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IMPROVING HIGH SCHOOL STUDENTS' PERFORMANCE IN ELECTRICITY UTILIZING INCREASED STUDENT INVOLVEMENT IN THE LEARNING PROCESS

By

Tamera Sue Hetfield

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ABSTRACT

IMPROVING HIGH SCHOOL STUDENTS' PERFORMANCE IN ELECTRICITY UTILIZING INCREASED STUDENT INVOLVEMENT IN THE LEARNING PROCESS

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This project was based on the belief that active student involvement in the learning process would result in an increase in the overall level of knowledge and understanding in the area of electricity. This was accomplished through the use of activities such as demonstrations with discussion, labs, hands on activities and computer activities, which replaced the standard lecture, labs and reading activities. I believed that such activities along with improved teacher preparation would increase active student participation in the classroom and therefore increase test scores.

The concept of electricity was researched to improve teacher knowledge. The students were surveyed as to their preference of activities for various situations. Demonstrations with discussions were used to present some of the new concepts. Labs were revised to include more student discovery. Lectures were reduced and used to present some new concepts. Computer activities were used as review and extension activities. Pre and posttests were administered to document changes in student learning. An end of unit project was also used to assess student knowledge.

Pre and posttest scores show an overall improvement in the students' knowledge of electricity. Surveys show that students found demonstrations and end of unit projects interesting, enjoyable and helpful.

ACKNOWLEDGMENTS

I would like to thank Merle Heidemann and everyone in the Division of Science and Mathematics Education at Michigan State University. Their dedication to creating quality programs for teachers is unparalleled. Thank you for listening to our needs and responding to the best of your abilities to create courses and programs to help meet those needs.

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LIST OF ABBREVIATIONS

MEGOSE - Michigan Essential Goals and Objectives for Science Education

PME - Using Scientific Knowledge - Physical Science - Matter and Energy

R - Reflecting on Scientific Knowledge

C - High School Objective

OPS - Okemos Public Schools

INTRODUCTION

RATIONALE

Electricity is one of several units in the area of physics that I teach in my freshman level physical and earth science course, which also includes units in the areas of chemistry and earth science. The course is to cover the basic concepts in various areas of science. The order in which the material is presented is up to each individual teacher. Approximately 12-14 weeks is spent covering physics topics including electricity, electromagnetism, waves, sound and light. The past few years I have started the year with the physics units after a review of the scientific method, measurements and lab procedures. About one fourth of the twelve weeks is spent teaching electricity.

Electricity is an important topic because of the large role it plays in our society. Many students believe they know all they need to know about electricity. Yet when asked to explain various observations involving electricity they have difficulty doing so. When I began teaching this unit I found that I was very uncomfortable with my background in the area of electricity and how it works. I followed recommendations given by the text book as to how to implement this unit but always ended up unsatisfied, not only with how I presented the unit to my students but also with the level of understanding and interest on the part of my students. Because I was not very confident in my own level of understanding of electricity, I was often hesitant to try something new in my lessons. This unit had only a few hands on activities and limited student to student and teacher to student involvement. I felt I needed to spend time making changes that would most benefit my students as well as myself.

First, I needed to improve my understanding of electricity so that I could present it in a positive manner to my students. Second, I needed to create activities in which the students were more involved in the learning process. I feel that an active learner is more likely to learn and remember the concepts involved. Therefore my hypothesis is: the use of activities such as demonstrations with discussions, labs, "hands on " activities and computer activities will more actively involve the students in the learning process which will increase their level of knowledge and understanding in electricity.

DEMOGRAPHICS

The students in this study come from a suburb of Lansing, Michigan. The school student population for the school year 1999-2000 was approximately 1,422. The school population is not very diverse with 85.9 % White, 1.7 % Hispanic, 4.7 % Black, 6.9 % Asian, and 0.8 % American Indian students.

The community is middle to upper class socioeconomically. The community is well educated with many parents working as doctors, lawyers and university professors. The emphasis on a quality education is high. The community is very supportive of the school and has high expectations of its students. The school is one of the top schools in the state for its academic programs.

Most of the students are highly motivated to learn and have high expectations of themselves. On average, ~45% of the school population maintains a grade point average of 3.50 or above and ~75% maintains an average of 2.80 or above. Approximately 92% of graduating seniors attend a post-secondary institution. In 1999, 97% of the seniors enrolled graduated.

The students were all in the freshmen level of a high school, which included grades 9-12. In the three physical and earth science courses I teach, there were 80 students enrolled and 67 participated in the research. 37.3% of my students were male and 62.7% were female. 86.6% were White, 1.5% Hispanic, 6% Black, 6% Asian and 0% American Indian.

REVIEW OF BACKGROUND SCIENCE

Electricity involves the movement of charged subatomic particles. The atom is composed of three basic particles: protons which are positively charged, neutrons which contain no charge, and electrons which are negatively charged. The protons and neutrons are found together in the center of the atom called the nucleus. The electrons are traveling in various orbitals surrounding the nucleus called the electron cloud. It is important to realize that under most conditions the protons and neutrons do not leave the nucleus. However, the electrons often leave one atom and become part of another atom. Also the position of the electrons within the atom can and does change. Electricity is the result of the movement of electrons and the interaction of atoms as a result of this movement. An atom is considered neutral when the number of protons equals the number of electrons. Should an atom lose one or more electrons, it becomes positively charged because it has lost negative charge. Should an atom gain one or more electrons, it becomes negatively charged because it has gained negative charge. Various forces result from the interaction of charged objects or atoms. Two atoms both with a positive charge would exhibit the force of repulsion. Two atoms both with a negative charge would also exhibit the force of repulsion. Two atoms, one with a negative charge and one with a positive charge, would exhibit the force of attraction. As a result of these forces, negatively charged particles can travel from one point to another. The movement of these particles results in electricity.

Friction, induction or conduction may charge objects. Friction removes negative charges from one object and retains them on another by rubbing of the objects. Induction results in the rearrangement of charges due to the presence of a charged object without direct contact. Conduction occurs when an object becomes charged due to direct contact with a charged object.

Static electricity is the result of charges moving from one object to another and then remaining at rest. The release of this built up charge is called electric discharge. The shock you receive after scuffing your feet on a carpeted floor then touching a metal doorknob is an example of discharge. Due to friction between your feet and the carpet your body picks up excess negative charge. The metal doorknob provides an avenue for the negative charges to travel from you to the door. This release of excess charge occurs very quickly and you feel a slight shock. Lightning is also an example of electric discharge but on a much larger scale.

With the use of metal wires (which are good conductors of electricity), batteries or generators (which provide an initial source of electrons) and loads (such as resistors and light bulbs) circuits can be built to allow the flow of electrons from one point to another. Circuits can be arranged in series, in parallel, or in a combination of series and parallel circuits. For any load in a series circuit to function, they all must function. However, loads in a parallel circuit function independently of each other. Current, or the flow of charge through a circuit, is equal to voltage divided by resistance. This relationship is known as Ohm's Law. Voltage is a measurement of the energy carried by charges that make up a current and is sometimes referred to as potential difference or electromotive force. Resistance is the measurement of the opposition to the flow of electrons of the loads within the circuit.

Current can flow as either DC or AC current. DC current is direct current, which means the current flows in only one direction. Dry cell batteries are an example of a source that provides DC current. AC current is alternating current. This current reverses the direction of current flow by constantly and quickly changing the polarity of the positive and negative terminals of the wire ends. Current provided by generators is AC current. In the United States, the AC current provided by power plants alternates 60 times per second and is 110 V. In Europe the AC current provided alternates 50 times per second and is 220 V.

REVIEW OF PEDAGOGICAL LITERATURE

With the introduction of a new concept or even reintroducing a concept but taking it a step further, one must take a look at the knowledge the students bring with them to the classroom. Often included with this knowledge are commonly held misconceptions. A case study in current electricity refers to misconceptions as "intuitive conceptions". According to this study, these misconceptions are strongly held and make logical sense to the student but they differ from the concepts we are teaching. (Heller and Finley, 1992) Following is a list of misconceptions (as printed in the MSTA Journal 1998 by A. Hapkiewicz) in electricity that I used to help structure my lessons for this unit.

Electricity Misconceptions

1. Objects become positively charged because they have gained protons.
2. Objects become positively charged because their electrons have been destroyed.
3. All atoms are charged.
4. Current flows from a battery (or other source of electricity) to a light bulb (or other item that consumes electricity), but not from the light bulb to the battery.
5. Current flows out of both terminals of a dry cell or both connections in an electrical outlet.

Another study on the implications of cognitive research for physics teachers states that these misconceptions occur regardless of how well the material is presented by the teachers and they "interfere with the students' ability to understand concepts" (Mestre and Touger, 1989). During this unit, the basic ideas of electricity needed to be addressed while keeping in mind these common misconceptions. Overcoming misconceptions is often a difficult task because the beliefs are so deeply seated. According to Heller and Finley from the electricity case study, "the central or hard-core ideas are those ideas that learners persist in believing, even when evidence contradicting these ideas is available" (Heller and Finley, 1992). I feel that the best way to deal with these misconceptions is to use activities that keep the students in an active learning mode. Active participation by students is important in overcoming misconceptions because these ideas are difficult to change (Mestre and Touger, 1989).

Haury (1993) supports this idea by stating that science curriculum should "promote active learning, inquiry, problem solving, cooperative learning, and other instructional methods that motivate students." I felt that my unit on electricity before my research lacked enough activities to keep my students motivated and interested. When I reflected on the units that I teach that I felt were very successful, I had numerous activities in which the students were "actively" involved. "Students need to be actively involved in their own learning" (Blosser, 1992). Johnson and Johnson also assert that the research data associated with cooperative learning shows numerous positive aspects including the learning of more material, higher achievement, better attitudes towards subject matter and increased levels of confidence and motivation. (From an article by Blosser, 1992)

I believe that the more I can "actively" involve my students the more they will learn and remember. By "active" involvement I mean that students should be exposed to as many activities as possible where they are interacting with the teacher and with each other in explaining the processes at hand. This type of learning would require minimal lecturing activities and maximal activities such as labs, demos with discussion, projects with student presentations and the like. Studies have shown that the lecture approach associated with most textbooks leaves students as passive learners of facts and is an ineffective way to teach (Weaver, 1998).

Many people in the field of education assume that there is a lot of cooperation and group learning in a science classroom because the nature of such courses involves hands on activities called labs. This type of activity is considered active learning by many. However, I believe that cooperative learning is much more than just working together once in a while in a lab investigation. "One study defines cooperative learning as students working together to accomplish shared learning goals and maximize their own and their group mates' achievement" (Johnson, D., Johnson, R. & Smith, 1998). During my research I learned much about what cooperative learning actually entailed and I tried to adapt some of this knowledge to my new unit on electricity. I kept in mind four basic goals of cooperative learning: positive interdependence, face-to-face interaction among students, individual accountability for mastering the assigned material, and appropriate use of interpersonal and small-group skills (Blossar, 1992).

In my desire to actively involve students in the learning process, I felt it necessary to vary the types of activities I provided. Although I feel that long periods of lecture are not effective, I believe that some students prefer lecture to group or lab work. Other students feel more comfortable participating openly in small groups rather than in a whole class discussion. Much research has been done over the years about various learning styles. Many of my students are at a point where they realize what types of activity work best for them and which ones do not. Yet they are not always ready to take responsibility for their own learning. Therefore, along with varying my activities, I wanted my students to begin to take a responsible role in their own learning. Research by Thomson & Mascazine (1997) indicates that adjusting lessons to various learning styles encourages an increase in learning and students begin to take responsibility for their own learning.

I feel that involving the students in class discussions is imperative in helping them overcome their misconceptions and to accept difficult concepts. The class discussions could revolve around lecture material, lab material and demo material, just to name a few. One study that looked at active learning in the college classroom suggests planning lectures around questions. The length of time for lectures should be a maximum of 15 minutes, which is when students begin to drift away (Johnson, D., Johnson, R. & Smith, 1998). Therefore, I needed to find a way to break up lectures and incorporate questions that would help with the lecture material. I planned to do more demos in this unit on electricity to help accomplish this. With these demos, there would be periods where students will need to reflect on their initial beliefs and respond verbally to teacher initiated questioning. Research indicates that when teachers initiate and facilitate discussions around misconceptions students begin to reflect on their own knowledge which in turn leads to conceptual change (Weaver, 1998).

I felt that another way I could actively involve students in their own learning was to provide opportunities, other than lab situations, where they could work together and share ideas. Small group work gives students a chance to express their opinions, to hear the opinions of others, and to learn to adjust their beliefs if necessary based on information provided by group members. One study that compared group and individual activities found that the use of groups leads to successful task completion (Seymour and Padberg, 1975).

Part of actively involving students in the learning process requires finding ways to hold their interest and to encourage them to voluntarily participate in class discussions. I needed to find ways to relate the concepts of electricity to something they could connect with and relate to. If I could find a way to relate the concepts of electricity to their lives then I could increase their interest, hold their attention and possibly get some to participate more in the classroom. One study on pupil participation and curriculum relevance indicates that relating content to real life experiences of the students will result in voluntary student participation (Rumadas and Kulkarni, 1982). Based on this basic belief, I worked on demos and projects that would be relevant to my students' lives.

I started my research with the belief that activities involving computers would maintain my students' interests and keep them actively involved in the learning process. Research in this area was not very supportive of this belief. One such study found that although computers have some positive aspects to classroom use, they tend to limit student interaction among groups in significant ways (Roth, Woszczyna, and Smith, 1996). Some research also suggests that the use of computers for simulations of lab situations may not be as beneficial as once believed. In one report, Shavelson, Baxter, & Pine found no significant benefit to computer use when comparing computer simulations to hands on activities. (As reported in an article by David Kumar for Eric Digest, 1996) What research I was able to find was inconclusive on the ability of computers to improve the level of real learning by the students. Most research related to the educational use of computers failed to address the issue of assessment of such activities to measure their effect on student achievement. One writer comments that computers will not be successful in science assessment unless they are also used as a significant part of instruction and learning (Kumar, 1996). Some research, however, does suggest that supplemental use of computers can aid teachers in more effective instruction (Roblyer, 1985). With little research to conclusively support or negate my belief, I developed a couple of computer activities and planned to document student use of and attitudes toward computers as an educational tool.

One of the most important of my goals of my research was to improve my knowledge of electricity. I felt that my discomfort with this topic was due mostly to my lack of self-confidence in my own knowledge in this area. In a Dutch STS study by Eijkelhof & Lijnse the researchers found that teachers are insecure when they lack sufficient background knowledge in any given content area and would therefore avoid discussions and extension activities, (as reported by Weaver, 1998). I needed an opportunity to research and learn the concepts of electricity that I was expected to teach to my students. I needed the opportunity to do labs myself, work with the latest technology available to me and to develop activities for my instruction of this unit. Therefore, I spent 5+ weeks on the campus of Michigan State University during the summer of 1999 doing exactly that. I was able to meet with professors in various fields of science, meet with teachers in my field, and experiment to my heart's delight. I feel that teacher preparation programs need to provide such time for future and new teachers. The National Research Council states that teachers should be exposed to content courses along with methods courses to improve teaching abilities (National Research Council, 1996). It is also important for teachers not so new to the field to have such opportunities for research. "Practicing teachers have too few options to upgrade their skills" (National Research Council, 1996). If we expect our students to learn by doing then shouldn't we expect our teachers to learn by doing?

IMPLEMENTATION OF UNIT

OVERVIEW OF NEW UNIT

I begin many of my units initially with the students reading part of the unit the preceding evening. Because background knowledge plays a role in what students learn, I feel that reading background information before I begin teaching the material helps provide a base to build upon. This activity began both my old and new unit. Otherwise, my old unit consisted mostly of lecture to present new material with one demo used to help present the topic of static electricity. Some material was just briefly mentioned as we progressed through the chapter. One short lab on series and parallel circuits was completed after the lecture on the same material. Some additional problem solving was done, either individually or in small groups, after lecture on Ohm's law, calculating total resistance in series and parallel circuits, power and energy. The unit ended with a test that included multiple choice, problem solving and short answer questions.

My new unit also started out with reading. However, I began my presentation of electricity with a series of demos. There were three demos, covering a period of 2 1/2 days including discussions. Questions were developed to be posed before, during and after the demos, some of which were answered verbally during the demo and some of which were both written and answered during discussion. An internet activity related to batteries was included between the days spent on demos. The demos and computer activities led into short lectures about new vocabulary and electricity concepts. Lectures were used to present remaining new concepts within the chapter. However, the lectures were brief and were initiated by questions to stimulate discussion both before and during lectures. Three labs were done throughout the chapter covering Ohm's Law and series and parallel circuits. Homework problems related to static electricity and problems involving calculations with voltage, current and resistance were given throughout the chapter. The unit ended with a test, which included multiple choice, problem solving and short answer questions and a group electric circuit project, which counted for a portion of the test grade for the unit.

PRE-UNIT PREPARATION

I began making notes about the changes I would like to make to the unit on electricity and my goals for the unit during the 1998 - 1999 school year. I talked to my colleagues who also taught this course about how they felt about the unit and some of the changes they felt were necessary. The biggest concerns were better labs, especially to address Ohm's Law and making sure the Michigan Essential Goals and Objectives for Science Education (MEGOSE) were taught during the unit. I made a list of my objectives for my summer research, the related MEGOSE objectives and the Okemos Public Schools (OPS) objectives for electricity. They are listed on the next page in
Table 1.

I spent five weeks at Michigan State University speaking with professors in the Departments of Physics and Geology, meeting with teachers, researching electricity, researching teaching methods and practicing various hands on activities. Through my conversations with professors as well as my father (an electrical engineer), reading various physics textbooks, and reading various physics web sites, I learned more about and became more comfortable with electricity.

Table 1: Objectives for electricity unit.

create more student involved activities	PME 24 - construct and explain simple circuits using wires, light bulbs, fuses, switches and power sources	explain electrical charges and currents in terms of electron movement
increase my knowledge in electricity	R 2/R 14 - discuss the historical development of key scientific concepts and principles	
	R 8 - Show how common themes of science, mathematics and technology apply in real world contexts	
	C 20 - discuss topics in groups by being able to restate or summarize what others have said, as for clarification	

During my time at MSU and the remainder of the summer, I redeveloped my unit on electricity. The new unit was to include activities to more actively involve my students in their own learning. I included demonstrations to introduce new topics, two computer activities, and a project. I revised the existing lab and added two other labs. I shortened lectures and included them between labs or problem solving activities. The unit test was revised to cover the MEGOSE and OPS objectives. An outline of the unit is listed in Table 2 on the following pages.

BASIC OUTLINE OF UNIT

Table 2: Ch. 19 - Electricity - Unit Outline

9/22/00 9/23/00 9/24/00	◆ Pre-Survey ◆ Pre-Test ◆ Heat Test	◆ read pp. 481-492/notes
Day 1: 9/27/00	◆ ***Demos**: static electricity, balloon, pith ball, electroscope	
Day 2: 9/28/00	◆ ***Computer Lab** - Batteries	◆ read pp. 492-500/notes
Day 3 & 4: 9/29/00 - 9/30/00	◆ Discuss computer lab ◆ Continue with demos ◆ Lecture/discussion - electric discharge and lightning	
Day 5: 10/1/00	◆ ***Computer Lab** - circuits	
Day 6 & 7: 10/4/00 - 10/5/00	◆ Discuss computer lab ◆ Lecture/discussion - voltage, batteries, resistance, current, AC, DC	◆ read electrostatics handout ◆ dryer sheet problem
Day 8: 10/6/00	◆ Discuss dryer sheet problem ◆ Finish/review current ◆ Lecture/discuss/ problem solving - Ohm's Law	◆ ***handout** #3-6
Day 9: 10/7/00	◆ ***Ohm's Law Lab**	◆ complete lab questions ◆ lab report due 10/11/00
Day 10 & 11: 10/8/00 - 10/11/00	◆ Discuss Lab ◆ Review circuits ◆ ***Lab** - Investigating Series and Parallel Circuits ◆ Discuss total resistance	◆ lab questions ◆ lab report due 10/12/00 ◆ read pp. 501-509/notes

***Bold print** denotes new or improved learning activities

Table 2: Ch. 19 - Electricity - Unit Outline

DAY/DATE	PLANS	[illegible]
Day 12: & 13: 10/12/00 - 10/13/00	Review Lecture - resistance factors ***Electricity History** Pre -lab	handout #1-9
Day 14 & 15: 10/14/00 - 10/15/00	***Lab**: Circuits	lab calculations and questions lab report due 10/19/00
Day 16 & 17: 10/18/00 - 10/19/00	Review lab and problem solving Discuss power Review for test ***Assign project**	handout #10-14, 20-25 review sheet
Day 19: 10/20/00	Electricity Test Work on project	work on project
Day 20: 10/25/00	Work on project	work on project
Day 21 & 22: 10/26/00 - 10/27/00	Project presentations Post-Survey	read pp. 515-519/notes

***Bold print** denotes new or improved learning activities

PRE AND POST SURVEYS - Appendix A

In my quest for knowledge on how to keep my students interested and involved in the subject matter I was teaching, I felt that it was important to question them about the various ways material can be presented. Just as my students come into my classroom with preconceived notions about science, science classes and science teachers, I also had preconceived notions about how my students preferred to be presented with new material, as well as what their misconceptions were. I believed at the beginning of this unit that students in general preferred to work in groups, to do hands on activities and labs, and to work with computers. I felt a survey (Appendix A1 and A2) both before and after the unit would give me some insight on how my students actually felt about various learning activities.

The first few questions in both surveys are similar. I asked what students liked and disliked about science in general. I then provided them with a list of various activities and asked them a series of questions relating to which activities they prefer in general, which they prefer when first presented with a concept, and activities they prefer as review of previously learned material. In the pre-survey I also asked about their interests in the area of electricity and what questions they might have about this topic. In the post-survey, I asked them to evaluate and rank the various activities used in the unit.

By knowing my students' preferences for various learning activities, I could provide appropriate activities in my classroom and involve more of my students in classroom work. I also felt that this would keep the interest of more of my students for a longer period of time. All of these factors were key in my overall goal of increased student knowledge and understanding of electricity.

PRE-TEST AND POST-TEST - Appendix A

I have found in my previous teaching of this course that my students come in with a wide range of abilities and knowledge in various areas of science. Much of this is dependent on which science teachers they had during middle school. Although certain concepts were to be covered at specific grade levels, the depth of that coverage is not always consistent. Therefore, some students may have extensive knowledge of electricity and some may only know how to construct a simple circuit. I have also found various misconceptions about electricity to exist in the minds of my students. I felt a pre-test for this unit would help me gauge the areas that needed only brief review and those that would need to be treated as new concepts. I developed a pre-test (Appendix A3) consisting of multiple choice, matching and short answer questions covering the MEGOSE and OPS objectives previously mentioned.

The post-test (Appendix A4) was also my unit test for electricity. I began preparing this test by using items from tests given in previous years. I then adapted the test to make sure that the MEGOSE and OPS objectives were covered as well as the student objectives for the unit. Two versions of the test were developed to cut down on student cheating. Both versions of the test consisted of multiple choice, short answer, and problem solving questions. I varied the question type from the pre-test to the post-test so that specific objectives were not questioned in the exact same manner on both tests. For example, a pre-test short answer question that had a drawing provided was changed to a short answer question in which the student had to provide the drawing.

I feel that it is important to vary question type for several reasons. First, some students do better with one type of question than another. Second, I wanted to expose students to styles of questions that they did not like. A student will not learn to perform better on multiple choice questions if he or she is never exposed to multiple choice questions. The same holds true for short answer questions.

Varying question type also permits me to tell whether a student has only a base understanding or an in depth understanding of a concept. Multiple choice questions often require only rote memory or a vague understanding of a concept. Short answer questions often require a deeper understanding of a topic. Some students simply memorize all the information given to them and all they can do in return is provide that information in the same format. They cannot apply it to a new situation. I feel that a true understanding of a concept comes when it can be applied correctly in a new situation.

To judge a change in the students' knowledge from pre-test to post-test, it is also important to vary question type. Some students will simply remember the question and the correct answer from the previous test. Or they will base how well they need to know a concept by the type of question from the pre-test. By varying question type, I am increasing the chance that the students' answer is based on their knowledge and not on luck due to previous knowledge of the same question.

NEW ACTIVITIES AND HANDOUTS - Appendix B

Demonstrations

I decided to begin this unit with a series of three demonstrations on static electricity. By starting with static electricity, I was starting with something they could relate to. The results of the pre-survey (which will be discussed later in this paper) showed that many of my students liked the use of demonstrations and discussions to present new material.

I prepared a handout for the students with a section for each of the three demonstrations. (Appendix B1) For each demo, students had to describe the demonstration and their observations, give an explanation of their observations, and space was provided for discussion notes. When providing an explanation for their observations, I told the students to write whatever came to mind even if they thought it was wrong. After they had time to write their responses, we would discuss what had occurred. I began by having several students tell what they thought had occurred, which normally included both correct and incorrect responses. I would then respond with questions to help lead the students to an agreement as a class as to what actually took place.

The first of the three static electricity demos was a balloon demo. In this demonstration, I rubbed the balloon with a cloth, a shirt, or in some cases, students' hair, then brought the balloon near a wall and the balloon would stick to the wall. At this point I had the students write an explanation of why the balloon was sticking to the wall. Because my students had read about charged particles and methods of charging, many had some idea of what was occurring. During the course of this demo and discussion, I would have several students do the same thing with the balloon and had them talk about what they felt when they put the balloon on the wall. I would also use two balloons and student volunteers and have them charge the balloons, bring the balloons close together, and describe what they felt.

I found this demo very good at getting the students involved and keeping their attention. It also brought out some of the misconceptions students have, especially the belief that protons are moving from atom to atom. It also opened up a discussion and brief lecture on the structure of the atom and a discussion on the methods of charging objects and the notion of an electric field. Because the students were involved by answering questions directed by me as well as by other students, there was very little lecture.

In the second demo, a pith ball was hung on a string attached to a small stand setting on the overhead projector at the front of the room. I charged a plastic rod by friction with a cloth and brought the rod close to the pith ball. The students observed the pith ball at first attracted to then repelled from the rod. I then set up a nail resting on top of a foam cup with the nail just touching the pith ball. I charged the rod again, touched the nail and had the students observe the pith ball once again attracted to the nail then get pushed away and remain in a position away from the nail. We discussed the methods of charging and the idea of a field force and a contact force.

I found this demo helpful in illustrating the various ways to charge an object and the idea of an electric field. During discussion the idea that protons are moving came up again which gave me another opportunity to work on that misconception. It also gave the students a chance to apply what they just learned from the balloon demo to another situation. I found during this demo that using the balloon as a charged object worked better than the plastic rod, because it held the charge for a longer period of time.

The third demo was an electroscope demo. The students labeled the parts of an electroscope on the drawing in the demo handout. I charged a balloon and brought it close to the electroscope. The students observed the leaves separate and come together again when I removed the balloon. I touched the knob of the electroscope with a charged balloon. We discussed the difference in the charge on the leaves between the two actions. I then touched the knob with a charged balloon while also touching the knob with a finger from my free hand. When I removed the balloon, the leaves remained separated. We discussed the charge on the balloon and the action of my body in the process.

I found this demo to be very helpful. It came up in class discussion for several days afterward and again during review for the test. It was used to show charging by all three methods discussed in class (induction, conduction, and friction). It also brought up the idea of grounding and was a lead- in to our discussion on lightning. It once again brought up the misconception of protons moving and yet another chance to work on changing that misconception. It gave the students an opportunity to actually see and use an instrument illustrated in their textbooks. Many students would refer back to it when asking me questions and giving me explanations of how charged particles moved and resulted in the charging of other objects.

Overall I found the demos to be extremely helpful in teaching this unit. I was happier with the level of participation and with the types of questions I was getting from the students. However, I found that the demonstrations took considerably longer than I had expected, requiring 2 1/2 days of initial presentation and discussion and about another day throughout the unit on discussions of the demos.

Internet Activities

I developed handouts to guide students through two internet activities dealing with electricity to have the students effectively using computers. I believed that using the computer would pique and keep the interest of the students. However, survey data (to be discussed later) as well as classroom observations proved to not support this notion.

The first activity was about batteries and utilized a web site titled "How Stuff Works" at www.howstuffworks.com/battery.htm (Appendix B2.) I asked a series of questions based on the information provided on the website. The site discussed the history of batteries, which was helpful because the text does not provide much of this history. The site also discussed electrochemical reactions within batteries, arrangements of batteries and voltage of batteries.

I also had the students visit the Duracell Battery website at www.duracellusa.com (Appendix B3.) This site had a diagram of the inside of a dry cell battery and explained the function of each part of the battery. It also discussed batteries in various arrangements and voltages as well as giving a history of the development of batteries. This site also has a shockwave demonstration, but I was unable to get school authorization to download shockwave for student use before we used this site. This site was a little more detailed than the other site but less accessible.

The second internet activity involved the use of a college physics on line course developed at Michigan State University by Gerd Kortemeyer, Wofgang Bauer, Gary Westfall and others at the address lecture.lite.msu.edu (Appendix B4.) Although the terminology related to resistance was above the level of most of my students, I believed they could weed through the information and use a particular applet. This applet gives the student an opportunity to vary the arrangement and numbers of the resistors involved. Students can look at a series arrangement, a parallel arrangement, and a combined arrangement; they could vary the resistance of the resistors and the computer calculated the total resistance. My goal was to have them use this site before we discussed how to calculate total resistance in a circuit. I hoped that this site would help them come up with a way to express or describe total resistance in a circuit.

Unfortunately, the computer system at my school did not have the needed hardware/software to download the applet. Due to conflicts with scheduling the computer room, I also had to schedule computer time for both computer activities earlier in the unit than I would have liked. As a result, the resistor activities left the students frustrated and confused.

Problem Solving Handout

The textbook offers little opportunity for students to practice new knowledge requiring calculations. I developed a handout (Appendix B5) involving diagrams with the movements of charged particles as well as problems involving Ohm's Law, series and parallel circuits, and power. Various problems were assigned at different points in the unit as the material was covered. Some problems were assigned as review at the end of the unit.

Some problems involved distinguishing between correct and incorrect illustrations of concepts, calculations based on drawings, and calculations requiring student drawings. I feel that it is important for students to see questions presented in a variety of ways to help them learn how to apply information to different situations. Sometimes rewording a question, deleting a diagram, or including an incorrect drawing will throw students an unexpected twist, which confuses them. It encourages them to have some confidence in themselves by answering the questions based on their knowledge despite the confusing pieces. Also solving problems helps to make the connection between science and math. When solving problems requiring an equation, it is also helpful to change which variable is the missing piece of information. Using diagrams is helpful because many high school proficiency exams, as well as college entrance exams, utilize questions based on diagrams or require an explanation based on a diagram.

History of Electricity

Because of the MEGOSE objective focusing on the historical development of scientific concepts, I prepared a lecture on the history of electricity. I utilized information presented in a web site by Learning Power at www.sourthernco.com/site/learningpower. Students took notes on the information. The students were very familiar with some of the scientists, such as Benjamin Franklin. Other scientists, such as Michael Faraday, were names the students had heard before. However, they were not familiar with their contributions to science.

LABS - Appendix C

The students were randomly assigned lab partners using the seating chart option of my grading program for each new lab situation. I began doing labs this way to help students interact with their classmates and to learn to work with people that either they don't know or they don't like. I find that students are less likely to be consistently stuck in a group where only one student does all of the work. Students come more prepared to do the lab because they don't know with whom they will be working. Students worked in lab groups of two or three.

The first new lab activity was titled "Ohm's Law Lab", which focused on using Ohm's Law to calculate the resistance of three different resistors in a simple circuit. (Appendix C1) The purposes for this lab were: 1) to get my students into a lab situation with a somewhat simple activity, 2) to have the students learn how to use and read the meters, and 3) to have students perform some calculations, answer some questions and write a conclusion about the activity.

The students were to set up a simple circuit with one resistor, two batteries, a switch, wire, and voltmeters and ammeters and verify that they had an appropriate set up. They gathered data on the voltage provided by the batteries and the current flowing through the circuit. After collecting data, they were to use Ohm's Law to solve for the resistance of the resistors and in the conclusion they were to compare their data with the known resistance of each resistor.

Problems with the lab included faulty meters (couldn't measure current) and student misuse of meters. Therefore, the students measured only voltage and resistance and used these values to calculate current.

I found that this lab was not as useful as I had anticipated because of technical and human errors. I wanted the students to use Ohm's Law to solve problems by manipulating the equation as it was presented to solve for resistance. Since they ended up solving for current, there was no need to manipulate the equation. Many students have difficulty explaining a concept when you change variables. I discussed with the students the various relationships that this law represented later in the unit. Despite the difficulties, the students enjoyed doing the lab, preferring to do the calculations in this setting rather than simply having some problems to solve to practice using Ohm's Law. The students learned to show work with calculations, to write using complete sentences, to work in groups that were new to them, and to record data. They were eager to get back into the lab and to do more work with electricity. This was encouraging because one of my goals was to spark and maintain student interest.

The next lab was titled "Investigating Series and Parallel Circuits." (Appendix C2) This was based on the only lab that I did with this unit in the past; however, no circuits sketches were provided so as to encourage independent thinking. I rewrote this lab so that the students had to set up a series and a parallel circuit and draw a sketch of each circuit with three light bulbs. Their final setup had to be checked by me before they could break down the circuit. They also recorded brightness of the bulbs in the circuit with reference to standard brightness, which was the brightness of one bulb in a series circuit. They predicted what would occur in each circuit if the switch was moved to various positions within the circuit and then performed the experiment to test their predictions. They had to set up a simple series circuit including a diode. They sketched the diode, put it in the circuit, recorded observations, flipped the diode and repeated. They came up with their own reasons as to why such a device would be used in a circuit.

This lab overall was useful. Some students were very familiar with series and parallel circuits, but most initially did not know which circuit was which. This lab required students to make predictions about what should occur within a circuit. I found the students remembered a lot from this lab and that I could refer to this lab when answering review questions. However, the lab required two days rather than the one day planned, because of the time it took to set up each circuit. Students had difficulty properly manipulating the components and they easily became frustrated. They also failed to adequately read directions, so they had to redo some steps to get all of the needed data. They also incorrectly installed batteries. This turned out to be a good learning point: I did not tell the students how to set up the batteries and I did not immediately tell them what was wrong with their circuits. They had to use their knowledge to eliminate problems. The table where they recorded data for predicting and recording what occurred by moving the position of the switch in a circuit also was confusing to the students. Because of this, each group had to explain their data to me so they could make proper conclusions. Despite the stumbling blocks, this lab was useful in that students could determine problems with circuits and it emphasized the direction of movement of the charged particles.

The last lab was titled "Circuits." (Appendix C3) Students were required to set up a series circuit with two equivalent resistors and measure the total voltage across the circuit and the voltage across each resistor. They also had to measure current. They then added one more resistor to the circuit and measured total voltage and total current only. They followed this by setting up a parallel circuit and repeating the previous steps. The students calculated the total resistance in each circuit using Ohm's Law. This activity was followed by a series of questions, leading the students to make a relationship between total resistance, voltage, and current in each type of circuit. They also determined the individual voltages and currents across each resistor in both the series and parallel circuits with three resistors.

I was very excited about this lab. The students were not simply solving problems using Ohm's Law, but were using observations to determine relationships among variables not yet discussed in class. However, there were several problems. Because the multimeters did not measure current, the students used these to measure voltage only and used ammeters separately to measure current. I set up the labs so that students were measuring either voltage or current, but not both; they did either a series or a parallel circuit, but not both. They were then to combine data with other groups. This proved to be a wise decision. The students once again had technical problems (wires falling out of connections with battery holders, meters and switches) which delayed the process. The groups measuring voltage had more success than the groups measuring current. Some groups measuring current had difficulty setting up the ammeter and reading it accurately.

We spent one class day collecting data. We spent another day talking about the lab, what should have occurred, and the problems we came across. During that second day, I provided the students with data (which I collected) and had them work on the questions and calculations using this data. Many students initially struggled with the questions. They asked me a lot of questions and worked through their confusion and lack of self-confidence. Several students were on the right track and had the right answers but did not trust that they knew what they were doing. My goal of having the students determine the relationship between individual voltage and current and total voltage and current in series and parallel circuits was achieved with this lab.

ELECTRICITY PROJECT - Appendix C

At the end of the unit, I had the students do a group project based on an idea presented to me by a fellow teacher at Okemos High School. The students had to use their new knowledge of electricity and apply it to a given situation. For example, one group had to construct a circuit to indicate when a door was opened. The students were put into assigned groups of approximately four. One member from each group drew a project description out of a hat. The students followed guidelines presented in class to construct and present their circuits. (See Appendix C4 and C5 for project choices, guidelines, and grade sheet) The project counted for 20% of their test score for this unit.

Overall, the students enjoyed doing this project and it provided an alternative to the traditional pen and pencil assessment. Some groups had trouble getting started and some groups finished the project in one day; some groups worked very well together while some groups experienced major delays due to ineffective group dynamics. This assignment was useful in getting students to work together and share ideas. At the end of the project I had the students fill out a questionnaire (Appendix C6) about how they felt the project and group work went. If I received any reports in which group members were dissatisfied, I spoke with that group before giving them a common grade. Most groups received full credit for this project. I would like to find alternatives to the evaluation of this project.

EVALUATION

PRE & POST SURVEYS

With both the pre and post survey the first question asked students what they most liked about science class and the second question asked what they liked least about science class. This data is presented in Tables 3 and 4. The "other" category represents a combination of answers mentioned only once.

Table 3: Pre-survey (question #1)

PRE-SURVEY RESPONSE	PERCENT (85 STUDENT ANSWERS)
Experiments	44
Hands on activities	20
How and why	10
Other sciences/math	10
Other	10
Discussion/Demos/Lecture	6

Table 4: Post-survey (question #1)

POST-SURVEY RESPONSE	PERCENT (87 STUDENT ANSWERS)
Experiments	38
Hands on activities	18
How and why	3
Other sciences/math	12
Other	9
Discussion/Demos/Lecture	20

In both surveys, experiments were mentioned as the most liked part of science classes. After the unit however, the second most liked part of science was a category that included discussions, lectures, demonstrations, and worksheets. This same category was near the bottom of the list in the pre-survey. I believe this shows that breaking up lectures and lab exercises with discussions and demos increased student interest and involvement.

Question #2 on both surveys asked students what they disliked about science. Before this unit, bookwork and reading followed by labs and homework were the most disliked. After this unit, lectures were at the top of the list followed by labs and math related work. I found it interesting that lab related work appeared as one of the most liked as well as one of the most disliked parts of science classes. I found that what they most disliked was not performing the actual lab but the writing of lab reports and answering questions related to the lab. I also found that this shows differences in learning styles among students and that not all students like doing labs. Therefore it is important to provide a variety of activities throughout the unit to keep as many students as possible involved in their learning. Tables 5 and 6 below list the results from this question from each survey.

Table 5: Pre-survey (question #2).

PRE-SURVEY RESPONSE	PERCENT (84 STUDENT ANSWERS)
Bookwork/Reading	19
Labs	17
Homework	15
Vocab/Repetition/Memorization	10
Other activities	8
Other	7
Math/Sciences	7
Tests	7
Lack of Understanding	6
Lecture	4

Table 6: Post-survey (question #2)

POST-SURVEY RESPONSE	PERCENT (81 STUDENT ANSWERS)
Bookwork/Reading	11
Labs	17
Homework	1
Vocab/Repetition/Memorization	9
Other activities	10
Other	11
Math/Sciences	10
Tests	8
Lack of Understanding	0
Lecture	23

Listed in the Table #7 below are the top three answers to questions 3-6 in the pre-survey which concerned activity choices for learning new concepts and for reviewing previously learned concepts.

Table 7: Pre-survey questions #3-6 (n=number of student responses)

#3 - MOST LIKED NEW CONCEPTS (n=181)	#4 - LEAST LIKED NEW CONCEPTS (n=147)	#5 - MOST LIKED REVIEW (n=127)	#6 - LEAST LIKED REVIEW (n=117)
DEMOS	LECTURE	LABS	LECTURE
SMALL GROUP WORK	INDIVIDUAL WORK	SMALL GROUP WORK	PROBLEM SHEETS
CLASS DISCUSSIONS	PROBLEM SHEETS	CLASS DISCUSSIONS	INDIVIDUAL WORK

With the pre-survey, I found that students had a strong interest in the use of demos and class discussion and disliked lectures when presented with a new concept. I found this interesting and was pleased because I began my unit with demonstrations. I was intrigued, however, by the lack of interest in the use of computers in science classes. When reviewing previously learned concepts students preferred small group work and lab work and once again disliked the use of lectures. This data convinced me that I needed to keep lectures brief and to do them in between other activities if I wanted to keep the students involved in their own learning. I also found from the pre-survey that students wanted to know how and why things worked the way they do in regards to electricity.

Listed in the Table #8 below are the top three answers to questions #4,5 and 7 in the post survey that dealt with activities most and least liked with the electricity unit and activities they would like to do in the future.

Table 8: Post-survey #4,5 & 7 (n=number of student responses)

#4 - MOST LIKED (n=125)	**#5 - LEAST LIKED (n=94)**	**#7 - DO IN FUTURE (n=137)**
GROUP WORK	LECTURE	GROUP WORK
LABS	PROBLEM SHEETS	LABS
DEMONSTRATIONS	COMPUTER WORK	PROJECTS

This data was consistent with the most liked and least liked learning activities in general from the previous questions. I found that students enjoyed group work more than I previously believed and that they did not find the computer activities very useful or helpful. Many commented that they liked to use computers for games and personal interests but that they didn't find much use for them for science in general. They believed that the computer provides a wealth of information but if the topic is not something they are interested in on a personal level then using the computer is similar to using the textbook.

Responses to #6 of the post-survey were difficult to interpret and categorize. However, I did learn that the students really enjoyed the circuits project at the end of the unit as well as the lab work and demonstrations. As a result, I included a technology group project at the end of the next unit on electromagnetism and have been working on group projects for other units as well. I also plan to include more demonstrations when presenting new material in the upcoming school year.

PRE AND POST TESTS

Throughout this section on pre- and posttest scores as well as lab evaluation and new activity evaluation, I will make references to the "focus group". This unit was taught to all of the three classes I had for this course. In each of the three classes, I kept data for all the students that participated in the research. However, I also followed closely three students from each class and kept all of their written work. I have one student from each class in each of the following average grade ranges: A to B+ range, B to C range, and C to D range. Students 1 through 9 in all of the data presented are from this focus group. Students 1-3 are A range students; students 4-6 are the B to C range students; and students 7-9 are the C to D range students. Any student answers used as examples are from this focus group as well.

Rubrics for the grading of the pre and posttests are in Appendix D1, along with student responses to selected short answer questions. Multiple choice questions were graded for correct responses and were worth one point each on the pretest and two points each on the posttest. Short answer questions varied in points ranging between one and five depending on the information required to answer the questions. On all tests, the multiple-choice section is worth 40%- 50% of the test score and the short answer section is worth 50% - 60% of the test score. Listed on the following pages are the pre and posttest scores for the whole group.

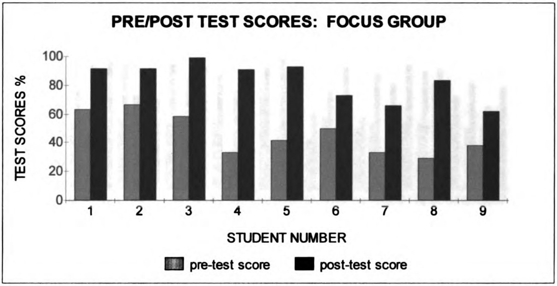

Figure 1: Pre/Post Test Scores - Focus Group

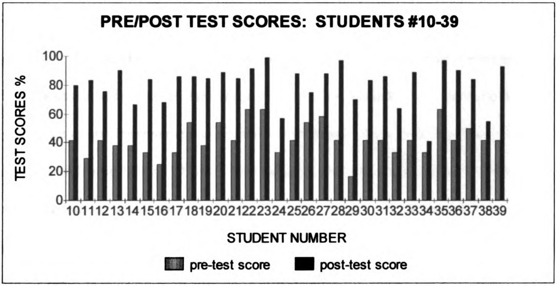

Figure 2: Pre/Post test scores: Students 10-39

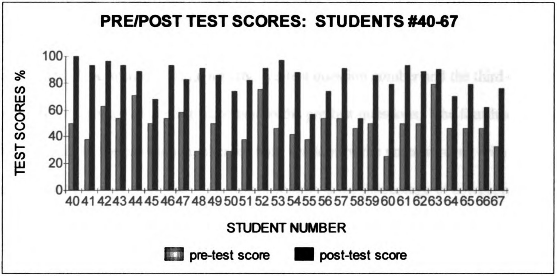

Figure 3: Pre/Post test scores: Students 40-67

The average pretest score was 45.5%. The average posttest score was 82.1%. A T-test was applied to determine if the differences in pre and posttest scores were significant. The standard deviation of the differences in pre and posttest scores was 13.4. This indicates a wide range in differences between these scores. As a result, actual significance of any improvement is difficult to determine. However, the t-value for this data is 22 with a probability of zero. This indicates that there is no probability that a similar random sample of data would have the same results. This means that there is a significant difference between pre and posttest scores. Therefore it is highly likely that the changes made in this unit were successful in improving the knowledge base of the students for this unit.

When determining if the new method of teaching is truly effective, it is important to also look at the type of questioning on pre and posttests. Tables 9-12 show the percentage of correct responses and provide information about individual questions.

Each table contains a title referring to the question style on the pre-test compared to the question style on the posttest. The first column refers to the MEGOSE or OPS objective being tested. The second column lists the pre-test question number and the third column shows the percentage of correct responses to the pre-test questions. The fourth and fifth columns refer to the question number for both versions of the posttest along with the percentage of correct responses. The totals column is the percentage of correct responses to posttest questions as a whole. The last column indicates the increase in percentage from pre to posttest. In tables 10 and 12 no information is provided for the individual versions of the posttest because there was no difference in question numbers.

Table 9: Pre/Post test data chart #1

		MULTIPLE CHOICE TO MULTIPLE CHOICE						
OBJECTIVE	PRE-TEST	% CORRECT			POST TEST			CHANGE
			A %CORRECT		B %CORRECT		TOTAL	
	4	13.4	3	100	10	93.8	97	83.6
PME 24	6	62.7	2	100	9	96.9	98.5	35.8
	10	26.9	4	42.9	11	43.8	43.3	16.4
	1	55.2	5	85.7	12	84.4	85.1	29.9
	2	73.1	7	91.4	14	81.3	86.6	13.5
OPS 1	5	61.2	8	88.6	15	81.3	85.1	23.9
	7	52.2	9	88.6	1	87.5	88.1	35.9
	8	56.7	11	80	3	71.9	76.1	19.4
	9	20.9	10	82.9	2	81.3	82.1	61.2

Table 10: Pre/Post test data chart #2

		MULTIPLE CHOICE TO SHORT ANSWER					
OBJECTIVE	PRE-TEST	% CORRECT		POST TEST			CHANGE
			A %CORRECT	B %CORRECT	TOTAL		
	3	17.9			20	50	32.1
	3	17.9			21	44.9	27
PME 24	4	13.4			17	47	33.6
	4	13.4			20	50	36.6
	4	13.4			21	44.9	31.5

Table 11: Pre/Post test data chart #3

		MATCHING TO MULTIPLE CHOICE				
OBJECTIVE	PRE-TEST	% CORRECT		POST TEST		CHANGE
			A %CORRECT	B %CORRECT	TOTAL	
R2/R14	21	51.3	13 97.1	5 96.9	97	45.7
	21	51.3	14 74.3	6 65.6	70.1	18.8

Table 12: Pre/Post test data chart #4

		SHORT ANSWER TO SHORT ANSWER				
OBJECTIVE	PRE-TEST	% CORRECT		POST TEST		CHANGE
			A %CORRECT	B %CORRECT	TOTAL	
	23	42.2			20 50	7.8
PME 24	23	42.2			21 44.9	2.7
	24	58.2			23 94.4	36.2
	25	64.2			23 94.4	30.2
OPS 1	22	32.3			19 69	36.7

For the posttest, the multiple-choice questions were the same in both versions but in a different order. The short answer questions were the same questions but with different numerical parameters. The last question dealt with series and parallel wiring but version A asked about this in reference to tree lights and version B in reference to home wiring.

This data shows that the greatest improvement of scores from pre to posttest occurred when students had multiple choice types of questions to test the same objective. The changes in short answer questions from pre to posttest were not as large. All of the objectives were covered in the various forms of questioning presented. I feel this indicates that there still needs to be improvement in the learning by the students. Students are still having difficulty applying their knowledge to new or similar situations. This indicates that a deeper understanding has not been fully achieved by the majority of students. There was improvement in this area but more attention needs to be given to learning activities in which students must apply their knowledge to new situations.

The average test score for this unit in the previous school year (1998-1999) was 86%, which is somewhat higher than the average for this year. However, there were some significant differences between the two tests. In 1998-1999 no information was included on the history of electricity. Also, the test was revised to be sure that all of the MEGOSE objectives were met and the short answer questions were revised to make sure that all objectives were adequately covered. There was no pretest given in 1998-1999 so it is difficult to determine the actual significance of this test average. However, it does indicate that the degree of change based on new materials may not be as significant as the pre and posttest scores would indicate.

LABS

All labs were graded based on 10 possible points. Points assigned vary somewhat depending on the amount of data and number of questions involved. The averages for the three labs are listed in table 13 below. Also listed in this table is the average for the one lab done with this unit during the 1998-1999 school year. This lab was similar to but not the same as the series and parallel circuit lab from this school year. Table 28 in appendix D2 shows lab scores for the focus group. As expected, lower end students didn't do as well.

Table 13: Lab averages

OHM'S LAW LAB	SERIES/PARALLEL LAB	CIRCUITS LAB	SERIES/ PARALLEL LAB '98-'99
8.6	8	7.6	8.9

The overall average dropped progressively. However, the difficulty of the labs also increased at the same time. Student errors in the first lab report were mostly minor math errors and failing to write a conclusion for the lab report. Errors for the second lab report included incorrect answers to questions and incorrect data. The students considered the third lab the most difficult and the average reflects the students' opinion. Student reports contained many errors from incorrect data to incomplete answers to questions and poor conclusions. I feel that even a C average is encouraging and that the labs were at least minimally effective based on averages alone. When comparing results from the series and parallel circuits lab from '99-'00 to that of '98-'99, one might believe that the new method was not effective. However, a direct comparison is really not accurate. The previous lab included only the set up of a series and a parallel circuit with three light bulbs and students recorded only observations. The new lab incorporated a better record of data collected and work with diodes. This lab also contained more questions that the students needed to answer.

The Ohm's Law lab was the first one done in this unit, and went well even with the change from calculating resistance to calculating current. The students were able to complete the lab, calculations and questions in one class period (50 minutes.) The students enjoyed working with the multimeters and using resistors rather than light bulbs. Some students didn't even know what a resistor was until this lab. The lab activity gave the students an opportunity to work with new people, practice calculations and learn what is expected in writing lab reports. The students came out of this lab actually asking for something more challenging to do.

The second lab involved determining properties of series and parallel circuits as well as how diodes function in circuits. I found that about half of the students knew the differences between the two types of circuits before engaging in the lab. Because of problems with keeping the wires hooked up in the circuits it helped to have several students who were familiar with the concepts involved. Once I checked their circuits I could then send these students to other groups to help them determine solutions to the problems they were having. It gave several students the opportunity to test their knowledge by teaching. Many students failed to read the directions, which slowed the work. The data tables included in the lab materials were confusing as well. However, despite the confusion and frustration, the students seemed to enjoy working in this lab situation. I found that many students wanted reassurance that their answers to the lab questions were correct before turning in their lab report. For instance, a student would ask "your home is wired in series - right?" They became frustrated when I would not give a direct answer. Instead, I asked them what occurred in lab that brought them to that conclusion. Whether or not the student had the right or wrong answer, this type of questioning forced them to apply their data to another situation. In some cases, we discussed these questions during class the day before the labs were due. This lab showed me that many of my students did not trust their data and therefore did not trust their answers to the questions.

The third lab related to circuits was the one I found most exciting and frustrating. I really wanted the students to come to some conclusions about the relationships between voltage, current and resistance with this lab. I found that at the beginning of the lab the students were excited and eager to do another lab activity. However, after equipment problems I found the students were getting extremely frustrated and that all they really wanted by the end were the right answers. I sent the classes home without any homework and started fresh the next day. I gave the students the required data and discussed the lab the next day. This seemed to have a calming effect.

The students did not have any difficulties with the calculations section of this lab. However, they struggled greatly with the question section. With the first few questions, they were reading more into the questions than what was being asked for. Many students were on the right track with their answers but did not trust that they had any idea of what was going on. The classes spent a considerable amount of time asking questions related to this lab. After lab reports were turned in, we discussed the relationships between voltage, current and resistance in the two types of circuits. I feel that the lower lab average is the results of several aspects of this lab. Many students complained not about doing the labs but about having to write so many lab reports in a short period of time. I feel that this contributed to students rushing through the lab questions and making simple errors as a result. There was also a lot of frustration at the beginning of this lab. Most importantly, this lab required the students to explain the connections between the variables in a simple circuit. I have found that students want to simply repeat what you tell them. They do not want to have to think through the problem apply what they know to solve it. Overall, I feel this lab was effective in helping students to determine the relationship between the variables in Ohm's Law and circuits.

The students learned important skills needed for their electric circuits projects by doing the labs. Also, students use some of these skills at home when wiring speakers and setting up stereo/TV equipment.

NEW ACTIVITIES AND HANDOUTS

The three demos and accompanying handouts dealing with static electricity were successful. As the demos progressed, fewer students were stating that the protons were moving to cause charges, addressing a major misconception.

They also were very helpful in prompting student discussions. Because this material is presented fairly early in the school year, the students are still a little hesitant to participate due to peer pressure. Yet, once we got started, many students had an opinion that they wanted to express. Despite the success I felt the demos provided, the amount of time spent on them was too long. Some adjustments should be made to shorten the amount of time spent on the demos without diminishing their positive effects.

The first internet activity was discussed in class and became part of their notebook grade. The Duracell activity was completed by only a handful of students and was not counted for credit. The resistors activity was discussed briefly the day after the computer lab time was provided and I returned to it after we had discussed how to calculate total resistance. I did not find these sites particularly helpful and in fact found that they contributed to the confusion of the students instead.

The students were excited at first about using the computers and going to the computer lab instead of regular class. However, that is where the excitement ended. The students were disappointed that they were expected to look for specific information and write down answers and observations. They found the websites interesting but did not like the work that came with them. Many students commented that they were simply writing down answers to complete the assignment. In some cases, they even commented that they had no idea what the answer meant and they were learning nothing from the activity. With each new website, I had their attention and interest for about 5-10 minutes. This left about 40 minutes of ineffective use of class time.

Although the students indicated in surveys that they did not like problem-solving handouts, I feel that this handout was useful. Because it was used after concepts were presented and at various points throughout the unit, it gave me the opportunity to have the students reflect on their learning as well as provide practice for the math-related concepts. It also gave me the opportunity to work with students on an individual basis and to check students work more closely. Some students found that they thought they understood a concept when it was presented in class or knew how to solve a problem, but had difficulty when having to repeat the problem or explain the concept. This handout was checked for completion and reviewed and discussed in class. Even though it was not the preferred method of work, many students commented (directly to me) that they felt they needed such handouts to help them use the material presented in class. I feel this handout helped prepare the students for problem-solving questions on the tests. It also showed the students what concepts they needed more review and reflection on before taking the test.

The history of electricity was interesting and helpful but I feel it could be presented in a better way. The students spent more time taking notes with this activity than I prefer for one class period. However, they did ask questions about the scientists and the discoveries involved. The questions gave breaks in the lecture/note taking situations, which helped the activity go a little smoother. The answers to the test questions that pertained to the history of electricity indicated that they remembered some scientists quite well, and forgot about others. Changes need to be made for the students to remember the contributions of more of the scientists in this unit.

ELECTRICITY PROJECT

This activity was successful in that it kept the students active and involved in what they were learning. They were excited about doing a hands on project rather than simply writing a report. They were happy that the project counted for part of their test grade. They were pleased that it did not involve simply repeating a lab already done in class. I found that most of the students were involved and engaged in the activity. The group members bounced ideas amongst themselves, consulted with other groups and consulted with me. They had to think about what they had learned during the unit and apply it to a new situation. Some groups had more difficulty than others, but ultimately all groups constructed a working circuit. All but one group received full credit for this activity. Appendix D3 contains a sample student report for this project.

CONCLUSION

Overall, I feel that this unit was very successful. I was more comfortable teaching the unit and the students were more involved in the learning process. Both of these factors contributed to significant improvement in posttest scores compared to pre-test scores.

What I found to be most effective in this unit were the demonstrations and the electric circuits project. The demonstrations got the students actively involved in the presentation and discussion of the movement of charged particles. They kept the students' interest by using familiar items and experiences. The demonstration handout enabled the students to write down their ideas, to write down proper explanations and to compare the differences between the two. This enabled them to revise their own beliefs regarding these concepts. The demos provided an avenue for changing a big misconception (that the protons are moving and cause positive charges in objects.)

Although the demos were very useful, I spent too much time with them. This unit took approximately 20 days to complete. I need to pare this down to about 10-13 days to accommodate other required instruction. Next year I will spend less time with the balloons and possibly skip the pith ball demo. This gives me the opportunity to briefly discuss the parts of the atom and how objects obtain a charge. I feel the electroscope demo is the one that was most successful in promoting student learning. It required that the students really think about the movement of the charged particles to determine the charge on the leaves of the electroscope. I feel the pith ball demo was not as helpful as the electroscope demo and could be deleted.

The electric circuits project was a good end of unit activity. It gave the students an opportunity to work together and share ideas, as they would most likely do in a genuine job. It gave them the opportunity to either teach what they learned or to learn from fellow students. It required that they look at several possible solutions and not just the first one to come their way. I was very pleased with the student interactions and the circuits that the students built. However, I would like to find another way to grade this project. Group projects are always more difficult to grade because of issues involved with sharing responsibilities. I plan to consult with other teachers and look at other ways to grade group projects. One possibility is to add a small component (about 5 points) for competency.

Due to the success of the demonstrations and final project, I plan to incorporate more of these types of activities into other units that I teach. Several other units now have some type of project and in some cases it is a culminating project similar to this one. The electromagnetism unit followed this unit and I had the students do a group project on a specific type of technology (such as TVs or X-rays.) I plan to spend some in the summer of 2000 reviewing various demonstrations in order to incorporate a few more in several other units in this course.

I feel that the labs were needed and useful, but several changes need to be made. I feel the Ohm's Law lab was a good introductory lab for the students. However, I would like to do the lab as originally planned and have them calculate resistance rather than current which would require better equipment, which is on order. I will include a brief activity before we start the lab with the meters to teach them how to set up, use and read the meters correctly. This should carry over into the next two labs so that learning how to read meters is not a stumbling block in data collection.

The directions for the series and parallel circuits lab need to be written more clearly. The data tables need to be redesigned so they are easier to read and use. This lab should also be distributed and discussed on the preceding day, for more effective use of class time on lab day. The circuits lab also needs a discussion on the preceding day. Possibly on these pre-lab days the overall goal of the lab could be introduced and the students could determine the lab procedures needed to achieve this goal, as well as develop data tables for recording information collected. This would promote inquiry-based learning. I believe that I will divide the activities up among the student groups and have groups share data. Some groups will work on series circuits and others on parallel circuits, each group measuring voltage and current. Along with the new meters, wires with alligator leads and banana clips have been ordered. This will provide better set up of the circuits and less time will be wasted on reconnecting wires. It will also cut down on the amount of student frustration with this lab. With the use of better equipment, prelab discussions, and less student frustration, I plan to cut one day of the time spent on the circuits lab.

For effective use of the Internet, I should revise current activities, develop new activities, or perhaps not use computers for this unit. I should research how to effectively use the internet as a classroom tool. I need to utilize the computer in a way that reinforces the concepts I want the students to learn as well as keep their interest. More information is becoming available on their appropriate use in the classroom and I need to access this. I have found that most students know how to use the computer better than I do. One strategy might be to give the students an overall task or goal to be completed using the computer and allow them to find what they need. Later on in the course, I asked some students to do a search on glaciers and let me know about any sites they found useful. The students were very responsive with this activity. They told me not only about the site they liked and learned from but also about the sites that they did not like and why. They were actively engaged in the activity and covered the required material.

Even though the students indicated a dislike for problem solving handouts, they did request them in later units. Even though they don't enjoy doing them, they feel that they need the extra practice. I find the more practice situations I can give them that the more confident they become regarding their problem solving skills. The more confident they become, the more involved they are in class. I plan to spend some time revising and reviewing questions I have collected over the years to develop practice handouts for various units in this course.

As a result of this unit, I focused more on the MEGOSE and OPS objectives than I have in the past. I feel that this is important for me to do with all of my units. By focusing on the objectives, I found it was easier to write questions that would test for what I wanted to know. With so much material to cover, narrowing down the material to that relevant to the above-mentioned objectives has helped. The other teachers that teach this course and I are in the process of rewriting our exams and to reevaluate our course based on the MEGOSE and OPS objectives. With so many concepts to cover, and so little time to cover them, the focus of our material on the objectives will help us improve our course.

In this unit, the students were more actively involved in the learning process. Including activities such as demonstrations with discussions, lab activities, and group activities increased active student involvement. The students showed more excitement and interest in electricity with the variety of activities used than those in previous years. Activities that required limited student involvement, such as lectures, were shortened and included in between these other activities.

I was more prepared to teach the unit; more comfortable teaching the unit and more excited about the unit. I no longer dread teaching any of the physics units. Although I feel I have a lot to learn, I am more open to learning. I am no longer afraid to ask questions of my colleagues. I am no longer afraid to try something new. And I am no longer afraid of not knowing all of the answers. Preparing and teaching this new unit has taught me to better react to unexpected situations. It has made me excited about teaching in unfamiliar territory. I will carry this experience with me into the future as I begin to make similar changes to other units of instruction.

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BIBLIOGRAPHY

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APPENDIX A

PES
Hetfield 1999

Name ______________________________
Date _________ Period _____

ELECTRICITY AND MAGNETISM UNIT

PRE SURVEY

1. What do you like most about science class?

2. What do you like least about science class?

Use the following list of activities to answer # 3-4:

LECTURE, LAB, SMALL GROUP WORK, PROJECTS, COMPUTER WORK, PROBLEM WORKSHEETS, INDIVIDUAL WORK, DEMONSTRATIONS, CLASS DISCUSSIONS

3. a. When presented with a science concept for the first time, which activity or activities do you prefer to do? (limit of 3)

   b. What about this (these) method(s) do you like?

4. a. When presented with a science concept for the first time, which activity or activities do you least prefer to do? (limit 3)

   b. What about this (these) method(s) do you not like?

5. When reviewing a previously learned science concept, which activity do you prefer to do? (limit 3)

6. When reviewing a previously learned science concept, which activity do you least prefer to do?(limit 3)

7. What interests you about the topics of electricity and magnetism? Why?

8. Using the activities listed before question #3, which would keep you interested and learning with the topics of electricity and magnetism? (You may use one or a combination of activities.)

9. Is there anything specific that you would like to learn about the above topics?

PES
Hetfield 1999

Name ______________________________

Date ________ Period ____ Page # ________

ELECTRICITY UNIT

POST SURVEY

1. What do you like most about science?

2. What do you like the least about science?

Use the following list of activities for #3-5:

LECTURE, LAB, SMALL GROUP WORK, PROJECTS, COMPUTER WORK, PROBLEM WORKSHEETS, INDIVIDIUAL WORK, DEMONSTRATIONS, CLASS DISCUSSIONS

3. Which of the above activities were used in this unit?

4. Which method(s) did you like the best? Why?

5. Which method(s) did you like the least? Why?

6. See next page

7. In future units, what type of activities would you prefer to do

Thank you for participating in my research project. ☺

For each of the following activities, answer the following:

A) What did you like the most about the activity?
B) What did you like the least about the activity?
C) How do you think the activity could be improved?
D) On a scale of 1-10 (with 1 being the worst, and 10 being the best), rank this activity.

ACTIVITY	MOST	LEAST	IMPROVE	RANK
STATIC ELECTRICIY DEMOS				
BATTERIES DEMO				
OHM'S LAW LAB				
INVESTIGATING CIRCUITS ACTIVITY				
CIRCUITS LAB				
ELECTRIC CIRCUIT PROJECT				
LECTURES				
BOOK PROBLEMS				
PROBLEM HANDOUTS				
COMPUTER ACTIVITIES				

PES
Hetfield 1999

Name ______________________________
Date _________ Period _____ Page # _____

PRE-TEST
ELECTRICITY

Directions: Answer each of the following in the space provided.

_____ 1. Electrons that move from one object to another and then remain at rest produce
a. current electricity b. series electricity c. static electricity d. parallel electricity

_____ 2. The opposition to the flow of electricity is called
a. amperage b. resistance c. electric current d. voltage

_____ 3. If the different parts of an electric circuit are found on separate branches of a circuit, the circuit is called a (an)
a. open circuit b. transistor circuit c. parallel circuit d. series circuit

_____ 4. According to Ohm's law, if the resistance in a circuit is 25 ohms and the voltage is 5 volts, then the current flow in the circuit will equal
a. 0.2 ampere b. 5 amperes c. 30 amperes d. 125 amperes

_____ 5. If an object contains more electrons than protons, it is said to be
a. positively charged b. neutral c. negatively charged d. energized

_____ 6. For electricity to flow through a circuit, the circuit must be
a. open b. in series c. closed d. in parallel

_____ 7. A force of attraction would exist between a
a. proton and a neutron b. neutron and an electron
c. proton and a proton d. proton and electron

_____ 8. Lightning is a powerful form of electric
a. circuit b. insulation c. current d. discharge

_____ 9. When speaking of an objects ability to become electrically charged, it is important to remember that
a. only the protons move b. both the protons and neutrons move
c. only the electrons move d. both the protons and electrons move

_____ 10. An automobile battery is an example of a
a. wet cell battery b. dry cell battery c. thermocouple d. fuse

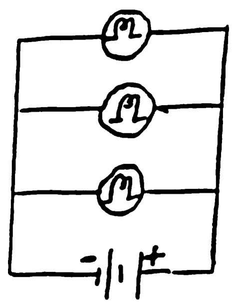
11. Match the scientist with his achievement in the areas of electricity and magnetism.

_____ a. Benjamin Franklin
_____ b. Alessandro Volta
_____ c. Sir Humphrey Davy
_____ d. Michael Faraday
_____ e. Thomas Edison

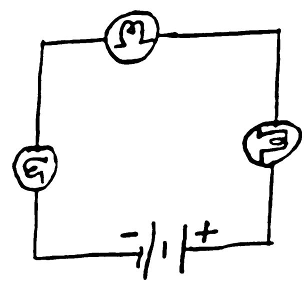
1. Invents a light bulb
2. Creates a battery-powered electric current
3. Invents the battery
4. Discovers electricity experimenting with lightning
5. Discovered that an electric current can induce magnetism

12. Explain why you get a shock after scuffing your feet on a carpeted floor and touching a metal door knob.

13. a. Which of the following circuit diagrams represents a series circuit? _____
    b. Which of the following circuit diagrams represents a parallel circuit? _____
    c. Label the direction of current flow in each diagram.



A



B

14. If you remove a light bulb from Circuit A (in the previous question), what will happen to the rest of the light bulbs?

15. If you remove a light bulb from Circuit B (in the previous question), what will happen to the rest of the light bulbs?

PES #_________

CH. 19 TEST **FORM A**

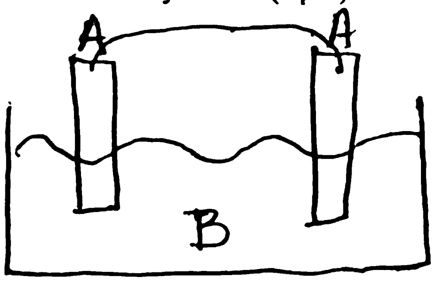
Multiple Choice: Choose the best answer for each of the following. Write your answers on the scan sheet provided. (2 pts. each)

1. A protective devise that contains a thin strip of metal that melts if current flow becomes too high is called a a. circuit breaker b. load c. fuse d. transistor
2. For electricity to flow through a circuit, the circuit must be
   a. in series b. in parallel c. open d. closed
3. According to Ohm's Law, current flow equals
   a. resistance times voltage b. voltage divided by resistance
   c. resistance divided by voltage d. voltage plus resistance
4. An example of a dry cell battery is
   a. car battery b. D cell battery c. photocell d. all of these
5. Electrons that move from one object to another and then remain at rest produce
   a. direct current b. alternating current c. resistance d. static electricity
6. Silver, copper, and iron are examples of good electric
   a. conductors b. inductors c. insulators d. radiators
7. The opposition to the flow electricity is called
   a. resistance b. voltage c. current d. power
8. If an object contains fewer electrons than protons, it is said to be
   a. positively charged b. negatively charged c. neutral d. energized
9. A force of repulsion would exist between
   a. proton and a neutron b. neutron and an electron
   c. proton and a proton d. proton and an electron
10. When speaking of an object's ability to become electrically charged, it is important to remember that
    a. only the electrons move b. only the protons move
    c. both the protons and the electrons move d. neither the protons nor the electrons move
11. The crackle that you hear when you separate socks which are stuck together from the dryer is an example of a. electric insulation b. static resistance c. static discharge d. all of these
12. A device that permits electricity to flow in one direction but not the other is called
    a. transistor b. resistor c. diode d. load
13. Alessandro Volta created the first
    a. light bulb b. battery c. lightning rod d. A & B
14. The scientist who is credited for discovering that an electric current can induce magnetism is
    a. Benjamin Franklin b. Sir Humphrey Davy c. Thomas Edison d. Michael Faraday
15. In a parallel circuit, every time you add resistance to a circuit the total current
    a. increases b. decreases c. does not change d. both increases and decreases

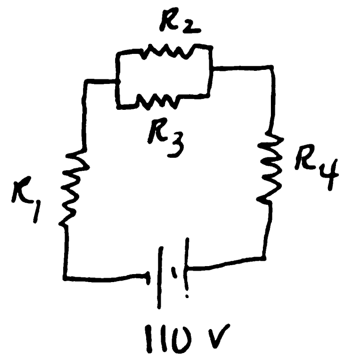
Short Answer section is on the back

SHORT ANSWER: Answer each of the following in the space provided on the answer sheet. Be sure to show all work and use complete sentences. Equations: P=V x I, E=P x t

16. Does the following diagram represent a dry cell or a wet cell? Letter A represents what? Letter B represents what? Explain how the battery works. (5 pts.)



17. What is the voltage flowing in an electric circuit if it has a current of 4 amps and 15 ohms of resistance? (2 pts.)
18. A refrigerator operates at 220 volts with 10 amps.
    a. What is the pOwer used by the refrigerator? Be sure to include units. (1 pt.)
    b. How much energy does the refrigerator need in order to operate for 4 hours? (1 pt.) Be sure to include units.
    c. How much will it cost to operate this refrigerator for 4 hours at a rate of 8 cents per kilowatt- hour? (1 pt.)
19. When you rub a balloon in your hair: (5 pts.)
    a. What charge does the balloon obtain?
    b. What charge does your hair obtain?
    c. What method of charging does this represent?
    d. When you bring this balloon near, but not touching , an electroscope what will happen?
    e. Explain why part d happens. Be sure to include the charge on the electroscope knob and leaves and the method of charging.
20. Draw a series circuit with 2 loads. If load 1 has a resistance of 10 ohms and load 2 has a resistance of 15 ohms and the voltage source supplies 100 volts, calculate the total resistance and the total current. (5 pts.)
21. Draw a parallel circuit with 3 loads. Include a switch controlling load 3 only. If the resistance of the loads are 10 ohms, 10 ohms, and 5 ohms and the voltage is 10 volts, calculate the total resistance and the total current. (5 pts.)
22. For the following circuit, calculate the total resistance and the total current. (3 pts.)



$R_1=2\ \Omega$

$R_2=10\ \Omega$

$R_3=15\ \Omega$

$R_4=5\ \Omega$

23. In an older string of Christmas lights when one light bulb goes out the whole string goes out. In a new string of Christmas lights, when one light bulb goes out the others remain lit. What is the difference between the two and why make a change? (2 pts.)

PES #__________

CH. 19 TEST **FORM B**

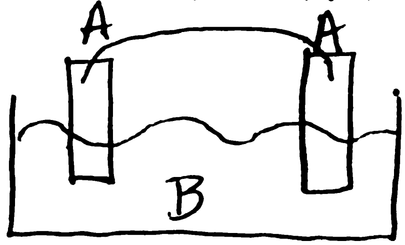
Multiple Choice: Choose the best answer for each of the following. Write your answers on the scan sheet provided. (2 pts. each)

1. A force of repulsion would exist between
   a. proton and a neutron b. neutron and an electron
   c. proton and a proton d. proton and an electron
2. When speaking of an object's ability to become electrically charged, it is important to remember that
   a. only the electrons move b. only the protons move
   c. both the protons and the electrons move d. neither the protons nor the electrons move
3. The crackle that you hear when you separate socks which are stuck together from the dryer is an example of a. electric insulation b. static resistance c. static discharge d. all of these
4. A device that permits electricity to flow in one direction but not the other is called
   a. transistor b. resistor c. diode d. load
5. Alessandro Volta created the first
   a. light bulb b. battery c. lightning rod d. A & B
6. The scientist who is credited for discovering that an electric current can induce magnetism is
   a. Benjamin Franklin b. Sir Humphrey Davy c. Thomas Edison d. Michael Faraday
7. In a parallel circuit, every time you add resistance to a circuit the total current
   a. increases b. decreases c. does not change d. both increases and decreases
8. A protective devise that contains a thin strip of metal that melts if current flow becomes too high is called a a. circuit breaker b. load c. fuse d. transistor
9. For electricity to flow through a circuit, the circuit must be
   a. in series b. in parallel c. open d. closed
10. According to Ohm's Law, current flow equals
    a. resistance times voltage b. voltage divided by resistance
    c. resistance divided by voltage d. voltage plus resistance
11. An example of a dry cell battery is
    a. car battery b. D cell battery c. photocell d. all of these
12. Electrons that move from one object to another and then remain at rest produce
    a. direct current b. alternating current c. resistance d. static electricity
13. Silver, copper, and iron are examples of good electric
    a. conductors b. inductors c. insulators d. radiators
14. The opposition to the flow electricity is called
    a. resistance b. voltage c. current d. power
15. If an object contains fewer electrons than protons, it is said to be
    a. positively charged b. negatively charged c. neutral d. energized

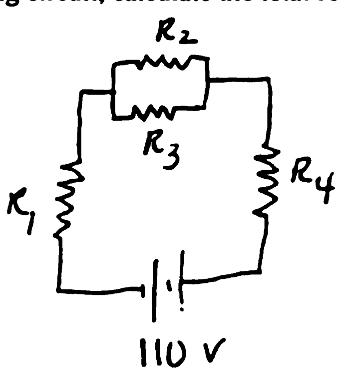
Short Answer section is on the back

SHORT ANSWER: Answer each of the following in the space provided on the answer sheet. Be sure to show all work and use complete sentences. Equations: P=V x I, E=P x t

16. Does the following diagram represent a dry cell or a wet cell? Letter A represents what? Letter B represents what? Explain how the battery works. (5 pts.)



17. What is the voltage flowing in an electric circuit if it has a current of 5 amps and 20 ohms of resistance? (2 pts.)
18. A refrigerator operates at 220 volts with 10 amps.
    a. What is the p0wer used by the refrigerator? Be sure to include units. (1 pt.)
    b. How much energy does the refrigerator need in order to operate for 8 hours? (1 pt.) Be sure to include units.
    c. How much will it cost to operate this refrigerator for 8 hours at a rate of 6 cents per kilowatt- hour? (1 pt.)
19. When you rub a balloon in your hair: (5 pts.)
    a. What charge does the balloon obtain?
    b. What charge does your hair obtain?
    c. What method of charging does this represent?
    d. When you bring this balloon near, but not touching , an electroscope what will happen?
    e. Explain why part d happens. Be sure to include the charge on the electroscope knob and leaves and the method of charging.
20. Draw a series circuit with 2 loads. If load 1 has a resistance of 15 ohms and load 2 has a resistance of 5 ohms and the voltage source supplies 110 volts, calculate the total resistance and the total current. (5 pts.)
21. Draw a parallel circuit with 3 loads. Include a switch controlling load 3 only. If the resistance of the loads are 20 ohms, 20 ohms, and 10 ohms and the voltage is 10 volts, calculate the total resistance and the total current. (5 pts.)
22. For the following circuit, calculate the total resistance and the total current. (3 pts.)



$R_1 = 5\ \Omega$

$R_2 = 10\ \Omega$

$R_3 = 15\ \Omega$

$R_4 = 5\ \Omega$

23. For the most part, is your home wired in series or in parallel? How do you know? Why is your home wired this way instead of the other way? (2 pts.)

APPENDIX B

PES/CH. 19
Hetfield 1999

Name________________________________
Date __________ Period _____ Page # _____

STATIC ELECTRICITY DEMOS

Directions: Write a description of each demonstration (using complete sentences) and record any additional observations or comments.

#1: BALLOON DEMO

*Description/observations:

*Explain what you observe. Give possible reasons why this is happening. (You are brainstorming here. Write down whatever comes to mind. We will go back and discuss later.)

*Discussion notes:

#2: PITH BALL DEMO

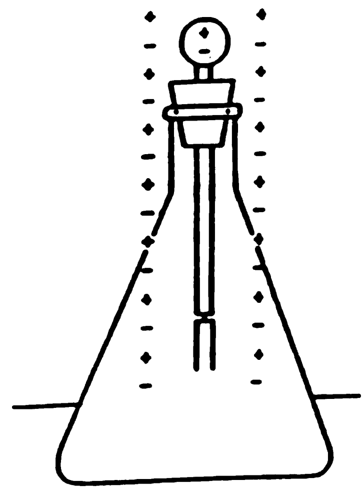
*Description/observations:

*Discussion notes:

Field force:
Contact force:
Methods of charging:

#3: ELECTROSCOPE DEMO

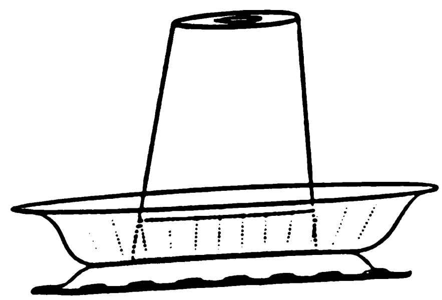
*Label the drawing:



*Description/observations:

*ELECTROPHORUS: describe and label drawing

Electrophorus



*1) Is the force that causes movement of the leaves in the electroscope a field or contact force?
2) What happens when you touch the electrophorus before bringing it towards the electroscope?

3) What is the purpose of the foam cup on the electrophorus?

*Discussion notes:

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BATTERY ACTIVITY USING THE INTERNET

- Log on to your computer.
- Click on
- In the location box, type the following address: http://www.howstuffworks.com/battery.htm
- Answer all of the following questions using this site in the space provided.

HOW BATTERIES WORK

1) What is an electro-chemical reaction?

2) Describe how a battery works.

3) Why does a battery "not dry out" just sitting on a shelf?

4) Explain the significance of the work of Alessandro Volta?

5) Compare Volta's experiment to the one we did in class.

6) Why do the alternating metals have to be different?

7) What is the purpose of the salt water and lemon juice?

8) What type of cell is the "voltaic pile"?

Note: This activity utilizes a web site titled "How Stuff Works." The URL is given at the beginning of the first page.

9) What type of cell is the baby jar set up?

10) Describe the Daniell Cell?

11) List at least 3 examples of batteries and how they are used.

12) Draw and describe the 2 arrangements of batteries shown.

13) Describe a 9-V battery.

Note: This activity utilizes a web site titled "How Stuff Works." The URL is given at the beginning of the first page.

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DURACELL WEBSITE ACTIVITY

- Log on to your computer.
- Click on the EARN BROWSER icon.
- In the location box, type the following address: http://www.duracellusa.com
- Click on the "Fun & Learning" bar.

- **Click on "Battery Science" to the left of the page.**

WHAT GOES ON UNDER THE COPPERTOP?

1) Batteries are really what? ____________
2) What is the energy conversion involved in a battery? ____________
3) What are the 3 most important material in a battery? ____________
4) What are the 3 parts in #3 made of usually? a. ____________
   b. ____________
   c. ____________

- **Click on "Anatomy".**

ANATOMY

Note: The sketch at the right is the same sketch on your screen.

5) Give the name of each labeled part and a brief description of that part.
   1. ____________
   2. ____________
   3. ____________
   4. ____________
   5. ____________

6. ________________________

7. ________________________

8. ________________________

9. ________________________

- ❑ **Go to the top left of the page and click again on "Battery Science".**
- ❑ **Click on "Chemistry".**

<u>CHEMISTRY</u>

6) 1ST PICTURE:
   a. The anode is made of ___________________
   b. It is oxidized so it ____
   c. This leaves behind ____

7) 2ND PICTURE:
   a. Where do the electrons re-enter the battery? ____
   b. They then combine with ____
   c. This process is called ____

8) 3RD PICTURE:
   a. What is the purpose of the water in the battery? _______________________________________
   b. When e- enter the cathode they react with ___________________ to form ________________
   c. The ___________________ reacts with ___________________ which causes the water to split into ___________________ and ___________________
   d. The hydrogen ion _____ combines with ___________________ to form _________________
   e. The hydroxide ion _____ flows to the ___________________and combines with ___________ to form ___________________ and ___________________.

- ❑ **Go back to the top left of the page and click on "Battery Science".**
- ❑ **Click on "Performance".**

<u>PERFORMANCE</u>

9) Explain how the batteries are lined up if they are in series and draw a sketch.

10) What happens to the voltage in such a setup?

11) What is a 9V battery really?

12) What is "capacity"?

13) What is the capacity of a cell in series?

14) Describe and draw a sketch of a battery with cells in parallel.

15) What is the total voltage in this cell?
What is the total capacity in this cell?

❑ **Go to the top left of the page and click on "Battery History".**
<u>BATTERY HISTORY</u>

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SERIES AND PARALLEL CIRCUITS INTERNET ACTIVITY

- ❑ Log on to your computer.
- ❑ Click on the EARN BROWSER icon.
- ❑ In the location box, type in the following address: http://lecture.lite.msu.edu
- ❑ Enter the following information:
  Username: **demo**
  Password: **demo**
  Class: **phy232c**
- ❑ Click on the login button
- ❑ Click on ∇ to the right of the welcome bar then click on chapter 4.
- ❑ Click on ∇ to the right of the Ch. 4 bar then click on 4.13.

RESISTORS IN SERIES

1) Draw a sketch of the series circuit example shown.

2) What is the total voltage for a series circuit equal to?

3) Describe (use an equation) the relationship between I_T and the current through each resistor.

4) How do you find the total resistance of a series circuit?

- ❑ **Click on ∇ to the right of the Ch.4 bar then click on 4.14.**

5) Write the question, draw the picture, and do the example.
(Ignore the potential divider section)

- ❑ **Click on ∇ to the right of the Ch. 4 bar then click on 4.15.**

Note: This activity utilizes a demo version of a lecture on line physics course offered through Michigan State University.

RESISTORS IN PARALLEL

6) Draw a sketch of the parallel circuit example shown.

7) Describe the voltage relationship for a parallel circuit.

8) Describe the current relationship for a parallel circuit.

9) Describe the resistance relationship for a parallel circuit.

10) What does adding a resistor in parallel always do to the total resistance of the circuit?

❑ **Click on ∇ to the right of the Ch. 4 bar then click on 4.16.**

11) Write the question, draw the picture, and do the example.

(GO TO THE NEXT PAGE)

❑ **Click on ∇ to the right of the Ch. 4 bar then click on 4.19.**

Note: This activity utilizes a demo version of a lecture on line physics course offered through Michigan State University.

APPLET: RESISTORS

On this page, you can experiment with the resistors in either series or parallel arrangements or a combination of both. As you do so, you will see the change in total resistance displayed. Review the page to become familiar with it and then do the following examples. If time remains, you may try some more arrangements on your own.

12) Initial Setup SKETCH:

R_1 = _____
R_2 = _____
R_T = _____
Series or Parallel (circle one)

13) Change the setup as follows: leave the setup as two resistors in series, double the resistance of R_1, leave R_2 as it is.

R_1 = _____
R_2 = _____
R_T = _____
Series

14) Change the setup as follows: leave the setup as two resistors in series, find at least 2 other combinations of R_1 and R_2 that will give R_T = 60 ohms.

R_1 = _____	R_1 = _____
R_2 = _____	R_2 = _____
R_T = 6O ohms	R_T = 60 ohms

15) Change the setup as follows: go to five resistors in series.

R_1 = _____ SKETCH:
R_2 = _____
R_3 = _____
R_4 = _____
R_5 = _____
R_T = _____

16) Change the setup as follows: leave the setup as five resistors in series, find at least 2 other arrangements of five resistors that will give RT = 150 ohms.

R_1 = _____	R_1 = _____
R_2 = _____	R_2 = _____
R_3 = _____	R_3 = _____
R_4 = _____	R_4 = _____
R_5 = _____	R_5 = _____
R_T = 150 ohms	R_T = 150 ohms

17) Change the setup as follows: go to two resistors in parallel.

Initial setup: SKETCH:

R_1 = _____
R_2 = _____
R_T = _____

18) Change the setup as follows: leave the setup as two resistors in parallel, double the resistance of R_1, leave R_2 as it is.

R_1 = _____
R_2 = _____
R_T = _____

Note: This activity utilizes a demo version of a lecture on line physics course offered through Michigan State University.

19) Change the setup as follows: leave the setup as two resistors in parallel, find at least 2 other combinations of two resistors that will give R_T = 15 ohms.

R_1 = _____	R_1 = _____
R_2 = _____	R_2 = _____
R_T = 15 ohms	R_T = 15 ohms

20) Change the setup as follows: go to five resistors in parallel.

R_1 = _____ SKETCH:
R_2 = _____
R_3 = _____
R_4 = _____
R_5 = _____
R_T = _____

21) Change the setup as follows: leave the setup as five resistors in parallel, find at least 2 other arrangements of five resistors that will give R_T = 5 ohms.

R_1 = _____	R_1 = _____
R_2 = _____	R_2 = _____
R_3 = _____	R_3 = _____
R_4 = _____	R_4 = _____
R_5 = _____	R_5 = _____
R_T = 5 ohms	R_T = 5 ohms

22) Change the setup as follows: go to series, parallel setup.

R_1 = _____ SKETCH:
R_2 = _____
R_3 = _____
R_T = _____
CLASS DISCUSSION:

23) Change the setup as follows: go to series, parallel, series setup.

R_1 = _____ SKETCH:
R_2 = _____
R_3 = _____
R_4 = _____
R_5 = _____
R_T = _____
CLASS DISCUSSION:

Note: This activity utilizes a demo version of a lecture on line physics course offered through Michigan State University.

24) What relationship do you see with each individual resistance and the total resistance in the series circuit? In the parallel circuits?

25) In # 22 – 23, explain how you might actually solve these problems for total resistance.

- ❑ **Click on ∇ to the right of the Ch. 4 bar then click on 4.29.**
- ❑ Copy and solve the problem. DO NOT SUBMIT.

❑ **Click on ∇ to the right of the Ch. 4 bar then click on 4.33.**

26) Copy and solve the problem. DO NOT SUBMIT.

- ❑ **Click on ∇ to the right of the Ch. 4 bar then click on 4.41.**
- ❑ Answer the first 3 questions on the computer.

❑ **Close the online browser and log off of your computer.**

CLASS NOTES:

Note: This activity utilizes a demo version of a lecture on line physics course offered through Michigan State University.

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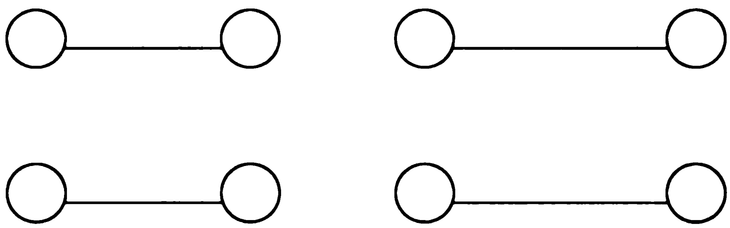
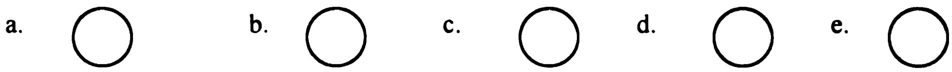
CH. 19 – ELECTRICITY – PROBLEM SOLVING

1. In the following diagrams, place an arrow in the direction current will flow on the wire if the circuit is closed:



2. In the blanks given below the drawings, place the letter of thediagram which best represents the charge on an electroscope during each of the procedures described. An answer may be used more than once.



_____ a) A positively charged rod is brought near, but does not touch, a neutral electroscope.

_____ b) A positively charged rod touches an uncharged electroscope.

_____ c) A negative rod is brought near a neutral electroscope but does not touch.

_____ d) A negative rod touches a neutral electroscope.

3. Write the formula, which represents Ohm's Law. Explain how to solve for any variable in the equation.

4. A load has a resistance of 40 Ω when a current of 20 amps flows through it. What is the **voltage** on the load?

Note: Some problems were taken from work prepared by Steve McGiveron – Science Teacher – Okemos High School.

5. There is a 22 Ω resistance in the heating element of a coffee percolator. It is plugged into a 110-V circuit. How much current passes through the heating element?

6. A 12 V battery produces a 500mA current when attached to a load. Calculate the resistance of the load.

7. A voltage of 25 V is applied to a 1.5 kΩ load. Calculate the current which will flow through the load.

8. A 22 Ω resistance is connected to a 110 V source of voltage. Calculate the current in the circuit.

9. A lamp operates at 115 volts with a current of 250 mA. What is the lamp's resistance?

10. A series circuit is made with a 50 V battery and a 100 Ω, 250 Ω, and a 500 Ω. A) Draw the circuit (include a switch) B) calculate the total resistance C) calculate the current flowing in the circuit D) show the direction of current flow in the circuit.

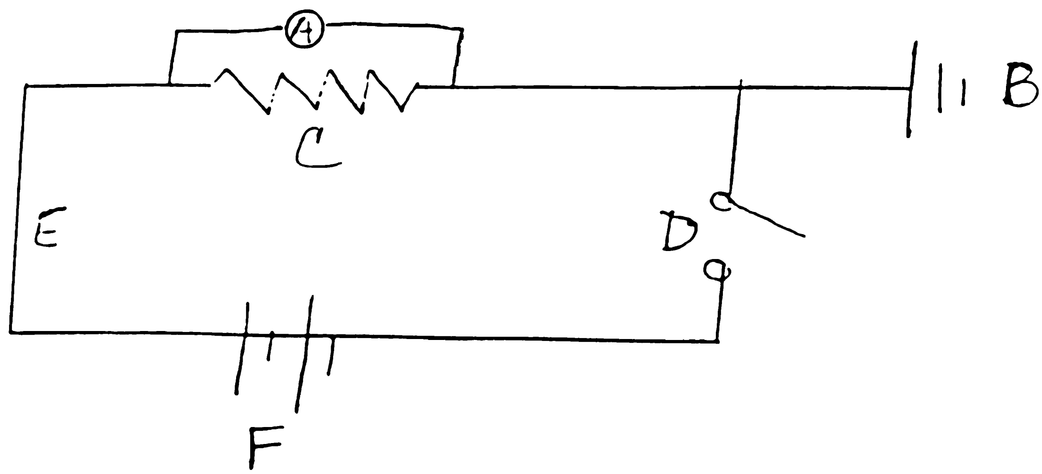
11. Draw a parallel circuit using the same loads given in question #10 and place the switch so it shuts off current to all loads. B) calculate the total resistance C) calculate the total current.

Note: Some problems were taken from work prepared by Steve McGiveron – Science Teacher – Okemos High School.

12. Three lamps with a load rating of 40 Ω, 60 Ω, and 80 Ω are connected in parallel to a 120 V circuit. A) what is the current in the 60 Ω lamp B) what is the total resistance C) what is the total current?

13. Five loads of 8 Ω, 4 Ω, 2 Ω, 6 Ω, and 10 Ω are connected in series. What is the total resistance? If a 120 V battery is connected to the circuit, what is the total current?

14. Use the schematic diagram below to match the letter with the circuit component. Draw an arrow loop inside the schematic to indicate the direction of current flow and then use + and – signs to indicate the polarity on the meter.



_____ a) meter _____ b) load _____ c) ground _____d) battery

_____ e) switch _____ f) wire

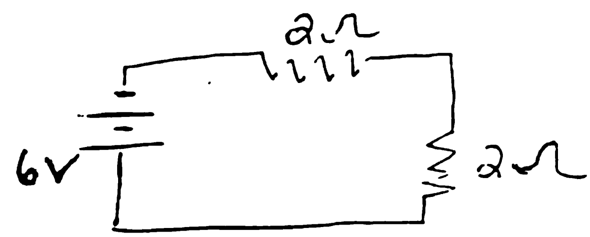
Note: Some problems were taken from work prepared by Steve McGiveron – Science Teacher – Okemos High School.

15 - 17: **Find the total resistance and the total current and state whether the circuit is series or parallel.**

15. R_T = _______________

I_T = _______________

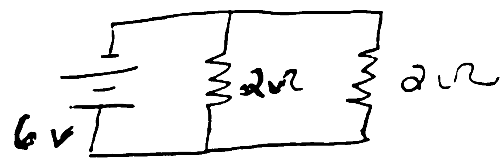
series or parallel



16. R_T = _______________

I_T = _______________

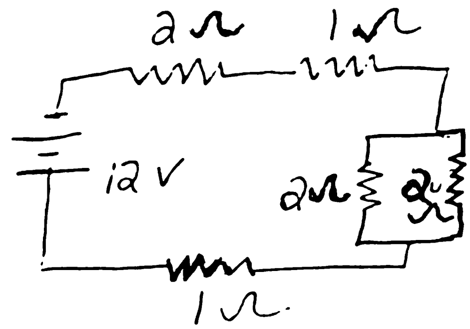
series or parallel



17. R_T = _______________

I_T = _______________

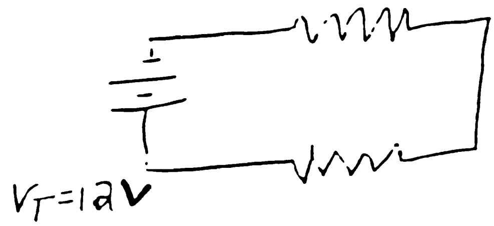
series or parallel

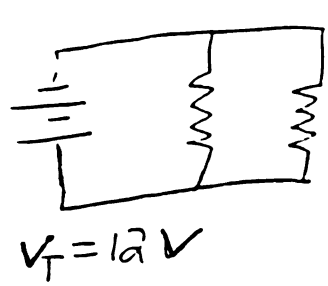


18 - 19: a.) find I_T, I_1, I_2, V_1, V_2, R_T if R_1=R_2= 1.5Ω

b.) find I_T, I_1, I_2, V_1, V_2, R_T if R_1 = 4Ω , R_2=2 Ω

18. I_T = __________
I_1= __________
I_2= __________
V_1= __________
V_2= __________
R_T= __________





19. I_T = __________
I_1= __________
I_2= __________
V_1= __________
V_2= __________
R_T= __________

Note: Some problems were taken from work prepared by Steve McGiveron - Science Teacher - Okemos High School.

20. Each time a load is added to a series circuit, the total resistance goes __________ so total current goes __________.

21. Each time a load is added to a parallel circuit, the total resistance goes __________ so total current goes __________.

22. What is the quick way to calculate the total resistance of several, equal loads which are connected in series?

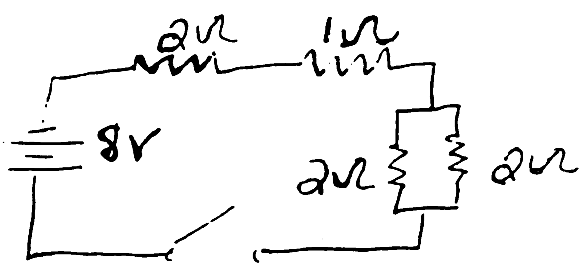
23. What is the quick way to calculate the total resistance of several, equal loads which are connected in parallel?

24. What is the quick way to calculate the total resistance of several, unequal loads which are connected in parallel?

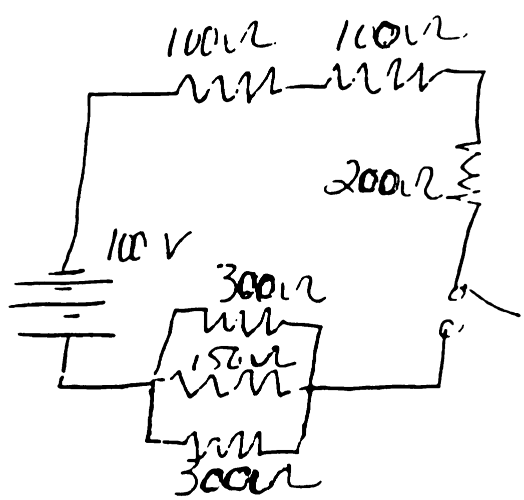
25. Describe the structure of an atom. How are atoms related to electric charge?

26 - 27: For each network circuit shown below: a) determine the total resistance of the circuit, b) calculate the total current, c) calculate the power used by the circuit.

26.



27.



Note: Some problems were taken from work prepared by Steve McGiveron - Science Teacher - Okemos High School

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CH. 19 REVIEW SHEET

1. What are subatomic particles?

2. What electric charge does a proton have? an electron?

3. What is the simple rule for the behavior of electric charges? Draw a picture showing this rule.

4. Describe an electric field. Draw a picture showing the electric field between two positive charges. Draw a picture of an electric field between 2 negative charges.

5. What is electricity?

6. What is static electricity?

7. Describe the three methods of charging an object.

8. How is lightning related to electricity?

9. What is voltage?

10. State Ohm's law. Describe what current and resistance are.

11. What is the difference between a wet cell and a dry cell?

12. What do DC and AC stand for?

13. Draw an example of a series circuit. Label each part of the circuit and show the direction of the flow of electrons.

14. Draw an example of a parallel circuit. Label each part of the circuit and show the direction of the flow of electrons.

15. Describe electric power and electric energy. Write the equation for each.

16. Explain why fuses or circuit breakers are used.

APPENDIX C

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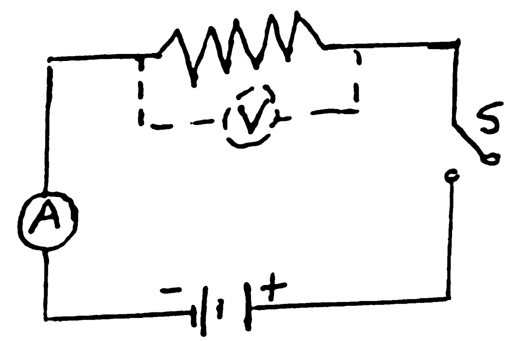
OHM'S LAW LAB

Purpose:



Procedure:

1. Using the +/- signs on the battery symbol, Determine the polarity of your two meters And mark them with a + and – sign. Now Set up the simple circuit shown to the right. Be sure you have your meters hooked up With the polarity shown on your diagram. **DO NOT PLUG IN THE POWER OR CLOSE THE SWITCH.**
2. Study the scales on the two meters and determine the value of the smallest division on the scales so you will be able to read the meters quickly.
3. When your circuit is set up correctly and you can read the scales, raise your hand and your teacher will come and check your circuit. You will be asked to show you can read the meters before you may continue with the experiment.
4. Once your circuit has been checked, record the color bands on the resistor in your data table, be sure the switch is open, turn the power knob on the power pack about halfway, and plug in the power pack. You will not change the setting on the power pack for the rest of the experiment. Have a member of the lab group at each meter ready to take readings and close the switch just long enough to read the meters. Open the switch immediately. **THE RESISTORS WILL GET HOT ENOUGH TO BURN YOUR SKIN! LET IT COOL FOR A MINUTE BEFORE YOU TOUCH IT.**
5. Without changing the setting on the power pack replace the resistor with another, which has different color bands. Station lab group members at each meter, close the switch , and quickly measure current and voltage. Open the switch.
6. Get another resistor and repeat step #5.

Data:

RESISTOR	COLOR BANDS				VOLTAGE (V)	CURRENT (A)
1.	a)	b)	c)	d)		
2.	a)	b)	c)	d)		
3.	a)	b)	c)	d)		

Calculations:

1. Use Ohm's law to calculate the value of the resistance for resistor #1.
2. Use Ohm's law to calculate the value of the resistance for resistor #2.
3. Use Ohm's law to calculate the value of the resistance for resistor #3.

Questions:

1. What current will flow in a circuit which has a 12 V battery hooked up to a load whose resistance is 100 Ω?
2. A 150 Ω is in a circuit, which has a 500 mA current. What is the voltage in the circuit?

Conclusion

Note: This lab was adapted from material prepared by Steve McGiveron - Science Teacher - Okemos High School.

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LAB: INVESTIGATING SERIES AND PARALLEL CIRCUITS

Purpose:

Procedure:

1. Set up a switch, battery and 1 light bulb in a circuit. Observe the brightness of the light bulb and record in the data table. Use the following chart for recording brightness for this lab.

S	Standard brightness
L	Less than standard brightness
M	More than standard brightness
N	No light

2. Add another light bulb to the first in series. Observe the brightness of the bulbs and record your observations in the data table.
3. Add a third light bulb in series. Observe the brightness of the bulbs and record in your data table.
4. Have your teacher check your circuit. Draw a sketch of your circuit. Be sure to include the polarity of you battery.
5. Unscrew one bulb from your circuit. Observe all the bulbs and record their brightness in your data table. Unscrew each of the other bulbs (one at a time) and record your observations.
6. Change the position of the switch by placing it between the first and second light bulb. Predict which light bulbs will light with the switch open and with the switch closed. Record your predictions in the appropriate data table. Test by closing your switch. Record your observations.
7. Put the switch between the 2nd and 3rd bulbs and repeat #6.
8. Put the switch between the 3rd bulb and the battery and repeat #6.
9. Take apart your circuit. Set up another circuit with a switch, battery, and 2 bulbs in parallel. Observe the brightness of the bulbs and record.
10. Put a 3rd bulb in parallel in your circuit. Observe and record the brightness.
11. Repeat step #4.
12. Repeat step #5 above with the parallel circuit.
13. Repeat steps #6-8 with the parallel circuit.
14. Set up a circuit as you did in step #1. Check the circuit to make sure it works.
15. With the switch open, arrange the diode in the circuit using the fahnestock clips. Sketch the diode as it appears in the circuit. Close the switch and record your observations.
16. Flip your diode over and repeat step #15.

Data:

SERIES SKETCH

PARALLEL SKETCH

Note: Portions of this lab were adapted from Electric Circuits, student activity book, National Science and Resources Center and the Science and Technology for Children.

Data:

TABLE #1

circuit	# of bulbs	bulb brightness			Take out bulb		
		1	2	3	1	2	3
series	1						
	2						
	3				*		
						*	
							*
parallel	2						
	3				*		
						*	
							*

TABLE #2

switch	SERIES						PARELLEL					
	prediction			actual			prediction			actual		
	1	2	3	1	2	3	1	2	3	1	2	3
P-B1												
B1-B2												
B2-B3												
B3-P												

TABLE #3

SKETCH	CIRCUIT OBSERVATIONS

Diode notes:

*symbol:

*diode:

*rectifier:

*uses:

Note: Portions of this lab were adapted from Electric Circuits, student activity book, National Science and Resources Center and the Science and Technology for Children.

Questions:
1. Which group of 3 bulbs gives the brighter light?
2. Is your home wired in series or parallel? Explain.
3. What does the arrow in the diode symbol represent?
4. What does a diode do?
5. Why would a diode be used?
6. What effect does moving the switch have on a series circuit? A parallel circuit?

Conclusion

Note: Portions of this lab were adapted from Electric Circuits, student activity book, National Science and Resources Center and the Science and Technology for Children.

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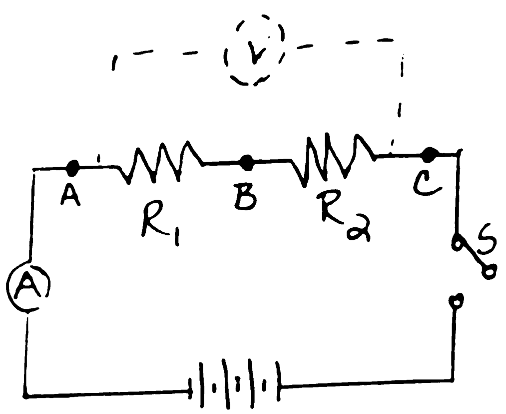
LAB: CIRCUITS

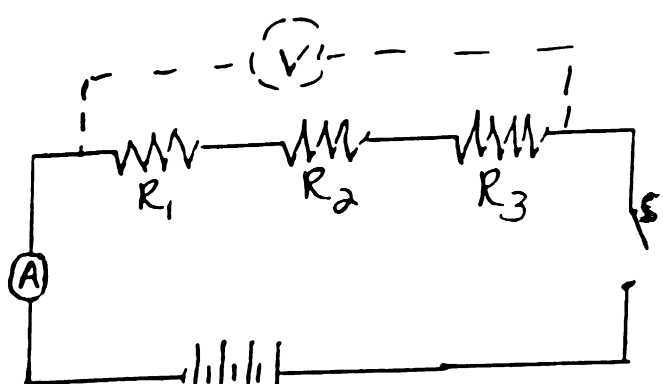
Purpose:

Procedure:

SERIES CIRCUIT

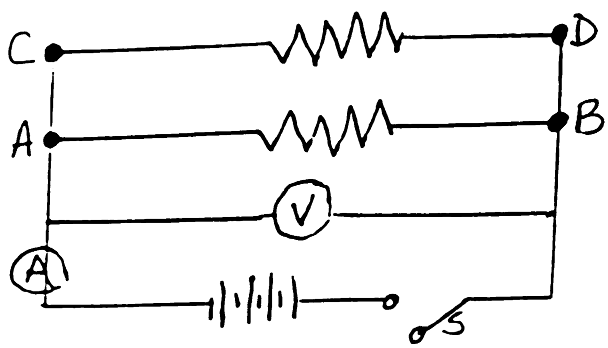
1. On the two resistor series circuit below (circuit A), label the polarity of the meters shown. With the power pack unplugged and the switch open set up the circuit. Make sure the polarity of the meters matches that shown in your diagram.
2. In your data record the color bands on each resistor and review how to read the meters. You have to read the meters quickly and open the switch to prevent the resistors from burning up.
3. When you have the circuit set up and you know how to read the meters raise your hand and your teacher will check the circuit. You will be asked to demonstrate your ability to read the meters.
4. Once your circuit has been checked, plug the circuit in, close the switch, and quickly read the meters. Open the switch immediately.
5. Connect the voltmeter to R_1 at points A and B in the diagram. Repeat step 4.
6. Connect the voltmeter to R_2 at points B and C in the diagram. Repeat step 4.
7. Disconnect wires at point B and connect the ammeter (+) to R_1, (-) to point B. Repeat step 4.
8. Disconnect wires at point C and connect the ammeter (+) to R_2, (-) to point C. Repeat step 4.
9. Repeat step #1-4 **only** with the three-resistor series circuit below (circuit B).

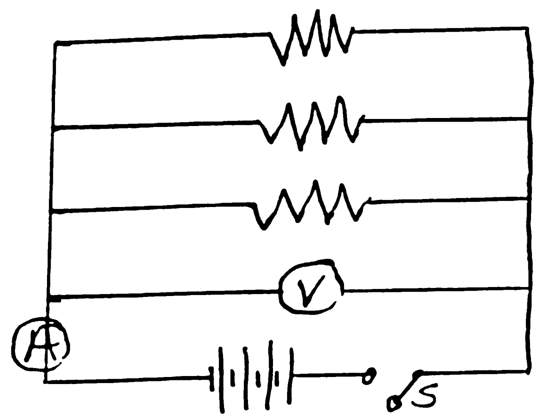




PARALLEL CIRCUIT

10. Repeat steps #1-4 for the two resistor parallel circuit below (circuit C).
11. Measure the voltage of R1 by connecting the voltmeter at points A and B. Repeat step 4.
12. Measure the voltage of R2 by connecting the voltmeter at points C and D. Repeat step 4.
13. Measure the current of R1 by connecting the ammeter between R1 and point B. Repeat step 4.
14. Measure the current of R2 by connecting the ammeter between R2 and point D. Repeat step 4.
15. Repeat steps #1-4 **only** for the three resistor parallel circuit below (circuit D).





Data:

circuit	color		bands		volta ge				curre nt			
					Vt	V1	V2	V3	It	I1	I2	I3
A	a)	b)	c)	d)								
	a)	b)	c)	d)								
B	a)	b)	c)	d)								
	a)	b)	c)	d)								
	a)	b)	c)	d)								
C	a)	b)	c)	d)								
	a)	b)	c)	d)								
D	a)	b)	c)	d)								
	a)	b)	c)	d)								
	a)	b)	c)	d)								

Calculations:
1. Calculate total resistance for circuit A.
2. Calculate total resistance for circuit B.
3. Calculate total resistance for circuit C.
4. Calculate total resistance for circuit D.

Questions:
1. Add the voltages V_1 and V_2 for circuit A. Is V_t equal to this sum? Is V_t equal to each individual voltage?
2. Add the currents I_1 and I_2 for circuit A. Is I_t equal to this sum? Is I_t equal to each individual current?
3. Add the voltages V_1 and V_2 for circuit C. Is V_t equal to this sum? Is V_t equal to each individual voltage?
4. Add the currents $I_1$and I_2 for circuit C. Is I_t equal to this sum? Is I_t equal to each individual current?
5. Based on your data, why do the bulbs in a series circuit burn dimmer than in a parallel circuit?
6. Based on questions 1-4, calculate each individual current and voltage for circuits B and D? (Show all work or give an explanation of how you did this. Record your answers in the data table.)
7. A 100 V battery is hooked up to a circuit that has 4 resistors in series. Each resistor is 50 Ω.
   a) draw the circuit (include a switch) b.) calculate total resistance c) calculate total current
   d) calculate the voltage that would be read on one resistor.
8. A 100 V battery is hooked up to a circuit that has 4 resistors in parallel. Each resistor is 40 Ω.
   a) draw the circuit with a switch that only controls two of the resistors b) calculate the total resistance c) calculate the total current

Conclusion: Answer the following in addition to the standard conclusion.
*As more resistors are added to a series circuit what happens to the total resistance and total current? What happens to total current and total resistance as more resistors are added to a parallel circuit?

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ELECTRIC CIRCUITS PROJECT

NOTE: This project will count as **20%** of your Ch. 19 **Test Score**. You will be given <u>some</u> class time to develop, build and test your circuits. However, you may need to spend additional time after school or during lunch to complete your circuit project.

Purpose:

Materials: Some materials will be provided. You may bring in other materials from home. Provided materials include wires, switches, bulbs, cardboard, and foam.

Procedures:
1. Draw a selection from your teacher for your project choice.
2. Brainstorm possible solutions to your problem. Come up with at least 3 solutions. Draw sketches of your solutions. Check in with your teacher when you have completed this step.
3. Choose the best solution form your list. Gather the needed materials and begin building.
4. Test your circuit. If needed repeat steps #2-3 until your circuit works.
5. Draw a sketch of your final setup. Include a list of the materials used and directions for building your circuit.

Data: For your data, attach your 3+ solutions with sketches. Also attach your final sketch and directions as stated in step #5. (See attached data sheet.)

Conclusion: In your conclusion, include an overview of the project. Also include what you learned from this project, what you liked about this project, and what you would do differently next time.

Turn In: ONE PER LAB GROUP – Be sure all group members names are on this!!!!

A. Solutions with sketches		5 pts.
B. Final product sketch		5 pts.
C. Final presentation		5 pts.
D. Conclusion		<u>5 pts.</u>
	TOTAL	20 pts.

Note: This project was adapted from a project created by Dave Chapman – Science Teacher – Okemos High School.

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Name ______________________________
Name ______________________________
Name ______________________________
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ELECTRIC CIRCUITS PROJECT

A) SOLUTIONS WITH SKETCHES – 5 PTS.	_____
B) FINAL PRODUCT SKETCH – 5 PTS.	_____
C) FINAL PRESENTATION – 5 PTS.	_____
D) CONCLUSION – 5 PTS.	_____

TOTAL = _____

A. SOLUTIONS:

Note: This project was adapted from a project created by Dave Chapman – Science Teacher – Okemos High School.

B. FINAL PRODUCT SKETCH AND DESCRIPTION

C. PRESENTATION

D. CONCLUSION

Note: This project was adapted from a project created by Dave Chapman – Science Teacher – Okemos High School.

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ELECTRIC CIRCUIT PROJECT CHOICES

- Indicate when rising water reaches a certain point. (This should work even if the water is distilled water and does not conduct electricity.)
- Indicate each time a person enters through a doorway.
- Indicate each time a pop can is passed into a holding container (i.e., box).
- Indicate each time a door is opened.
- Indicate if a desk drawer is opened.
- Indicate when moving air has stopped moving.
- If the level of water is dropping, your device should indicate when it reaches some specific low level.
- Indicate when the lid of a cardboard box is opened.
- Indicate when standing water starts moving horizontally.
- Indicate when an object is lifted off a specific spot on a table. (You won't be cutting holes in tables – but you can create a surface covering upon which the object is placed.)
- Indicate when water that is flowing horizontally stops moving.
- Create a "silent alarm". (i.e., a device that indicates that something has happened by turning on an "indicator" in another room.) – You get to decide what action is to be "announced".

Note: some of this list was adapted from a project created by Dave Chapman – Science Teacher – Okemos High School

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Hetfield 1999

Name ______________________________
Date __________ Period _____

CH. 19 PROJECT
GROUP WORK SURVEY

Topic: ____

Group Members: __________________________________

____

____

____

1. What task was your responsibility?

2. Did you complete your responsibility?

3. How do you feel **you** worked with the group?

4. Did other group members complete their responsibilities?

5. Comment on how the group worked as a whole.

APPENDIX D

PRE AND POSTTEST GRADING RUBRICS

The pretest was graded out of a total possible points of 24. The table below shows the points assigned to various questions. Rubrics for the grading of the short answer questions as well as student answers are presented on the next few pages.

QUESTION	POINTS
MULTIPLE CHOICE #1-10	10
MATCHING #11	5
SHORT ANSWER #12	3
SHORT ANSWER #13	4
SHORT ANSWER #14	1
SHORT ANSWER #15	1

Table14: Pretest point spread

SHORT ANSWER #12	3 POINTS POSSIBLE
KEY ELEMENT 1	build up of negative charge on the body
KEY ELEMENT 2	transfer of charge through a conductor (door knob)
KEY ELEMENT 3	shock due to quick release of charge (electric discharge)

Table 15: Pretest rubric #12

Student Example: 3 points

22 Explain why you get a shock after scuffing your feet on a carpeted floor and touching a metal door knob.

Static electricty 1 builds up so when you touch a conductor 1 you transfer the electricty off and get 1 shocked

Student Example: 0 points

22. Explain why you get a shock after scuffing your feet on a carpeted floor and touching a metal door knob.

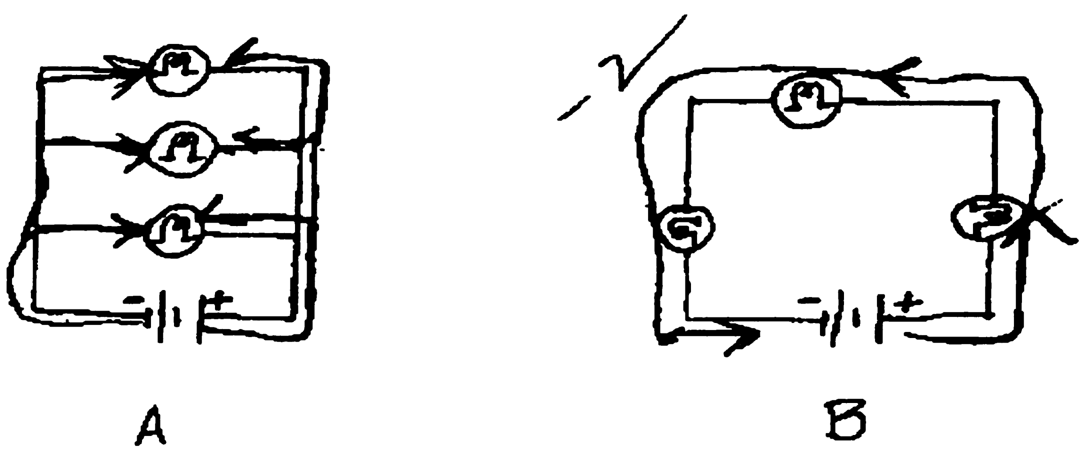
Because you gain protons then you touch the door knob and the proton jump to the door, to even out.

SHORT ANSWER #13	3 POINTS POSSIBLE
KEY ELEMENT 1 - 1 point	correct answer to a. B
KEY ELEMENT 2 - 1 point	correct answer to b. A
KEY ELEMENT 3 - 2 points	current flow labeled from the negative

Table 16: Pretest Rubric #13

Student Example: 2 points

23. a. Which of the following circuit diagrams represents a series circuit? A
b. Which of the following circuit diagrams represents a parallel circuit? B
c. Label the direction of current flow in each diagram.



Note: There were no student examples from the focus group nor from the whole group that received 4 points on this question.

PRETEST QUESTION #14	1 POINT POSSIBLE
KEY ELEMENT	the two remaining bulbs will still be lit

Table 17: Pretest Rubric #14

PRETEST QUESTION #15	1 POINT POSSIBLE
KEY ELEMENT	all bulbs will go out (open circuit)

Table 18: Pretest Rubric #15

Student Example: 1 point for each answer

24. **If you remove a light bulb from Circuit A (in the previous question), what will happen to the rest of the light bulbs?**

They will still turn on, it shouldn't effect the circuit

✓

25. **If you remove a light bulb from Circuit B (in the previous question), what will happen to the rest of the light bulbs?**

They will shut off because it will make the circuit open.

Student Example: no points

24. **If you remove a light bulb from Circuit A (in the previous question), what will happen to the rest of the light bulbs?**

The rest of the lightbulb will not work

25. **If you remove a light bulb from Circuit B (in the previous question), what will happen to the rest of the light bulbs?**

• The lightbulb may still work because of the direction in the currents.

The posttest was graded out of a possible 60 points. There were two versions of the test. The table below show the points assigned to various questions. Rubrics for the grading of the short answer questions as well as student answers are presented on the next few pages.

QUESTION	**POINTS**
MULTIPLE CHOICE #1-15	30
SHORT ANSWER #16	5
SHORT ANSWER #17	2
SHORT ANSWER #18	3
SHORT ANSWER #19	5
SHORT ANSWER #20	5
SHORT ANSWER #21	5
SHORT ANSWER #22	3
SHORT ANSWER #23	2

Table 19: Posttest point spread

SHORT ANSWER #16	**5 POINTS POSSIBLE**
KEY ELEMENT 1 - 1 POINT	wet cell
KEY ELEMENT 2 - 1 POINT	electrodes
KEY ELEMENT 3 - 1 POINT	electrolyte
KEY ELEMENT 4 - 2 POINTS	electrolyte reacts with electrodes causing one to gain electrons and one to lose electrons which creates a potential difference and allows the electrons to flow

Table 20: Posttest rubric #16

Student Example: 5 points

Wet Cell cell type ✓
electrodes ✓
electrolyte ✓

The electrodes are made of different metals One of the electrodes chemically reacts to the electrolyte, causing it to lose electrons, which the makes it positivly charged. The other electrode chemically reacts to the electrolyte to, only this time it gains electrons, causing it to be negativily charged. A wire is the connected from one electrode to the other, & current is also to flow.

Student Example: 1.5 points

16. Wet cell type ✓
Batteries A
lemon juice (conductor) N

The current flows through the juice, into the battery, through the wire and into the other battery. This makes a complete circuit.

SHORT ANSWER #17	2 POINTS POSSIBLE
KEY ELEMENT 1	used appropriate equation - V=I/R
KEY ELEMENT 2	correct solution - A: v=60v, B: v=100v

Table 21: Posttest rubric #17

SHORT ANSWER #18	3 POINTS POSSIBLE
KEY ELEMENT 1	correct equation and solution for power - A: p=2,200 W, B: p=2,200 W
KEY ELEMENT 2	correct equation and solution for energy - A: E=8.8 kwhr, B: E=17.6 kwhr
KEY ELEMENT 3	correct cost - A: $0.70, B: $1.06

Table 22: Posttest rubric #18

SHORT ANSWER #19	5 POINTS POSSIBLE
KEY ELEMENT 1	negative
KEY ELEMENT 2	positive
KEY ELEMENT 3	friction
KEY ELEMENT 4	leaves separate
KEY ELEMENT 5	charge of balloon rearranges the charge of the electroscope, knob becomes positive, leaves become negative and separate due to repulsion of like charges

Table 23: Posttest rubric #19

Student Example: 4 points

19 a. negative ✓
b. positive
c. conduction X
d. Induction will occur and the leaves will separate.
e. This is because when the negatively charged balloon comes close to the neutral electroscope, the rod's electrons will repel and move down leaving the top positive and the bottom and the leaves negative which causes the leaves to move and separate.

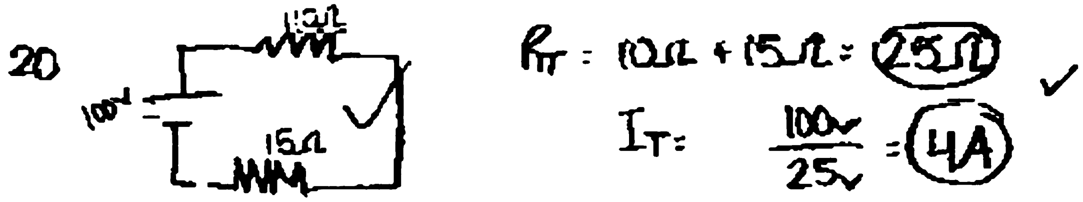
Student Example: 1 point

19. a. ~~negative~~ positive
b. negative
c. friction
d. the ~~two~~ ~~things~~ leaves will attract each other
Method is conduction, electrons leave the balloon and go to the knob, some electrons go to a leaf

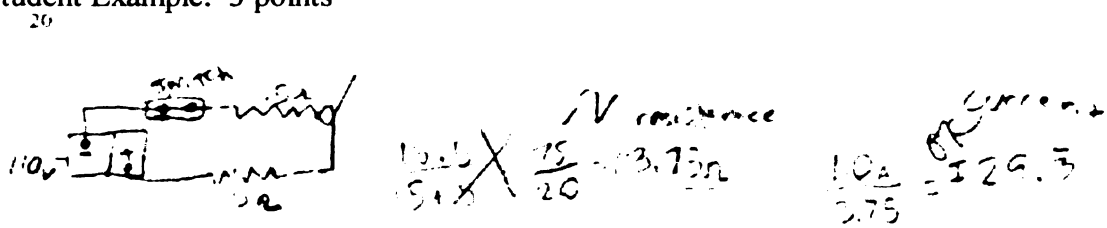
SHORT ANSWER #20	5 POINTS POSSIBLE
KEY ELEMENT 1 - 2 points	correct drawing and labeling of series circuit
KEY ELEMENT 2 - 2 points	used correct equation and solution for total resistance - A: R=25 W, B: R=20 W
KEY ELEMENT 3 - 1 point	correct solution for current - A: I=4 A, B: I=5.5 A

Table 24: Posttest rubric #20

Student Example: 5 points



Student Example: 3 points



SHORT ANSWER #21	5 POINTS POSSIBLE
KEY ELEMENT - 2 points	correct drawing and labeling of parallel circuit
KEY ELEMENT - 2 points	used correct equation and solution for total resistance - A: R=2.5 W, B: R=5 W
KEY ELEMENT - 1 point	correct solution for current - A: I=4 A, B: I=2 A

Table 25: Posttest rubric #21

SHORT ANSWER #22	3 POINTS POSSIBLE
KEY ELEMENT 1 - 2 points	correct solution for total resistance - A: R=13 W, B: R=16 W
KEY ELEMENT 2 - 1 point	correct solution for current - A: I=8.46 A, B: I=6.88 A

Table #26: Posttest rubric #22

SHORT ANSWER #23	2 POINTS POSSIBLE
KEY ELEMENT 1-TEST A	difference- old is series, new is parallel
KEY ELEMENT 1 - TEST B	parallel
KEY ELEMENT 2 - TEST A	keep lights longer, more use, easier to find/replace bad bulbs
KEY ELEMENT 2 - TEST B	when one light burns out-others still work, easier to find/replace bad bulbs

Table #27: Posttest rubric #23

Student Example: 2 points

23. The old string is strung as a series circut and the new one is strung as a parallel circut. In series if one goes out all the others will because it breaks the flow. In parallel it doesn't matter because the connection is different. The change allows us to only replace one bulb, rather than a whole strand.

Student Example: 2 points

23 For the most part it is wired in parrallel. I know that because if it was not than if you were to turn off one light than everything else in the whole house would go off.

Student Example: no points

23. my home is wired series ~~because~~ it is cost effective and it takes less power. also because it would take alot more wires for it to be hooked up paralel

I know because my mom told me it was.

STUDENT	OHM'S LAW LAB	SERIES/PARALLEL LAB	CIRCUITS LAB
1	9.5	9.5	9.5
2	8.5	9.5	6
3	10	10	9.5
4	9.5	7.5	7.5
5	8.5	7.5	9
6	8.5	9	9
7	0	7	6.5
8	10	8	8
9	4.5	7.5	3.5

Table 28: Focus group lab scores

STUDENT EXAMPLE: ELECTRIC CIRCUITS PROJECT

PES/CH. 19
Hetfield 1999

Name
Name
Name
Name
Date 10/21/99 Period 2-5 Page #

ELECTRIC CIRCUITS PROJECT

A) SOLUTIONS WITH SKETCHES – 5 PTS.	5
B) FINAL PRODUCT SKETCH – 5 PTS.	5
C) FINAL PRESENTATION – 5 PTS.	5
D) CONCLUSION – 5 PTS.	5

TOTAL = 20

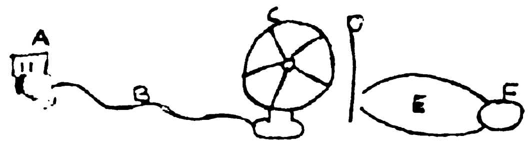
A. SOLUTIONS:

On seperate paper

Note: This project was adapted from a project created by Dave Chapman – Science Teacher – Okemos High School.

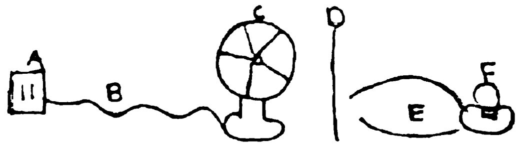
Solutions

1-Solution



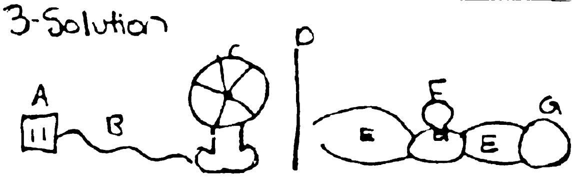
A: Outlet
B: fan wire
C: fan
D: tin foil
E: wires
F: buzzer

2-Solution



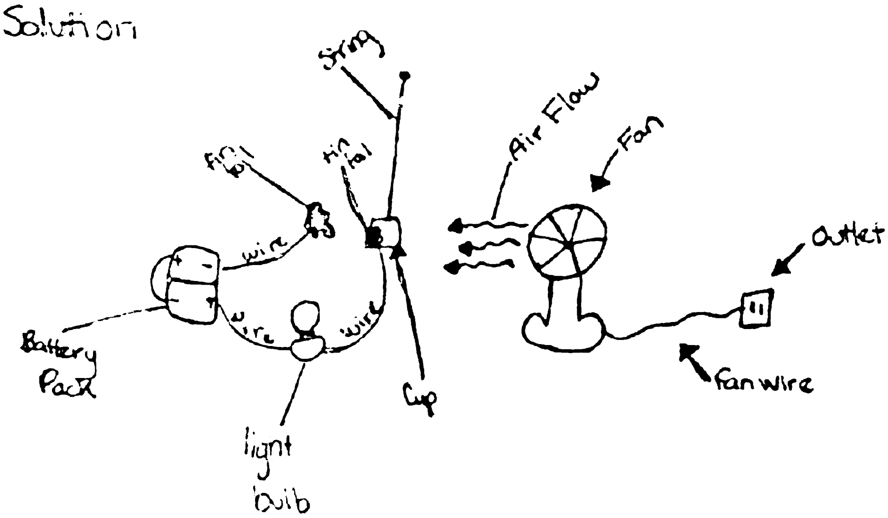
A: Outlet
B: fan wire
C: fan
D: tin foil
E: wires
F: light bul

3-Solution

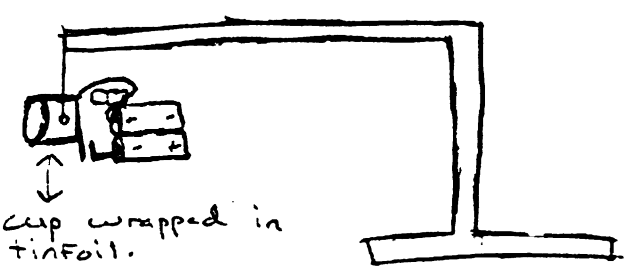


A: Outlet
B: fan wire
C: fan
D: tinfoil
E: wires
F: light bulc
G: Buzzer

4-Solution



B. FINAL PRODUCT SKETCH AND DESCRIPTION



C. PRESENTATION

Good

D. CONCLUSION

This was by far the most difficult circut we've ever had to set up. In our circuit the movement of air is represented by the sounding of the buzzer. We learned how to set up a more complicated circut, and use most of the information we learned in the chapter.

Note: This project was adapted from a project created by Dave Chapman – Science Teacher – Okemos High School