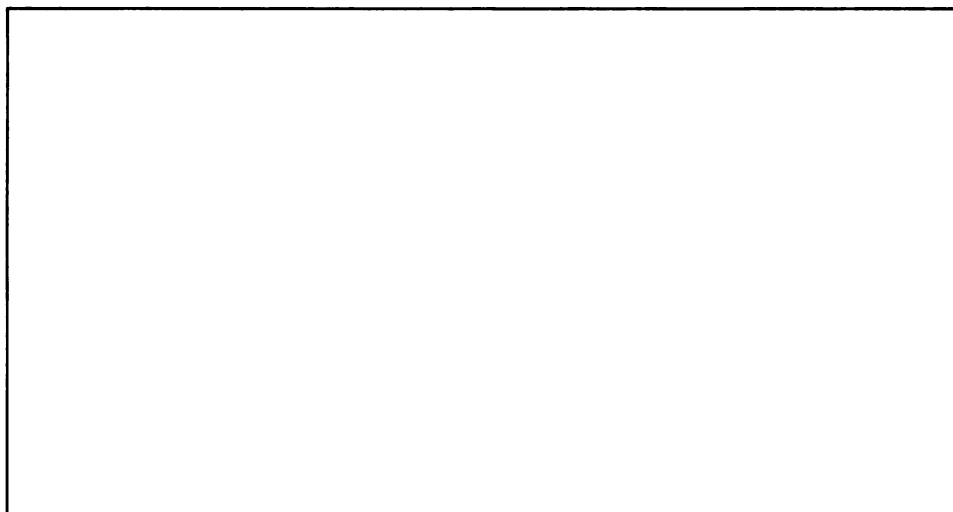
Draw each of the circuits described below as a rectangular circuit with the correct symbols and then draw how you would wire the circuit. Have your pictures checked, then wire each circuit on a circuit board.

<u>Circuit 1:</u> A circuit with 3 cells in series and 1 bulb.	<u>Circuit 2:</u> A circuit with 3 parallel cells and one bulb.
<u>Circuit 1:</u> 	<u>Circuit 2:</u> 

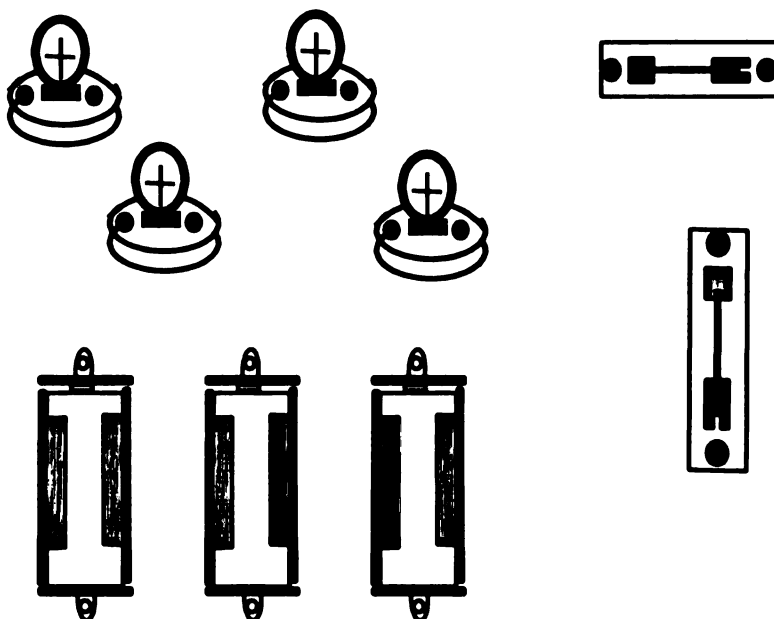
Compare the brightness of the bulb in each for the two different ways you wired the same parts. Explain why you see a difference in the brightness of the bulb.

Checked_____

Circuit A: Draw a circuit consisting 3 // cells // 2 bulbs // 2 bulbs and 1 switch.



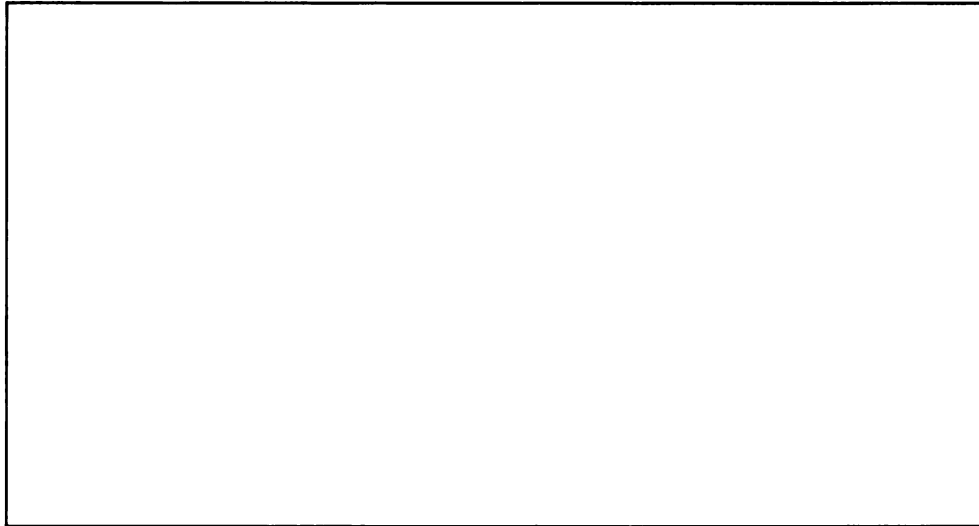
Checked _____



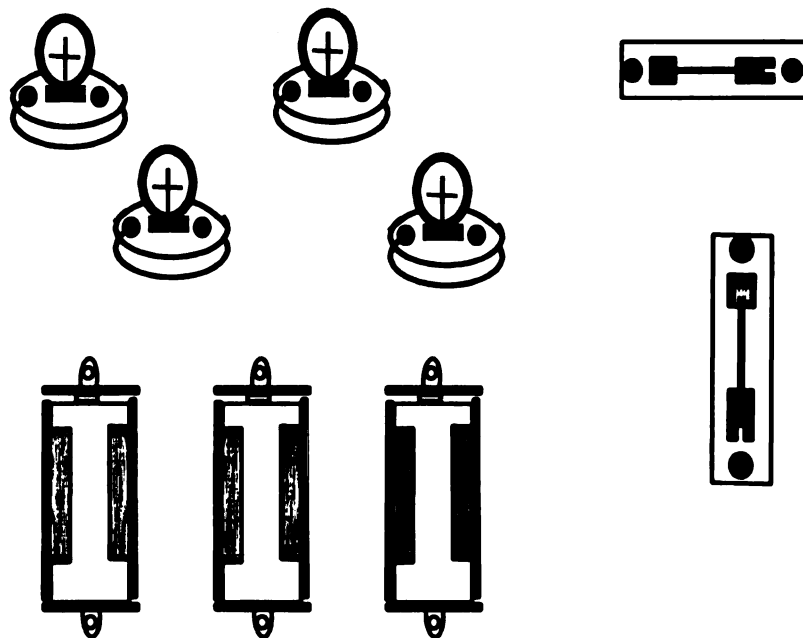
Checked _____

Circuit B:

Draw a circuit consisting of 3 // cells // 1 switch and 2 bulbs // 1 switch and 2 bulbs.



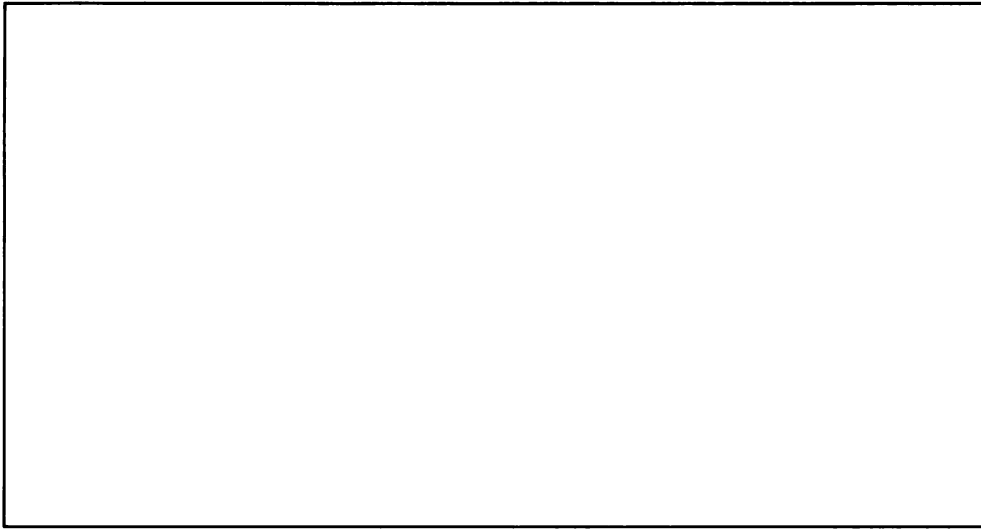
Checked_____



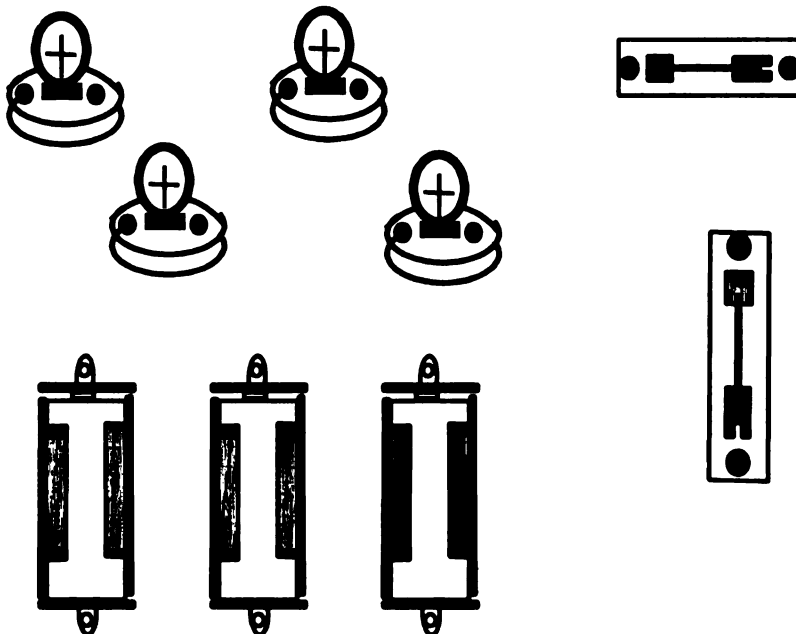
Checked_____

Circuit C:

A circuit consisting of 3 series cells // 1 switch and 2 bulbs // 1 switch and 2 bulbs.



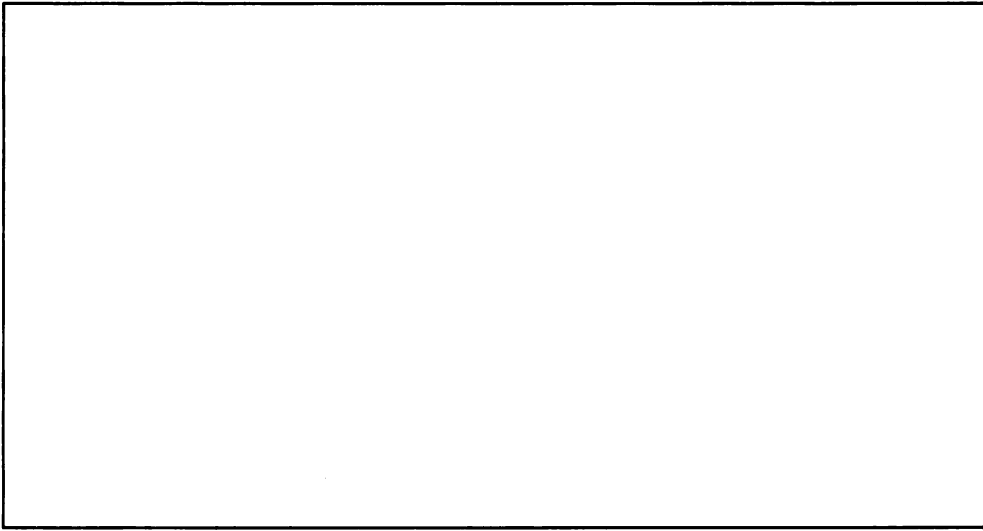
Checked _____



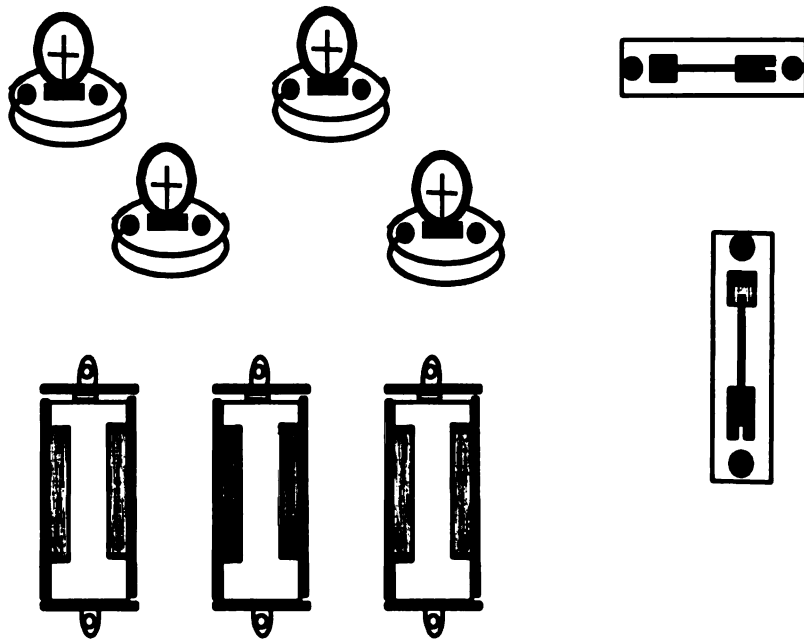
Checked _____

Circuit D:

Draw a circuit consisting of 2 cells // 1 switch and 3 bulbs // 1 switch and 1 bulb.



Checked_____



Checked_____

Physical Science: Physics**Electricity****B 11 Activity 7: Resistance**

Hour_____ Number _____

Name_____

Date_____

Ammeters are used to measure current (I) in units of Amperes, abbreviated amps or A. You will use an ammeter to find the amount of current in different circuits so that you can calculate the resistance in the circuit.

The purpose of doing this activity is to determine the resistance of wires in relationship with the wire's thickness and length.

You will need: 1 wire resistance board 1 ammeter 4 wires
2 cells wired in series 1 lamp and bulb

There are five different wires wrapped on the wooden spool.

Wire No. 1	10 meters long	22 gauge copper wire
Wire No. 2	10 meters long	28 gauge copper wire
Wire No. 3	20 meters long	22 gauge copper wire
Wire No. 4	20 meters long	28 gauge copper wire
Wire No. 5	10 meters long	22 gauge copper-nickel wire

Procedure:

1. Wire the 2 cells in series.
2. Attach 2 wires to the lamp and check to make sure that your bulb is working and gives off a fairly bright light using 2 cells.
3. Attach one wire from the lamp to one of the terminal posts for wire number 1.
4. Attach the other wire from the lamp to the negative end of the cells in series.
5. Attach a wire from the positive end of the cells to the post marked with a (+).
6. Attach the last wire to the post marked *low* on the ammeter and to the other terminal post for wire #1.
7. Repeat this procedure by moving the wires connected to the terminal posts for each wire on the board.
8. Compare the brightness of the bulbs on a scale of 1 to 10, 10 being brightest.

	Ammeter Reading	Description of wire	Brightness Rating
<u>Wire No. 1</u>			
<u>Wire No. 2</u>			
<u>Wire No. 3</u>			
<u>Wire No. 4</u>			
<u>Wire No. 5</u>			

8.) Rank the wires in order according to their resistance.

Most Resistant_____
Least Resistant

Physical Science: Physics**Electricity****B 12 Activity 8:****Drawing Circuits & Using Ohm's Law**Ohm's law Formula: $I = V \div R$ Power Formula: $P = V \times I$

Hour _____ Number _____

Name _____

Date _____

Circuit #1: 3 cells in series // 2 bulbs and 1 switch in series

// 2 bulbs, 1 resistor and 1 switch in series

// 1 switch, 2 bulbs, 1 resistor and 1 switch in series.

Number each series, one to three, from left to right.

Calculate the current and power in each of the series circuits within circuit #1.

Each cell has a voltage of 1.35 V, each resistor is rated at 4.25 ohms and each bulb has a resistance of 1.8 ohms.

Series #1:

GivensFormulaCalculations

Current _____

Power _____

Series #2:GivensFormulaCalculations

Current _____

Power _____

Series #3:GivensFormulaCalculations

Current _____

Power _____

Circuit #2

4 // cells // 3 bulbs and 1 switch // 2 bulbs, 1 switch and 1 resistor.

Letter the two series circuits A and B.

Calculate the current and power in each of the series within circuit #2.

Each cell has a voltage of 1.5 V, each resistor is rated at 3.5 ohms and each bulb has a resistance of 0.8 ohms.

Series A:

Givens

Formula

Calculations

Current_____

Power_____

Series B:

Givens

Formula

Calculations

Current_____

Power_____

Circuit #3: 4 cells in series // 3 bulbs and 1 switch // 1 switch, 2 bulbs and 1 resistor// 5 bulbs, 1 switch, 1 resistor, 2 bulbs and 1 switch.

Number each series, one to three, from left to right.

Calculate the current and power in each series within circuit #3 when each cell has a voltage of 1.55 V, each resistor is rated at 2.5 ohms and each bulb has a resistance of 1.2 ohms.

Series #1:

Givens

Formula

Calculations

Current_____

Power_____

Series #2:

Givens

Formula

Calculations

Current_____

Power_____

Series #3:

Givens

Formula

Calculations

Current_____

Power_____

Physical Science: Physics

Unit 3: Electricity

B 13 Homework #2: Circuits & Ohm's Laws

Hour _____ Number _____

Name _____

Date _____

1. Electricity is _____

2. A circuit is _____

A. How is a series circuit different from a parallel circuit?

B. How is a series circuit similar to a parallel circuit?

3. Identify each of the following as they related to the terms:
current, voltage, or resistance. Use the correct symbol for each quantity.

_____ 1. The quantity that is measured in ohms.

_____ 2. The quantity that is measured in volts.

_____ 3. The quantity that is measured in amperes.

_____ 4. The quantity that flows from negative to positive.

_____ 5. The rate at which charges pass a given point in a circuit.

_____ 6. The flow of charge past a certain point.

_____ 7. Is measured with an ammeter.

_____ 8. Describes a potential difference between two different positions.

_____ 9. The quantity that opposes the flow of electric charge.

_____ 10. A property of wire depending on the material, of which the wire made.

_____ 11. A property of wire that can vary with the temperature of wire.

_____ 12. A property of wire that depends on the length and gauge of a wire.

4. What happens if one bulb is removed or broken in Figure 12? (when the switch is closed)

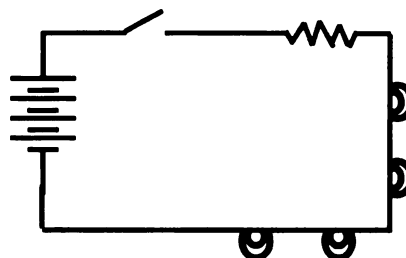


Figure 12

5. Use figure 1 and calculate the amount of current that will flow given the following:

Ohm's law Formula: $V = I \times R$ Label the values on figure 1 and show your work below.

Each cell has a potential difference of 1.5 volts.

Each bulb has a resistance of 0.8 ohms.

Each resistor has a resistance of 6 ohms.

Answer: _____

6. Which switches in figure 13 would have to be closed to get bulbs A and B to light up?

7. Which switches in Figure 13 would have to be closed to get bulbs C, D and E to light up?

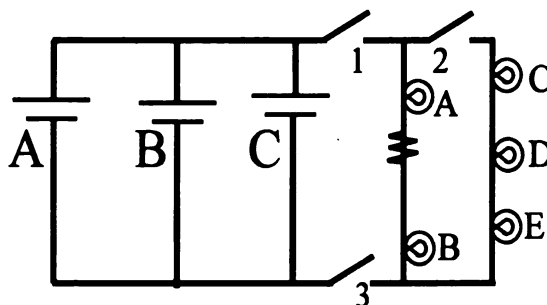


Figure 13

8. If all three switches are closed and bulb D is taken out or broken, what would occur with each of the remaining bulbs?

9. Using Figure 13, calculate the potential difference across the circuit when switches 1 and 3 are closed.

Ohm's law Formula: $V = I \times R$ Label the values on figure 2 and show your work below.

A current of 0.20 A is flowing through the circuit.

Each bulb has a resistance of 0.8 ohms.

Each resistor has a resistance of 6 ohms.

Total Voltage = _____

What is the voltage of each cell? A _____ B _____ C _____

Drawing Circuits

10. Draw each circuit with the parts listed. Make your drawings NEAT!!!

Circuit A: 3 //cells // 3 bulbs, 1 switch and 1 resistor in series // 2 bulbs,
1 resistor and 1 switch in series // 1 switch, 2 bulbs and 2 resistors in
series.

Circuit B: 4 series cells // 1 bulb, 1 switch and 1 resistor // 2 bulbs, 2 resistors
1 switch // 1 switch, 3 bulbs, 1 resistor and 1 switch in series.

Physical Science: Physics

Magnetism & Electricity

B 14 Activity 5: Magnets

Hour _____ Number _____

Name _____

Date _____

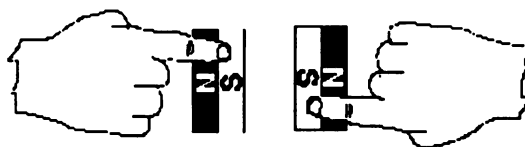
What happens when you put two magnets next to each other?

Sometimes there is a force between the magnets.

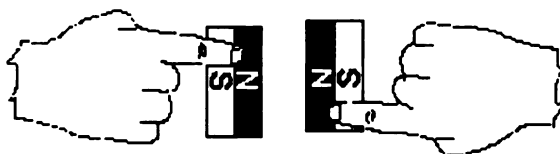
This experiment will help us understand and describe what happens when we put magnets together.

Take two of the magnets and try the following experiments, write down what you see.

1: Try holding two magnets with their south poles facing each other. What happens?



2: Try holding two magnets with their north poles facing each other. What happens?



3: Try holding two magnets with north and south poles facing each other. What happens?



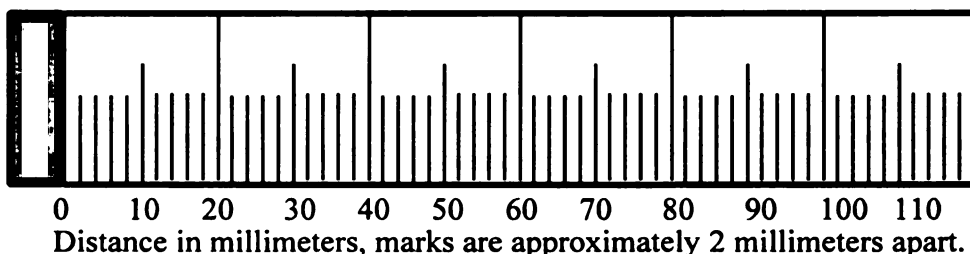
- 4: Write a rule stating how the force between the magnets behaves for the three experiments.

The rule should use the following words: **attract**, **repel**, **north**, **south**, and **pole**.

- 5: How far does the magnetic force reach?

This is an important question for machines using magnets.

Place one magnet on the black rectangle on the ruler printed below. Slowly slide a second magnet closer and closer until the first magnet moves. Record the distance between the magnets when you first see movement. Do this three tries with the **same magnet**. Your results should be pretty close for all three tests. Conduct the three tests with each of the three combinations of poles, North-North, South-South, and North-South.



- 6: Does the distance change much between the three kinds of interactions (N-S, N-N, S-S)?

Slide the second magnet closer and closer until the first one moves.

distance

First magnet

Second magnet

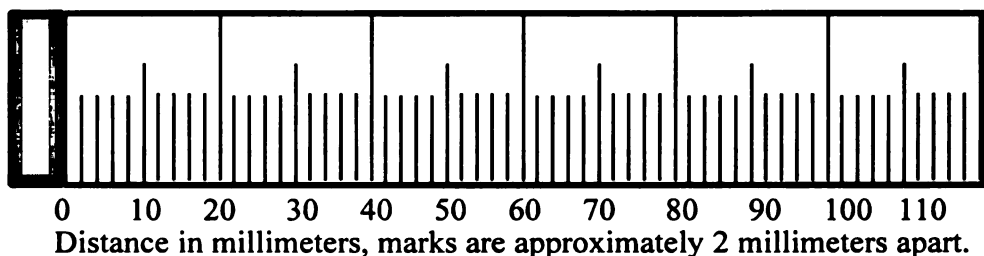
	N-S	S-S	N-N
	 ☐ Attract ☐ Repel	 ☐ Attract ☐ Repel	 ☐ Attract ☐ Repel
Distance 1			
Distance 2			
Distance 3			

As seen on student worksheet.

Explain your answer. Your answer should use the words **force** and **distance**.

1. Do magnets have different “strengths”?

Test to determine if more than one magnet placed together is stronger than one single magnet. Then test to see if some of the other types of magnets are stronger or weaker than the original magnets that you used.



Slide the magnet or magnets along the measuring strip until the single magnet on the black space moves. Record how far away the interaction occurs.	Number of Magnets	Distance for Movement	Different Magnets		
			dist. 1		
			dist. 2		
			dist. 3		
			dist. 4		

2. What did you find out about different numbers of magnets and how it affects the strength of magnets? Your answer should apply the words **force** and **distance**.

Physical Science: Physics

Hour _____ Number _____

Magnetism & Electricity

Name _____

B 16 Activity 11: Magnetic Materials

Date _____

1. What kinds of things are affected by magnets?

Not all materials interact with magnetic forces.

Use your test magnet to try ten materials around the classroom.

Record whether there was an attraction, repulsion, or no effect.

Material Tested	Attract	Repel	No Effect
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

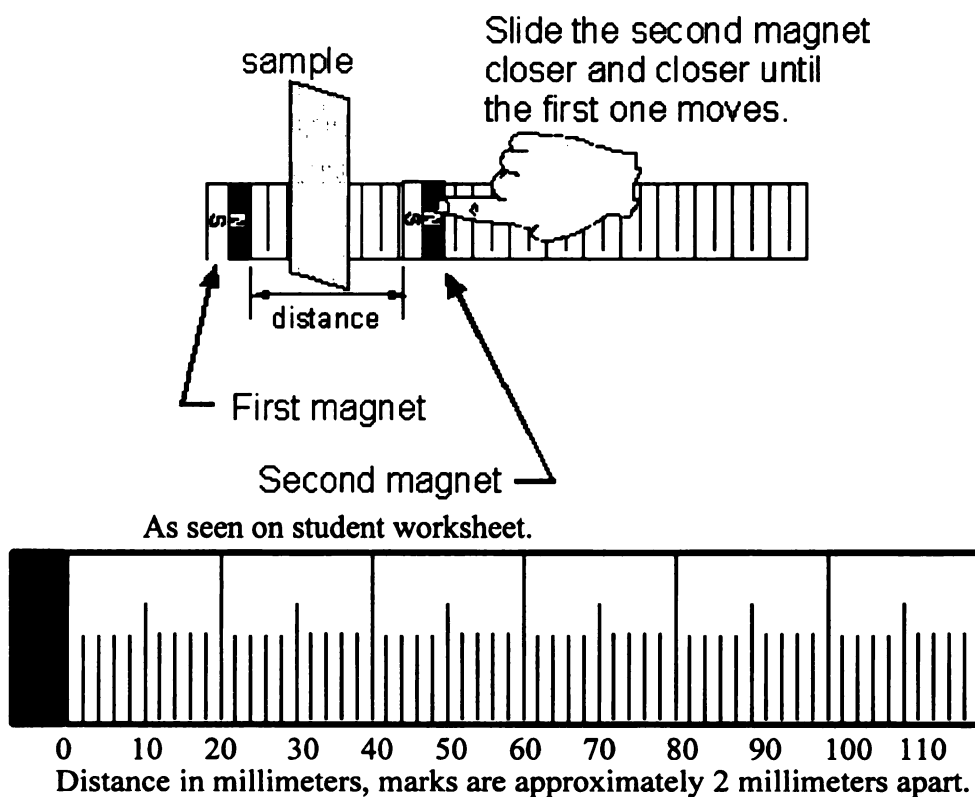
2. The word **magnetic** is used to describe things that are strongly affected by magnets.

From your experiments can you say anything about which things were magnetic and which were not? Your answer should apply the words **magnetic** and **non-magnetic**.

3. Do magnetic forces get weaker or stronger passing through non-magnetic materials?

Test some non-magnetic materials and see.

Start with a magnet at the end of the ruler below. Slide a second magnet in from the end of the ruler, coming closer and closer until the first magnet just starts to move. Record the distance at which the first magnet moved under the column "No Sample". Put your test material in front of the first magnet and repeat the experiment. Enter the distance with the sample in place under the column "With Sample". Try at least 5 different materials.



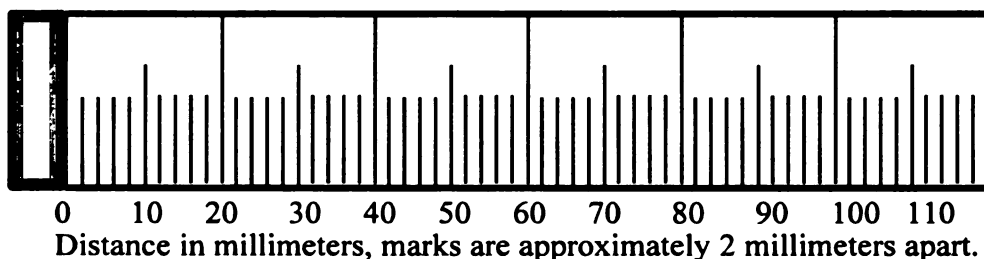
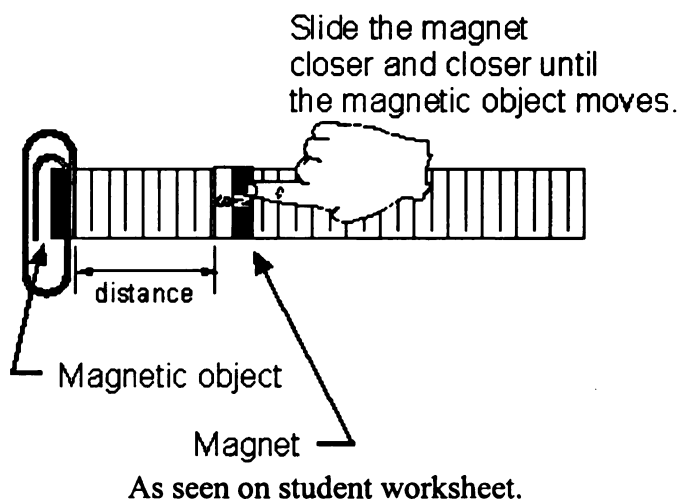
Material	Distance With Sample	Distance Without Sample
1.		
2.		
3.		
4.		
5.		

4. What did you find out about how magnetism is affected by non-magnetic materials?

Your answer should apply the words **force** and **distance**.

5. How strong is the magnetic force acting on magnetic objects **other than magnets**?

You probably found that some materials are attracted to magnets. We call these **magnetic materials**. Pick something small that is magnetic and try to find the distance that the magnet can move (or be moved by) your magnetic object. Try both the north and south poles to see if there is a difference.



Object	Distance at which object moves (south pole)	Distance at which object moves (north pole)
1.		
2.		
3.		
4.		

6. How does the magnetic force acting on magnetic objects compare with the magnetic force acting on other magnets? Use the following words in your answer: **force**, **magnet**, and **magnetic**.

Magnetism

Name _____

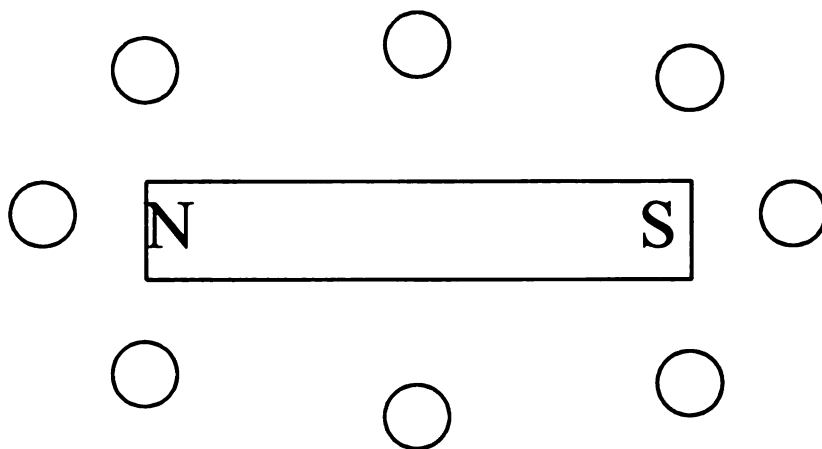
B 17 Activity 12: Magnets & Magnetic Fields

Date: _____

Obj. #3: The student will be able to describe how magnetism, magnetic fields and magnetic poles interact and how they relate to motors, generators, and transformers.

Purpose: To visualize the invisible magnetic field around a magnet.

Get a compass and a bar magnet. Place the magnet on the table and start with the compass in any one of the positions shown in the drawing below. From the first position draw the needle position on the compass in the picture. Then move the compass around the magnet to the seven other positions, each time drawing in the needle's position.



The 'N' stands for _____ on the bar magnet.

The 'S' stands for _____ on the bar magnet

From your observations:

Look at your compass. One end of the needle is colored and the other end is silver.

Which end of the compass needle points to the 'N'? _____

Which end of the compass needle points to the 'S'? _____

What happens when two north poles are brought close together? _____

What happens when two south poles are brought close together? _____

What happens when two opposite poles are brought together? _____

Iron, nickel, and cobalt are the only **pure metal elements** that are magnetic. Any metal objects that have some iron, nickel, or cobalt will also be **attracted** to a magnet. Atoms of magnetic materials are arranged in groups called **domains**. Each domain is made up of one positive charge and one negative charge. Look at the diagram below. Block A shows 7 domains in each block. Block A has domains arranged so that each positive is next to a negative charge. This iron bar is not a magnet. Block B show 10 domains and each block is arranged in the same repeated pattern creating a magnet.

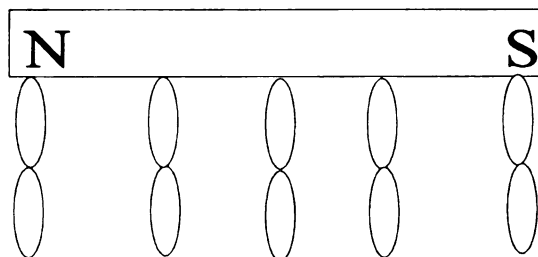
+	- +	- +	- +	<---Block A	+ -	+ -	+ -	+ -	+ -
-	+ -	+ -	+ -	Block B --->	- +	- +	- +	- +	- +

In order for an object to be magnetic, the domains must be lined up in the same direction as shown in block B. When the domains are lined up and the object acts as a temporary magnet. The alignment of the domains is the situation occurring in **permanent magnets**.

Find the strongest points of the magnetic field that surrounds a bar magnet.

Use paper clips as masses. Hang as many paper clips as you can from the magnet in the five positions shown in the picture at the right.

Predict where do you think the bar magnet will be strongest.



Write the total number of paper clips held in each of the positions on the magnet above.

From your observations, where are the strongest positions along a bar magnet?

The magnetism from a magnet can be transferred to other iron containing objects.

Use a nail and a bar magnet. Rub the nail along the bar magnet slowly, **in one direction**, about 25 to 30 times. Then bring the nail close to a small paper clip.

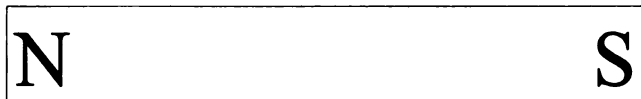
What do you observe?

Rubbing the nail over the magnet causes the _____ in the nail to line up.

Place a bar magnet under the plastic magnet viewer.

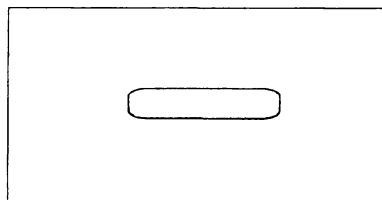
Observe what is happening to the iron filings.

The **magnetic field** around a magnet is where the magnetic forces are observed. We cannot feel or see the magnetic field, but we can see what happens when we use iron filings, small bits of iron, that are attracted to the magnet and line up in the magnetic field. Sketch a simple depiction of what you observed on the magnet below.



Observe one of the two plastic containers that have a cow magnet inside.

The small iron pieces inside the plastic case are attracted to the magnet and position themselves along the magnetic field lines. Make a simple sketch of what you observe.



In your observations, where did you see more iron filings around the two magnets?

Answer the following questions from what you have read and done.

1.) Magnetism is caused by _____

2.) What three metals are magnetic?

A _____ B _____ C _____

3.) In order for a piece of iron to be a magnet, its _____ must be lined up.

4.) A bar magnet is strongest at its _____ .

5.) What is the magnetic field? _____

6.) Which statements are true?

_____ Some magnets are made of lead.

_____ Some magnets are made of cobalt.

_____ Lines of magnetic force run from one pole of the magnet to the other pole.

_____ Lines of force are strongest at the center of the magnet.

7.) Predict what the lines of force would **look like** for the situations below.

Draw in the magnetic field lines as they would look for both situations.

N

S

N

N

Physical Science: Physics

Hour _____ Number _____

Magnetism

Name _____

B 18 Activity 13: Electromagnets

Date: _____

Obj. #3: The student will be able to describe how magnetism, magnetic fields and magnetic poles interact and how they relate to motors, generators, and transformers.

Materials: One-150 cm length of coated wire with the ends stripped off.

1- Iron Nail 4- D-cells Paper clips 1-Bar magnet

Magnets and Electromagnets

1. Coil the wire tightly 25 times around the nail, leaving a length of wire on each end of the coil long enough to reach the battery.
2. Connect the ends of the wires to a 1.5 volt battery.
3. When the circuit is completed, the electromagnet will be on.
4. Try to pick up as many paper clips as possible with this electromagnet.
Repeat this step 2 or 3 times.
5. Complete the data chart on the following page, noting how many paper clips this electromagnet lifts.
6. Repeat steps 2-5, adding one battery to the magnet at a time until you reach have all four batteries hooked together.
Use a masking tape to connect multiple batteries together.
7. Coil the wire tightly 25 more times around the nail (for a total of 50 turns), leaving a length of wire on each end of the coil long enough to reach the battery.
8. Repeat steps 2-6 for this new electromagnet.
9. Experiment with a bar and horseshoe magnet from the supply table.

How many paper clips does this magnet pick up? _____

How does the permanent magnet interact with the electromagnet? _____

****BE CAREFUL: THE WIRES MAY BECOME HOT DURING USE****
DISCONNECT THE MAGNET FROM THE BATTERY
WHEN YOU ARE NOT TESTING THE MAGNET'S STRENGTH!

Magnets and Electromagnets - Questions for Discussion

Directions: Answer the following questions about what you discovered.

1. Does it make a difference where the windings are located or how neat the wire is wound?
2. How does it change the electromagnet to increase or decrease the number of turns of wire?
3. How does the electromagnet compare with a permanent magnet?

Which did you determine to be stronger?

How do the two interact?

4. Write any questions you have about electromagnets.

1.

2.

3.

4.

1. Electric motors are everywhere. Name five appliances or tools (or places) you know where there is an electric motor and briefly state what the motor does or what the motor causes to happen.

1. _____

2. _____

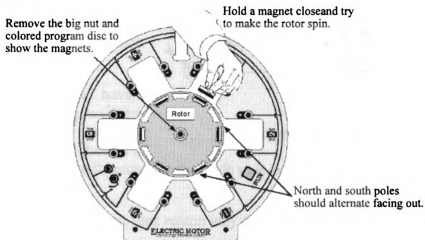
3. _____

4. _____

5. _____

2. Take your Electric Motor apart and set it up like the picture shows.

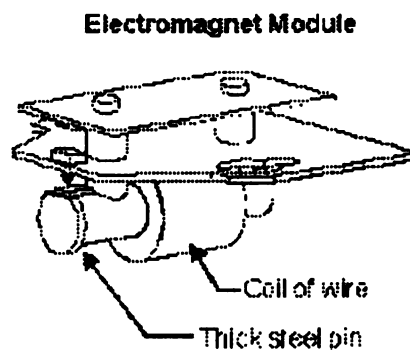
- The rotor should be uncovered and empty of magnets.
- Put six magnets in the rotor evenly spaced with north and south poles alternating around the edge.
- Take another magnet and bring it close so that it repels a magnet in the rotor.
- What happens? Try to come up with a way to make the rotor spin using your single magnet and pushing and pulling on the rotor magnets.



As seen on student worksheet.

3. How did you get the rotor to spin in one direction?
What did you have to do with your extra magnet?
-
-

Electromagnets are magnets that use electricity to create the north and south poles. When no electricity flows, they are not magnetized. Look at one of the Electromagnet Modules. You will see a coil of copper wire wrapped around a thick steel pin. That is how an electromagnet is usually made, a coil of wire wrapped around a steel or iron core. The coil of wire is where the electricity flows. When electric current flows around the coil, the steel pin becomes magnetized with a north and south pole, just like your other magnets.



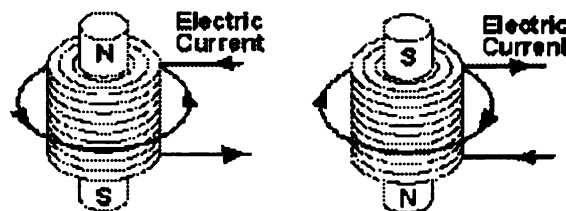
As seen on student worksheet.

The Right Hand Rule



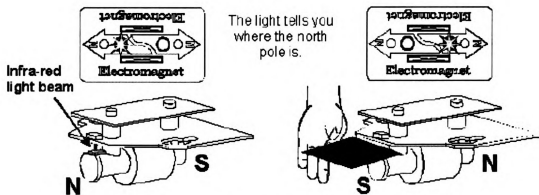
Electromagnets have a big advantage over permanent magnets. By changing the direction of the electric current we can reverse the north and south poles. The fingers of your right hand can tell you where the north pole will be if you know the direction of the current.

The Electromagnet Modules have a light switch, like the Photogate Clamp. Blocking the light beam makes the current reverse direction in the coil of wire. The little green lights tell you where the north pole is.



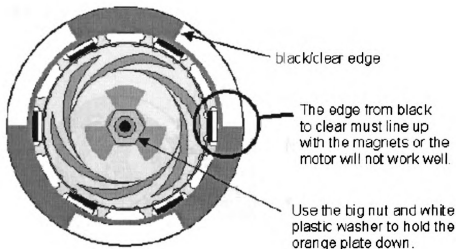
As seen on student worksheet.

- Can you think of an important reason why the north and south poles have to switch in an Electric Motor?



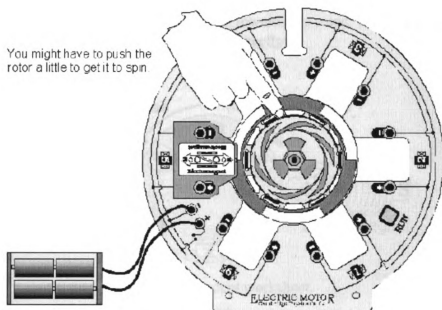
As seen on student worksheet.

4. Find the orange disc, which has three black spaces and three clear spaces around the edge. Put the disc on the rotor like the picture shows. Make sure that the boundaries from black to clear line up with the centers of your six magnets!



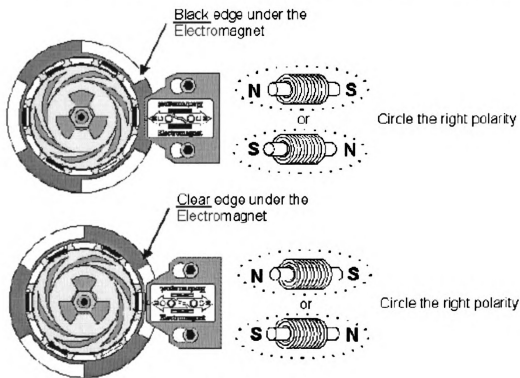
As seen on student worksheet.

- Put one electromagnet on the Electric Motor and GENTLY tighten down the thumb-nuts to hold it in place and make electrical contact.
- Connect the battery pack with the red (+) wire in the red (+) socket and the black (-) wire in the black (-) socket.
- Push the RUN button and give the rotor a push to start it spinning.
- You should have a working electric motor!



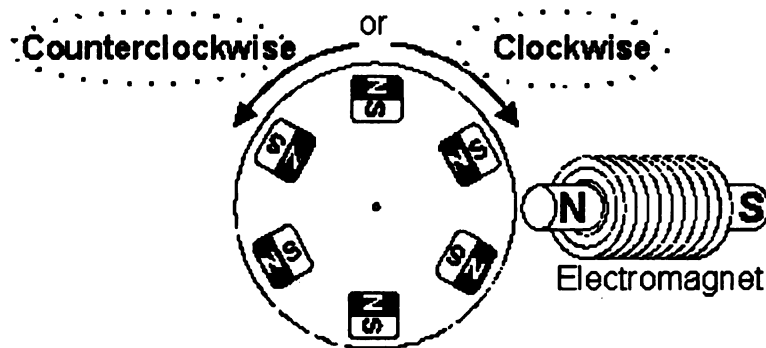
As seen on student worksheet.

5. Why does it work? Where is the north pole when the disk is in the following positions? Try the experiment and find out. **Circle the correct polarity for each picture.**



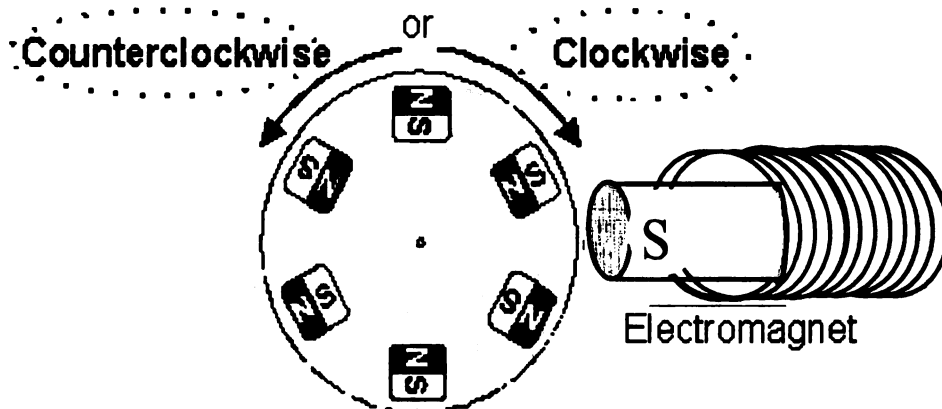
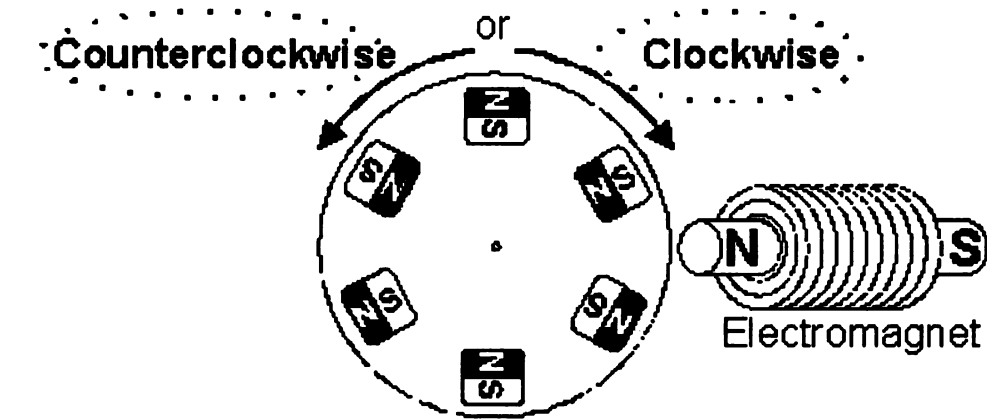
As seen on student worksheet.

6. Suppose you have a rotor with magnets like the ones in the picture below.
The electromagnet has a north pole facing in towards the rotor. Which way will it turn?
Circle the right direction.



As seen on student worksheet.

7. How can you make your motor spin the other way?
Find a way to make the motor spin the direction you choose.
What did you have to do?



As seen on student worksheet.

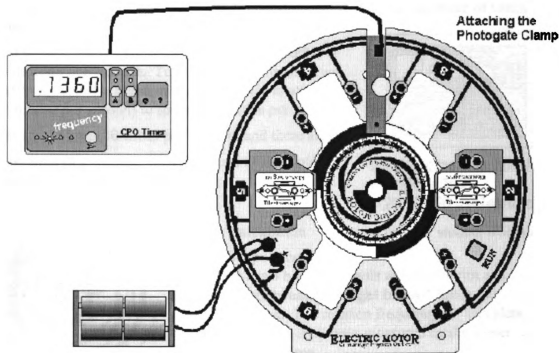
What makes a good electric motor design? Of course, a motor must turn to be a good design.

But, there are other considerations. Some other important things to consider are:

- What is the maximum speed of the motor?
- How much torque (rotating force) does the motor develop?
- How reliable is the motor? Does it always start?

Testing for Performance

When building a new machine we always try to build the best possible design given the materials and constraints. One way to tell the best design for the electric motor is to measure the speed of the motor and try to design the fastest motor that gives the highest speed. We can compare different designs to evaluate which is best by comparing the speeds. The speed of the motor is measured with the Timer and Photogate Clamp. Attach the Clamp to the motor in the slot at the top as shown in the diagram. If the Clamp is pushed in as far as it will go, the black parts of the switching plate will break the light beam in the timer. This is how we measure the speed of the motor.



As seen on student worksheet.

Using Frequency Mode

In frequency mode the Timer measures the number of times per second that the light beam is interrupted. Use only one Clamp attached to input "A". In frequency mode the "A" button controls the measurement much the same way as in stopwatch mode. Use the "A" button to toggle the "A" light on and off.

- When the A light is on the Timer measures frequency and updates the display every two seconds
- When the A light is off the Timer displays the last frequency measurement and freezes the value.

The Timer measures frequency in kilohertz (kHz). To convert to cycles/second (Hertz) you must multiply the Timer reading by 1000. This is the same as shifting the decimal point three places to the left.

$$1 \text{ kHz} = 1000 \text{ cycles/second} = 1000 \text{ Hz.}$$

A frequency of 20 Hertz means that the light beam is being broken 20 times per second.

How does the frequency of breaking the light beam tell us the speed of the motor?

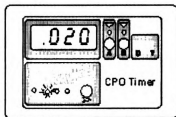
The answer depends on the switch plate being used.

For the 4 pole switch plate the light beam is broken 2 times for each turn of the rotor.

The rotation speed of the rotor is the frequency divided by the number of black segments on the switch plate.

Most electric motors are specified in terms of **RPM**, or **revolutions per minute**. To be a good comparison we need to convert our speed measurements (in rotations or revolutions per second) to rpm (revolutions per minute).

If the motor turns **20 times per second**, and there are **60 seconds in a minute**, then the speed of the motor is $20 \text{ rev/s} \times 60 \text{ s/min.} = 1,200 \text{ rpm.}$



Measurement is .020 kHz
= 0.020 x 1000
= 20 Hz (20 cycles/sec)

As seen on student worksheet.



**The 6 Pole
Switch Plate**

As seen on student
worksheet.

Example Calculation

The 6 pole switch plate has 3 black segments around the rim and therefore **breaks the light beam 3 times per revolution**. The rotation frequency for this plate would be the frequency measured by the Timer divided by three.

Timer measurement: 0.033 kHz = 33 Hz

Rotor frequency = 0.033 x 1000 ÷ 3 = 11 rev/s
(revolutions per second)

Rotor speed = 11 rev/s x 60 s/min. = 660 rpm

B4.1: Calculate the rotation speed of the motor from the given measurements for practice. Check your answers to be sure you know how to calculate the speed. Then complete your own measurements with the photogate and calculate the actual speed of the different motor configurations.

Switch Plate		Timer Reading (kHz)	Rotation Frequency In Cycles/Sec (Hz)	Rotation Speed in RPM
	2 Pole	0.012 kHz		
		Your Timer Reading		
	4 Pole	0.024 kHz		
		Your Timer Reading		
	6 Pole	0.061 kHz		
		Your Timer Reading		
	8 Pole	0.015 kHz		
		Your Timer Reading		
	12 Pole	0.053 kHz		
		Your Timer Reading		

Conclusion:

- What is the maximum speed of the motor? _____
- Did the motors always start on their own? Which ones did? _____
Which ones didn't? _____
- Which motor design was the most reliable?
Which motor started rotating with the least assistance? _____

Physical Science: Physics

Hour _____ Number _____

Unit 4: Electricity & Magnetism

Name _____

B 22 Activity 16: Intro to Transformers

Date _____

Use the computer to look up the article: "Inside a Power-Cube Transformer" at the following address: <http://www.howstuffworks.com/inside-transformer.htm>

Read through the information and look at the pictures of the transformer that has been taken apart.

How many of those little Power Cube thingies do you have around your house?

1. What do the windings refer to? _____

2. What is the purpose of a transformer? _____

3. The 120 volts comes in on the _____.

4. The AC current in the primary winding creates an _____

5. In this case the transformer converts _____

6. If the primary and secondary windings have the same number of turns,
the primary and secondary voltage _____.

7. If the secondary winding has half as many turns as the primary then the voltage in the
secondary _____ that of the voltage in the primary.

8. To drop down to 3 volts, there needs to be _____ more turns in the
primary than in the secondary.

Physical Science: Physics
Unit 4: Electricity & Magnetism
B 23 Activity 17: Transformers & Voltage

Hour _____ Number _____
Name _____
Date _____

Observe the three different transformers that are disassembled on the back table.

Transformer A:

1. How can you determine the primary windings from the secondary windings?

2. How can you determine whether this is a step-up or step-down transformer?

3. Is this a step-up or step-down transformer? _____

Transformer B:

1. Are there more primary windings or secondary windings? _____

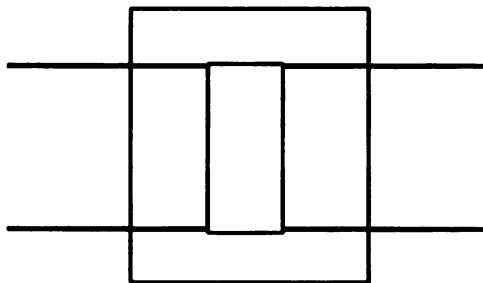
2. Is this a step-up or step-down transformer? _____

Transformer C:

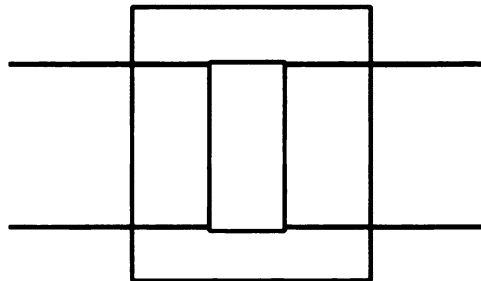
Follow the plug-in cord to the transformer.

1. The side of the transformer where the cord enters would be the _____ coil.

Power companies use transformers to increase the voltage and transformers near your home are used to decrease voltage. Sketch the turns of wire to represent transformers on the figures below. Label the primary and secondary windings on both pictures.



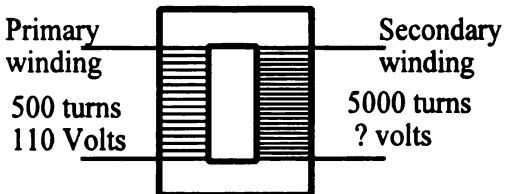
Step-up Transformer



Step-down Transformer

1. A _____ is a device that _____ the voltage in a circuit.
2. A step-up transformer _____
3. A step-down transformer _____
4. Figure 3 shows an example of which type of transformer? _____

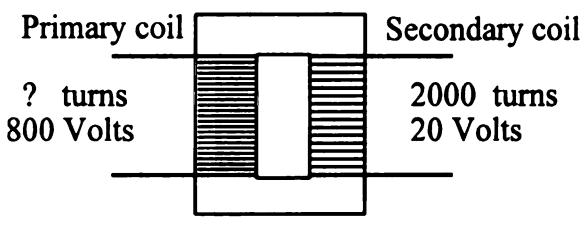
5. What is the turn ratio of the transformer in Figure 3?



6. What is the resulting voltage in the secondary coil in figure 3?
- _____

7. Figure 4 shows an example of which type of transformer? _____

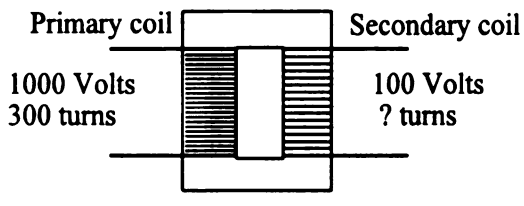
8. What is the ratio of the transformer in figure 4?



9. Calculate the number of turns in the primary coil in figure 4?
- _____

10. Figure 5 shows an example of which type of transformer? _____

11. What is the ratio of the transformer in figure 5?



12. Calculate the number of turns in the secondary coil in figure 5?
- _____

Physical Science: Physics
Unit 4: Electricity and Magnetism
B 24 HOMEWORK #3 Review

Hour _____ Number _____
 Name _____
 Date _____

1. If each cell in Figure 1 has a voltage of 1.5 volts, what is the total voltage in the circuit?

2. Which switches, in Figure 1, would need to be closed in order for bulb G to light up?

3. Which switches, in Figure 1, would need to be closed in order for bulb E to light up?

4. Calculate the current flowing through the circuit in Figure 1 if ONLY switch one is closed.

Show your calculation!

Givens

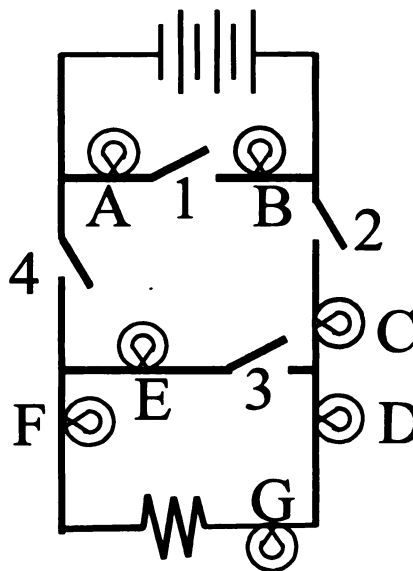
Total Voltage =

Number of bulbs lit =

Total Resistance =

Formula

Calculation



Each cell is rated at 1.5 volts.
 Each bulb has 2.3 ohms of resistance.
 Each resistor has 5 ohms of resistance.

Current = _____

5. Calculate the current flowing through the circuit in Figure 1 if ONLY switches two and four are closed. **Show your calculation!**

Givens

Formula

Calculation

Total Voltage =

Number of bulbs lit =

Total Resistance =

Current = _____

6. What is the **total** voltage in figure 2?

7. Which switches, in Figure 2, would need to be closed in order for bulbs F, G and H to be lit?

8. Which switches, in Figure 2, would need to be closed in order for bulbs D and E to be lit?

9. For Figure 2, if bulbs D and E light up, what other bulbs will be lit up?
List them ALL!

10. Calculate the current flowing through the circuit in Figure 2 if **ONLY** switches 3 and 4 are closed. **Show your calculation!**

Givens

Formula

Calculation

Total Voltage =

Number of bulbs lit =

Total Resistance =

Current = _____

11. Calculate the current flowing through the circuit in Figure 2 if **ONLY** switches 1 and 4 are closed. **Show your calculation!**

Givens

Formula

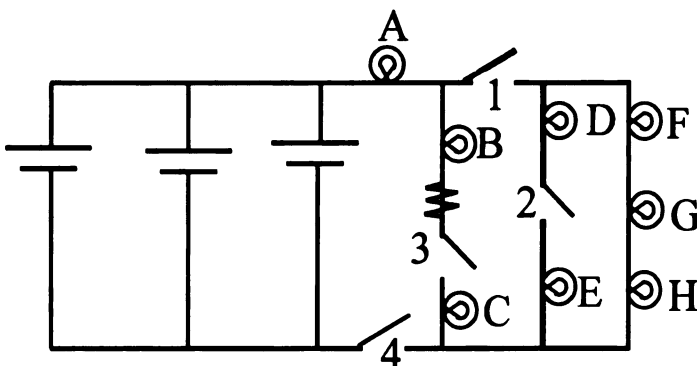
Calculation

Total Voltage =

Number of bulbs lit =

Total Resistance =

Current = _____



Each cell is rated at 1.5 volts.
Each bulb has 2.3 ohms of resistance.
Each Resistor has 5 ohms of resistance.

12. The transformer in Figure 3 shows an incoming voltage of 1000 volts and an outgoing voltage of 100 volts. What type of transformer would this represent?

13. What is the ratio of the voltages?

Primary to Secondary

_____volts to _____volts

What is that same ratio in lowest terms? _____

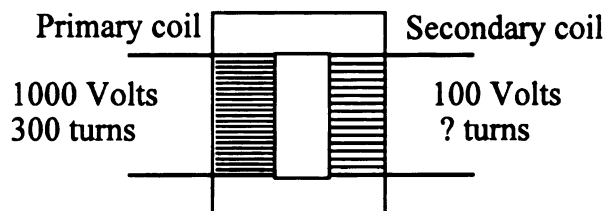


Figure 3

14. From the ratio of voltages, what can you determine to be the ratio of the turns of wire wrapped around the iron core of the transformer?

15. The transformer in Figure 4 shows what type of transformer?

16. From the ratio of turns of wire, determine the ratio of the voltage for the secondary coil.

Ratio of turns = _____

Secondary voltage = _____

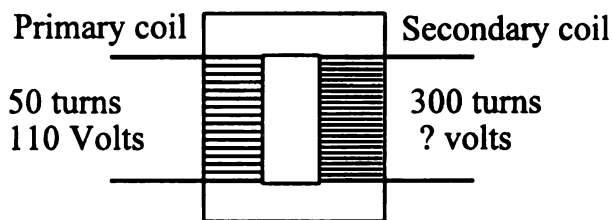


Figure 4

17. The transformer in Figure 5 shows what type of transformer?

18. From the ratio voltage determine the ratio of the number of turns of wire for this transformer.

Ratio of voltage = _____

Primary coil number of turns of wire = _____

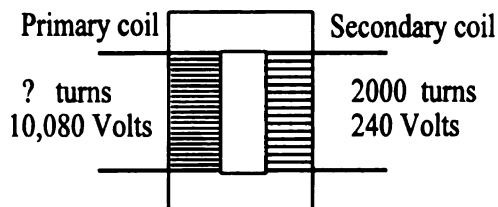
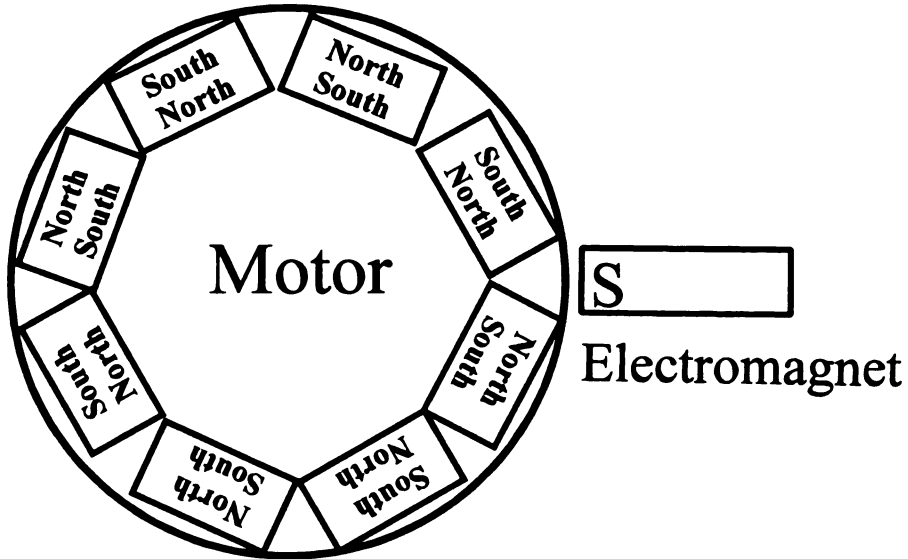


Figure 5

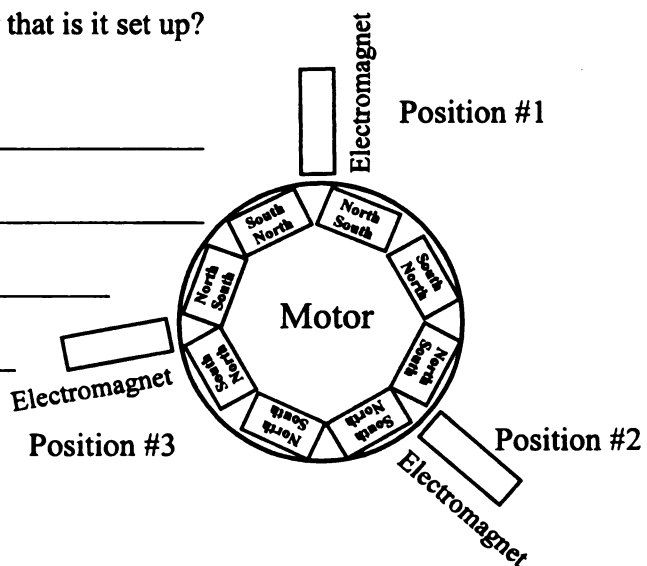
19. Label the picture showing which direction the rotor will turn and the repulsion and attraction positions between the permanent magnets and the electromagnet.



20. What makes a motor turn? _____

21. If all three of the electromagnets had their north pole pointing in toward the rotor, which electromagnets would be working together to turn the motor clockwise?

22. Would this motor work the way that is it set up?
Why or why not?



As seen on student worksheet.

Physical Science: Physics
Unit 4: Electricity & Magnetism
B 25 TEST

Hour _____ Number _____
 Name _____
 Date _____

Objective #1: The student will be able to define electricity, in terms of circuits, and discuss the relationship among voltage, current, and resistance within different circuits and calculating values within a circuit using Ohm's law.

_____ 1. Calculate the current flowing through the circuit in Figure 1 if ONLY switch one is closed.

- A. 1.02 A B. 0.98 A
 C. 0.98 V D. 0.33 A

_____ 2. Calculate the current flowing through the circuit in Figure 1 closing ONLY switches 2 and 4.

- A. 0.32 A B. 0.98 A
 C. 0.49 A D. 0.38 A

_____ 3. The unit used to measure electric current is the

- A. Amp B. Ohm
 C. Watt D. Volt

_____ 4. Potential difference or voltage is measured in the unit called a(n)

- A. ampere B. ohm.
 C. watt D. volt.

_____ 5. The opposition to the flow of electricity or current is called

- A. amperage. B. resistance.
 C. electric current. D. voltage.

_____ 6. According to Ohm's law: $I = V/R$.

If the resistance in a circuit is increased current _____

- A. stays the same B. decreases
 C. increases D. doubles

_____ 7. If the voltage within a circuit is increased the current will _____.

- A. stay the same B. decrease
 C. increase D. double

_____ 8. The unit of measurement for resistance is the _____

- A. ampere. B. ohm.
 C. watt. D. volt.

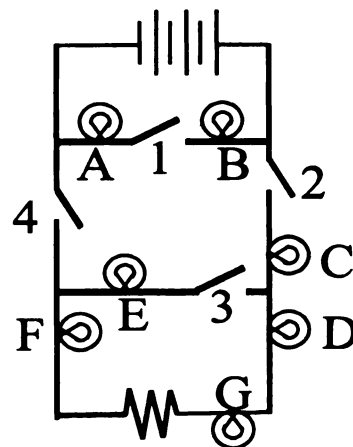


Figure 1
 Each cell is rated at 1.5 V.
 Each bulb has 2.3 ohms of resistance.
 Each resistor has 5 ohms of resistance.

- _____ 9. AC current is electricity that
 A. alternates the flow of voltage B. alternates the parallel paths of current.
 C. alternates the resistance. D. alternates the direction of the current.
- _____ 10. For electricity to flow through a circuit, the switch must be _____
 A. open. B. in series. C. closed. D. in parallel.
- _____ 11. Batteries (cells) provide the potential difference or ____ to make current flow.
 A. amperage B. resistance C. electric current D. voltage
- _____ 12. Calculate the current in Figure 2 if ONLY switches 3 and 4 are closed.

- A. 0.13 A B. 14.4 A
 C. 0.16 A D. 11.9 A
 E. 0.38 A

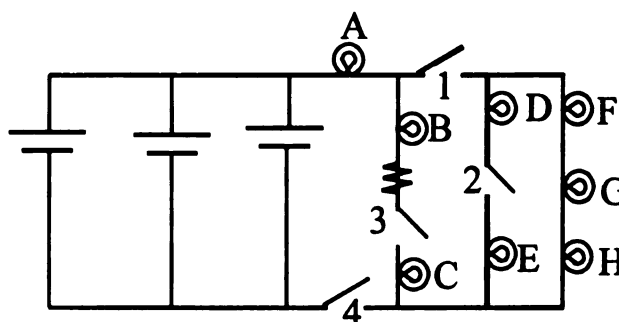


Figure 2
 Each cell is rated at 1.5 volts.
 Each bulb has 2.3 ohms of resistance.
 Each Resistor has 5 ohms of resistance.

- _____ 13. Calculate the current flowing through the circuit in Figure 2
 if ONLY switches 1 and 4 are closed.
 A. 0.13 A B. 14.4 A C. 0.16 A
 D. 11.9 A E. 0.38 A
- _____ 14. Calculate the current that would flow through the circuit in figure 3.
 A. 0.86 ohms B. 7 ohms
 C. 6 volts D. 1.2 A
 E. 0.86 A

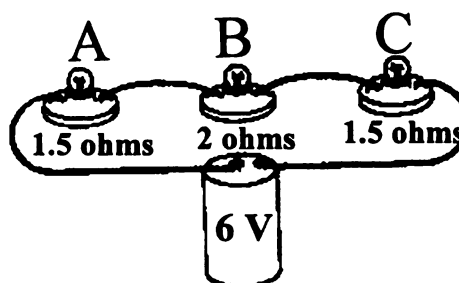


Figure 3

Objective #2: The student will be able to identify parts within an electrical circuit, diagram and construct circuits and identify properties associated with series and parallel circuits.

_____ 15. What is the total voltage of the cells in Figure 1?

- A. 1.5 V B. 3 V C. 4.5 V D. 4.5 A

_____ 16. Which switches MUST be closed in Figure 1 in order for bulb F to light up?

- A. 1, 2 and 4 B. 2 and 4 C. 3 and 4
D. 1 and 3 E. 1, 2, 3 and 4

_____ 17. Which switches MUST be closed in Figure 1 in order for bulb E to light up?

- A. 1, 2 and 4 B. 2 and 4 C. 3 and 4
D. 1 and 3 E. 2, 3 and 4

_____ 18. What is the total voltage of the cells in Figure 4?

- A. 1.5 V B. 3 V
C. 4.5 A D. 4.5 V

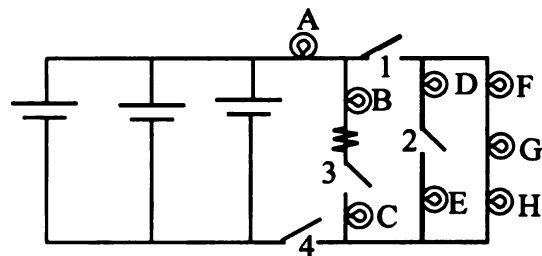


Figure 4

Each cell is rated at 1.5 volts.

Each bulb has 2.3 ohms of resistance.

Each Resistor has 5 ohms of resistance.

_____ 19. Which switches MUST be closed in figure 4 in order for bulbs F, G and H to be lit?

- A. 1, 2 and 4 B. 1 and 4
C. 3 and 4 D. 1 and 3
E. 1, 2 and 3

_____ 20. Which switches MUST be closed in figure 4 in order for bulbs D and E to be lit?

- A. 1, 2 and 4 B. 1 and 4
C. 3 and 4 D. 1 and 3 E. 1, 2 and 3

_____ 21. The cells in Figure 1 are wired in

- A. parallel B. series C. unison

_____ 22. If the electric current can flow through different paths it is called a(n) circuit.

- A. open B. parallel C. series D. transistor

_____ 23. An electrical circuit connected one part after another is called a(n)_____ circuit

- A. open B. transistor C. parallel D. series

_____ 24. If bulb B were removed in **Figure 3**, what would happen to bulbs A and C ?

- A. Bulb A would remain lit.
B. Bulb C would go out, bulb A would stay lit.
C. Bulb B would go out, bulbs A and C would stay lit.
D. Bulbs A and C would both go out.
E. Bulbs A and C would remain lit.

Objective #3: The student will be able to describe how magnetism, magnetic fields and magnetic poles interact and how they relate to motors, generators, and transformers.

- _____ 25. A generator is a device that converts
A. heat energy into electrical energy.
B. electrical energy into heat energy.
C. electrical energy into mechanical energy.
D. mechanical energy into electrical energy.
- _____ 26. The device that increases AC voltage as it leaves an electrical power plant is called a(n)
A. AC transformer
B. step-up transformer
C. AC galvanometer
D. step-down transformer
E. step-up generator
- _____ 27. The device that decreases AC voltage as it enters your CD player is called a
A. AC transformer
B. step-up transformer
C. AC galvanometer
D. step-down transformer
E. step-up generator
- _____ 28. The device that decreases AC voltage as it enters your home is called a(n)
A. AC transformer
B. step-up transformer
C. AC galvanometer
D. step-down transformer
E. step-up generator
- _____ 29. A motor is a device that converts
A. heat energy into electrical energy.
B. electrical energy into heat energy.
C. electrical energy into mechanical energy.
D. mechanical energy into electrical energy.
- _____ 30. Figure 5 shows an example of a(n)
A. AC transformer
B. step-up transformer
C. AC galvanometer
D. step-down transformer
E. step-up generator
- _____ 31. What is the ratio in figure 5?
A. 5:2 B. 2:5
C. 2:1 D. 5:1
- _____ 32. What is the voltage in the secondary coil in figure 5?
A. 20 volts B. 25 volts C. 10 volts
D. 250 volts E. 100 volts

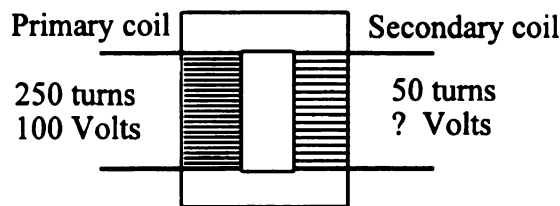


Figure 5

_____ 33. Figure 6 shows an example of a(n)

- A. AC transformer
- B. step-up transformer
- C. AC galvanometer
- D. step-down transformer
- E. step-up generator

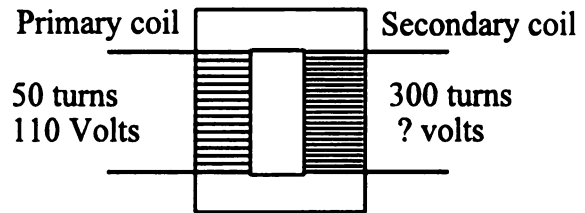


Figure 6

_____ 34. What is the ratio in figure 6?

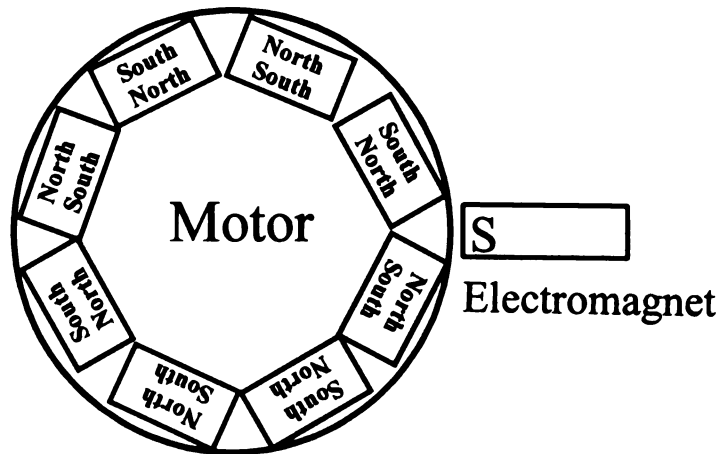
- A. 5:2
- B. 6:1
- C. 1:10
- D. 1:6

_____ 35. What is the voltage in the secondary coil in figure 6?

- A. 18.33 volts
- B. 3000 volts
- C. 11 volts
- D. 660 volts
- E. 50 volts

_____ 36. The motor in Figure 7 would turn in which direction?

- A. Clockwise
- B. Counterclockwise
- C. It would not turn at all.

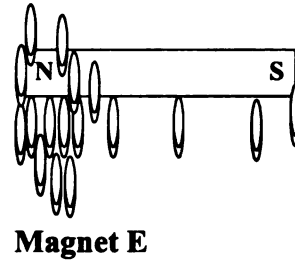
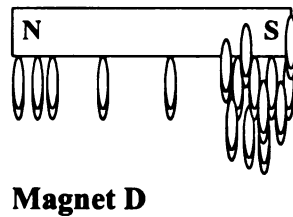
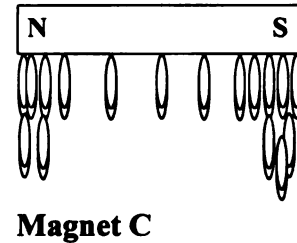
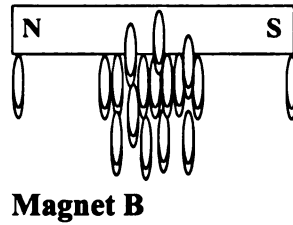
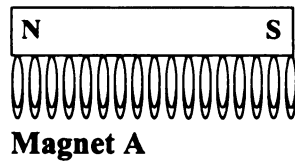


_____ 37. For the motor in Figure 7 to turn in a clockwise direction what would have to be changed?

- A. The direction of the electromagnet.
- B. The magnets should have their north to pole to the outside.
- C. The magnets should have their south to pole to the outside.

- _____ 38. What makes the shaft of a motor rotate?
- A. The force of attraction between the magnets and the electromagnets.
 - B. The force of repulsion between the magnets and the electromagnets.
 - C. The force of repulsion and attraction between the magnets and electromagnets.
 - D. The mechanical energy turns the shaft of the motor.

- _____ 39 Which picture best shows the strength of the magnetic field for a bar magnet?



Total points possible for the unit 4 test = 39

Your Score _____

Please help me by being honest and truthful when answering each question.

1. Please list and describe some of the information that you learned and found most interesting during the electricity and magnetism unit.

2. What are some of the things you liked or enjoyed learning *most* about the electricity and magnetism unit?

3. What are some of the things you liked or enjoyed learning *least* about the electricity and magnetism unit?

4. What are some of the things that you did, activities or labs that helped you understand the information about electricity and magnetism.

5. What suggestions would you offer to help me improve the electricity and magnetism unit?

6. Rate your knowledge of the topic before and after the unit was taught.

Place a "B" in the area that would relate to before the unit and an "A" for after.

No understanding	Very little understanding	Understand fairly well	Good understanding
1	2	3	4

7. Please make any other comments that you feel would be beneficial to me as a teacher.

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