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DEVELOPMENT OF A PHYSICAL SCIENCE LABORATORY MANUAL FOR NON-SCIENCE MAJORS

By

Kendall Jay Sumerix

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Physical Science

1994

ABSTRACT

DEVELOPMENT OF A PHYSICAL SCIENCE
LABORATORY MANUAL FOR NON-SCIENCE MAJORS

BY

KENDALL JAY SUMERIX

Students with a non-science background entering college often encounter difficulty fulfilling their science requirement. These students, in particular, tend to avoid the physical sciences. A general introductory course in physical science called Introduction To Physical Science, meets the minimum science requirement for most non-science programs. To provide a more complete "hands-on" educational experience for these students, a physical science laboratory manual was developed to promote success in and understanding of the physical sciences.

A fifteen week, fifteen laboratory exercise manual was developed which would coincide with topics being taught in lecture. During development of the laboratory, emphasis was placed on students setting up equipment and performing selected tasks. These labs would reinforce lecture topics and provide some real world applications. Pre-testing and post-testing were done to assess the impact of five individual laboratory exercises.

Analysis of the pretest and post test scores revealed that the laboratory exercises did significantly improve student ability to understand basic scientific concepts. The students, several of whom had always despised science-related classes, indicated that the laboratory was their favorite part of the class. They were able to experience science "hands-on", which they then internalized and were able to apply, as their improved test scores indicate.

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INTRODUCTION

Physical science is a broad subject area encompassing physics, chemistry, astronomy, and the earth sciences. When condensed into one course offering at the college level, the study of physical science can easily become a game of trivial pursuit. As teachers, our task is not to burden students with the memorization of insignificant details, but rather to engage them in meaningful thought. This can best be accomplished by students experiencing the science laboratory in a way which has applications both in everyday life and in the scientific community.

At Alpena Community College, students enter under the open door policy with a wide range of interest and ability. Introduction To Physical Science (PHS 113) is a course which meets the science requirement for students seeking a non-science degree. This means that the majority of students enrolled in this course would not be enrolled if it were not a requirement for their degree. Almost all students in this course indicate that they have never been successful in science related courses, nor do they have any interest in the subject matter. It is essential for students to understand how science is connected to their everyday lives. I have chosen the science laboratory as the place in which to make that impact.

Creating laboratory exercises is never an easy task. Experiments which are too easy are boring for students, while those that are too difficult become frustrating. All of the exercises need to fit into a two hour time slot each week. Fifteen weeks were split into three major sections. The first five weeks would cover physics, the second chemistry, and the third earth science and astronomy. Weekly laboratory exercises would relate to the topics covered in lecture that same week. Usually, I tried to cover the subject without "giving away" the result of the next experiment.

I was looking for simplicity and content in a laboratory manual. After reviewing seven laboratory texts, I found none which met the goals I had set. Most did not follow the material set forth in the lecture text and therefore would have been considered irrelevant by students. Some of the manuals contained laboratory exercises so remedial in nature that they were better suited to third grade, rather than college. Therefore, a new manual specific to this course would have to be developed.

This new manual was needed by the Fall, 1992 semester. At a round table meeting held only four months before it was to be used, a preliminary schedule of laboratory exercise topics was decided upon by the department. At that time the math prerequisite for physical science changed to include intermediate algebra. Discussion of data about student ability indicated many would be unable to operate a scientific calculator. My first observation of the physical science room revealed that a "real lab" would be difficult to perform. The room was really nothing more than a lecture room with two sinks. Changes were necessary to accommodate the new laboratory experience. All of the laboratory exercises could not be carried out in the physical science laboratory. Therefore, while the first five experiments (physics) would remain in the physical science laboratory room, the second (chemistry) would have to be relocated to the adjacent chemistry laboratory. The third section of the course (earth science) was held in the physical science room. College course schedules were rearranged to accommodate these changes. Other changes included the development of a calculator exercise to familiarize students with the correct use of the scientific calculator. This would prepare them for solving problems in lecture as well as in the laboratory setting.

Although choosing the rooms and topics for new laboratory exercises was cumbersome, developing a workable laboratory manual would prove to be difficult. After pouring through dozens of textbooks and laboratory manuals, I came to rely most heavily on my old laboratory assignments from high school and college. For example, I felt that students would like to prepare aspirin during organic chemistry. Everyone knows what aspirin is, and producing it would be directly related to their everyday lives. Other exercises were developed in a similar manner. Student interest and participation were kept foremost in mind. To understand science, students need to be engaged in meaningful scientific experiments.

While, perhaps we are unsure what constitutes a scientifically literate citizen, we can state that society is in need of them. Those non-science students enrolling in science classes must learn to appreciate the physics of the world they live in, the chemistry of the bodies they occupy, and the fragile environment of the Earth they populate. How can they achieve this if they are unable to experience that which they have heard about? By affording these students a science lab that is not only practical but interesting and thought provoking, we enable them to become scientifically literate.

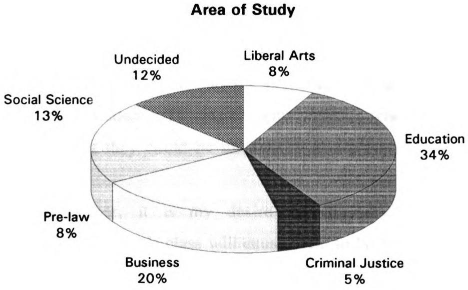
TEACHING TECHNIQUES AND STRATEGIES

Including laboratory exercises as part of a physical science class is accepted by almost all of the publishers of physical science texts. Most of the texts I reviewed offered an accompanying laboratory manual. However, there were vast differences in the experiments included in these manuals. Some manuals included unmodified physics and chemistry experiments which were far too mathematical for a general physical science course. Students would become bogged down in the details of the math involved, and too often miss the general concept being conveyed. The majority of the manuals, on the other hand, offered laboratory exercises suitable to an elementary classroom. These manuals included such elaborate equipment as flashlights and batteries. Students would surely view such exercises as busywork and would be soon turned off by laboratory work altogether. The only acceptable solution was to create laboratory exercises which involved students interacting with scientific materials, and apparatus in a professional laboratory setting.

Of the manuals reviewed, several contained good ideas and practical science. The authors usually began with physics, progressed to chemistry, and followed up with earth science and astronomy. Often it was quite obvious that an author was not an expert in all of these areas. Moreover, it was often evident that the author did not write all of the experiments. This could be observed by examining the differences in writing styles between the chemistry and physics sections of the same manual. These differences usually resulted in a contradiction of quality between the exercises. Most manuals did contain some good material. However, even these seemingly good manuals lacked progression from detailed directions at first to independent work later in the course. A good laboratory manual includes direction, focus, use of related terminology, as well as the ability to generate student interest. In addition, laboratory experiments designed to be completed in an actual laboratory setting, such as a chemistry laboratory, increase student involvement.

The laboratory setting is a very important part of teaching. Surroundings can influence behavior. Students are naturally curious about science, and most physical science students are also fearful of it as well. Their fear had never occurred to me until one day I led a class of 16 students to the chemistry laboratory for the first time. They followed me to the lab entrance and simply stopped, all 16 of them, at the doorway. After walking into the laboratory facility, I realized they were no longer behind me. I went back to the doorway and instructed them to enter the and view what was being described. They then moved forward approximately eight feet, and stopped again as one large mass of bodies. I had to tell them to enter and spread out into the aisles. These students were scared. This type of setting was completely foreign to them. From this point on, I knew that the decision to take the students into a real laboratory setting was the right one. How could I possibly teach chemistry to those who had never touched the apparatus or even seen the chemicals? Once I had seen these signs it was obvious that we needed both a physics laboratory for the physics section and a chemistry laboratory for the chemistry section. From this day forward the physical science classroom took on the appearance of a physical science laboratory.

Figure 1



Another piece of the teaching puzzle is to understand the audience. To determine this, a survey was taken every semester for two years. A total of 146 students were asked to describe their major area of study (Figure 1). Results indicated that the largest group of students (34%) were education majors. These future teachers, primarily elementary, would someday be responsible for teaching the same concepts I was trying to convey. It would undoubtedly be useful for them to have experience in the areas that they will someday be asked to teach. Another group of students (12%) were undecided about their educational goals.

Most students were fresh out of high-school, some were parents, and a few were even grandparents. Ages ranged from 17 to 55. Their math backgrounds extended from general math to calculus. Some had taken high-school chemistry, though most often 9th grade science was their last encounter. Popular topics usually include things students can either see or eat. For this reason, laboratory exercises were designed using predominantly common materials. Density of iron ore, horsepower generated by climbing stairs, and the preparation of aspirin sparked the interest of every student. The experiments were designed and also taught with the idea that they could be understood and enjoyed by a variety of students.

As a teacher, it is my desire that the student retain useful information. Perhaps this class will cause them to be better citizens. Our society desperately needs more individuals who understand the chemistry of nutrition, the physics of their body, and the earth upon which they live. It seems people remember best that which they have experienced for themselves. It is also obvious that they will be better apt to recall that part of science which they themselves have experienced.

LABORATORY INSTRUCTION

The first mistake that an instructor can make in a general survey course is to assume that the students have knowledge about the subject matter. This was especially true in the physical science laboratory. Some students could not use their scientific calculator to perform the most basic of operations, while others couldn't measure liquids in a graduated cylinder. Many had no recollection of ever using the metric system. I had considered these skills to be basic knowledge, familiar to all students. My initial plan had not taken into account the need for remedial instruction. Successfully integrating a review of basic skills with modern science would require significant transformation of my own theory. Laboratory exercises would need to begin with fundamental principles, and progress to a more sophisticated level. Directions would need to be explicit. Pre-laboratory discussion would require a review of use of laboratory equipment and problem solving strategies, along with the usual introduction. In the development of these laboratory exercises, modifications were made over a period of four semesters leading to the final laboratory manual presented here. Figure 2 lists the laboratory exercises which were developed and taught. Copies of these exercises are included in the appendix.

Figure 2

WEEK	NAME OF LABORATORY EXERCISE
1	CALCULATOR
2	DENSITY OF SOLIDS
3	ACCELERATION DUE TO GRAVITY
4	PENDULUM
5	SIMPLE MACHINES
6	HORSEPOWER
7	ELECTRICAL CONDUCTIVITY
8	DENSITY OF LIQUIDS
9	CHEMICAL REACTIONS
10	CHEMICAL/PHYSICAL CHANGES
11	ESTERS, THE FLAVORS OF LIFE
12	PREPARATION OF ASPIRIN
13	COMPUTER SPREADSHEETS
14	VECTORS AND DEEDS
15	GEOLOGY OF MICHIGAN

The Calculator exercise was developed to prepare students both for homework problems and for problem solving in subsequent exercises. This was the first laboratory exercise of the semester and was scheduled for the second class meeting. Required for this exercise was the purchase of a Casio fx-570 scientific calculator which students used as part of the exercise. First, students were made aware that their ability to use a scientific calculator would determine successful completion of the course. I demonstrated several functions of the Casio fx-570, including the memory, function keys, and the different modes in which the calculator could perform. Then it was time for the students to practice. Sample problems were written on the board for the students to solve on their own. After discussing the functions of about 10 additional keys, I pretended to be ignorant of a particular key's function, providing me an example with which to model problem solving. My silence forced the students to determine how they could use the calculator to figure out a particular key's function. In the remaining 90 minutes of the period, students were instructed to form groups and solve the problems on their laboratory sheet. This group work also caused the students to work together to accomplish a task. Team skills would be a necessary factor in the successful completion of future laboratory exercises.

This laboratory exercise was more successful than I had expected. An average grade of 91.8% indicated that students were able to use the calculator and its manual to solve mathematical problems. Solving equations such as those used in determining projectile motion solutions require the understanding of several calculator functions. The result of this action was that the students were able to use their calculator effectively throughout the semester.

The second laboratory exercise, Density of Solids, was a "real" science exercise in that students measured, analyzed, and recorded their own data. At that point directions needed to be very explicit. All of the directions were detailed, formulas were provided, and the report sheet indicated where all data were to be recorded. The objects used for measurement were all familiar. This helped students relate to the formulas involving rectangular boxes, cylinders, and spheres. Emphasis in this exercise was placed on procedure, structure, and organization. All student work had to be laid out in what has been termed the Alpena Community College Problem Solving Format. This format included listing all known, or measured values, as 'given'. Following the given, students had to list what they were trying to solve for as 'find'. In this exercise, they were solving for volume and density. The method then involved listing the equations used, such as $V = L \times W \times H$. Students then show all steps used to solve the problem, including units of measurement. Many students said that this was the first time they had been asked to show their work with all steps included. They resented having to follow a format and would have preferred to simply "get" an answer. However, later in the course several students stated that they appreciated this format when solving more complicated mathematical problems. The final part of this laboratory exercise involved students finding volume by displacement.

This was perhaps the most useful laboratory exercise of all to the students. They appeared to better understand density when the exercise was completed. Student work in later exercises clearly shows that they used the ACC Problem Solving Format. Obviously, they realized that they had been given a tool with which to do their work. Most students continued to follow the method throughout the course even if they were not asked to do so.

The third week's lecture topic coincided with the Acceleration Due to Gravity laboratory exercise. In this exercise, students dropped objects from a fixed height and measured the time it took them to fall. These data were used to calculate 'g', the acceleration due to gravity. I also incorporated the use of photogates for measuring time more accurately. Students were asked to drop a variety of objects, and then propose why these objects did not fall at the same rate. Measuring their own reaction time also created interest in this assignment. Students really enjoyed the acceleration activity, and seemed to gain additional understanding from completing this exercise. They often asked questions pertaining to material not yet covered in lecture. Also, this was to be by far the most mathematical exercise that these students had completed in physical science. At that point in the course, many students were still wondering what they needed to memorize to understand the material. After the gravity exercise, most recognized that their math and problem solving skills needed additional honing. It always amazes me when, for many students, gravity seems to fall in place during this exercise.

The Pendulum laboratory exercise was an investigation of the simple pendulum. As in the previous exercise, the stated purpose was to calculate 'g'. As with most early exercises, another purpose was to have students further develop their problem solving skills. Learning to collect the data, substitute it into a formula, and calculate an answer was critical. By that time, the class atmosphere had relaxed. Often, I could sit back and observe them rather than continually assisting students. They appeared to have gained confidence in their own ability. Also, they had achieved an appreciation for the fundamental units of length, time, and mass. Student confidence was perhaps one of the best measures of success in this laboratory setting. This exercise was basic enough that students felt confident that they could complete it on their own. This was important preparation for the more difficult labs to come.

The most confusing and unpopular laboratory exercise was working with Simple Machines. It was merely a watered down version of a physics laboratory exercise that I had done in school. The math involved wasn't the problem. As one student put it, "There are just too many different machines." Perhaps I had included too many machines in the same exercise. Students were rushed to finish and often offended when hurried from one machine to the next. However, this laboratory exercise was fundamental. It was very important because it represented the only chance students had to investigate and explore the various machines discussed in lecture. For this reason, discarding a portion of this exercise would be like indicating one machine is less important than another. Some students described it as challenging, while others simply referred to it as confusing. Most were successful in the completion of the activity, even though their calculations had to be done outside of the period. Overall, this exercise does serve the purpose of allowing students to explore the operations of various simple machines.

The Horsepower laboratory exercise was popular with those students who enjoy physically engaging exercises. The students were required to time themselves climbing a flight of stairs and then calculate their own horsepower. I used it as an exercise in tying together the concepts of work, energy, and power, including their respective units. Students calculated their horsepower using both the metric and English system, comparing their answers in each system. Using their own personal data such as weight and time to climb stairs placed a human value on their answer. Student ownership of their data proved valuable as the grades for this exercise were very high.

Electrical Conductivity serves as a bridge between the physics and chemistry units. Students were given unknown (but common) objects, which included predominantly minerals and household chemicals. They were asked to determine their conductivity. This exercise connects the physics of electricity with the chemistry of electrons and chemical reactions. First, students built their own conductivity tester. They were then allowed to choose 10 of the 20 available samples for testing. This freedom allowed them to become investigators of the great unknown.

The Density of Liquids laboratory exercise was designed to be an introduction to the chemistry laboratory. Students measured the mass and volume of several common liquids and used this data to calculate density. Samples of unknown liquids were then assigned. Students were asked to determine the density of each unknown, and, by comparison, identify it by name. One intentionally misleading part of this exercise was the use of rubbing alcohol. The bottle was clearly labeled isopropyl alcohol. However, since student results were usually 10% higher than those published, they assumed that they had made an error in their measurements. The following week, after reports were turned in, I disclosed that rubbing alcohol contains 70% isopropyl alcohol and 30% water. This reinforced the idea that even if their data were different, it wasn't necessarily incorrect. I believe that the concept of absolute right or absolute wrong answers are frequently overemphasized in the educational setting.

The ninth laboratory exercise was titled Chemical Reactions. The development of this exercise stemmed from the Science Olympiad tournament. Students were asked to complete a series of chemical reactions after they were given samples of unknown solutions (clear and colorless). They had to determine the identity of the solutions based upon information collected in the initial reactions. For both simplicity and waste disposal purposes, chemical analysis was completed drop by drop on acetate sheets. In this manner, the entire exercise could quickly and easily be repeated if necessary for identification of unknowns. Also, students saved their original reactions on one sheet for comparison to their unknown samples. Frequently, determining the identity of the unknowns brought about intense discussion between laboratory partners. Each group could only submit one answer. For this reason, Chemical Reactions is an excellent exercise involving team cooperation. Two years and over 150 students later, I have had only 3 teams of students incorrectly identify an unknown.

Chemical and Physical Changes was an investigation of the nature of chemistry. It included melting compounds, burning compounds, and the traditional treatment of an iron and sulfur mixture. Throughout the laboratory exercise, students were asked to perform tasks and then indicate whether they observed a chemical or physical change. Evaluation was based fifty percent on completion of the exercise and fifty percent on the correct answer indicating physical or chemical change. Students indicated that this was one of the three best labs of the semester. Without question, the most exciting part of the exercise was when students conducted a recrystallization. White crystals forming in solution and falling to the bottom of the test tube caused their eyes to light up as if they were once again six years old.

The eleventh week was titled Esters, the Flavors of Life, which gave students a brief introduction to organic chemistry. Students enjoyed preparing esters from carboxylic acids and alcohols. Ninety percent of the students rated the laboratory exercise as "good". Learning how organic compounds such as esters were prepared helped students make connections with several of the other organic groups discussed in their text. The esters they produced were common flavors such as wintergreen, apple, pineapple, rum, and banana. Preparing such commonly recognized compounds helped connect organic chemistry to the world which surrounds them. To evaluate their understanding of the exercise students were required to write a chemical equation for each reaction showing the molecular structure of each product and reactant. Once again, fifty percent of their grade came from the completion of the exercise, and fifty percent was a direct result of the correct chemical equations.

The chemistry unit ended with The Preparation of Aspirin. After several attempts on my part, a simple procedure for the preparation of aspirin was discovered. In my old organic chemistry text, Introduction to Organic Chemistry (Streitwieser and Heathcock), I discovered that aspirin could be safely and easily produced in a very short time. After reviewing three texts which described the preparation of aspirin, I created a fast and effective procedure. Students heated a mixture of salicylic acid and acetic anhydride using phosphoric acid as a catalyst. They then cooled it and collected the aspirin. Due to product purity, recrystallization was not necessary to obtain a fairly accurate melting point.

To perform this particular experiment in micro scale would have detracted from the outcome. Sometimes it is desirable to see the results on a larger scale. This exercise was especially well suited for larger amounts since the products, aspirin, water, acetic acid, and salicylic acid are not extremely hazardous waste. Students completed the activity by collecting their product through suction filtration, drying it, and obtaining a melting point. Their product was submitted in a labeled vial to be graded. Grades were based fifty percent on yield and purity, and fifty percent on the accompanying report.

Laboratory exercise thirteen, titled Computer Spreadsheets, was held in the newest college computer laboratory. Students created a spreadsheet dealing with the economics of iron mining, and also an x-y graph which showed the relative distance of the planets from the sun. The idea for the iron mining exercise originated on a trip to the Empire Mine as part of a class I attended called The Geology of Michigan. Students used a spreadsheet on Microsoft Works 2.0 to analyze the profitability of mining different types of iron ore. The examples used were discussed in the lecture portion of the course. The graphing segment of this exercise was covered during the astronomy unit.

The idea for a computer exercise in a physical science course is not new. The college, especially the science department, is adamant that every college course integrate the use of computers. At that point it was obvious that having the students complete a separate computer exercise was best. Incorporating extensive use of computers into an existing exercise would have been futile. Many of the freshman enrolled in this course had never used a spreadsheet before. Some indicated that they had never even used a computer before. Students were graded on their ability to produce a spreadsheet using the given data.

Due to differences in student ability, this exercise can be difficult to teach. After the first semester I concluded that the best instructional approach was for students to help one another. In spite of several problems in this exercise, student rating has been very generous. Sixty-nine percent said it was a "good" exercise. Additionally, since all math and science classes have incorporated at least one computer exercise, the incoming students to physical science were much better prepared for this exercise in subsequent semesters.

The Vectors and Deeds laboratory exercise begins the unit on the study of planet Earth. My introduction to this exercise began with the globe, and included a discussion of longitude, latitude, and the discovery of direction (i.e. magnetic north). This exercise was designed for use with the local Alpena County Plat Book. Students were shown the importance of direction in determining property descriptions. Since the majority of students come from a geoponic background, property descriptions presented a natural way to generate interest. A drawing of an irregularly shaped piece of property using a compass and protractor to measure length and angles concluded the activity. This exercise was graded on the correct completion of their report and two scaled vector diagrams.

The final laboratory exercise, The Geology of Michigan, was perhaps the most fun to teach. Although it was part lecture, I taught it as a laboratory exercise. This exercise surveyed the geology of Michigan, and was primarily the result of my participation in The Geology of Michigan. A portion of this session involved students viewing a slide show. I frequently interrupted the slide show to turn on the lights, and passed around samples of the various rocks shown in the slides. Throughout the presentation, students were encouraged to take notes. These notes were then to be compiled into a one page report describing the geology of Michigan.

EVALUATION

Evaluation is often a difficult task. One must choose a method which best fits the material being tested. Multiple choice tests, although very common, are difficult to prepare correctly. Essay questions and story problems often produce a more accurate representation of student knowledge. However, problems can arise when the time comes for grading these evaluations. Multiple choice tests can be graded objectively by an instructor with little or no variance between one test and the next. Essay questions and story problems are much more subjective in nature. These types of questions are almost always graded by allowing partial credit for a partially correct answer. A problem arises when, after grading fifty exams, an instructor begins to allow different amounts of credit for almost identical answers. For these reasons the perfect method of evaluation will probably never be developed. Other factors which should be incorporated into the measurement of student performance include laboratory skills and homework assignments. All of these evaluation procedures added together can assess student performance better than a single evaluation method. However, will evaluation of student performance alone indicate the success or failure of a particular course or, in this case, a laboratory manual?

Another part of the evaluation of this manual will include changes in student attitude. Physical science is designed for non-science majors. This means that the majority of students enrolled have either failed, or never developed an interest in science. Many students indicate that it is their intention to "just pass" this class. One of the most important goals of this course is to further science literacy among those who are not part of the scientific community. Therefore, for this particular course it would seem that success could also be indicated by a change in student attitude reflecting not only an understanding but also an interest in science. This new interest in science could then perhaps be carried along into their future role as conscious citizens.

As a major evaluation instrument to determine the success of this new manual, I have chosen to evaluate five of the fifteen laboratory exercises in the laboratory manual. The five were chosen primarily since they would be easy to evaluate. A separate test was developed for each of the five exercises to measure both the concepts and skills being taught. Careful testing would be required to accurately assess learning. Some students possessed knowledge before taking the class, while others learned the material in the lecture portion of the course. Still another group of students may have gained understanding of the material for the first time in the laboratory. All of the laboratory test topics were, to varying degrees, covered in lecture prior to being introduced in the laboratory.

Three testing times were required to assess learning that occurred solely due to the laboratory. The entire class was given an initial pretest hereby referred to as the initial test. For the physics portion of the course this test was given during the first week of class. The initial test over the chemistry unit was given five weeks later, just prior to the chemistry portion of the course. Then these same tests were given again as pretest or post test either before or after the laboratory exercises. Since there were two different sections of laboratory students, one group was given a pretest, and the other a post test. Tests given to students upon entering the laboratory were considered pretests. If they were tested after the completion of the laboratory exercise, it was considered a post test. The three tests are therefore named initial test, pretest, and post test in further discussions.

All of these tests were necessary to evaluate the effect of the laboratory exercises on student comprehension. The initial test is useful as a base line comparison. Pretests were given after a lecture but before the laboratory session. Therefore, it was anticipated that some students who learned the material in lecture would improve their scores on the pretest. Any increase from the pretest to the post test could then be considered attributable to the laboratory.

Table 1

MEAN SCORES

	Density	Simple Machines	Horsepower	Chemical Reactions	Chemical Physical Changes
Initial Test	$\bar{x}$ = 5.0 n =20	$\bar{x}$ = 1.8 n =19	$\bar{x}$ = 0 n =19	$\bar{x}$ = 8.0 n =20	$\bar{x}$ = 5.1 n =19
Pretest	$\bar{x}$ = 7.5 n =12	$\bar{x}$ = 3.5 n =8	$\bar{x}$ = 2.8 n =9	$\bar{x}$ = 8.8 n =8	$\bar{x}$ = 4.6 n =10
Post Test	$\bar{x}$ = 9.1 n =11	$\bar{x}$ = 4.0 n =11	$\bar{x}$ = 7.5 n =10	$\bar{x}$ = 10.0 n =10	$\bar{x}$ = 6.9 n =10

Scale of table is 0 - 10.
Table includes all students who took the test.

The first laboratory exercise tested was Density. In the column titled density (Table 1), the average score on the density test increased steadily (copies of these test are included in the appendix). Students were given a ten for a correct answer and a zero for an incorrect answer with no partial credit. A progression of the mean from 5.0 on the initial test to 7.5 on the pretest and 9.1 on the post test indicates that substantial learning occurred both in lecture and in the laboratory.

Table 2
T-TEST, STUDENT BY STUDENT

		Density	Simple Machines	Horse-power	Chemical Reactions	C/P Changes
Initial	N	11	8	9	8	9
vs	Mean increase	1.818	2.250	2.778	0.000	0.444
Pretest	P-value	0.083	0.021	0.025	0.50	0.22
Initial	N	9	10	10	9	10
vs	Mean increase	5.556	2.500	7.5	1.111	1.100
Post test	P-value	0.0067	0.011	0.000	0.17	0.024

Table includes only students who took both tests.

A computer program called Minitab (IBM) was used for statistical analysis. This program can be used to calculate several different statistical values such as a T-test by utilizing a single command. Using a right-tailed T-test on Minitab, results (Table 2) indicate that the amount of learning is statistically significant. Data used for this analysis includes only those students who completed both of the tests. Comparison of the individual student scores of 9 students on the initial and post test resulted in a P value of 0.0067. Since this P value is less than the significance level of 0.05 for a 95% confidence level we must reject the null hypothesis. Thus, there is significant evidence to support the claim that the post test scores are higher than the initial scores. However, a comparison of 11 individual initial and pretest scores is interesting. In this case, since the P value of 0.083 is greater than the significance level of 0.05 for a 95% confidence level, we must accept the null hypothesis. Therefore, these students performed no better, statistically, the second time they took the test than they did the first time. In conclusion, the scores of those students who completed the laboratory exercise increased significantly while the scores of those who did not complete the exercise did not increase significantly. The density laboratory exercise was therefore successful in teaching students about density.

The second laboratory exercise tested was Simple Machines. This test was also objective in that students were asked to order the pulleys by mechanical advantage. No partial credit was given, and eight points were possible. Their scores increased from 1.8 on the initial test and 3.5 on the pretest to 4.0 on the post test. The P value of 0.011 for the comparison of the initial and post tests indicates that this exercise did significantly increase the individual student scores. Analysis of the initial and pretest scores shows that the lecture also significantly increased student scores, with a P value of 0.021. Analysis of the means show an average individual increase of 2.5 for students completing the exercise and an increase of 2.25 for those not having done it. Students did have a larger increase in their score after the exercise, but it could not be shown to be statistically significant. Therefore it cannot be said that this laboratory exercise alone increased the scores on the simple machines test.

The third laboratory exercise was tested to demonstrate student understanding of Horsepower. Surprisingly, not a single student could calculate horsepower on the initial test, even when they were given the equations and conversions. Students were assigned a score of zero for a wrong answer, five points when the answer was correct but did not include the weight of the crate, and ten points if the answer was entirely correct. The five point partial credit was given because the students had never before included any additional weight when solving problems in the lecture or the laboratory. Also, the partial credit would help distinguish between those who understood enough to repeat an exercise and those who could apply their knowledge to other situations. The mean increase of 2.778 was significant on the initial and pretest results. Comparing the initial versus the post test showed a mean increase of 7.5. This is astounding and reflects a P value of 0.0000 (essentially zero). It can therefore be stated that the horsepower exercise is very successful in teaching students how to calculate horsepower. It could also be said that these students had an understanding of horsepower. Also, a mean increase of 7.5 (for the laboratory group) versus 2.778 (for the lecture only group) is statistically solid evidence to support the use of this laboratory exercise as a teaching tool.

The fourth laboratory exercise tested was Chemical Reactions. Students received a zero for the wrong answer and a ten for the correct answer. Unfortunately, the results are inconclusive since the chemical reactions test is more of a puzzle than a chemistry test. The mean progressed from 8.0 on the initial test to 8.8 on the pre-test and 10.0 on the post test. Results are so close on this small sample group that we cannot state any difference in the test scores. Once again, although the mean scores did increase, we cannot be certain that this was not simply due to chance according to the T-test. It should be noted that students may have learned something from the laboratory exercise that I did not test.

The fifth and final laboratory exercise tested was titled Physical and Chemical Changes. In testing this exercise, students were given examples of reactions and asked if they represented chemical or physical changes. No partial credit was given and a score of 10 was possible. The examples on this test were not covered either in lecture or in the laboratory. Mean scores of 5.1 for the initial test, 4.6 for the pretest, and 6.9 for the post test are confusing. The answer lies in the fact that the group of students given the post test performed much better on the initial test than did those who were given the pretest. Comparing individual scores on the initial and pretest shows a mean increase of 0.444 and a P value of 0.22. Thus, the students taking the pretest did, on average, increase their scores. But a P value of 0.22 indicates that, statistically, we cannot be 95% sure that this is not due to chance. Therefore, we must conclude that no significant increase in these scores occurred. In contrast, students who completed the initial and post test obtained a mean increase of 1.1. Since this P value of 0.024 is less than 0.05 we can therefore report a significant increase in the scores of students completing this laboratory exercise. In summary, those students who were only taught about physical and chemical changes in lecture did not retain sufficient information to increase their scores. Students who then experienced physical and chemical changes in the laboratory obviously learned more and were able to apply their knowledge to real world situations.

The results of these five tests clearly indicate that students do learn concepts and applications from hands on experience in a laboratory setting. They also understand and are better able to apply their knowledge. If properly prepared to accompany lecture topics, students can learn additional information from the laboratory to compliment what they learn in lecture. Other, more subjective, factors may also support this theory.

Grades aren't always an accurate indicator of student learning. They most generally reflect what a particular student knows and not what they have learned in class. Also, the group of students and their ability level changes from year to year. This makes comparing one year of grades with the next almost impossible. Grades, grading curves, and grading scales are rather subjective in nature. However, by looking at grades compiled over the past three years (Table 3) it can be seen that grades are increasing.

Table 3

COMPARISON OF STUDENT GRADES

	FALL '91		FALL '92		FALL '93	
GRADE	N	%	N	%	N	%
A/A-	6	11	8	20	11	22.4
B+/B/B-	14	27	18	45	11	22.4
C+/C/C-	18	34	9	23	13	26.5
D+/D/D-	5	9	1	2	4	8.3
E	2	4	2	5	2	4.1
W	8	15	2	5	8	16.3
TOTAL	53	100	40	100	49	100

Motivating students to succeed seems to be the most difficult task of all. I believe that laboratory exercises which are interesting provide motivation for students to learn. Some students do not understand science until they have experienced it. Student evaluations of the laboratory assignments (Table 4) show how students felt about these exercises. This data represent 162 students who completed these laboratory exercises over the past four semesters. They enjoyed the laboratory assignments as evidenced by their approval rating. Over 72% of those surveyed reported them as being good. One can only assume that student approval indicates student interest. Student interest is, in my opinion, prerequisite to student learning. Interest level was very high in the laboratory setting.

Table 4

STUDENT EVALUATION
OF
LABORATORY ASSIGNMENTS

NAME OF LAB	GOOD	FAIR	POOR
CALCULATOR	47%	49%	4%
DENSITY OF SOLIDS	60%	39%	1%
ACCELERATION DUE TO GRAVITY	79%	21%	--
PENDULUM	69%	30%	1%
SIMPLE MACHINES	63%	31%	6%
HORSEPOWER	67%	30%	3%
ELECTRICAL CONDUCTIVITY	73%	27%	--
DENSITY OF LIQUIDS	77%	22%	1%
CHEMICAL REACTIONS	77%	21%	2%
CHEMICAL/PHYSICAL CHANGES	80%	19%	1%
ESTERS, THE FLAVORS OF LIFE	90%	10%	--
PREPARATION OF ASPIRIN	88%	9%	3%
COMPUTER SPREADSHEETS	69%	24%	7%
VECTORS AND DEEDS	69%	28%	3%
GEOLOGY OF MICHIGAN	76%	23%	1%

An additional source of subjective evidence is the Student Opinion of Instruction survey which is given at Alpena Community College. This survey is anonymous and students were told that instructors would not be allowed to observe survey results until after the course had ended. Therefore, the students opinions should be considered as being accurate. Surveys were distributed in each individual laboratory section and a sample of the results is reported below. Students were asked, "What do you like most about the instruction of this course (lab)? Some responses were:

> "Overall, I enjoyed the labs. Their design is beneficial to my understanding of course material. Labs designed by instructor are organized well and appreciated by students."

> "The labs have a great variety to them, are for the most part interesting, and almost always 'bring it all together' or help with what the lectures bring out."

> "The labs are very exciting and fun. They go with the material that we learn in lecture the day before."

> "It is interesting to learn in an active atmosphere - rather than just listening to lectures."

> "I always know and understand what it is the teacher wants done. That was what worried me the most when I started. Now, it's no problem."

The students were then asked, "What do you like least about the instruction of this course (lab)?" Student responses indicated only one major complaint, that the simple machines laboratory exercise was too long and confusing. No other complaint was written about the other exercises except the fact that they did not like having to wear goggles. This survey information suggests that the students perceived the laboratory exercises as being necessary to their understanding of material presented in lecture. They also appreciated the fact that laboratory topics coincided with lecture topics. Students valued the laboratory experience. Many of them indicated that the laboratory was the best part of the class.

To improve existing laboratory exercises, I required another informal survey. In this survey, students were asked questions about the laboratory exercises. This is perhaps the ultimate evaluation of the success of a laboratory. Some student responses to those questions are presented here.

1) Q: Did you find the lab demonstrations/instructions helpful?

A: "Lab demonstration/instruction is helpful. It helps get rid of confusion. It clarifies the application of what is learned in lectures."

2) Q: Did you find the format of the lab reports useful?

A: "The format is good, not just for purposes of conducting the experiment, but for teaching the importance of organization. Many of the students in this course are first semester freshmen and they have learned an important point (thru) this format, I think."

3) Q: How did you feel about working with unknowns?

A: "Finding (identifying) the unknowns was great ! I may never take another chemistry course, but when I determined what my unknown was, I felt like I'd really done something!"

4.) Q: Do you think that the choice of labs was appropriate ?

A: "I think our labs are very appropriate. Because you design lectures and labs, and you tie them in together and when you do something after hearing about it, it is reinforced and really comes across."

5) Q: Do you feel that you understood the labs?

A: "I feel that the labs are done in a way so that everyone is able to understand."

6) Q: Did you enjoy science before taking PHS 113 ?

A: "I enjoyed science before this class, but not as much as I do now. Taking this course has increased my interest and enjoyment of it. I like classes which offer the 'hands on' approach rather than reading."

7) Q: How do you feel about science now?

A: "I enjoy lab, it helps me to learn and better understand the material discussed during lecture. In fact, I'm going to further my studies in science."

Evaluation of this subjective information is always less exact than the evaluation of the laboratory tests which were given. Laboratory test scores indicate that the laboratory exercises helped students understand and apply concepts and skills. Student opinions show that they value the laboratory experience. Not all exercises are equal in their ability to help students learn, nor in their ability to generate interest. Successful laboratory exercises coincided with lecture topics and were simplistic in nature. Designing laboratory work which teaches concepts is perceived by students as lending purpose to the laboratory setting. Education is enhanced by having students complete laboratory exercises.

REFLECTIONS

A new laboratory manual was developed which included fifteen laboratory exercises. Most important to the success of these exercises was the fact that they would teach students concepts and skills. Additional factors taken into account during the development of these laboratory exercises included: student ability, student interest, and relevance to lecture topics. The first few exercises were very structured. This was necessary at first to help teach the students organizational skills. Another major goal of these beginning exercises was to teach problem solving skills. Helping students to organize their work is a prerequisite to student learning. As one of my colleagues impressed in my mind, "Students need to be taught how to learn."

The problem solving technique which I have included in all laboratory exercises has proven to be an invaluable tool to the students. Organization provided by this type of structure has allowed me as an instructor to grade their laboratory papers more objectively. Student ability to solve problems is not the only benefit of the problem solving format. With everyone using the same format, I spend considerably less time grading papers and more time developing new laboratory exercises.

Updating laboratory exercises is a job which is never done. New exercises are always in various stages of development. At first I kept waiting for the day when this laboratory manual would be finished. Now, the realization has set in that this manual will never be finished. As new technology becomes available it must be incorporated into the classroom whenever possible. Some exercises, such as the one covering simple machines, are in need of immediate revision. Although students performed well on the assignment they seem to dislike its complexity. At the present time I am also developing an environmental laboratory exercise. In this exercise, students will test their own water and soil samples for selected impurities. This exercise will replace The Geology of Michigan activity which will be henceforth covered in lecture.

Another part of what I learned during this process involves students. Student opinion can sometimes, but not always, be used to indicate success or failure of a laboratory exercise. Good students are usually able to communicate the value of a particular exercise. However, student opinion cannot be taken at face value. One student who completed a survey in my class reported almost every exercise as being 'poor'. Students such as this are most likely failing the course and are not a reliable source of information. Just as a few students are always negative, a few are always overly generous in their evaluation. For this reason, it is better to consider a sample of students as a whole.

One problem with this study is sample size. Two groups of ten students each represented a relatively small sample size. This, however, can not always be controlled when people are involved. Humans are, at best, unpredictable. A total of thirty students were enrolled at the beginning of the class but an average attendance of twenty was normal.

Taking into account that only nineteen of them passed the course, perhaps the sample size of twenty was quite good. I will not attempt to account for those who did not complete the course successfully. It cannot even be hoped that all enrolled students will succeed in, or even begin to like, a particular subject. With this in mind, even if only a portion grasp that which has been presented, it will have been worth the effort. It is for these students that I continue to work developing materials.

The strength of these laboratory exercises lie in their ability to capture the students attention, cause them to question, and motivate them to find solutions. Most of these activities are tied to the real world and include no black boxes. Black boxes can be defined as equipment which students work with, but really have no understanding of. All of the exercises are directed toward topics currently being addressed in lecture. An especially effective activity was Preparation of Aspirin. Students enjoyed creating a product which was common to their lives. They learned many skills in the laboratory which would be difficult to measure on any written test. Use of suction filtration, a hot plate, and a melting point apparatus gave them an understanding of how other organic chemicals could be synthesized and identified.

Test results were astonishing. Before beginning this project it seemed improbable to me that there would be measurable gains in student achievement. After all, two hours is not a very long period of time. In spite of this, sizable gains can be recognized. Not included in these test results is long term retention. While it would have been interesting to see the results of a post test taken a month later, this would have been tainted data as the students could have acquired the information during lecture.

Another change altering test results would be omitting the laboratory test on Chemical Reactions. This test was far too elementary and students were able to answer it without referring to any chemistry. I did feel that this test was helpful in measuring their problem solving skills before completion of the laboratory.

The results indicate that non-science majors are overwhelmingly interested in science applications and that they can be taught to understand and appreciate the concepts involved. The individual laboratory tests evaluating gains in student knowledge and ability clearly show that these laboratory exercises were successful in teaching scientific concepts in ways which could not be accomplished through mere reading assignments or lectures. This study provides evidence that laboratory exercises greatly enhance and sometimes initiate scientific understanding.

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APPENDICES

APPENDIX A
TESTING INSTRUMENTS

Density

You have obtained a block of material which is 10 cm long, 8 cm wide, and 5 cm high and is shaped like a rectangular box. The mass of the object is 3560 grams and it is made entirely from only one of the metals listed below. Which of the following elements (listed below) is this object made from? (Use the information below to choose one of the 10 elements.)

Answer ____________________

Density

1) Iron
2) Silver
3) Copper
4) Aluminum
5) Zinc
6) Gold
7) Nickel
8) Lead
9) Magnesium
10) Sodium

Simple Machines

From the following diagrams of pulleys, answer the questions below.

A. B. C.

D E. F.

1. Which would be the most useful to multiply force (greatest mechanical advantage)?

____

2. Which would be the least helpful? ________

3. Now, rank the pulley systems from lowest to highest mechanical advantage?

lowest _____

_____

_____

_____

_____

highest _____

Horsepower

Calculate the horsepower generated when a 175 pound person carries a 100 pound crate up a flight of stairs in 4 seconds which has a vertical distance of 10 feet.

(Use the following information.)

$$1\text{hp} = 746\text{W},\ 1\text{hp} = 550\,\frac{\text{ft lbs}}{\text{s}}\quad W = F \times d,\ P = \frac{W}{t}$$

Chemical Reactions

You are examining the results of a laboratory test of an unknown substance. Assuming that the unknown substance is one of the 10 known substances below, determine the identity of the unknown. (Choose one letter(a through j) as your answer from below.)

Answer _______

	dissolves in water	turns black in Iodine	dissolves in alcohol	fizzes w/ NaOH	changes red litmus blue
a	x	x	o	o	o
b	x	o	x	o	x
c	x	o	x	o	o
d	o	o	x	o	o
e	o	x	x	o	x
f	x	x	o	x	x
g	x	x	x	o	x
h	o	x	x	x	x
i	x	o	x	x	x
j	x	o	o	o	x

x indicates reaction
o indicates no reaction

The unknown substance dissolves in both water and alcohol and changes red litmus blue. It doesn't fizz with NaOH but it turns black in Iodine.

Chemical and Physical Change

Write P for physical change or C for chemical change to indicate the type of change occurring. Write P or C in the spaces provided beside each example.

_______ 1. burning wood

_______ 2. melting iron

_______ 3. boiling water

_______ 4. dissolving sugar in water

_______ 5. baking clay

_______ 6. using a natural gas heater

_______ 7. mixing gold and silver to make an alloy

_______ 8. cooking meat (well done)

_______ 9. using a candle for light

_______ 10. burning gasoline

APPENDIX B
TEST SCORE DATA

DENSITY (RAW DATA)

LAB GROUP I
INITIAL TEST
(10 POSSIBLE)

SCORE	RECEIVED BY
"0"	6 STUDENTS
"10"	3 STUDENTS

POST TEST

SCORE	RECEIVED BY
"0"	1 STUDENT
"10"	10 STUDENTS

LAB GROUP II
INITIAL TEST

SCORE	RECEIVED BY
"0"	4 STUDENTS
"10"	7 STUDENTS

PRE TEST

SCORE	RECEIVED BY
"0"	3 STUDENTS
"10"	9 STUDENTS

SIMPLE MACHINES

LAB GROUP I

(8 POSSIBLE)

INITIAL TEST

SCORE	RECEIVED BY
"0"	4 STUDENTS
"2"	4 STUDENTS
"3"	1 STUDENT
"5"	1 STUDENT
"8"	1 STUDENT

POST TEST

SCORE	RECEIVED BY
"1"	1 STUDENT
"2"	1 STUDENT
"3"	4 STUDENTS
"4"	1 STUDENT
"5"	1 STUDENT
"6"	2 STUDENTS
"8"	1 STUDENT

LAB GROUP II

INITIAL TEST

SCORE	RECEIVED BY
"0"	5 STUDENTS
"2"	1 STUDENT
"3"	1 STUDENT
"5"	1 STUDENT

PRETEST

SCORE	RECEIVED BY
"1"	2 STUDENTS
"3"	4 STUDENTS
"6"	1 STUDENT
"8"	1 STUDENT

HORSEPOWER

LAB GROUP I
INITIAL TEST
(10 POSSIBLE)

SCORE	RECEIVED BY
"0"	9 STUDENTS

PRE TEST

SCORE	RECEEIVED BY
"0"	5 STUDENTS
"5"	3 STUDENTS
"10"	1 STUDENT

LAB GROUP II
INITIAL TEST

SCORE	RECEIVED BY
"0"	10 STUDENTS

POST TEST

SCORE	RECEIVED BY
"5"	5 STUDENTS
"10"	5 STUDENTS

CHEMICAL REACTIONS

LAB GROUP I
INITIAL TEST
(10 POSSIBLE)

SCORE	RECEIVED BY
"0"	1 STUDENT
"10"	9 STUDENTS

POST TEST

SCORE	RECEIVED BY
"10"	10 STUDENTS

LAB GROUP II
INITIAL TEST

SCORE	RECEIVED BY
"0"	3 STUDENTS
"10"	7 STUDENTS

PRE TEST

SCORE	RECEIVED BY
"0"	1 STUDENT
"10"	7 STUDENTS

CHEMICAL PHYSICAL CHANGES

LAB GROUP I

INITIAL TEST | PRE TEST

(10 POSSIBLE)

SCORE	RECEIVED BY
"2"	1 STUDENT
"3"	2 STUDENTS
"4"	1 STUDENT
"5"	3 STUDENTS
"6"	3 STUDENTS

SCORE	RECEIVED BY
"3"	3 STUDENTS
"4"	4 STUDENTS
"6"	2 STUDENTS
"9"	1 STUDENT

LAB GROUP II

INITIAL TEST | POST TEST

(10 POSSIBLE)

SCORE	RECEIVED BY
"4"	1 STUDENT
"5"	3 STUDENTS
"6"	4 STUDENTS
"7"	1 STUDENT
"8"	1 STUDENT

SCORE	RECEIVED BY
"5"	1 STUDENT
"6"	3 STUDENTS
"7"	2 STUDENTS
"8"	4 STUDENTS

APPENDIX C

STATISTICAL ANALYSIS (SAMPLE)

```
                                        Minitab
  File  Edit  Calc  Stat  Graph                                        |F1=Help
DATA> 3 3
DATA> 0 1
DATA> 2 2
DATA> 0 3
DATA> 0 6
DATA> 2 4
DATA> 2 5
DATA> 0 6
DATA> 5 3
DATA> 2 8
DATA> END
     10 ROWS READ
MTB > LET C9=C8-C7
MTB > TTEST MU=0 C9;
SUBC> ALTERNATIVE=+1.

TEST OF MU = 0.000 VS MU G.T. 0.000

             N      MEAN     STDEV   SE MEAN        T     P VALUE
C9          10     2.500     2.838     0.898     2.79       0.011

MTB >
```

APPENDIX D
LABORATORY EXERCISES

CALCULATORS

Theory:

The mathematical theory of this lab is covered in your textbook.

Purpose:

The purpose of this lab is to help you teach yourself how to utilize more of your calculators power through the use of the manual. For reference in this class, the two books that came with your calculator will be numbered by you and called:

Book 1: This book is the small booklet that came with the calculator. It is specific to your model of the calculator.

Book 2: Computing with the Scientific Calculator will be supplied. This book is a general manual which covers the basic and more advanced features of all Casio fx scientific calculators.

Procedure:

1. Record the number of your Casio fx-570 calculator.

2. Complete the table by using the index of each book to find the page containing the explanation of the required function. Use this explaination to perform the problem. **Using the exact method given in the text.** (Note: failing to follow this procedure exactly will affect your result.)

CALCULATORS

Model number of your Casio calculator fx________

Task	Book 1 or 2		Page	Calculator Function	Problem to be Solved	Your Answer
1.				Addition using **Mode 9**	6.36 + 1.03 + 18 +700 =	
2.				Subtraction	345 - 6 - .14 -278 =	
3.				Multiplication	6 x 445 =	
4.				Mult & Add	34 x 4.1 + 22 {x & / done before - & +]	
5.				Mult, Add, & ()	45 x (2 + 1.7) = [unless changed by ()]	
6.				Mult, Add, & ()	(45 x 2) +1.7 =	
7.				Constant (K) Memory	To 2056 add 11.125 four times (by putting 11.125 into the constant memory)	
8.				+/- key	Add (-31) to 21 =	
9.				Percentage	Take 15% of 43.45 [shift = key is %]	
10.				Percentage	Sales increased from 130 units to 323 units calculate the percentage increase	
11.				Using MIN, M+, & MR	Add: 295 + 128 + 128 + 128 +128 =	
12.				Using **Min, M-, &MR**	Subtract 24.7 from 191.9 and add this result to 223.72	
13.				Using π key	Find π to 6 decimal places (round it off to six)	
14.				Using Fix 3 & [Mode 7 3]	4.2345 + 5.9871= [change back to normal mode when done **Mode 9**]	
15.				Using x^y key	$(2.821)^3$	
16.				Using x^2 key	$156^2/12$ =	
17.				Using $\sqrt{}$ key	$\sqrt{26.980}$=	

CALCULATORS

Task	Book 1 or 2		Page	Operation	Problem to be Solved	Your Answer
18.				Using $\sqrt[3]{\text{key}}$	$\sqrt[3]{49.567} =$	
19.				Using 1/x key	Find $\frac{1}{8.126}$	
20.				Using x! key	Find 9 factorial (9!) [9x8x7x6x5x4x3x2x1]	
21.				Using a b/c key	$81\frac{2}{3} + \frac{84}{4} =$	
22.				Using a b/c key	Reduce $\frac{234}{66} =$	
23.				Using a b/c key	Write $14\frac{5}{9}$ as an improper fraction	
24.				Set **mode 8** & Using exp key	$2.24\text{x}10^{-8} / 3.34\text{x}10^{2} =$ [leave in **Mode 8**] (Write your answers in scientific notation)	
25.				Using exp key	$5.64\text{x}10^{-6} \text{ x } 4.23\text{x } 10^{3} =$	
26.				Using exp key	$3.78\text{x}10^{-14} + 2.89\text{x}10^{-5} =$	
27.				Using exp key	$1.54\text{x}10^{-4} - 2.83\text{x}10^{-6} =$	
28.				Using exp & $\sqrt{\text{key}}$	$\sqrt{4.37\text{x}10^{8}} =$	
29.				Find page only	To do loan calculations	
30.				Find page only	To do amortization calculations	
31.				Find page only	To do depreciation calculations	
32.				Find page only	To do quadratic equation calculations	

DENSITY OF SOLIDS

Purpose: The purpose of this laboratory is to learn how to use metric devices and also to calculate the density of various materials.

Apparatus:
- metric ruler
- vernirer caliper
- micrometer
- 3 regularly shaped objects (rectangular box, cylinder, sphere)
- single pan balance
- graduated cylinder (to hold rock sample)
- 3 objects (A,B,C) of different length
- piece of rock or mineral (5cm-30cm in length)

Procedure: Measure the length of each of your objects using both a metric ruler and a standard length ruler and record on table 1.1. Use different parts of your ruler each time.

Table 1.1

	OBJECT A		OBJECT B		OBJECT C	
	cm	in	cm	in	cm	in
1st						
2nd						
3rd						
Avg						

Are all of your measurements of object A exactly the same? Why or why not?

Why is it necessary to take more than one measurement?

Why should you use different parts of your ruler to measure the same object?

DENSITY OF SOLIDS

Part II

Using the single pan balance mass each of your regularly shaped objects and record in Table 1.2. From the following equations calculate the volume of each of these objects and record in Table 1.2.

Rectangle $v = (\text{length}) \times (\text{width}) \times (\text{height})$ or
$v = l \times w \times h$

Cylinder $v = (\pi) \times (\text{radius})^2 \times (\text{height})$ or
$v = \pi \times r^2 \times h$

Sphere $v = (\frac{4}{3}) \times (\pi) \times (\text{radius})^3$ or

$$v = \frac{4}{3} \times \pi \times r^3$$

Show all calculations using the ACC problem solving format.

Rectangle: Given: l=
w=
h=
Find: v=
BPR: v=l x w x h

Cylinder:

Sphere:

DENSITY OF SOLIDS

Table 1.2

	Mass	Dimension in cm	Volume in cm^3
Rectangular box			
Cylinder			
Sphere			

Note: Use a vernier caliper where possible.

Density (D) is defined as mass per unit volume as follows:

$$D = \frac{\text{mass}}{\text{volume}} = \frac{m}{V}$$

Calculate the density of each regularly shaped object and record in Table 1.3 (Use the ACC problem solving format.)

<u>Rectangular Box</u> <u>Cylinder</u> <u>Sphere</u>

Table 1.3

	Calculated density in g/cm^3	Actual density in g/cm^3 from the CRC
Rectangular box		
Cylinder		
Sphere		

DENSITY OF SOLIDS

Part III

You will now determine the density of a rock/mineral specimen. After observing this oddly shaped specimen, it should be obvious that a formula for finding it's volume probably doesn't exist. Since calculation of density depends on volume, you will need an indirect method to find this value. We will use volume by displacement. Use a large graduated cylinder and tap water to find the volume of your sample. Record all measurements taken. Use the ACC problem solving format to help organize your work.

ACCELERATION DUE TO GRAVITY AND YOUR REACTION TIME

Purpose: The purpose of this exercise is to investigate the acceleration due to gravity of various objects and calculate this value. Also, you will calculate your reaction time based upon the known value of gravity.

Apparatus:

meter stick	metal ball
stopwatch	cork ball
photogate (w/timer)	paper ball

Procedure: From a measured height of two meters(200cm), drop each of the three objects and record how long it takes them to fall. Repeat this at least three times for each object. Calculate each objects' average time. Record your results in Table 1.(Note: You will want to practice dropping the objects a few times to become accustom to operating the stopwatch. Warm-ups are encouraged before you start recording times.

Table 1.1

			Time of fall			
	mass	height	1st	2nd	3rd	Avg.
metal ball		200 cm				
cork ball		200 cm				
paper ball		200 cm				

ACCELERATION DUE TO GRAVITY AND YOUR REACTION TIME

Calculation: Using the equation $d = v_i t - \frac{1}{2}gt^2$, where [d] is the distance, [g] is gravity and [t] is time, calculate the acceleration due to gravity for each of your objects. When the initial velocity is 0, (from rest) the equation becomes $d = -\frac{1}{2}gt^2$. Solved for g, we will get $g = \frac{-2d}{t^2}$, the value of [g] will be negative, which is good, since the objects are falling downward.

Metal ball　　　　Cork ball　　　　Paper ball

How do your values of [g] compare for the 3 objects ?

How could the size of an object affect your results ? Why?

Did the objects with a greater mass fall faster ? Why?

What can you say about the density of a free-falling object?

ACCELERATION DUE TO GRAVITY AND YOUR REACTION TIME

Now that you have solved for each objects gravity you can use this value to Calculate your percent error for each case using g= $-980\frac{cm}{s^2}$ as your accepted value.

$$\% \text{ Error} = \left(\frac{-980\frac{cm}{s^2} - \text{your value}}{-980\frac{cm}{s^2}}\right) \times 100$$

% Error (metal) = ______________

% Error (cork) = ______________

% Error (paper) = ______________

Part II

Have your lab partner hold a meter stick vertically above your hand with the end of the meter stick marked "0" at the top of your hand. The person holding the meter stick will drop the stick without warning to their partner who will catch it. As soon as the meter stick is dropped, try to grab it . Read on the meter stick how far it fell and calculate reaction time using a form of the equation $d = v_i t - \frac{1}{2}gt^2$. When $v_i = 0$, $d = -\frac{1}{2}gt^2$. Solved for t (reaction time) this becomes $t = \sqrt{\frac{-2d}{g}}$ where $g = -980\frac{cm}{s^2}$ when the distance that the meter stick fell is measured in centimeters.

ACCELERATION DUE TO GRAVITY AND YOUR REACTION TIME

If you were driving a car at 50 $\frac{mi}{hr}$ (which is the same as 73$\frac{ft}{s}$)how many feet would you have traveled before you could have reacted by putting your foot on the brake ?

What is likely to happen if you follow cars closer than 1 car length?(15 feet) Why?

Electronic measure of time using a photogate apparatus.

In this exercise, you will measure the amount of time that it takes for an object to fall using a electronic timing device called a photogate. Set up this device according to your instructor. Measure the distance between the centers of the photogates using a meterstick. Now, drop the object (usually a solid ball) and record the time it takes to fall from one gate to the other.

As before, calculate g (the acceleration due to gravity) using the proper equation.

PENDULUM

Purpose: The purpose of this lab is to discover that a pendulum can be used as a very simple device which measures the acceleration of gravity at any particular location. First you measure the length of the pendulum and set the pendulum into motion. Then using a stopwatch, time the period of one swing and determine the acceleration of gravity from the equation

$$T_p = 2\pi \sqrt{\frac{l}{g}}$$

Example 1 : Find the period of a pendulum which is 1.5m long

$$T_p = 2\pi \sqrt{\frac{l}{g}}$$

$$T_p = 2\pi \sqrt{\frac{1.50\text{m}}{9.80\text{m/s}^2}}$$

$$T_p = 2.46 \text{ s}$$

Example 2 : Find the acceleration of gravity as determined by a pendulum with a length of 1.50m and a period of 2.46s.

$$g = \frac{4\pi^2}{T_p^2}\text{length}$$

$$g = \frac{4\pi^2}{(2.46\text{s})^2}(1.50\text{m})$$

$$g = 9.78 \text{ m/s}^2$$

Theory: Now that you have an understanding of the relationships between a pendulums period, the length of its string and their effect on the acceleration due to gravity, you are ready to conduct an experimental procedure to prove these theories. You will need:

- A simple pendulum
- Stopwatch
- Meterstick
- A ball of string
- Photogate apparatus

PENDULUM

Part 1

1. Attach a string with a length of at least two meters to your pendulum.

2. Suspend the pendulum a distance of 1 meter from the support rod. (One meter from the center of the pendulum to the pivot point.)

3. Pull the pendulum back 30 cm and release it. Let it swing back and forth a couple of times. Then, using a stopwatch, measure the amount of time it takes to swing from one side to the other and then back to the same initial position where you started timing. This amount of time is the "period" of this particular pendulum. Record your measurement.

4. Record how long you think it will take for 10 swings.(Your guess)

5. Now time the pendulum through 10 swings and record.

6. Calculate the average swing. (The period)

Part II

7. Record how long you think it would take for 10 swings if you only pulled it back 10 cm. Record.

8. With the length of the string (l) at 100 cm, pull the pendulum back 10 cm and record how long it takes for 10 swings. Calculate the time for one swing.

9. Repeat steps 7 and 8 for 10 swings each at 20, 40, 60, and 80 cm lengths of string and calculate the period for each.

Part III

10. Record how long you think it would take for 10 swings of a pendulum if the length of the string was changed to 50 cm.

11. Now change the length of your pendulum to 50 cm and using the photogate apparatus record the actual amount of time for 10 swings and calculate the time for one swing. (Each time pull the pendulum back about 25 cm.)

12. Using the stopwatch, repeat steps 10 and 11 for string lengths of 50, 100, 150, and 200 cm. (The 200 cm pendulum will be set up for you.)

13. Calculate g for all of Part III.

PENDULUM

PART 1

Table 1.1	PERIOD
STEP 3	

Table 1.2	GUESS	TIME	PERIOD
STEPS 4-6			

PART 2

Table 1.3	GUESS	TIME	PERIOD
10 CM			
20 CM			
40 CM			
60 CM			
80 CM			

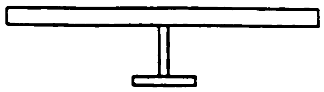
PART 3

Table 1.4	GUESS	TIME	PERIOD	GRAVITY
50 CM				
100 CM				
150 CM				
200 CM				

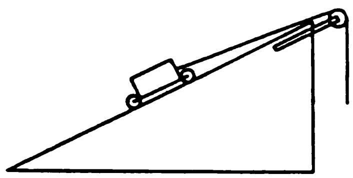
Physical Science Lab
Simple Machines

E = Effort
D_i = Distance in
R = Resistance
D_o = Distance out
AMA = Actual Mechanical Advantage
IMA = Ideal Mechanical Advantage

	E	R	D_i	D_o	AMA	IMA	% Efficeint
Lever							
Inclined Plane							
Wheel and axle							
Screw							
Pulley - Fixed							
Pulley -Mobile							
Pulley -System							
Pulley -System							

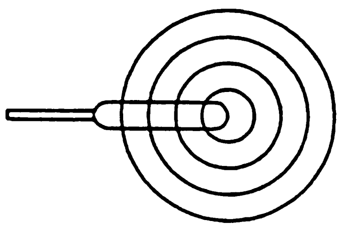


I.M.A. = Di/Do
A.M.A. = R/E



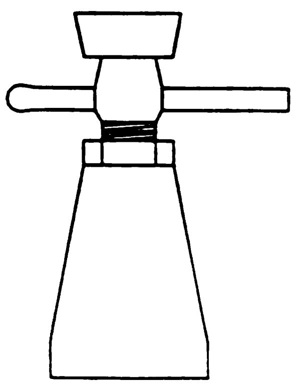
I.M.A. = length/height (l/h)

A.M.A. = R/E



I.M.A. = D/d

A.M.A. = R/E

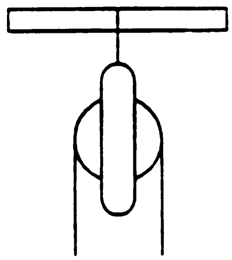


I.M.A. = (distance in)/(distance out)
= (2 r)/(1 thread)

(r = radius)

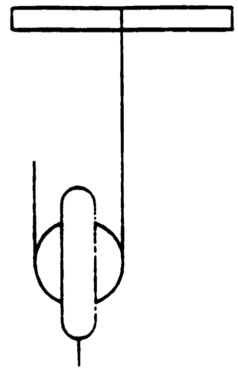
(where 1 thread is the height of 1 very small)

A.M.A. = R/E



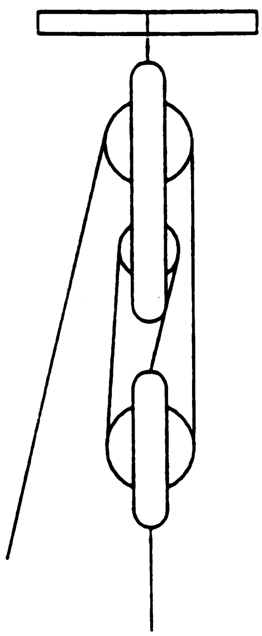
I.M.A. = Di/Do

A.M.A. = R/E



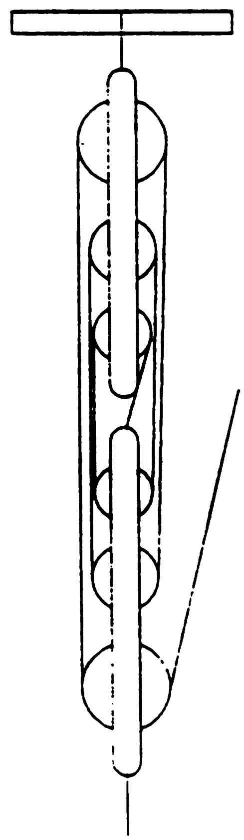
I.M.A. = Di/Do

A.M.A. = R/E



I.M.A. = Di/Do

A.M.A. = R/E



I.M.A. = Di/Do

A.M.A. = R/E

69

HORSEPOWER

Purpose: To study the ways that work, energy, and power are related.

Apparatus: Meter stick,20 ft tape measure,Stopwatch and a Bathroom scale

Theory: Work, which is equal to force times distance ($W = F \times d$), is the same as potential energy ($PE = mgh$). Since $F = mg$, we see that as an object is raised to a height (h) it gains potential energy. The amount of this potential energy is exactly equal to the work it took to place it at that height. Power is the rate at which work is done, and since work and energy are nearly the same, we can say that power is also the time rate change of potential energy. In this lab, you will calculate your power output as you change your potential energy by climbing some stairs. Your own weight will be the force and the height of the stairs will be the distance traveled. The time will be the amount of time it takes you to climb the stairs.

$$\text{Power} = \frac{\text{work}}{\text{time}} = \frac{\text{force x distance}}{\text{time}} = \frac{\text{weight x height}}{\text{time}}$$

$$P = \frac{W}{t} = \frac{F \times d}{t} = \frac{w \times h}{t}$$

Your Power output will be your weight [w] in Newtons, times the height [h] of the stairs in meters, divided by the time [t] it takes you to climb them.

Procedure: Using a stop watch, read the time it takes you to climb to the top of the stairs. You try to get up the stairs as fast as possible any way that you can without endangering yourself. Do this three times to get your best effort. Measure the height, in meters of the total vertical distance you climbed. Record your times in Table 1.

Table 1

	Time (t)
1st	
2nd	
3rd	

HORSEPOWER

Vertical distance of stairs (feet) = ____________________

Vertical distance of stairs (meters) = ____________________

Force (your weight) moved (Newtons) = ____________________

Force (your weight) moved (pounds) = ____________________

Calculate your power output using the metric system:

$$P = \frac{w \times h}{t} = \underline{\hspace{6cm}} = \boxed{}$$

You have just calculated your power in Nm/s. A Nm is also called a joule (J), and a J/s is defined as a watt. Therefore, your power output in Nm/s is the same as watts.

Calculate your power output using the standard English system:

$$P = \frac{w \times h}{t} = \underline{\hspace{6cm}} = \boxed{}$$

You have just calculated your power in ft.lbs/s. A ft.lb/s is not commonly used to measure power. Another way to measure power is in horsepower (hp) . Using the fact that one hp equals 746 Watts, convert your power output in Nm/s to horsepower.

Using the fact that 550 ft.lbs./s equals one horsepower, convert your foot pounds per second to hp.

What factors could affect your power output?

ELECTRICAL CONDUCTIVITY

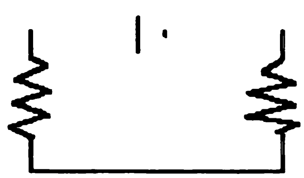
Purpose: The purpose of this lab is to study the wiring of batteries, bulbs, and switches, and to discover the most efficient arrangement, by measuring the bulb intensity. Also to learn how electricity moves from one place to another via conductors.

Theory: Many everyday devices are run on electricity, the electricity is transported thru circuitry. Some electrical circuitry is very complex, your job is to build a simple circuit, then use the arrangement with various substances to discover their conductivity, or lack of it.

Materials:

6v battery	power supply unit	2 sm. connector wires
12v light bulb	ammeter	4 med. connector wires
bulb base	digital multimeter	2 lg. connector wires
on/off switch	10 (of 20 possible) unknown substances	

Discussion: In this exercise you will be asked to sketch a diagram of simple circuitry, diagrams 7a and 7b are examples of simple circuitry.



7a

simple series circuit

7b

simple parallel circuit

ELECTRICAL CONDUCTIVITY

1. Wire a 6v battery to a 12v light bulb in a base till the bulb lights. Sketch your wiring job.

2. Add an on/off switch to your circuit. Check to see that the switch breaks the current. Sketch.

3. Replace the battery with a power supply. Sketch.

4. Note the intensity of light.

5. Connect the ammeter and record current flow.

6. With the bulb at its brightest (power supply at maximum) read current flow from ammeter.

7. Use the digital multimeter to measure the voltage difference.

8. Using the equation $P=IV$ calculate the power (rate of energy usage) in Watts for the bulb.

9. Use this apparatus to determine the relative conductivity of ten of the twenty unknown substances provided by your instructor. First make a guess as to whether or not you think the substance will conduct electrical current, write yes or no on the **guess** column of table 1.1. Test, and rate the conductivity for each unknown you've chosen. Watch the ammeter, not the light bulb! Rate each unknown as either non-conducting (no measurable change on the ammeter), semi-conducting (the ammeter shows current flow, even if the bulb does not light), or conducting (the bulb lights). Record the results as a reading in amperes.

ELECTRICAL CONDUCTIVITY

Table 1.1

#	guess	non-conducting	semi-conducting	conducting
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

DENSITY OF LIQUIDS

Purpose: The purpose of this lab is to learn how to determine the density of various liquids.

Materials
- pan balance with masses
- graduated cylinder
- Rubbing alcohol Isopropyl alcohol or 2-propanol)
- unknown liquids
- saltwater
- Distilled water

Procedure:

1) Obtain and wash a graduated cylinder with soap and warm water. Rinse well.

2) Shake out excess water carefully and dry with an air valve.

3) When the cylinder is completely dry, mass it on the balance to the nearest 0.1 gram and record in table 1.1.

4) Fill the graduated cylinder with 10 ml of the first liquid and re-mass. Record.

5) Repeat step 4 with each liquid.

6) To obtain the mass of a liquid subtract the mass of the empty cylinder from the mass of the full cylinder and record.

7) To calculate the density of a liquid use the formula, where $D=\frac{m}{V}$.

8) Find the textbook density for water and rubbing alcohol using the CRC.

DENSITY OF LIQUIDS

**DO NOT TASTE
OR SMELL
UNKNOWNS**

Table 1.1	Mass of Empty Cylinder	Mass of Full Cylinder	Mass of Liquid	Volume of Liquid	Density	Textbook Density
Water						
Rubbing Alcohol						
Saltwater						
Unknown #						
Unknown #						

CHEMICAL REACTIONS

Purpose: To distinguish how chemicals react with each other.

Materials: acetate sheets, waste bottle, pipettes filled with solutions below:

0.1M $Fe(NO_3)_3$	0.1M $Ba(NO_3)_2$	6M H_2SO_4
0.1M $K_2Cr_2O_7$	0.1M $Cu(NO_3)_2$	6M NaOH
0.1M $Al_2(SO_4)_3$	0.1M $AgNO_3$	6M HCl
0.1M K_2CrO_4	0.1M $Ca(NO_3)_2$	6M NH_4OH
0.1M $Zn(NO_3)_2$		

Procedure:

1) Wash and dry an acetate sheet.

2) Locate the various chemical solutions needed as above.

3) By following the table, use one drop of $Fe(NO_3)_3$ and one drop of H_2SO_4 in the first space on the sheet. Note: Using more than one drop can result in incorrect conclusions.

4) Note whether or not a reaction occurred, by filling in your table, based upon the following criteria:

A) color change
B) heat is produced
C) change in state (gas, liquid, solid precipitate)
D) fizzes, bubbles (gas production) note any smell
E) cloudy or clear

If none of these observations are noted, state (No RXN) in the correct box. If a reaction did occurr, note all changes in the box. (A-E)

5) Follow this procedure for each of the chemicals as shown in the table.

6) Unknowns: You have been assigned 2 unknown solutions by your instructor (be sure to record your unknown numbers).

7) Test these unknowns as you've done for the other 9 known solutions and record your observations.

8) From looking at the reactions of the known solutions, you should be able to identify your unknown solutions. Write the names of these solutions in the unknown box at this time.

CHEMICAL REACTIONS

Table 1.1	H_2SO_4 (dilute)	HCl (dilute)	NaOH (dilute)	NH_4OH (dilute)
$Fe(NO_3)_3$				
$Ba(NO_3)_2$				
K_2CrO_4				
$K_2Cr_2O_7$				
$Cu(NO_3)_2$				
$Ca(NO_3)_2$				
$Al_2(SO_4)_3$				
$AgNO_3$				
$Zn(NO_3)_2$				
Unknown #				
Unknown #				

PHYSICAL AND CHEMICAL CHANGES

Purpose: The purpose of this lab is to distinguish the difference between physical and chemical changes.

Materials:

candle	paper	bunsen burner
iron filings	sulfur	electron balance
magnet	scoopula	potassium nitrate
watch glass	test tubes	test tube tongs

Procedure: 1) Place a small piece of candle wax in a test tube and,using a test tube tongs, heat gently over a burner flame until the wax melts completely. Let the sample cool. Record your observations.

2) Light the candle and attach it to a watch glass. Allow the candle to burn until it extinguishes itself. Continue with the rest of the experiments while the candle burns. Record your observations when the candle is finished burning.

3) Tear a piece of paper into pieces. Record your observations.

4) Place the paper in a metal burn pan and ignite the paper with a match, allow the paper to burn completely. Record your observations.

5) Measure out the following using an electron balance. 0.50g of iron filings and 0.50g of powdered sulfur. Test each substance with a magnet then mix the two samples in a test tube and run a magnet along the bottom and sides of the test tube. Record.

6) Using a bunsen burner heat the Iron and Sulfur mixture until it glows red (about 2-3 minutes), and continue to heat for an additional 2 minutes. Allow this to cool. Break the teast tube and examine this substance, perform the magnet test again. Record your observations.

7) In a test tube combine 4.0g KNO_3 (potassium nitrate) and 5ml of water. Combine the two in that order. Using your burner heat the sample slowly for several minutes. Heat until dissolved. After this mixture has dissolved allow it to cool. Watch <u>very</u> closely while it cools for 4 minutes. Record your observations.

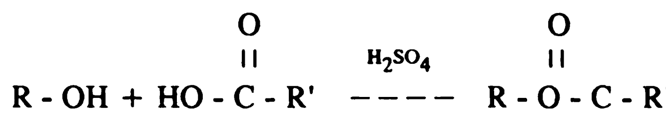
PHYSICAL AND CHEMICAL CHANGES

PROCEDURE	OBSERVATIONS	CONCLUSION
Melting candle wax		
Burning a candle		
Tearing paper		
Burning paper		
Fe	Magnet test	
S	Magnet test	
Mixing Fe and S	Magnet test	
Heating a mixture of Fe and S	Magnet test	
Heating a mixture of KNO_3 and H_2O		

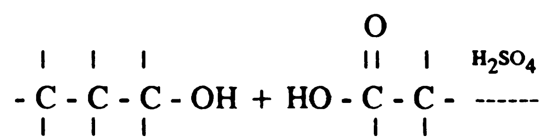
ESTERS, THE FLAVORS OF LIFE

Purpose: The purpose of this lab is for students to follow given formulas and create chemical compounds called esters,which resemble in scent, and taste some naturally occuring substances, such as wintergreen.

Theory: Esters comprise one of the eleven Major groups in organic chemistry. They are responsible for many of the "fruity" and "minty" smells and tastes in food products they are produced naturally by plants and incorporated into the plant product. Esters are what make pears smell and taste like pears. Also included are strawberry, raspberry, rum, roses, banana, spearmint, and wintergreen to name a few. Esters are prepared synthetically in laboratories. They are the artificial flavors listed on the labels of many products we purchase Most esters are very simple to prepare in the laboratory. The simple esters we will consider are derived from an alcohol combining with a carboxylic acid as follows:



Where R stands for any hydrocarbon and R' stands for any other hydrocarbon (Although unlikely - R and R' could be the same.) as an example, consider the preparation of the ester you know as being "pear" which is made from propanol and acetic acid.



Note that one molecule of water is produced for every one molecule of ester produced. In the reaction, as indicated above by the lines drawn under the elements H and O, the water molecule is produced from the OH group on the alcohol and from the H atom on the carboxylic acid. It has been determined that the oxygen atom does not come from the carboxylic acid to produce the water molecule. This process of synthesizing an ester is called esterfication.

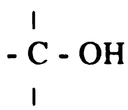
Your instructor will demonstrate the preparation of artificial pineapple due to the obnoxious odor of the carboxylic acid used to make the ester. This acid, butyric acid, smells like spoiled butter or cheese and the odor tends to stay around for quite some time. The reaction for producing the ester is written for you in the appropriate place. you will then go to the laboratory and prepare the other four esters as indicated in the procedure and write the reaction for each esterfication.

ESTERS, THE FLAVORS OF LIFE

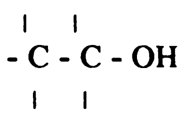
Materials: test tubes
water bath apparatus
glass rod (for stirring)
H_2SO_4 (concentrated)
Also the following chemicals

Alcohols

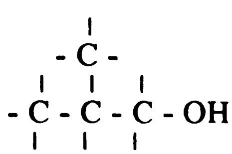
Methyl alcohol



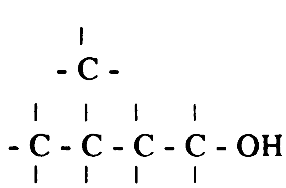
Ethyl alcohol



Isobutyl alcohol
(2 - (methyl) 1 propanol)

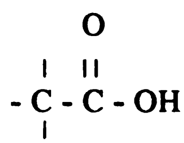


Isopentyl alcohol
(iso - Amyl alcohol)
(3 -(methyl) - 1 butanol)

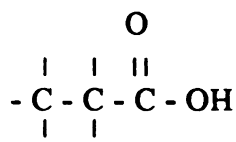


Carboxylic acids

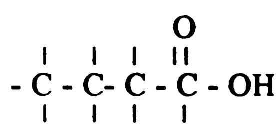
Acetic acid



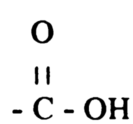
Propanoic acid



Butyric acid
(for instructor use only)



Salicylic acid



ESTERS, THE FLAVORS OF LIFE

Procedure:

1) Prepare banana by placing 3.0 ml of isopentyl alcohol (iso - Amyl alcohol) into a test tube and adding 3.8 ml of glacial acetic acid. Only then, add 10 drops of concentrated sulfuric acid (H_2SO_4). Heat the test tube in a hot water bath for 5 minutes. Observe. (Smell carefully!) Stir if necessary to reveal the desired scent. Record your observations and write the reaction.

2) Prepare apple by adding 3 ml of ethyl alcohol to3 ml of glacial acetic acid. Then add the H_2SO_4 as in step 1 , heat, and report the results.

3) Prepare wintergreen by adding 6.1 ml of methanol to 1.4 grams of salicylic acid. Then add the H_2SO_4 as in step 1, heat, and report the results. Be careful when heating the wintergreen - heat very slowly at first!

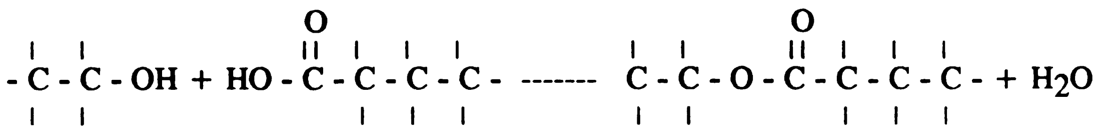
4) Prepare rum by adding 3 ml of isobuyl alcohol to 3 ml of propanoic acid (propionic acid). Then add the H_2SO_4 as in step 1, heat, and report the results.

ESTERS, THE FLAVORS OF LIFE

Report:

EXAMPLE: pineapple

ethanol + butryic acid pineapple



Smells like pineapple, yellow - brown color, 2 phases present.

1) banana

2) apple

3) wintergreen

4) rum

PREPARATION OF ASPIRIN

Purpose: The purpose of this lab is gain understanding into the chemical structure and properties of aspirin. You will determine the formula for aspirin and then, using this reaction formula you will prepare a sample of this product (aspirin).

Apparatus:

hot sand bath	large beaker for ice bath
Buchner funnel	25ml Erlynmeyer flask
filters and vial	thermometer and ring stand

Theory: Probably the most commonly used drug worldwide is the carboxylic acid (and ester) acetysalicylic acid known also as aspirin. As you discovered in the previous lab exercise on esters, esterfication is the term used for the combining of an alcohol and a carboxylic acid. Acetylation is the combining of an acetic anhydride and a carboxylic acid. In this procedure you will prepare approximately 1 gram of aspirin. NOTE: Aspirin is not as harmless as you may believe it to be. While the average dosage is 0.3-1.0 g, single doses of 10-30g can be fatal. DO NOT INGEST ANY OF YOUR PRODUCT.

Procedure:

1) Obtain a hot sand bath, turn the heat setting to low. This will serve as your heat source.

2) Wash a 25ml Erlynmeyer flask and dry it using acetone and the air valve.

3) Obtain 1.0g of salicylic acid and place in the clean flask.

4) Measure out 2.5ml of acetic anhydride and add to the flask. Be sure to rinse down any salicylic acid that may be clinging to the sides of your flask. CAUTION ACETIC ANHYDRIDE IS DANGEROUS WEAR AN APRON DO NOT TOUCH !

5) Add eight (8) drops of phosphoric acid to the flask, this will act as a catalyst.

6) Place the flask into the sand bath. If the sand is hot do this carefully.

7) Clamp a thermometer into the sand bath using a ring stand and a cork holder.

PREPARATION OF ASPIRIN

8) Heat mixture to 75°. Do not allow the temperature to exceed 80° closely watch over it.

9) Make up an ice bath by placing one to two inches of ice in a large beaker and fill to the two inch line with cold tap water.

10) When the temperature approaches 75°, turn off the hot plate and leave the reaction undisturbed for 15 minutes. Make sure that the temperature remains above 70°.

11) Remove the flask from the heat source. CAREFULLY ! Do not breathe over the flask. Add 2ml of deionized water to the flask. Wait 1-2 minutes before handling.

12) After 2 minutes have elapsed add 20ml of deionized water.

13) Allow the flask to cool. Crystals should form in a few minutes. This is aspirin.

14) Place the flask in the ice bath for at least 5 minutes. NOTE Do not place your flask in the ice bath until crystals have started to form, also the longer you cool your flask the more aspirin you will produce.

15) Collect the crystals in a Buchner funnel and a filter system.

16) Pour 5-10ml of ice water (from your ice bath) over the crystals you may use the rest of this water to rinse the remaining crystals from the flask.

17) Remove excess water from your product by pressing the crystals between filter papers. You may need to repeat this procedure several times.

18) This should be aspirin. Check the melting point and submit your product to your instructor.

Note: On your vial list your product, the students who made it, and the melting point.

PREPARATION OF ASPIRIN

Results: Submit your labled vial to your instructor.

1) Write the formula for the reaction between acetic anhydride and salicylic acid to form aspirin and acetic acid.

2) What is the melting point of salicylic acid?

3) What is the melting point of aspirin?

4) Why is acetic anhydride better to use than acetic acid in this reaction?

5) What is a catalyst, and why is one used in this laboratory exercise?

INTRODUCTION TO MICROSOFT WORKS - SPREADSHEETS

1) Format your disk. (See your instructor for directions on how to format a disc in this computer lab.) Write directions on how to format a disc in the space below.

2) Enter the works program, create a new file, and then spreadsheet.

3) In cell D1 type ["Iron Mining] and press enter. (The (") is necessary only as a code that this is a word.)

4) Iron mining doesn't fit in this cell so we need to make the cell longer. Do this by first making sure that D1 is highlighted and then selecting Format (press alt key then the highlighted letter in the word format at the top of the screen then select column width. This should display a 10 for 10 spaces. Type 11 to indicate that you need 11 spaces in column D.

5) Type your last name in F1 (up to 9 letters), type PHS and your lab hour in F2 and type todays date in F3.

6) You will now need to place the title [ORE] in C4 (press alt key then format then style then right). Type [COMPARISON] in D4.

7) Type [Gross] in D6 and [Income] in E6.

8) Change the column width of A9 to 9 spaces and enter [Hematite]. Enter A9-A13 as shown.

INTRODUCTION TO MICROSOFT WORKS-SPREADSHEETS

9) Change column B8 to 9 spaces and enter [% Iron]. Enter the correct % in B9-B13 as shown (do not use (") when you are entering numbers with which you want to do a calculation).

10) Leave column C as 10 spaces and enter the given information.

11) In D8 enter [Fe/tons] and move to D9.
You will use the computer to do calculations in column D. To complete this task, (while in cell D9), type [= sum (b9*c9)] and press enter. The number 450 should appear in D9 as the computer multiplied b9 by c9.
To calculate the remainder of column D, highlight D9-D13 (hold down shift key while pressing the down arrow) and select edit and then fill down. The correct number should appear in D10 - D13.

12) Move to cell E8 and change the column width to 11 spaces. Place the correct heading and then enter[= sum (D9*90)] in cell E9. The correct answer (40500) should appear in E9.

13) To complete E10 - E13, repeat as before using "fill down".

14) Change column F to a width of 9 spaces. Then complete the calculations by using [= sum (E9/1000)] and fill down. Column F gives you the value per ton of the various ores.

15) Now save this file on your own disk. (See Instructor) Also, you must print a copy of your work to hand in for a grade. Note! Handing in a copy of someone else's work will be looked upon as cheating. You may now close this file and proceed to the next part of the assignment.

Hint: If your printout is on 2 pages, check your column width.

INTRODUCTION TO MICROSOFT WORKS-SPREADSHEETS

On your own, you must reproduce a file on MS Works which is similar to the attached sheet titled **Production Cost**. Be sure to use the commands to make the computer do the calculations and do not simply enter the information. To earn credit you must hand in printed copies of both spreadsheets and a disc containing your work. In addition, you must write at least one paragraph which describes the profitability of iron mining based on the information available on these spreadsheets. As discussed in class, center your writing on which ore('s) would be profitable to mine.

INTRODUCTION TO MICROSOFT WORKS-GRAPHING

1) Enter MS Works.

2) Create a new file.

3) Select SPREADSHEET.

4) It is assumed at this point that you have two sets of information. One which you will graph on the x-axis and one which you will graph on the Y axis Enter one set of information (data) in column A (usually from smallest to largest since this is the order in which they will appear on the graph).

5) Enter the other set of data in column B.

6) Highlight all of the data that you want to be on the graph.

7) Now select CHART WIZARD from the toolbar. (This will allow you to make a graph.)

8) Select a line graph from the toolbar.

9) Now instruct the computer as to which data you want graphed on which axis by selecting EDIT and SERIES.

10) Enter A1:A8 and the X-series (to put the data from column A on the X axis).

11) Enter B1:B8 to the 1st Y series line to place the data from column B on the Y axis.

12) To put a title on your graph select EDIT and then TITLES.

13) Enter the chart title **Kepler's Third Law.** Enter your name as the subtitle.

14) Enter **Distance from Sun-Au** on the X axis line.

15) Now, on the y-axis, enter the title **Period of Rev.-Years**.

16) Save your data on your disk and then print your graph to hand in.

VECTORS AND PROPERTY DEEDS

Purpose: This lab is designed to teach you how to use a Plat Book. Due to availability, an Alpena County Plat Book is used for this course.

Procedure: Attend the lab lecture and then fill out the attached tables as you are instructed. Fill in the first table using the accompanying Michigan map. Use the Plat Book for the others.

Table 1	**Township**	**Range**
Cheboygan		
Charlevoix		
Saginaw		
Oakland		
Gennesee		

Fill in the boxes of table 1.2 with numbers which indicate how a Survey Township is ordered.

Table 1.2

Why weren't Survey Townships numbered left to right top to bottom?

Refer to the Alpena County Plat Book to fill in the missing information in Table 1.3.

Number	Location	Section	Township	Range
9	Beaver lake			
33	Long Rapids			
34	Muskrat Lake			
23	Sulphur Island			
25	Golf Course Rd			

Table 1.3

Complete Table 1.4 using the Index to Owners in the Plat Book.

Property	Section	Township	Range
Alpena Cycle Club			
Deer Lane Hunting Club			
Indian Acres Club			
Alpena Power Co.			
Allen S. MacArthur			

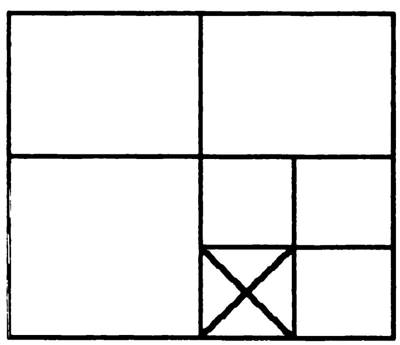
Table 1.4

VECTORS AND PROPERTY DEEDS

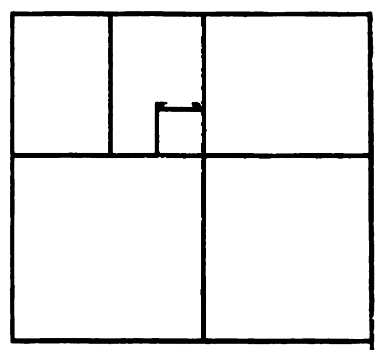
PART 2

Thus far, you have learned to identify the section, township, and range of a parcel of land. But what if the section has been further divided into smaller parcels? In the next exercise you will learn to identify and write the property descriptions for two different pieces of land within the same section. You will describe these parcels the same way as their description would appear on a deed or a tax bill.

Both parcels are in: Section 27
T 30 N.
R 5 E.
Green Township
Alpena County
State of Michigan



Property description A

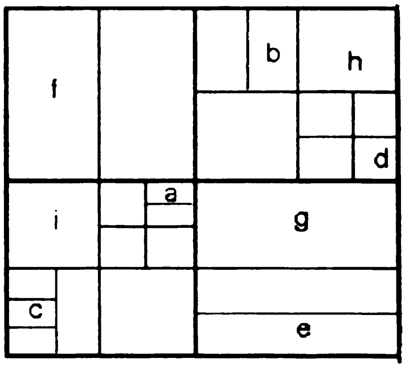


Property description B

VECTORS AND PROPERTY DEEDS

Part 3

Now that you can describe a small parcel of land, let's see if you can match the parcel with it's description. There are nine parcels of land lettered in the figure below. However, there are only seven property descriptions. Match the lettered parcel to it's numbered description. Note: Some descriptions don't match any lettered parcel.



Section 11

1. The Northwest corner of the Southeast half of Section 11

2. The West half of the Northwest quarter of Section 11

3. The North half of the Northeast quarter of the Southwest quarter of Section 11.

4. The East half of the Northwest quarter of the Northeast quarter of Section 11.

5. The South half of the South half of the Southeast quarter of Section 11.

6. The left side of the upper corner of Section 11.

7. The Southeast quarter of the Southeast quarter of the Northeast quarter of Section 11.

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