

A COMPARATIVE STUDY OF THE COGNITIVE EFFECTS OF
THE USE OF TAKE HOME LABORATORY MATERIALS ON
STUDENT ACHIEVEMENT IN COLLEGE LEVEL
PHYSICAL SCIENCE CLASSES

By

RONALD EUGENE APPLEMAN

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1955

Master of Education
University of North Carolina
Chapel Hill, North Carolina
1959

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF EDUCATION
July, 1967

OKLAHOMA
STATE UNIVERSITY
LIBRARY
JAN 9 1968

A COMPARATIVE STUDY OF THE COGNITIVE EFFECTS OF
THE USE OF TAKE HOME LABORATORY MATERIALS ON
STUDENT ACHIEVEMENT IN COLLEGE LEVEL
PHYSICAL SCIENCE CLASSES

Thesis Approved:

Kenneth E. Wiegman
Thesis Adviser

H. H. Harrington
C. Fremont Hamel

Irlo R. Schmidt

N. D. Dussan
Dean of the Graduate College

658309

ACKNOWLEDGMENTS

I want to acknowledge my indebtedness and gratitude to several people for their help in making this research project a reality.

I express thanks to Dr. Kenneth Wiggins, Chairman of the doctoral committee, for his generous help and expenditure of time; to Dr. Harold Harrington, Prof. Arlo Schmidt, Prof. C. Fremont Harris, and Dr. J. W. Blankenship, members of the doctoral committee, for their helpful suggestions concerning the experimental design; to Dr. E. E. Vineyard, President of Northern Oklahoma College, for his encouragement and advice while I was conducting the experiment with Northern Oklahoma College students; and to my students who provided the means whereby the particular techniques of instruction were tested.

TABLE OF CONTENTS

Chapter	Page
I. THE PROBLEM	1
II. REVIEW OF LITERATURE.	6
III. METHODOLOGY AND DESIGN.	22
Sample	22
Materials and Methods.	22
Analysis	24
IV. RESULTS	29
V. DISCUSSION.	39
VI. SUMMARY AND CONCLUSIONS	46
Recommendations for Further Study.	49
BIBLIOGRAPHY	50
APPENDICES	52

LIST OF TABLES

Table	Page
I. Analysis of Observed Means on Total Test.	30
II. Analysis of Observed Means of the Sub-Tests for the Total Sample.	32
III. Analysis of Observed Means of the Sub-Tests for the Upper Third of the Sample	33
IV. Analysis of Observed Means of the Sub-Tests for the Lower Third of the Sample	34
V. Summary of the Check-List of Student Responses.	36
VI. Mean Scores on the Zero to Eight Point Rating Scale for Teaching Effectiveness.	38

CHAPTER I

THE PROBLEM

College enrollments as reported by the United States Office of Education for the fall of 1962 revealed that the increase over 1961 was 8.1 per cent. As the enrollment explosion in the nation's colleges and universities continues the need, but unfortunately not the supply, for professional persons in teaching, research, and administration also reaches new highs. One of the major problems of colleges and universities today is the number of students in ratio to the number of full time faculty members. Since projected enrollment studies promise continued rapid increase with even greater student-faculty ratio problems, educators must investigate all methods of instruction that may prove useful and effective in alleviating the conditions imposed by crowded classrooms and laboratories.

The purpose of this paper is to investigate the effectiveness of take home laboratory materials as a method of laboratory teaching in physical science classes for non-science majors. It is also intended that information concerning student attitudes toward the physical science program following the respective classes will be studied.

According to the report of the 1964 Boulder Conference on Physics for Non-Science Majors, physical science courses often have a professional dimension; for they are frequently required for the preprofessional training of elementary and, in some cases, secondary school

teachers. The committee recommended that efforts in the development and study of physical science courses should be encouraged. In view of the future possible effects of this training, class programming for both student competencies and attitudes should be given consideration. With this in mind, a secondary concern in this experiment was the gathering of data concerning the students attitudes toward the physical science course.

If it can be determined that all or a portion of the laboratory experience can be mastered equally well or better through take home laboratory materials this part of the teacher's time might be released to devote to individual or small group instruction or to personal enrichment by keeping abreast with new teaching developments in the field.

This study will investigate whether students in college physical science classes receiving take home laboratory materials will demonstrate equal or better achievement than students who take the traditional laboratory sections. Data will also be gathered to provide an indication whether students in physical science classes receiving take home laboratory materials will demonstrate equal or better attitudes toward their study than students who take the traditional laboratory sections.

Definition of Terms

Achievement is defined as the students mastery of the laboratory experiments.

Attitude is defined as the students positive or negative reactions to the physical science course.

Traditional laboratory is defined as two-hour weekly sessions in which students are exposed to experiments in the related physical

science fields of physics, chemistry, geology, astronomy and meteorology.

Take home laboratory materials is defined as individual materials which contain experiments in the related physical science fields of physics, chemistry, geology, astronomy, and meteorology.

Independent Variable

The manipulative element in this study is the type of laboratory experience each group received. The control group attended traditional two-hour laboratory sessions each week. The experimental group used take home laboratory materials. This group was sub-divided into two discussion groups which met once a month to discuss their independent laboratory study and to make plans for future study.

Dependent Variable

In this study the dependent variable is the measure of student achievement of the subject matter content in the physical science laboratory experience.

Assumptions

This study is first based upon the assumption that there is value in the laboratory experience as a means of transmitting knowledge, insight, and understanding. From the standpoint of learning theory, the activity of the student through stimulus-response, the sensorimotor nature of the experience, the individualization of the laboratory experience should contribute positively to learning. Kruglack's experiments which were reviewed in the literature also offer evidence to the

value of the experience (1953), (1954), (1955).

This study is furthered based upon the assumption that students can learn independently and that their attitude toward independent study is affected by the amount and type of study. This assumption is based upon the findings of Churchill (1957) and Churchill and Baskin's (1958) educational research programs on independent study which they carried out at Antioch College. The independent study experiment at Oberlin College by McCollough and VanAtta were also studied (1958).

Hypotheses

The hypotheses of this study, stated in the null form, are:

1. There are no significant differences in achievement scores on the total laboratory test between the students in the experimental group using their take home laboratory materials and the control group receiving the traditional laboratory experience.
2. There are no significant differences in achievement scores on the total laboratory test between the students in the upper third of the experimental group using their take home laboratory materials and the upper third of the control group receiving the traditional laboratory experience.
3. There are no significant differences in achievement scores on the total laboratory test between the students in the lower third of the experimental group using their take home laboratory materials and the lower third of the control group receiving the traditional laboratory experience.
4. There are no significant differences between the experimental group and the control group on sub-test achievement scores for each

experiment.

5. There are no significant differences between the upper third of the experimental group and the upper third of the control group on sub-test achievement scores for each experiment.

6. There are no significant differences between the lower third of the experimental group and the lower third of the control group on the sub-test achievement scores for each experiment.

CHAPTER II

REVIEW OF LITERATURE

Survey of Descriptive Studies of Physical Science Courses

Review of the literature revealed that studies were generally concerned with methods of providing instruction, with course goals and objectives, with subject matter content, with types and procedures of courses, with textbooks and related materials, and with teacher competencies. Since each of these topics is of vital concern in the preparation and organization of a physical science course each area will be considered individually.

Methods of Providing Instruction. From an original survey of 568 junior and senior colleges and universities to ascertain what was being done in the sciences to meet the needs of non-science majors, 313 institutions replied (Morrow, 1959). From this group 40 respondents were asked to reply to an opinionnaire. This group was represented by six state universities, twelve independent colleges, eight teachers colleges, and three junior colleges, making a total of 37 consultants. According to Morrow, data from the 313 institutions indicated that 87 per cent of the group were attempting to meet the needs of their non-science majors through special courses or programs. Approximately 55 per cent of the schools provided separate integrated courses in biological and physical science while less than 10 per cent attempted a single integrated course. Over 22 per cent of the institutions

provided special courses in the several science departments.

Objectives and Goals. The course objectives of the institutions surveyed by Morrow were in agreement with those that the reporting consultants were striving to attain. The objectives most frequently listed were:

1. To gain an understanding of science as it relates to everyday living.
2. To gain a broad understanding of science by providing a core of scientific knowledge.
3. To develop various scientific attitudes of mind and appreciations of the values of science.
4. To develop an understanding of the scientific method and the facility for its application.
5. To acquire the ability for judging the merits of a case whereby one's opinions and decisions can be made without prejudice.

A rather extensive study of 234 southern association junior and senior colleges revealed the following three major objectives for the junior and senior college general education science courses (Wilson, 1952). The junior college teachers stated that they hoped (1) to develop appreciation of the social implications of science, (2) to promote a full personal life through a more complete understanding of the natural environment, and (3) to develop an understanding of the leading laws and concepts of science that affect the daily life of the individual. The senior college teachers listed as their three main objectives: (1) to develop an understanding of the leading laws and concepts of science that affect the daily life of the individual, (2) to promote a full personal life through a more complete understanding of the natural environment, and (3) to develop the ability to think critically. The teachers of these integrated science courses said that they were

definitely not aiming at the development of laboratory skills, ability to read technical literature, or foundations for advanced work in science.

Goals 4-7 of the goals set forth by the 1950 Summer General Education Workshop were concerned with the physical science curriculum. These goals stated that members aimed to help each student increase his competencies in:

4. Using the basic mathematical and mechanical skills necessary in everyday life.
5. Using methods of critical thinking for the solution of problems and for the discrimination among values.
6. Understanding his cultural heritage so that he may gain a perspective of his time and place in the world.
7. Understanding his interaction with his biological and physical environment so that he may better adjust to and improve that environment. (Johnson, 1957)

Although there is some overlapping, there is some variation and difference of emphasis in Rankin's survey (1952). These 148 administrators and 348 physical science instructors from 42 states and the District of Columbia selected the following top five objectives: They wanted (1) to help the student build for himself a unified picture of the universe as conceived by modern science, (2) to acquaint the student with the nature of scientific inquiry, (3) to give the student experience in accurate and critical thinking and jolt him out of his habit of authoritarian learning, (4) to acquaint the student with the role of science in society in order to fit him for intelligent responses to the social problems which center around the progress of science, (5) to help the student read intelligently and critically scientific information intended for the layman.

It is ironic to note that course objectives as surveyed in a study of subject-matter content of general education science courses by

Bullington, was listed as the basis of selection of course content in only three to fifteen courses (1952). One hundred and fifty courses were investigated by questionnaire and other procedures in Bullington's study.

Subject Matter Content. Of the courses surveyed by Morrow, the time allotted to the major fields of physical sciences varied greatly among the schools. The average percentages were approximately: physics, 37 per cent; chemistry, 27 per cent; astronomy, 16 per cent; geology, 14 per cent; meteorology, 3 per cent; miscellaneous topics 3 per cent. Time allotments suggested by the consultants was very similar.

In the 110 courses surveyed by Wilson, the subject matter content of the physical science courses studied was approximately 40 per cent physics, 25 per cent chemistry, 20 per cent earth sciences, and 15 per cent astronomy. Teachers of these courses said that course content was based upon such factors as course objectives, needs of students, and instructor's judgments.

Bullington's study of the physical sciences listed the following subjects in rank order of emphasis:

Physical Science (one semester)

- | | |
|--------------|----------------|
| 1. Physics | 4. Geology |
| 2. Chemistry | 5. Mathematics |
| 3. Astronomy | |

Physical Science (one year)

- | | |
|--------------|----------------------------|
| 1. Physics | 4. Astronomy |
| 2. Chemistry | 5. Mathematics |
| 3. Geology | 6. Other physical sciences |

Topics given major emphasis in courses in physical science, in order of emphasis by the 150 respondents in Bullington's survey:

- | | |
|--------------------|-------------------------|
| 1. Electricity | 3. Solar system |
| 2. Heat and energy | 4. Properties of matter |

- | | |
|----------------------------------|-------------------------------------|
| 5. Atomic theory | 13. Geological history of the earth |
| 6. Light | 14. Acids and bases |
| 7. Force and motion | 15. Periodic table |
| 8. Chemical reactions | 16. Sound |
| 9. Magnetism | 17. Radiation |
| 10. Stars | 18. Organic compounds |
| 11. Materials of the earth | 19. Oxidation and reduction |
| 12. Forces that change the earth | |

Types of Courses. The survey type course was used by 56 per cent, and the block-and-gap type course was used by 39 per cent of the 313 institutions surveyed by Morrow. Eighty-three per cent of the respondents who reported block-and-gap courses considered them satisfactory as compared to 64 per cent of the users of the survey type course.

The lecture-demonstration-laboratory combination was the principal instructional method used. The second most popular combination consisted of lectures, demonstrations, and discussion. A third satisfactory combination was limited to lectures and demonstrations. Lectures, when used as the sole instructional method, were considered unsatisfactory. The lecture-laboratory combination received only slight recommendation. In the opinion of the respondents, laboratory had a definite place in the physical science course. Eighty-four institutions did not use the laboratory as an instructional method; however, only ten of these respondents considered the method used as being entirely satisfactory. The usual time allotted to laboratory work was two hours per week, although 16 of the institutions allotted three or more hours to it while four limited it to only one hour per week. A majority of the respondents stated that two hours per week would be the correct amount of time to allot to laboratory work.

The 37 consultants in Morrow's study preferred the block-and-gap type course with intensive study of selected units, selected problems, or practical applications of scientific methods. They were opposed to

the survey course on the grounds that it is too thin and attempts to cover too much material. They recommended that basic laws and concepts should be emphasized in the course. They were also concerned with the development of scientific attitudes and the historical importance of scientific discoveries.

The consultants strongly recommended a combination of instructional methods including the lecture, demonstration, discussion, and laboratory. They wanted slightly more time than the respondents did for laboratory, however. They also wanted a two-semester course, with a total of eight semester hours.

In Wilson's study, the general survey type course was used by 60 per cent of the respondents. The block-and-gap organization was second with 18 per cent of the courses of that type. The historical study was least used with only one of that type. Nineteen per cent of the courses were described as combinations of the three types.

The lecture was the most frequently used teaching procedure in those courses. This was followed by lecture-demonstration and group discussion. Individual laboratory work was used in less than half of the courses. The lecture-demonstration was rated as the most valuable teaching procedure and students oral reports were rated the least valuable. Senior colleges, other than teacher's colleges, ranked individual laboratory work as the most valuable procedure.

Textbooks and Related Materials. Over 92 per cent in Wilson's survey reported standard textbooks as the principal source of instructional material. Over half of the group used locally prepared outlines or manuals as supplementary material. A total of 19 different textbooks were reported.

The 37 consultants recommended that teachers should depend upon locally prepared syllabi as the principal source of instruction. Teaching aids in their order of recommended frequency were models, charts and maps, supplementary reading, sound film or film strips, flat pictures, field trips, student reports, outside speakers, special problems or projects. Of the 150 courses surveyed by Bullington, 91 courses or 62 per cent used prepared syllabi or course outlines. These ranged from an outline of a few pages to large volumes comparable to textbooks.

The physical science courses in Wilson's study had concentrated on eight different books of which The Physical Sciences by Cable, Getchell, and Dadesch was most popular. This book was followed in popularity by Man and His Physical Universe by Jean, Herman, Harrah and Power; Fundamentals of Physical Science by Kraiskof; The Study of the Physical World by Cheronis, Parsons, and Ronneburg; Man's Physical Universe by Gray. These are in the order of ranked usage.

Teacher Competencies. In trying to determine what experienced administrators and physical science teachers thought adequate training for college physical science teachers should be, Rankin's 495 respondents ranked seven types of training. Mean ranks established for seven types of training by administrators and instructors were:

Type of Training	Admin.	Instr.
1. Specialization in one area of the physical sciences.	5.72	5.31
2. Specialization in one area of the physical sciences with some training in other areas of the physical sciences.	3.35	2.79
3. Training in all areas of the physical sciences without specialization in any one area.	3.70	3.77

	Admin.	Instr.
4. Training in both the physical and biological sciences without specialization in any one area.	4.28	4.28
5. Specialization in one area of the physical sciences with some training in psychology and methods of instruction.	4.15	4.17
6. Broad training in the physical sciences and some training in psychology and principles and methods of instruction.	2.73	3.28
7. Broad training in both the physical and biological sciences and some training in psychology and principles and methods of training.	3.18	3.68

Morrow's 37 consultants recommended that instructors should be trained in a broad field of physical science, should hold at least a Master's degree, and should have some background in most of the physical science areas. This group further recommended that the teaching load for the instructor should be limited to 10 hours of lecture and three hours of laboratory per week. Class size should not exceed 50 students in lecture, 15 in discussion groups, and 18 in laboratories.

Survey of Statistical Studies of Physical Science Courses

Most of the statistical studies pertaining to college physical science courses were one shot projects. One phase of the physical sciences has been investigated more thoroughly. The experiments of Haym Kruglack and his associates were concerned with achievement of physics students in lower division general classes. This is of particular value in that they studied aspects of physics laboratory experience and measurements of achievement resulting from these experiments.

In one of the earlier studies two general physics laboratory groups were compared in achievement with a group enrolled in the same course

without laboratory. The achievement was measured by two pencil-paper examinations and two laboratory performance tests. The analysis of variance and covariance method was used to hold constant three measures of initial differences among students. After testing the null hypothesis by the F -test, the following results were given. There were no statistically significant differences between the means of the groups on the mechanics theory test. The laboratory groups were significantly better than the no-laboratory group on all tests dealing with laboratory work. (Kruglack, 1953).

A later study dealt with characteristics of laboratory performance tests in general college physics. The relationships between performance tests and other measures of aptitude and achievement were explored. About 600 performance items were constructed and face-validated by four college physicists. Performance tests were administered during 1951-1952 to all students in general physics courses at the University of Minnesota. It was found that:

1. Performance tests can be scored with high reliability.
2. The reliability coefficient of a performance test could be increased to an acceptably high value by entering several subscores for each item.
3. The correlations were positive but low between performance tests and high school rank, ACE, mechanical comprehension tests and freshman honor points.
4. The correlations between the performance tests and other achievement measures in physics were positive and low to moderate.
5. The intercorrelations between tests for successive courses were positive and low.
6. The correlations were reduced by increasing the "performance" components of the laboratory tests. (Kruglack, 1954)

Another study dealt with the analysis of paper-pencil laboratory tests in general physics, constructed and administered at the University of Minnesota, 1952-1953. The characteristics of the tests were investi-

gated. Reliability of each pre-test and post-test was calculated by the Hoyt method. Davis Endexes were used for item analysis for physics laboratory tests. Point biserial correlation coefficients were computed between each item on the paper-pencil laboratory tests.

With the exception of the Identification and Function tests, pre-test intercorrelations were low. These two pre-tests were fair predictors for the corresponding post-tests. The correlations between the paper-pencil tests and other criteria of achievement in elementary physics were either nonsignificantly different from zero, or low. On three of the four tests in Mechanics, boys scored significantly higher than girls. On all the post-tests the means were significantly higher than for the pre-tests, irrespective of sex or course taken (Kruglack, 1954).

An attempt to convert laboratory performance tests into essay and multiple-choice items was the next investigation. Preliminary forms of the tests were administered to about 160 elementary physics students. It was found that the multiple-choice was the least difficult of the three tests; the performance, the most difficult. The correlation coefficients between relatively complex performance items and their paper-pencil analogs were very low. The correlations between the preliminary study supported the hypothesis that pencil-paper tests are poor substitutes for performance examinations (Kruglack, 1955).

The purposes of a study by Lahti were (1) to design or use laboratory experiments which would reflect the meanings of the scientific method; (2) to design instruments to measure the ability of the students use of the scientific method; (3) to evaluate the effectiveness of the teaching methods (Lahti, 1956). The group consisted of 338 students,

apparently typical of those enrolled in the course during other years. Students had the same lectures, and they showed no significant differences on tests covering the lectures. For laboratory work, about one hour per week, four approaches were used: (1) individual or small-group efforts by an inductive-deductive or problem-solving approach in which the answer sought was not known; (2) a case-history approach in which the answer sought was known; (3) a "theme" approach later changed to a discussion-recitation session; and (4) a standard "get the right answer" approach. The students proceeded throughout a year by one of the four approaches. Lahti used an "incomplete block" design with replications. In the null form, his hypotheses were that (1) individual laboratory work does not lead to greater resourcefulness in (a) solving new problems, (b) designing experiments, (c) interpreting results of experiments, and (d) utilizing facts and principles; also, (2) the hour of the day at which the session met was not important. Locally constructed tests entitled Interpretation of Data, Design an Experiment Test, and Performance Test were used. While Lahti did not find any statistically significant differences, the group which used Approach 1, problem-solving in the laboratory, scored highest on each of his three tests.

Wise (1957) hypothesized that students who take a course in general science have a right to expect their understandings of basic principles of science to be increased as a result of the completion of either a course in high school physics or a "survey" physical science course at the junior college level. The investigation used a test of the ability to apply twenty-four basic principles in the area of heat as a measure of pupil progress and development. Following statistical comparisons,

Wise concluded that pupils who have completed a course in general science at the ninth grade level may usually expect that their understandings of basic principles of physics will be increased as a result of the completion of a course in high school physics. Such an increase in understanding may not, however, be expected to accompany the completion of a physical science survey course taken at the junior college level. Pupils who have both general science and physics in high school may not expect that the completion of a survey course in the physical sciences at the junior college level will add materially to their understandings of the basic principles of physics.

Johnson (1965) also did a study to try to determine to what extent there is apparent duplication of effort to develop understandings of certain principles of physics at the junior high school, the senior high school, and the junior college levels. When groups were compared by mean scores with effect for intelligence controlled through use of variance and covariance techniques. In so far as the development of understanding of the principles of sound, static electricity and magnetism used in this investigation, ninth grade general science students can probably profit in a course in high school physics but not from a physical science survey course. Johnson further concluded that the major effort to develop functional understandings in the principles used in this study can justifiably be centered at the junior high school level.

A study of relationships between the development of the critical thinking ability of college freshman physical science students and science course organization, initial skill in science, and general college ability was conducted by Reckert (1961). With this group of

students the ability to think critically was improved in the one semester class when opportunities to examine assumptions, collect and organize data and test hypotheses were provided. This study showed there was a low correlation between scores on a test of academic ability and scores on a test of critical thinking. Tests indicated there was a significant correlation between achievement in natural sciences and critical thinking. Measuring instruments used were the School and College Ability Test, the natural science section of the STEP test, and the American Council on Education Test of Critical Thinking, Form G.

An investigation by Morris (1963) sought to ascertain whether selected items of available demonstration apparatus can be improved significantly for use as instructional aids in collegiate general education physical science instruction. Six items of demonstration apparatus were prepared by Morris. This apparatus and their counterparts were evaluated by nine experienced physical science teachers. Evaluators used a rating scale with three criteria. The earth inductor and the pith ball were judged to exhibit very definite improvements. The projections of wave forms and conservation of angular momentum items were placed in the same improvement category. Judgment on the other two items fell at the border between.

A project to construct supplemental programmed materials for use by certain students in general education physical science at the University of Florida was undertaken by Brown (1965). He then studied the effectiveness of these materials when used with a selected group of students in their C-22 course. After three and one-half weeks of the course, with two hours each week of programmed work, all students received the departmental first progress test. The experimental group

showed a higher level of performance than the control group with better than .01 point of confidence. After the first examination, the experimental group only studied one hour of programmed material per week. Later tests showed no statistically significant differences between the achievement of the groups.

Yoesting (1965) attempted to determine whether or not the general physical science course as taught in the state colleges in Oklahoma make a significant contribution toward the objective of developing critical thinking. Groups were pre-tested and post-tested in two Oklahoma state colleges by means of alternate forms of the Watson-Glaser Critical Thinking Appraisal. The statistical tests results revealed that the group enrolled in science made an increase in score from pre-test to post-test. The group enrolled in the physical science class was significantly different from the group who were not enrolled in the physical science class at the .01 level.

Zantitis (1965) studied the extent an authoritative communication of his level of ability to the student would influence the students performance as measured on standardized achievement tests. The three groups were given the STEP test. The results were analyzed by the Friedman-Two-Way Analysis of Variance by Ranks technique. Comparison of all possible combinations of any two groups were made through the application of the Mann-Whitney U Test. Students were also asked to fill out self rating scales. Post-test results indicated that there were significant differences in performance and student self-rating following the communication.

An investigation by Zitelli (1965) compared the achievement and gain scores of freshman non-science majors in a basic physical science

course when taught by a single teacher method and a cooperative teacher method. The experimental group was taught by three specialists, one in astronomy, one in physics, and one in chemistry. Each phase of the course had to be completed in five weeks. Indications that the achievement in each of the units was influenced by the method of instruction. The mean achievement scores of students were significantly higher in the astronomy unit when students were taught under the single instructor method. In the physics unit, there was no significant difference in the mean achievement. In the chemistry unit, there were indications that the cooperative method was statistically more effective.

White's (1965) study analyzed selected measures of science understanding and attitude for two groups of elementary education majors who had completed different general education science curricula. The groups were compared for general science, biology, physics, chemistry, and geology understanding by pre-test and post-test with the natural science portion of the STEP test. There was no significant difference except the Botany-Geology group did significantly better than the Biological-Physical Science group on the geology section.

One of the most comprehensive educational research programs on independent study was carried out at Antioch College by Churchill (1957) and Churchill and Baskin (1958). The courses involved varying periods of independent study in humanities, social science, and science. A serious attempt was made to study cognitive and affective achievement and to evaluate independent study upon learning resourcefulness. Although the results of the experiments are not conclusive, independent small groups learned more subject matter in physics than students working independently as individuals. The predominant results were of "no"

significant difference. An exception was found in various indices of student satisfaction in which several significant differences favor lecture-discussion over independent study and especially over independent small groups.

In another well controlled experiment at Oberlin College, McCollough and VanAtta (1958) required students in introductory science, psychology and mathematics to work independently of the instructor in small groups. This independent work occupied one third of the college year following several weeks of preliminary training. No significant difference in learning appeared as measured by achievement tests or by a test of learning resourcefulness. The students indicated they would have preferred several two-week periods of independent study to the single longer period.

CHAPTER III

METHODOLOGY AND DESIGN

Sample

The sample consisted of 60 of the 69 students enrolled in Physical Science 114 at Northern Oklahoma College during the spring semester, 1967. All 60 students were either freshman or sophomore non-science majors. These students were divided into two 30 member groups. Of the 30 students in the control group, 17 were male and 13 were female. Of the 30 students in the experimental group, 21 were male and 9 were female. The groups were divided so that the mean of the composite scores on the American College Test was 18.667 for each group. According to the high school records members of the experimental group had earned 41 credits in high school courses while members of the control group had earned 35 credits. Information on the groups' ACT scores, sex, and high school science courses is shown in Appendix A.

Materials and Methods

Following the philosophy of an integrated approach to the physical sciences the laboratory experiences were chosen so that they generally overlapped the various disciplines. For example, the experiment on relative humidity utilizes principles of physics, chemistry, and meteorology.

These experiments were selected on the basis of the interrelated-

ness of general education physical science courses. The course objectives and lecture and laboratory content were developed following a study of available literature of objectives and content of similar courses, a consideration of the particular institution, and of the interests and scientific educational background of the particular students in the program. A copy of the student survey form which was used to gather some of this information is in Appendix B.

The topics of the laboratory experiments in their order of performance are:

1. The Nature of Science
2. Dimensional Analysis
3. Measurement of Length
4. The Solar System
4. Relative Humidity
6. Weather Charts
7. Acceleration of a Freely Falling Body
8. Simple Pendulum
9. Velocity of Sound in Air
10. Topographic Maps
11. Topographic Profiles

Copies of instruction sheets for each of the eleven experiments are in Appendix C.

The 60 subjects met the physical science lecture-demonstration class for three one-hour sessions at 8 a.m. every Monday, Wednesday, and Friday for the entire semester. The first week of the semester the entire group met the laboratory session and discussed the different procedures that the groups would follow during the semester. During

the second meeting the students were divided into a control group and experimental group on the basis of composite ACT scores. The 30 students in the control group were further divided into two groups of 15 students each. In addition to the lecture-demonstration classes each of the 15 member sub-groups of the control group met weekly two-hour laboratory sessions. One group met from 1 to 3 p.m., the other group met from 3 to 5 p.m. every Tuesday. During these laboratory sessions the members conducted and discussed the eleven experiments.

During the final five minutes of the Monday class session, the 30 members of the experimental group picked up their laboratory experiment sheet and the necessary materials. These students worked independently at their own discretion and turned in their laboratory reports during the week or at the following Monday's lecture session. The experimental group also met four one-hour question and answer sessions during the semester to discuss their work and to receive guidelines for further independent study.

Analysis

A locally constructed test was prepared as the achievement evaluation instrument used in this study. The test consists of 27 multiple choice questions and one short answer problem in which each student was required to show the method of solution. Hence, the test was objective in its design. Each question on the test had one point value and the test was scored on the basis of total number of correct responses. A complete copy of the test is in Appendix D.

Careful review of the course objectives and content in comparison with each test item was concerned with the logical or curricular

validity of the test. The empirical validity of the instrument was evaluated by the method of internal consistency. The degree to which the test items included in the test discriminated between subjects of varying abilities was figured by using the item analysis index of discrimination called "biserial correlation with total test." The complete item analysis data is in Appendix E.

Reliability coefficient (r) of the appraisal instrument was measured by the Kuder-Richardson formula

$$r = \frac{ns^2 - M(n-M)}{ns^2},$$

where n = number of test items,

s^2 = variance,

and M = mean score of total group.

The computed value of the reliability coefficient was 0.64.

The standard error of measurement for the test was found from the following formula.

$$\sigma_s = \sigma_t(1-r)^{\frac{1}{2}}$$

where

σ_s = standard error of measurement,

σ_t = standard deviation of test scores in the group in which the coefficient of reliability has been computed,

and r = the coefficient of reliability of the test.

The standard error of measurement was computed to be 2.6.

A t -test was used to test the null hypothesis that there is no significant difference in the total laboratory achievement scores of the experimental group using take home laboratory materials and the control group receiving the traditional laboratory experience. The null hypothesis was tested at the .05 level of confidence.

The twenty-eight item test over the eleven experiments was divided into sub-tests so that there was a test of five questions on one experiment, tests of three questions on each of eight experiments, a test of two questions on one experiment, and a test of one problem on one experiment.

A closer study of the sub-tests show that questions 20 and 21 are concerned with Experiment Number 1, The Nature of Science. Question number 20 asks the students which ideas and observations cannot be classified as scientific. Question 21 is concerned with the idea of the usefulness of a scientific theory. The answers to these two questions come directly from the laboratory experience.

Experiment Number 2, Dimensional Analysis, is a study of a method of solving problems. This particular method is rarely found in textbooks. Question 28 is a problem which requires the dimensional method for a correct response.

The test questions over Experiment Number 3, Measurement of Length, are numbers 14, 15, and 16. Question 14 asks for an interpretation of the object of the experiment. Question 15 is concerned with the utilization of the data. Question 16 involves the interpretation of the results of the experiment.

Questions 11, 12, and 13 are for Experiment Number 4, The Solar System. This experiment had a twofold purpose: to give the student a better idea of the size of the solar system and to help the student learn to translate tabular information into meaningful ideas. Successful completion of the experiment should have resulted in correct responses on the three questions.

The test items for Experiment Number 5, Relative Humidity, are

questions 2, 6, and 7. Question 2 requires a knowledge of weather symbols and the ability to read dew point and air temperatures correctly from a weather chart. Question 6 asks for the definition of dew point which is given in the preliminary discussion part of the experiment. A correct response on question 7 could result if the questions following the experiment are answered correctly.

Questions 1 to 5 involve a recognition of weather symbols and an interpretation of the information given on weather charts. Experiment Number 7, Weather Charts, should have provided the necessary information.

Correct responses on questions 25, 26, and 27 require the successful completion of Experiment Number 7, The Acceleration of a Freely Falling Body. Questions 25 and 26 require the knowledge that the acceleration of a freely falling body is constant while question 27 is a calculation of the distance an object will fall in a given period of time.

The test questions on Experiment Number 9, The Simple Pendulum, are listed as 8, 9, and 10. Question 8 assumes the understanding of the term "period," and the factors which affect the period of a pendulum. Question 10 asks for a conclusion to be drawn from the results of the pendulum experiment. Successful completion of the experiment is vital for correct responses to these questions.

To answer questions 22, 23, and 24 (Experiment Number 9, The Velocity of Sound in Air) the student must know that the product of the frequency and wavelength is the velocity of sound. He must also have read the reference material in the text concerning the Doppler effect and the longitudinal nature of a sound wave.

Questions 17, 18, and 19 deal with topographic maps and topographic profiles. Question 17 deals with the elevation of points on a topographic map; question 18, cross-sections; and question 19, the properties of contour lines. The necessary information for the correct responses on these questions are found in Experiment 10, Topographic Maps, and Experiment 11, Topographic Profiles.

The t-test was also used to test the hypotheses of no significant difference in mean laboratory achievement scores of the groups on the sub-test items.

A suggestion check-list concerning the course, a rating scale for teacher effectiveness, and students' personal comments were the data collected concerning the students attitudes toward the physical science course.

CHAPTER IV

RESULTS

The data gathered for this experiment was analyzed using the t-statistic to test for difference of total laboratory achievement scores of the control group as compared with the experimental group. The t-test was also used to compare differences between the total laboratory achievement scores of the upper thirds of the two groups and the lower thirds of the two groups. Composite ACT scores were used as the basis for determining upper and lower third of each group. None of the computed values for t for the total test were found to be significant although the experimental group scored higher in each case. The observed mean scores and the t-statistics for the experimental and control groups are presented in Table I. Raw scores are presented in Appendix A.

The t-statistic to test for difference of sub-test achievement scores of the control group as compared with the experimental group was also used for each experiment. The results of Experiment Number 8, The Simple Pendulum, was the only one of the eleven sub-tests in which there was a significant difference. The observed mean score of 2.366 for the experimental group as compared with 1.800 for the control group resulted in the t-statistic of 2.590. This was significant at the .05 level. This allows rejection of the null hypothesis for the sub-test of Experiment Number 8. The observed mean scores and the t-statistics for the experimental and control groups on sub-test questions on each experiment

TABLE I
ANALYSIS OF OBSERVED MEANS ON TOTAL TEST

Source of Data	Means	df	<u>t</u>
Total correct responses of entire sample			
Control group	15.800	29	0.964
Experimental group	16.900		
Total correct responses of the upper third of sample			
Control group	18.400	9	0.576
Experimental group	19.200		
Total correct responses of the lower third of sample			
Control group	11.300	9	1.667
Experimental group	14.300		

are presented in Table II.

The t-test of significance was also used to compare differences between the mean sub-test achievement scores of the upper third and the lower third of each group. In the comparison of the upper third of the experimental and control groups on the sub-tests there was a significant difference in the achievement scores on Experiment Number 7, Acceleration of a Freely Falling Body. The observed mean score of 0.800 for the experimental group as compared with 1.900 for the control group resulted in the t-statistic of 3.221. This was significant at the .05 level. This allows rejection of the null hypothesis for the sub-test of Experiment Number 7. The observed mean scores and the t-statistic for the upper third of the experimental and the upper third of the control group on the sub-test questions to each experiment are presented in Table III.

In the comparison of the lower third of each group on sub-test questions for each experiment, the t-test of significance was again used. There was a significant difference on Experiment Number 8, Simple Pendulum. The observed mean score of 2.300 for the experimental group as compared with 1.400 for the control group resulted in the t-statistic of 2.770. This was significant at the .05 level. This allows rejection of the null hypothesis for the sub-test of Experiment Number 8. The observed mean scores and the t-statistics for the lower third of the experimental and the lower third of the control group on the sub-test questions for each experiment are presented in Table IV.

The student check-list and accompanying teacher rating scale provided indications of the students attitudes toward the physical science course. The percentage of the responses to the check-list concerning

TABLE II
ANALYSIS OF OBSERVED MEANS OF THE SUB-TESTS
FOR THE TOTAL SAMPLE

Experiment Number	Test Question Numbers	Means		<u>t</u>
		Experimental	Control	
1	20, 21	1.233	1.167	0.501
2	28	0.567	0.400	1.290
3	14, 15, 16	1.867	1.567	1.510
4	11, 12, 13	2.400	2.333	0.330
5	2, 6, 7	1.500	1.533	0.177
6	1, 2, 3, 4, 5	2.567	2.467	0.324
7	25, 26, 27	1.400	1.333	0.256
8	8, 9, 10	2.366	1.800	2.590*
9	22, 23, 24	1.333	1.300	0.153
10	17, 18, 19	2.033	1.867	0.722
11	17, 18, 19	2.033	1.867	0.722

*.05 level of significance

df = 29

TABLE III
ANALYSIS OF OBSERVED MEANS OF THE SUB-TESTS
FOR THE UPPER THIRD OF THE SAMPLE

Experiment Number	Test Question Numbers	Means		<u>t</u>
		Experimental	Control	
1	20, 21	1.300	1.300	0.000
2	28	0.600	0.500	0.429
3	14, 15, 16	2.300	2.000	0.709
4	11, 12, 13	2.700	2.600	0.477
5	2, 6, 7	1.900	1.600	1.125
6	1, 2, 3, 4, 5	2.800	2.900	0.280
7	25, 26, 27	0.800	1.900	3.221*
8	8, 9, 10	2.600	2.000	1.766
9	22, 23, 24	1.700	1.500	0.583
10	17, 18, 19	2.600	2.300	1.325
11	17, 18, 19	2.600	2.300	1.325

*.05 level of significance

df = 9

TABLE IV
ANALYSIS OF OBSERVED MEANS OF THE SUB-TESTS
FOR THE LOWER THIRD OF THE SAMPLE

Experiment Number	Test Question Numbers	Means		<u>t</u>
		Experimental	Control	
1	20, 21	1.300	1.000	1.964
2	28	0.300	0.100	1.096
3	14, 15, 16	1.400	0.700	1.634
4	11, 12, 13	2.00	2.00	0.000
5	2, 6, 7	1.100	1.300	0.572
6	1, 2, 3, 4, 5	2.100	1.800	0.471
7	25, 26, 27	1.800	1.000	1.987
8	8, 9, 10	2.300	1.400	2.770*
9	22, 23, 24	0.800	0.900	0.268
10	17, 18, 19	1.400	1.300	0.268
11	17, 18, 19	1.400	1.300	0.268

*.05 level of significance

df = 9

suggestions of means for improving the physical science program is presented in Table V. The responses of the two groups on the teacher eight point rating scale are presented in Table VI. Students comments and written recommendations concerning the course are in Appendix G.

TABLE V
SUMMARY OF THE CHECKLIST OF STUDENT RESPONSES

Item	% Response Control Group	% Response Exp. Group	% Response Total Group
More visual aids	23	38	31
More tests and examinations	45	47	46
Fewer tests and examinations	3	6	5
More required outside reading	26	29	28
Less required outside reading	0	0	0
Less emphasis of memorizing in examinations	3	3	3
A mimeographed outline of the course for the student	61	47	54
Use English of a higher standard	0	0	0
Reduce the monotony of his speaking	13	18	15
Use fewer unfamiliar words	6	12	9
Present material more slowly	23	24	23
Do less moving about while lecturing	0	0	0
Make chalkboard writing more legible	0	6	3
Be less hasty in erasing useful material from the chalkboard	13	3	8
Work demanded in this course is excessive for the amount of credit	6	12	9
Work demanded in this course is lighter than average for the amount of credit	35	24	29
Effectiveness of teaching in this course would be helped by the setting up of more rigorous prerequisites	6	3	5

TABLE V (Continued)

Item	% Response Control Group	% Response Exp. Group	% Response Total Group
More time should be devoted to the answering of student's questions	16	15	15

TABLE VI
MEAN SCORES ON THE ZERO TO EIGHT POINT RATING SCALE FOR
TEACHING EFFECTIVENESS

Item Number	Description	Control Group	Experimental Group
1	Preparation for class meetings	6.42	6.41
2	Teachers interest in subject	6.48	6.38
3	Reaction of students	4.77	4.88
4	Classroom management	6.07	6.51
5	Scholarship	6.93	7.09
6	Ability to express thought	5.64	5.45
7	Voice	6.58	6.29
8	Spirit of growth	5.67	5.69
9	Assignments	6.07	5.55
10	Class discussion	5.63	5.69
11	Feeling between teacher and class	5.97	6.00
12	Sense of humor	6.55	6.61
13	Self-confidence	6.63	6.41
14	Tolerance and mental flexibility	6.94	6.91
15	Personal appearance	7.23	7.47
16	Personal mannerisms	6.90	7.03
17	Conduct of class	6.48	6.19
18	Efficiency in procedure	6.10	5.94
19	Approachability	6.29	6.35
20	Stimulus to thinking	5.90	5.81
21	Validity of examinations	6.30	6.21
22	Major objectives of course	5.71	5.26
23	General rating of teacher	5.97	5.47

CHAPTER V

DISCUSSION

The finding that statistically there was no significant difference between laboratory achievement test scores of the control group and the experimental group on the total laboratory test does not allow rejection of the null hypothesis. Further statistical estimates, also by use of the t-test of significance, indicated no significant difference in the laboratory achievement test scores between the upper third of the experimental and control groups or between the lower third of the experimental and control groups. Selection of the upper and lower third subjects for each group was also based upon ACT scores. It should be noted that the difference between the lower thirds was greater than were the other comparisons.

Within the analysis of the sub-tests there were some differences that were statistically significant. The finding that there was a significant difference favoring the laboratory achievement of the experimental group as compared with the control group on Experiment Number 8, Simple Pendulum, allowed the rejection of the null hypothesis that there are no significant differences in achievement scores between the experimental group and the control group on sub-test questions pertaining to Experiment Number 8, Simple Pendulum. Further findings that there was a significant difference favoring the laboratory achievement of the lower third of the experimental group as compared

with the lower third of the control group on Experiment Number 8, Simple Pendulum, allowed the rejection of the null hypothesis that there are no significant differences in achievement scores between the lower third of the experimental group and the lower third of the control group on sub-test questions pertaining to Experiment Number 8, Simple Pendulum. The only other significant difference favored the upper third of the control group as compared with the upper third of the experimental group on Experiment Number 7, Acceleration of a Freely Falling Body. This allowed the rejection of the null hypothesis that there are no significant differences in achievement scores between the upper third of the experimental group and the upper third of the control on sub-test questions on Experiment Number 7, Acceleration of a Freely Falling Body.

At first reading these findings may appear to be diametrically opposed. This may be true. This may, however, be an indication that different types of laboratory experiences may lend themselves to different types of presentations to get the most effective results. The significant differences of the upper and lower third groups on experiments 7 and 8 respectively may add another dimension to the educational possibilities. Within these very limited indices, there may be an indication that certain groups of students will profit more from a traditional laboratory experience or independent laboratory experience depending upon the type of experiment and the type of group.

Of the eleven experiments compared by upper third groups, the only one where there was a significant difference was Experiment Number 7. It should be noted that on this experiment where the questions which were asked required a mathematical calculation with the use of a formula the control group scored significantly higher. Before even limited

generalizations can be considered it should be noted that Experiment Number 9 also required calculations and the use of formulas. Experiment Number 7 required by far the most use of formulas and detailed calculations.

It should be noted that in Experiment Number 8 there was a significant difference between the groups on the sub-test and also between the lower thirds on the sub-test. In each instance the experimental groups scored significantly higher than did the control groups. The upper third groups did not show a significant difference in their comparisons, however. This experiment also required calculations and the use of a formula to answer the questions at the end of the experiment. This, therefore, would seem to be contrary to the differences indicated in Experiment Number 7, or it may indicate a difference in the matter of student effectiveness being in proportion to the degree of difficulty of the task.

Other factors which must be taken into consideration in the interpretation of these findings include the size of the sample population, possible difference in the characteristics of the sample group, and the ever present possibility of the Hawthorne effect in such a study.

The problem of the size of the sample could not be avoided, however, for the study included all the students enrolled in Physical Science 114 for the spring semester of the 1966-67 academic term who finished the course and who had available ACT scores. This eliminated nine of the population since five members did not have available ACT scores and four students did not complete the course, leaving a sample of 60 members.

Care was taken to correlate the sample groups on the basis of ACT scores, previous science academic training and sex. By correlating factors of academic achievement, previous scientific study and sex of non-science majors who were either freshman or sophomore students an attempt was made to eliminate the differences of these characteristics within the sample.

There is also the possibility of the Hawthorne effect within such an experiment since members of this population were aware that they were in the study.

The indication that independent laboratory study for physical science students through the use of take home laboratory materials is as effective as the traditional laboratory experience could have far reaching effects. This would be particularly true in view of the simple, inexpensive items which were selected as a means of studying physical science principles. In the particular semester of this study eight hours per week of the instructor's time could have been taken out of the traditional laboratory and used for personal or small group consultations, for personal enrichment, or for assuming additional lecture responsibilities. This would also affect needed laboratory space and equipment purchases, not to mention the possible value of developing independence in study at this level.

As the 1964 Boulder Conference report pointed out, the physical science courses often have professional dimension; for they are frequently preprofessional training for elementary and sometimes secondary school teachers. The Committee recommended that in view of the future possible effects of this training both students competencies and attitudes should be given careful consideration.

As a secondary feature, data was collected pertaining to the students' attitudes toward the physical science course. A course check-list, students written comments, and a teacher rating scale were used as the means of comparing student attitudes.

The summary of the check-list of responses in Table V gives the per cent of students who responded to each of the eighteen points on the list by the per cent of responses of the control group, the per cent of responses of the experimental group and the per cent of responses of the total group. The two items on the check-list getting by far the most responses, almost twice as many as any other items, were: (1) more test and examinations and (2) a mimeographed outline of the course for the students. Forty-six per cent of the students requested more examinations with 45 per cent of the control group and 47 per cent of the experimental group indicating a desire for more tests. This group division was extremely close as is noted by the two per cent difference. This is not true of the second item. A mimeographed outline was requested by 54 per cent of the students with 61 per cent of the control group and 47 per cent of the experimental making the request. This would seem to be the opposite of what one would expect since the control groups course would have more structured form in the traditional laboratory experience. While the experimental group picked up their instructions on Monday morning and had until the following Monday to study and analyze the information, perform the experiments, and review their study; the control groups received their sheets at the beginning of the laboratory and had only that time to digest the information and perform the experiment. This time factor may be one reason for the request for mimeographed materials by more of the control group.

Thirty-one per cent of the students requested more visual aids. This item had the widest margin of difference with 38 per cent of the experimental group indicating a need and only 23 per cent of the control group. Thus, the demonstration-discussion portion of the traditional laboratory which was experienced only by the control group may have satisfied these needs for more of that group.

Twenty-eight per cent of the group indicated they would have profited by more outside reading. Here again, however, the groups were very similar with 26 per cent of the control group and 29 per cent of the experimental group indicating a need for more outside reading.

Twenty-nine per cent of the group indicated they believed the work was lighter than average for the amount of credit. The responses of the control group of 35 per cent was higher than the 24 per cent of the experimental group, however. This, coupled with the fact that 12 per cent of the experimental group indicated the work in the course is excessive to the amount of credit as contrasted with only six per cent of the control group, tends to indicate that the experimental group did feel that the course was more difficult than did the control group.

Other items on the check-list received responses of 15 per cent or less by both groups.

The teacher rating scale of both groups was favorable in that the entire rating was in the upper third of the eight point evaluation scale with the exception of the rating of the reaction of the students. This mean rating was 4.88 for the experimental group and 4.77 for the control group. Student reactions varied more between a number of the items both on the check-list and the teacher rating scale than they did between groups.

The check-list, teacher rating scale, and student comments which are in Appendices G, provide the indications of the students attitudes toward the physical science course.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate experimentally the effectiveness of a take home laboratory as a method of laboratory teaching in physical science classes for non-science majors. The study compared the achievement of physical science students resulting from traditional laboratory instruction with achievement resulting from the use of take home laboratory materials. As a secondary concern in the study, data pertaining to student attitudes toward the physical science course was collected.

Eleven laboratory experiments were selected on the basis of inter-relatedness of general physical science courses. The experiments were developed following a study of available literature on objectives and content of other physical science courses, a consideration of the particular institution, and the interest and science education background of the particular students in the program.

Sixty freshman and sophomore non-science majors enrolled in Physical Science 114 at Northern Oklahoma College for the spring semester of the 1966-67 academic term were used as subjects in this experiment. One 30 member group attended one two-hour traditional laboratory session. The other 30 member group used take home laboratory materials and attended four one-hour question and answer sessions during the semester.

The independent variable was the type of laboratory experience

each group received. The dependent variable was the measure of student achievement of subject matter content from the physical science laboratory experience.

The t-test of significance was used to test the major null hypotheses which were:

1. There are no significant differences in achievement scores on the total laboratory test between the students in the experimental group using their take home laboratory materials and the control group receiving the traditional laboratory experience.

2. There are no significant differences in achievement scores on the total laboratory test between the students in the upper third of the experimental group using their take home laboratory materials and the upper third of the control group receiving the traditional laboratory experience.

3. There are no significant differences in achievement scores on the total laboratory test between the students in the lower third of the experimental group using their take home laboratory materials and the lower third of the control group receiving the traditional laboratory experience.

4. There are no significant differences between the experimental group and the control group on sub-test achievement scores for each experiment.

5. There are no significant differences between the upper third of the experimental group and the upper third of the control group on sub-test achievement scores for each experiment.

6. There are no significant differences between the lower third of the experimental group and the lower third of the control group on

sub-test achievement scores for each experiment.

A student check-list, an eight point teacher rating scale, and student comments were the data indicating students attitudes toward the physical science program.

Results of the study indicated:

1. No significant difference between the achievement scores of the experimental group and the control group on the total test.
2. No significant difference between the upper third of the experimental group and the upper third of the control group on the total test.
3. No significant difference between the lower third of the experimental group and the lower third of the control group on the total test.
4. A significant difference in achievement between the experimental and the control groups on sub-test questions pertaining to sub-test, Experiment Number 8, The Simple Pendulum, favoring the experimental group.
5. A significant difference in achievement between the upper third of the experimental group and the upper third of the control group on one of the eleven sub-tests, Experiment Number 7, The Acceleration of a Freely Falling Body, favoring the control group.
6. A significant difference in achievement between the lower third of the experimental group and the lower third of the control group on one of the eleven sub-tests, Experiment 8, The Simple Pendulum, favoring the experimental group.

Difference of attitudes, as indicated by the data collected pertaining to student attitudes toward the physical science course,

revealed that attitude variations were greater between items than they were between groups.

On the basis of these findings the following conclusions were drawn: Take home laboratory materials with monthly one-hour question and answer sessions provide as effective a learning method as does the traditional laboratory experience. Take home laboratory materials would probably be effective in other general education introductory science courses. Significant differences on particular experiments indicate that some experiments may be best presented to certain groups by the traditional approach as contrasted with the experimental approach while the opposite may be true for certain other experiments. Student attitudes toward the physical science program were probably affected more by other factors than they were by the type of laboratory experience.

Recommendations for Further Study

One recommendation would be to make further comparisons of the effectiveness of take home laboratory materials for particular types of experiments, considering the possibilities that varying groups may profit from different procedures.

In searching for a standardized test instrument to use to measure achievement in this study, it became apparent that there were no recognized formal test instruments to test knowledge in the general physical sciences. It is recommended that the development of formal test instruments in general physical science is needed.

BIBLIOGRAPHY

- Brown, Willard Andres. "An Experiment Using Programmed Material As Supplemental Instruction in College Physical Science," (unpub. Ed.D. dissertation, University of Florida, 1963).
- Bullington, Robert A. "The Subject-Matter Content of General Education Science Courses," Science Education, XXXVI (December, 1952), 285-292.
- Churchill, Ruth. Preliminary report on reading course study. Yellow Springs, Ohio: Antioch College, 1957.
- Churchill, Ruth, and S. Baskin. Experiment on independent study. Yellow Springs, Ohio: Antioch College, 1958.
- Johnson, B. Lamar. General Education in Action. Washington, D. C.: American Council on Education, 1957.
- Johnson, Lloyd K. "A Comparison of Understandings of Selected Principles of Physics Developed by Students at Three Levels of Instruction," Science Education, XLIX (March, 1965), 123-126.
- Kruglak, Haym. "Achievement of Physics Students With and Without Laboratory Work," American Journal of Physics, XXI (1953), 14-16.
- Kruglak, Haym. "The Measurement of Laboratory Achievement," American Journal of Physics, XXII (1954), 442-462.
- Kruglak, Haym. "Measurement of Laboratory Achievement," American Journal of Physics, XXIII (1955), 82-87.
- Lahti, Arnold M. "The Inductive-Deductive Method and the Physical Science Laboratory," Journal of Experimental Education, XXIV (March, 1956), 149-163.
- McCollough, Celeste, and E. L. VanAtta. "Experimental Evaluation of Teaching Programs Utilizing a Block of Independent Work," Paper read at the American Psychological Association. Washington: September, 1958.
- Morris, Maurice F. "Improvement of Selected Demonstration Apparatus for Use in Collegiate General Education Physical Science Instruction," (unpub. Ed.D. dissertation, University of Colorado, 1963).
- Morrow, Elman A. "A Proposed Program of Physical Science Education for Non-Science Students," Science Education XL (February, 1959), 65-69.

- Rankin, Oren R. "A Study of Competencies Desirable for Instructors of College General Education Courses in Physical Science," Science Education, XXXVI (December, 1952), 297-306.
- Rickert, Russell Kenneth. "The Critical Thinking Ability of College Freshman Physical Science Students: A Study of the Relationship Between the Development of the Critical Thinking Ability of College Freshman Physical Science Students and Science Course Organization, Initial Skill in Science, and General College Ability," (unpub. Ed.D. dissertation, New York University, 1961).
- White, Calvin Sherman. "A Study of Selected Factors Related to Two General Education Science Curricular Patterns Used by Undergraduate Elementary Education Majors," (unpublished Ed.D. dissertation, University of Missouri, 1965).
- Wilson, L. L. "General Education Science in Southern Association Junior and Senior Colleges," Science Education, XXXVI (December, 1952), 293-296.
- Wise, Harold E. "A Comparison of the Effectiveness of Courses at Three Levels of Instruction in Developing Understandings of Selected Principles of Physics," Science Education, XLI (December, 1957), 418-424.
- Yoesting, Clarence Calvin. "An Evaluation of the Outcomes of a General Physical Science Course with Respect to Specific Objectives," (unpublished Ed.D. dissertation, University of Oklahoma, 1965).
- Zansitis, Jr., Peter Paul. "A Study of the Impact of Communicated Expected Achievement Upon Actual Achievement in College Science," (unpublished Ed.D. dissertation, University of Illinois, 1965).
- Zitelli, Patsy Anthony. "An Evaluation of a Cooperative Teaching Method in Basic Physical Science as Required of Non-Science Majors," (unpublished Ed.D. dissertation, Pennsylvania State University, 1965).

APPENDIX A

APPENDIX A

CHARACTERISTICS AND SCORES OF THE SAMPLE

Control Group				Experimental Group			
Sex	HS Sci. Credits	ACT	Lab. Test	Sex	HS Sci. Credits	ACT	Lab. Test
M	1	28	20	M	1	26	22
F	1	26	21	M	2	26	20
F	1	25	19	M	2	26	22
F	2	25	19	M	2	24	19
M	1	24	16	M	1	24	22
M	1	24	21	M	1	24	16
F	1	23	21	M	1	23	23
F	2	23	16	F	1	23	12
F	1	22	17	F	2	23	21
F	1	21	14	M	2	21	12
M	1	20	15	F	1	21	15
M	1	20	21	M	1	20	18
M	1	18	16	M	2	20	21
M	1	18	21	M	2	19	9
M	1	18	14	M	1	18	19
M	2	18	12	M	2	18	20
F	1	17	17	F	1	18	20
F	0	17	13	M	2	18	19
M	1	17	21	F	2	17	18
M	1	16	21	F	1	17	16
F	1	16	16	F	2	16	16
M	2	16	10	M	1	15	12
F	2	15	12	M	1	15	12
M	2	15	13	M	1	15	13
M	1	15	12	F	0	14	13
F	0	14	2	F	1	14	16
F	1	14	10	M	0	13	12
M	2	14	19	M	3	11	14
M	1	11	5	M	1	11	21
M	1	10	14	M	1	10	14

APPENDIX B

APPENDIX B
STUDENT SURVEY

The following is a list of the units in the textbook, Man and His Physical Universe--Wistar. Please rank them 1, 2, 3, etc. to indicate your interest in the topics.

- _____ Unit I Weather
- _____ Unit II Photography & Wave Motion
- _____ Unit III Electricity and Magnetism
- _____ Unit IV Atoms in Action
- _____ Unit V The Solar System and Beyond
- _____ Unit VI The Story of the Earth

List your high school science credits.

List any credits in college mathematics or science.

Class and Work Schedule

	M	T	W	T	F
8					
9					
10					
11					
12					
1					
2					
3					
4					
5					
6:30					

APPENDIX C

APPENDIX C

Physical Science 114

Experiment Number 1

THE NATURE OF SCIENCE

Man stands about halfway in size between a tiny atom and a great galaxy, and has great difficulty in experiencing both. What man experiences are the various reactions that we have to our sense of touch, taste, smell, hearing and, most important, sight. The reality of the universe may only reveal a certain range to us. A dog can hear "sounds" too high for the human ear. Such sounds can never be real to man. Similarly our eyes only reveal a part of the spectrum of which light is a part. With various man-made instruments we have been able to detect and even use various parts of the light and sound spectrums. But since we can't directly sense them, man must try to understand them as best he can. Science has provided the best means for understanding the reality of the universe in which we find ourselves.

In this experiment you will experience some of the limitations of our senses and attempt an experiment to determine if man has a sixth sense.

Because of man's difficulty in his search for the reality of the universe, we hold most of our generalizations as just temporary or tentative. This is the reason why you will find so many of the generalizations of science called theories. These theories are accepted, not because they are "true," but because they are consistent with observations and are useful in interpreting natural phenomena. When theories are no longer useful they are replaced by other theories which offer better explanations.

It has been estimated that we receive over 80% of our information about the physical world through our eyes. Our eyes are usually dependable but there are certain situations in which our brains cannot correctly interpret what our eyes tell it. Sometimes our eyes mislead us because we confuse the "real" thing with its picture.

1. Which post in Figure 1 appears the tallest? Now measure each post. Which is actually the largest "in the flat lines of the picture"? Discuss.

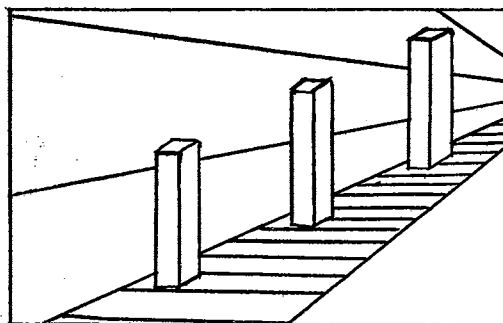


Figure 1

THE NATURE OF SCIENCE page 2

2. Our eyes mislead us sometimes because they tend to follow lines out beyond their extremities. For example, in Figure 2, which one appears to have the longest center section? Measure them. Discuss.

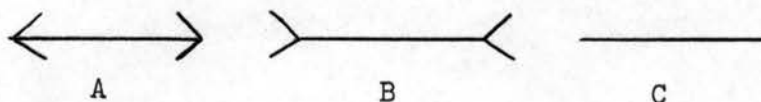


Figure 2

3. In a flat drawing we may confuse the direction of the shadows. How many cubes (blocks) do you see in Figure 3 (six or seven)? Count them again. Turn the page upside down and count again.

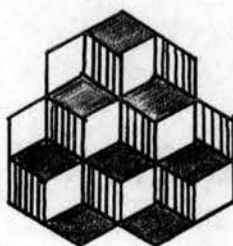


Figure 3

4. Do we all taste the same things? Use the P. T. C. taster paper (Phenol thio carbonamide) and determine whether you can taste this harmless chemical. Are you a taster? About eight out of ten people are tasters. If you do not taste this chemical, your genetic make-up does not provide for your tasting what other taste.

Is there a real world beyond our senses? The above experiences would seem to tell us that each person experiences a world that is slightly different from the way others experience it. Most scientists feel that in spite of these differences in our experiences that there is a consistent real world that exists beyond our senses and that we can measure, explore, and understand it.

5. Do you believe that (1) we experience our own world, or (2) there is but one real world? Defend your position.

To determine if an idea or observation is scientific it must (a) be experienced by people and (b) be testable and retestable. For example: "Texas is bigger than the state of Arizona." This can be measured (tested) by many people. Thus it can be scientifically determined. "Arizona oranges are the best oranges grown." This is a value statement and depends upon how "best" is defined. If it means Arizona oranges are juicier on the average than California oranges, then this can be scientifically tested through sampling.

THE NATURE OF SCIENCE page 3

6. Classify the following as to whether they are science or non-science:
- Living things are built of cells.
 - Stars can forecast your future.
 - The earth moves around the sun.
 - There are flying saucers with people from other planets.
 - The Law of Gravity applies to all things.

You have heard about or read of instances in which some sort of mental messages have been sent. For example: The wife of a pilot woke up screaming from a dream in which her husband was killed in an airplane crash. The next day she received word that her husband had indeed been killed in an airplane crash. Perhaps you have had an experience of seeming to know what another person was thinking. Such occurrences would seem to use another sense besides those of seeing, hearing, smelling, tasting, and feeling. Sending a thought message is called telepathy, while predicting an event is called clairvoyance. EXTRA SENSORY PERCEPTION (ESP) is the term most frequently used to describe these phenomena, commonly called a sixth sense. Scientists at Duke University and in England have pondered this and have experimented to discover if a sixth sense exists. So far they have found that some people seem to have a form of this ability for short periods of time, but always lose it.

7. Do you have a sixth sense? Use the slips of paper that have the different symbols drawn on them. Three people are necessary for this experiment. Person #1 arranges his slips in any order he wishes. Person #2 faces away from #1 and lays out his slips face up. Person #3 now tells them to do the first symbol, that is, #1 concentrates on the top symbol in his pile. #2 selects the symbol he thinks the other person is concentrating on. Each puts his slip of paper down to start a new pile. Person #3 now tells them to do the second symbol and so on. Now compare your choices. How many were matched?

Whether a person has a sixth sense or not is measured, like many things in science, in terms of the chance or probability of it happening. The probability for these five symbols are as follows:

If this many matched -----	1	2	3	4	5
your probability was one chance in--	5	20	60	120	120*
that you could do this by guessing.					

*There is no choice in selecting the fifth symbol, thus the probability does not change.

8. Do you think this method for determining the sixth sense is scientific? Discuss.

THE NATURE OF SCIENCE page 4

9. Do you believe that there is actually a sixth sense? Discuss.
10. Examine each item carefully and try to explain what is happening or how a certain generalization(s) will make the phenomena understandable.
 - a. Two people were seen to argue over whether a certain food tasted sweet or sour.
 - b. You hear someone say, "Black cats bring bad luck."
 - c. Fortune tellers must have sixth senses.
 - d. In a textbook you find this statement, "Stars are logically considered to be other suns."
 - e. Can we trust our senses to tell us what the world is really like?
 - f. Why do we not accept mental telepathy as a part of science?
 - g. A fat person excuses his obesity by saying, "Fat people are more jolly than thin people."

DIMENSIONAL ANALYSIS

Dimensional analysis is a method of solving problems of the simple ratio and proportion type. In using this method the assumption is made that units such as inches, meters, gallons, miles/hour, etc. can be treated the same as numbers. That is, they can be multiplied together. For example:

$$3 \text{ ft.} \times 2 \text{ ft.} = 3 \times 2 \times \text{ft.} \times \text{ft.} = 6 \text{ ft.}^2$$

$$2 \text{ in.} \times 5 \text{ mi.} = 2 \times 5 \times \text{in.} \times \text{mi.} = 10 \text{ in. mi.}$$

The latter example might be the calculation of the area of a 2 inch by 5 mile rectangle. The unit "inch-mile" is a unit of area just as square inches or square miles are units of area but the inch-mile is not commonly used.

Units can be divided in the same manner as ordinary numbers. For example:

$$\frac{6 \text{ gallons}}{2 \text{ gallons}} = \frac{6}{2} \times \frac{\text{gallons}}{\text{gallons}} = \frac{6}{2} \times 1 = 3$$

$$\frac{4 \text{ miles}}{2 \text{ gallons}} = \frac{4}{2} \times \frac{\text{miles}}{\text{gallons}} = 2 \text{ miles/gallon}$$

Many problems can be solved with much less difficulty and thought if the units are written down.

Imagine you drove your car 100 miles on 5 gallons of gas and you wanted to determine your gas mileage. You could solve the problem by dividing 100 by 5 to get 20. Twenty what? The unit for gas mileage is miles/gallon. Therefore, the problem could better be solved by writing:

$$\frac{100 \text{ miles}}{5 \text{ gallons}} = \frac{100}{5} \times \frac{\text{miles}}{\text{gallons}} = 20 \text{ miles/gallon}$$

If the units in the result are not correct then you would know a mistake was made earlier.

As another example let us assume eggs cost 80 cents for 2 dozen. What is the cost of 3 dozen eggs? From the information given you could determine that eggs cost 40 cents per dozen; therefore, 3 dozen would cost 120 cents or \$1.20. That is:

$$\frac{80}{2} = 40 \text{ and } 40 \times 3 = 120$$

The result is 120 what? Eggs? Dozen? Dollars? Cents?

DIMENSIONAL ANALYSIS page 2

Let us solve the same problem but this time we will write down the units.

The egg problem written down in units is:

$$\frac{80 \text{ cents}}{2 \text{ dozen}} = \frac{80}{2} \times \frac{\text{cents}}{\text{dozen}} = 40 \frac{\text{cents}}{\text{dozen}}$$

$$40 \frac{\text{cents}}{\text{dozen}} \times 3 \text{ dozen} = 120 \times \frac{\text{cents}}{\text{dozen}} \times \frac{\text{dozen}}{\text{dozen}} = 120 \text{ cents}$$

Or as one step:

$$\frac{80 \text{ cents}}{2 \text{ dozen}} \times 3 \text{ dozen} = \frac{(80)(3)}{(2)} \times \frac{\text{cents dozen}}{\text{dozen}} = 120 \text{ cents}$$

We know that our answer must be in cents so wrote:

$$\frac{80 \text{ cents}}{2 \text{ dozen}} \times 3 \text{ dozen}$$

and not

$$\frac{2 \text{ dozen}}{80 \text{ cents}} \times 3 \text{ dozen} \quad \text{or} \quad \frac{80}{2} \times 3$$

The unit "cents" must be in the numerator of the fraction.

Let us extend the method further with another problem. We are going to make 3 cakes. The recipe calls for 2 cups of butter for 5 cakes. Butter cost 82 cents for 3 cups. What is the cost of the butter in 3 cakes?

Since the unit of cost is cents, cents must be in the numerator, so we write:

$$\frac{82 \text{ cents}}{3 \text{ cups}}$$

We must eliminate the unit "cup" and we know there are 2 cups in 5 cakes so we write:

$$\frac{2 \text{ cups}}{5 \text{ cakes}}$$

The product of these two factors is:

DIMENSIONAL ANALYSIS page 3

$$\frac{82 \text{ cents}}{3 \text{ cups}} \times \frac{2 \text{ cups}}{5 \text{ cakes}} = \frac{82 \times 2 \text{ cents}}{3 \times 5 \text{ cake}}$$

We want the cost of 5 cakes so we multiply the $\frac{\text{cost}}{\text{cake}}$ by the number of cakes.

The total problem could be written then as:

$$\frac{82 \text{ cents}}{3 \text{ cups}} \times \frac{2 \text{ cups}}{5 \text{ cakes}} \times 3 \text{ cakes} = \frac{82 \times 2 \times 3}{3 \times 5} \text{ cents}$$

All the units divide out except the one for which we are looking -- cents.

Study the following examples and observe the method used:

A man gains 2 pounds of weight every 10 days. He pays \$35.00 per week for food. What will it cost him to gain 42 pounds? Solution:

$$\frac{\$35}{7 \text{ days}} \times \frac{10 \text{ days}}{2 \text{ pounds}} \times \frac{42 \text{ pounds}}{1} = \$1050$$

Find the number of inches in 10 miles. Solution:

$$\frac{12 \text{ inches}}{1 \text{ ft.}} \times \frac{5280 \text{ ft.}}{1 \text{ mile}} \times 10 \text{ mi.} = \underline{\quad ? \quad} \text{ inches}$$

Pecans cost 60 cents per pound; it takes 3 pounds of pecans to make 2 pans of fudge; each pan of fudge is cut into 200 pieces; each person eats 3 pieces. Find the cost of pecans in the fudge to feed 40 people. Solution:

$$\frac{60 \text{ cents}}{1 \text{ pound}} \times \frac{3 \text{ pounds}}{2 \text{ pans}} \times \frac{1 \text{ pan}}{200 \text{ pieces}} \times \frac{3 \text{ pieces}}{1 \text{ person}} \times \frac{40 \text{ persons}}{1} =$$

$$\frac{60 \times 3 \times 1 \times 3 \times 40}{1 \times 2 \times 200 \times 1} \text{ cents} = 54 \text{ cents}$$

1. Compose five problems of the type indicated in the preceding discussion. Show the method of solution of each. If you have trouble thinking of a problem visit a grocery or variety store.

MEASUREMENT OF LENGTH

The distance between the knot on the string is 20 centimeters.
The dimensions of the smaller sheet of paper is 8 inches by 10 inches.

1. Devise a method for determining the number of centimeters in one inch.
2. Determine the volume of the block of wood in cubic inches and in cubic centimeters.
3. Describe in detail the method you used in solving this problem.

MATERIALS PROVIDED

OTHER MATERIALS TO BE USED

1. string (20 cm between knots)
2. 2 pins
3. sheet of paper (8 inches x 10 inches)
4. large sheet of paper
5. block of wood

1. pencil
2. straight edge

THE SOLAR SYSTEM

The experiment has a twofold purpose. First to give you a better idea of the solar system and secondly to make you more conscious to translate tabular information to meaningful ideas.

1. Draw a planar diagram of the Solar System as follows. Select appropriate scales to show:
 - a. The distances of the planets from the sun. Select your scale to make effective use of your drawing paper. Locating the positions of the planets along the diagonal will likely be most effective.
 - b. The relative sizes of the planets. Your scale should show the relative sizes from the smallest to the largest planet. Do not attempt to draw the sun itself to the same scale. Why? Only indicate a portion of its surface.

Be sure to indicate your selected scales also on the drawing paper.

2. Could you have selected a single scale to show both a. and b. above?
3. Could you now determine other scales to fit a notebook sheet or a blackboard?
4. What is an astronomical unit?
5. From your diagram can you see a logical way of dividing the planets into groups according to their sizes and/or distances? It has recently been suggested that Pluto is actually not a planet but is a former satellite of Neptune.
6. Sketch in our moon giving only its size, 2160 miles diameter, to scale. Several of Jupiter's moons are of about the same size as our moon. How does the size relationship of these moons to their planet compare to that of our moon to the earth?
7. What differences in insolation (i.e. radiant energy received from the sun) would you expect to exist among the various planets? What approximate proportionality relation can you discover between the ratio of the solar constant of the planets Earth and Jupiter?
8. Why is Venus the brightest planet?

MATERIALS PROVIDED

1. drawing paper
2. ruler
3. table of information on the solar system
4. sheet for recording scale information

THE SOLAR SYSTEM page 2

PLANETS	MERCURY	VENUS	EARTH	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Mean Distance (in A. U.)	0.39	0.72	1.000	1.52	5.2	9.54	19.19	30.07	39.5
Mean Linear Dia. (miles)	3,100	7,700	7,900	4,220	86,800	71,500	32,000	31,000	2,000?
Volume (times Earth)	0.06	0.92	1.000	0.151	1310	734	59.3	72	?
Mass (Earth = 1)	0.05	0.06	1.000	0.108	318	95	15	17	1.000?
Gravity	.27	.85	1.000	.38	2.6	1.18	0.90	1.1	?
Solar Constant (Earth = 1)	6.9	1.9	1.00*	9.43	0.04	0.01	0.003	0.001	0.0006
Surface Temp. (°F)	572	86 to 212		-14	-216	-243	-300	-330	-348
Satellites	0	0	1	2	12	9	4	1	0

*1.94 calories/cm² - min

THE SOLAR SYSTEM page 3

NAME OF PLANET	DISTANCE		DIAMETER	
	SCALE		SCALE	
	A. U.		MILES	

RELATIVE HUMIDITY

The determination of the quantity of water vapor in the atmosphere per unit volume is an important adjunct to the study of atmospheric conditions. The number of grams of water vapor per cubic meter is a common measure used.

The air is said to be saturated when it contains the maximum number of grams of water vapor per cubic meter without condensing. The maximum quantity of water vapor per unit volume increases with temperature, but not linearly.

The mass (in grams) of water vapor actually present in the atmosphere per unit volume is called the absolute humidity, while the temperature to which the air must be reduced to reach saturation is called the dew point. Below this point, the excess water above the amount necessary for saturation will precipitate on some solid or even in the air as mist, clouds, fog, etc.

The term which is more frequently used to express the moisture content of the air is called the relative humidity. This is defined as the ratio of the mass of water vapor actually present per unit volume (absolute humidity) to the maximum mass of water vapor per unit volume that the atmosphere can hold at this temperature (saturated vapor). To express the relative humidity as percent, multiply the above ratio by 100.

In finding the relative humidity, the procedure is first to find the dew point temperature. The number of grams of water per cubic meter the air can hold at the dew point gives the absolute humidity. This quantity can be found from tables. Then look in the handbook for the number of grams of moisture per cubic meter the air can hold at the present temperature of the air. The ratio of the absolute humidity to the vapor content, if the air were saturated at the present temperature, gives the relative humidity.

The relative humidity may also be found by use of a wet-bulb and a dry-bulb thermometer if a current of air (say, greater than 3 meter per second) is directed towards the thermometers so that the water will evaporate from the wet thermometer without saturating the surrounding air layer. The greater the moisture content of the air, the less the evaporation from the wet thermometer, and consequently the smaller is the cooling effect due to evaporation. This means that the difference between the temperature reading of the wet and dry bulb becomes less the higher moisture content. When this method is used, tables are found in handbooks for calculating the results in terms of the relative humidity.

1. In this experiment you will determine the relative humidity of the atmosphere by the dew point method.

RELATIVE HUMIDITY page 2

The dew point method. To determine the dew point with ice and salt, chop the ice into small portions and add slowly to water, which is to about two inches deep in the can. Stir with a thermometer and take the reading of the thermometer when the dew first appears. Now add luke warm water until the dew disappears and take the temperature reading again. The average of these two temperatures gives a fair estimate of the dew point and becomes more accurately located the smaller the difference between the two readings for the appearance and disappearance of the dew. Make several trials, recording all readings, and find the average. Water should be removed from time to time to keep the height about two inches. Do not handle the polished side of the can with the fingers or breathe on the can while the experiment is in progress.

or

The dew point method. To determine the dew point when ether is used, partially fill the small nickel tube, fitted with a compression bulb, with ether. The quantity of ether used depends upon the apparatus. The increased evaporation brought about by forcing air through the ether with the compression bulb cools the apparatus. The dew point is noted as in the previous salt and ice method, and the calculations for the temperatures. It is desirable not to inhale the ether more than necessary. Repeat the experiment out of doors.

2. When may ice, or ice and salt, be used in place of ether?
3. What causes the appearance of dew on the side of the vessel?
4. What would be the relative humidity out-of-doors today according to your experiment?
5. What would the relative humidity have been if the room temperature had been found to be 10°C. higher than that actually found?
6. Find the handbook value for the latent heat of vaporization of diethyl ether and the latent heat of fusion for ice. What do these values mean? Refer to your textbook.

MATERIALS

- | | | |
|------------------------|----|---|
| 1. small "tin" can | or | 1. nickel tube fitted with bulb and ether |
| 2. medium sized vessel | | 2. thermometer |
| 3. salt | | |
| 4. ice | | |

WEATHER CHARTS

The weather charts used in this experiment are authentic charts obtained from McConnell Air Force Base in Wichita, Kansas. For information concerning weather data consult the manual, Theory of Instrument Flying, section 5.

1. Give the time and date of the weather chart.
2. Choose three widely separated weather stations. Record their identification symbols and the state in which each is located.
3. For each station record all the weather information given. Interpret each symbol.
4. For one of the chosen stations predict what the weather will be six hours later than the time given on the chart. Give reasons for your prediction.
5. How can relative humidity be determined from information given on weather charts?
6. What is the wind direction around a low? A high?

ACCELERATION OF A FREELY FALLING BODY

The Cenco free-fall apparatus has been demonstrated to you and tapes have been prepared. The spark interval is 1/120 second.

1. Take the strip of waxed paper bearing the spark marks and, starting at the zero point, lay off 1/30-sec intervals. This will be every fourth mark. Starting each time at the zero point, measure the distance to the ends of the successive 1/30-sec intervals. This will give you the distance traveled by the bob in 1/30 sec, in 2/30 sec, etc. Record these data in a table with proper headings.

For each time interval in your table you have a distance, and from time and distance you can calculate the average velocity for the interval. If we assume that the object is constantly accelerated, then

$$\text{Average velocity} = \frac{v(\text{start}) + v(\text{final})}{2}$$

or, since $v(\text{start}) = 0$

$$\text{Average velocity} = \frac{v(\text{final})}{2}$$

and arranging this we have the important statement that

$$v(\text{final}) = 2 \times \text{average velocity}$$

which, stated in words, says that the actual velocity at the end of any time interval equals two times the average velocity for that interval.

2. Record the average velocities for the intervals and the actual velocities at the ends of the intervals.

For each interval we have now a starting velocity (zero in each case), a final velocity, and the length of time in the interval. Thus, we can calculate the acceleration for each time interval.

$$\begin{aligned} \text{Acceleration} &= \frac{\text{change in velocity}}{\text{time}} \\ &= \frac{v(\text{final}) - v(\text{start})}{\text{time}} \end{aligned}$$

and since $v(\text{start}) = 0$,

ACCELERATION OF A FREELY FALLING BODY page 2

$$\text{Acceleration} = \frac{v(\text{final})}{\text{time}}$$

3. Record the values of acceleration for each of the intervals. Was your assumption of constant acceleration justified? What is the average value of acceleration? Compare your figures with the accepted value of the acceleration of gravity.

THE SIMPLE PENDULUM

Any rigid object that is suspended freely from a pivot can act as a pendulum, but the easiest case to study is that of the pendulum in which the mass is concentrated in the pendulum bob - the mass of the supporting rod or string being negligible compared with the mass of the bob.

The length of such a pendulum is measured from the supporting pivot to the center of mass of the hanging bob. If the bob has a spherical shape, the center of mass is at the center of the sphere.

The mass of the pendulum includes the entire pendulum, but since we are considering a simple pendulum in which the mass of the supporting rod or string is negligibly small compared to the bob, only the mass of the latter is of importance.

The amplitude of swing is the maximum horizontal distance from the rest position reached by the bob. The amplitude can also be indicated as the angle between the supporting string and the vertical.

The frequency is the number of complete swings made by the pendulum in a unit of time. The frequency is found by dividing a given number of complete swings by the time required to make those swings.

The period is the time required for the bob to make one complete swing. The period is the reciprocal of the frequency so that

$$\text{Period} = \frac{\text{time for given number of swings}}{\text{number of swings}}$$

Note in the procedure to follow that only one factor is varied at a time to see if it affects the period, while the other factors are kept constant.

1. The period of the pendulum. Suspend your pendulum at any convenient length; say about 50 cm. Let the pendulum swing with a small amplitude, one in which the string at the end of its path makes an angle of not more than 15° with the vertical. Measure the time required for an increasing number of swings - say 20, 40, and 60 complete swings. Record in a table with proper headings the total number of swings, the total time, and the calculated periods.

What generalization can you make concerning the period of a pendulum?

2. The effect of mass. Suspend the bob at a convenient length, and let the pendulum swing with a small amplitude as before. Measure the time required for the pendulum to make 30 or 40 complete swings. Record your results. Repeat the procedure with the heavier pendu-

THE SIMPLE PENDULUM page 2

lum bob. Make sure that all other factors remain constant.

What generalization can you make concerning the effect of mass on the period of a pendulum?

3. The effect of amplitude. Suspend the pendulum bob at any convenient length. Let the pendulum swing so that its starting angle with the vertical is successively 15, 45, and 75° from the vertical. In each case measure the time required for the pendulum to make 30 or 40 complete swings. Record your results and calculate the periods.

What generalization can you make concerning the effect of amplitude on the period of a pendulum?

4. The effect of length. Suspend the pendulum bob at different lengths, for example, 20, 40, 60, and 100 cm. Let the pendulum swing with a small amplitude - not more than 15° from the vertical. In each case, measure the time required for the pendulum to make 30 or 40 complete swings. Record your results and calculate the periods.

What generalization can you make about the effect of length on the period of a simple pendulum?

5. The period of a pendulum is directly proportional to the length of the pendulum. The mathematical expression for this relationship is

$$\text{Period}^2 = K \times \text{length} \quad \text{or} \quad K = \frac{\text{period}^2}{\text{length}}$$

Using this latter equation, you can calculate the value of K for each length, and then you can determine the average value of the constant K. The actual value of K is

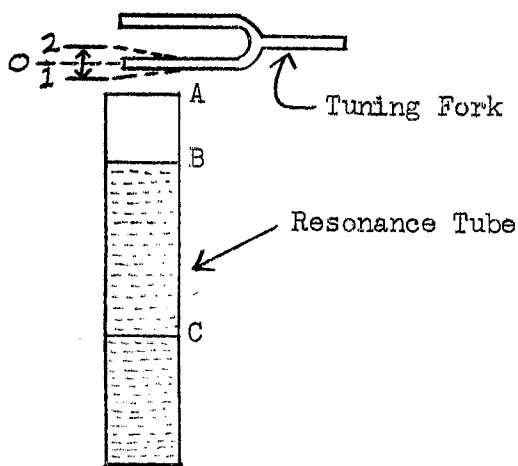
$$K = \frac{4\pi^2}{g} \quad \text{or} \quad g = \frac{4\pi^2}{K}$$

Now substitute your average value for K in the last equation, and calculate the value for g. How does this value compare with the value of g which you found in the falling body experiment?

THE VELOCITY OF SOUND IN AIR

The apparatus for this experiment will be in H - 314. You may perform the experiment anytime before noon Friday. Use pages 94-105 in your text as reference material.

The apparatus consists of a long tube, closed at the bottom but connected by flexible tubing to a container of water so that the level of water in the long tube can be easily adjusted. At the top of the tube is a tuning fork.



When the lower tine of the tuning fork moves from the center position at 0 to point 1, a compression layer is formed in the air and this compression layer moves downward in the tube. If the water surface is correctly positioned, the compression layer will be reflected and will arrive back at the fork by the time the tine has returned to the center position at 0. If this happens, the reflected sound will reinforce the action of the tine as it moves from 0 to 2, and the sound will be noticeably louder. This phenomenon is called resonance. Since the tine of the tuning fork must move from 0 to 1 back through 0 to 2 and back to 0 for one complete cycle, the movement from 0 to 1 and back to 0 represents one-half a cycle. Thus, the compression layer must have traveled $\frac{1}{2}$ wavelength in going from A to B and back to A. This would mean that AB was $\frac{1}{4}$ wavelength.

Actually, the open tube and the placement of the tuning fork make it difficult to define or measure the length of this first quarter wavelength. However, this same reinforcement will also occur as well when the compression layer moves $1\frac{1}{2}$ wavelengths. Thus you can lower the water level until the enhanced loudness is noticed again, say at C, and the increased distance, BC, will be exactly $\frac{1}{2}$ wavelength.

Knowing the wavelength and the frequency marked on the tuning fork, you can calculate the speed of sound:

THE VELOCITY OF SOUND IN AIR page 2

Speed of sound = frequency x wavelength

$$= \text{frequency} \times 2(BC)$$

1. Fix a tuning fork so that it just clears the top of the resonance tube. Carefully lower the water level in the resonance tube until you locate level B by noticing where the sound of the tuning fork is enhanced by resonance. Mark this level with a rubber band. Now lower the water level in the resonance tube again until you locate and mark level C. You may be able to locate a third and fourth resonance level if the tube is long enough or the frequency of the fork is high enough.

Measure the distance from B to C ($\frac{1}{2}$ wavelength) and carry out the calculation for the speed of sound. Compare this value with the value given in the text.

2. Repeat the procedure with a tuning fork of different frequency.
3. Explain how you can determine the frequency of an unknown tuning fork.

INTRODUCTION TO TOPOGRAPHIC MAPS

Scale. Ordinary geographic maps are a reduced scale representation of an area. The road map of Oklahoma shows the relative position of Oklahoma City and Tonkawa by drawing the map on the basis of a chosen number of feet on the ground will be represented by one inch on the map. Assuming that it is 90 miles from Oklahoma City to Tonkawa, if one inch on the map equals one mile on the ground, the map would be drawn so there were 90 inches between Oklahoma City and Tonkawa. If one inch on the map represents 10 miles on the ground, the two towns would be separated by 9 inches on the map.

Most maps have a graphic scale on them showing how many actual feet on the ground is represented by one inch on the map. Another method of giving the scale on maps is by a representative fraction. That is, one inch on the map equals a given number of inches on the ground. This is expressed on the map in the form of a fraction

$$\frac{1}{63,360} = 1 \text{ inch equals one mile.}$$

$$\frac{1 \text{ inch}}{1 \text{ mile}} = \frac{1 \text{ inch}}{1 \text{ mile}} \times \frac{1 \text{ mile}}{5280 \text{ ft}} \times \frac{1 \text{ ft}}{12 \text{ in}} = \frac{1}{63,360}$$

What would be the representative fraction of a map on which one inch equals 0.9 miles?

Direction. Maps are usually drawn so that the top of the map is North. Hence the right side of the map is East; the left side is West; and the lower edge is South. As Tonkawa is North of Oklahoma City, it will be shown on a map nearer the top of the map.

Topography. Most maps are compiled to show a distance (by scale) and direction between points. There is no attempt to show the character of the ground surface; in other words, topography is not shown. If the presence of hills, valleys, plains, etc. is shown on the map, it becomes a topographic map.

There are several methods used to indicate the irregularities of the earth's surface on maps. The most satisfactory method is by use of contour lines. A contour line is a line connecting points of equal elevation. For example, if we picture a cliff 100 ft high bordering a sea shore, a line along the face of the cliff drawn through all points on the cliff which were 10 feet above the water level would be a contour line. A second contour line would be drawn connecting all points 20 feet above the water level; a third contour line at 30 feet, etc. In this example, the vertical distance between the contour lines is 10 feet. This is the contour interval. The interval may be 1, 5, 20, 25, 50, or 100 feet or even more. If we use a contour interval of 10 feet, how many contour lines will be necessary on a map to show the height of

INTRODUCTION TO TOPOGRAPHIC MAPS page 2

the cliff mentioned above? (10)

How many contours if the contour interval is 5 feet?

Assume we are going to make a contour map of a cone-shaped island rising 203 feet out of the sea. The contact of the sea with the island would represent the zero contour line; that is, all contour elevations are measured from sea level. On a map of this island, the sea-land contact would, of course, outline the island. If this cone-shaped island is to be mapped using a contour interval of 25 feet, the first contour line will be drawn connecting all points 25 feet above sea level. As the island is cone-shaped, the contour line will go completely around the island to form a circle. It is a closed contour. A second line will be drawn 25 feet above the first or 50 feet above sea level; the third contour will be 75 feet above sea level; etc. A map of the complete contoured island is shown below.

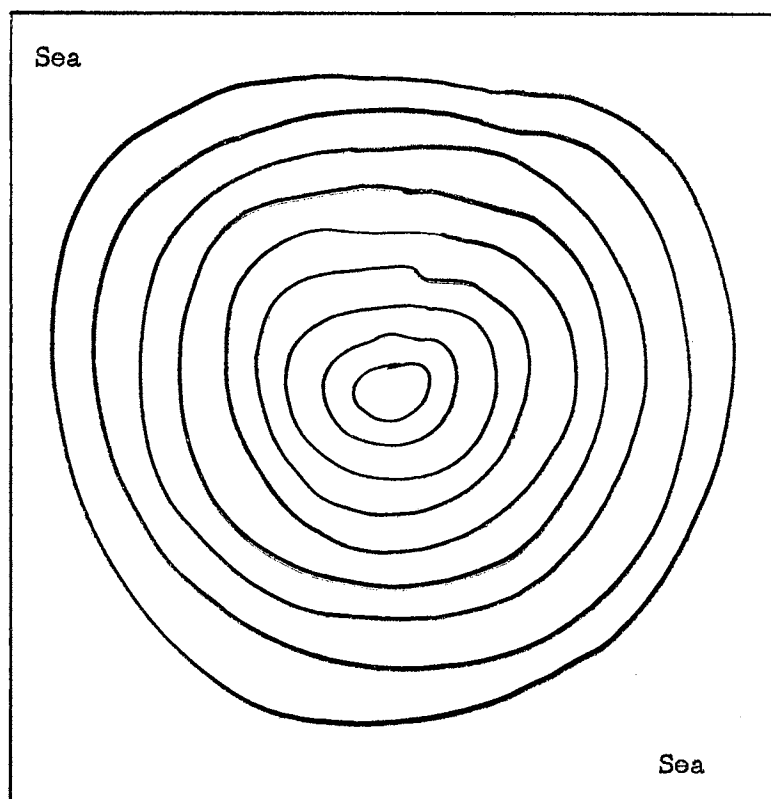


Figure 1

The exact height of the island is not given on the map. As eight closed contour lines are present on the map, we know the height to be at least 200 feet ($8 \times$ Contour Interval of 25 feet). We cannot tell from the contoured map if the island is 201 feet high or 224 feet high. Therefore, from the map the height is between 200 and 225 feet.

INTRODUCTION TO TOPOGRAPHIC MAPS page 3

How many contour lines would be necessary to show the island having a height of 251 feet? (C. I. = 25')

How many contour lines will be necessary to show the island having a height of 107 feet?

Elevation and Height. The elevation above sea level and the height of the island in the preceding example were the same. If we could move this same island (or hill) to Denver, Colorado, the height would still be 203 feet but the elevation of the top of the hill would be 203 plus the elevation above sea level of the area around Denver (approximately 5200 feet). Height is the vertical distance from the base to the top. Elevation is the vertical distance above sea level. The height of Pikes Peak is about 8,800 feet; the elevation of the top of the Peak is slightly more than 14,100 feet.

In Figure 2, a hill is shown. The elevation of the hill is somewhere between 560-570 feet.

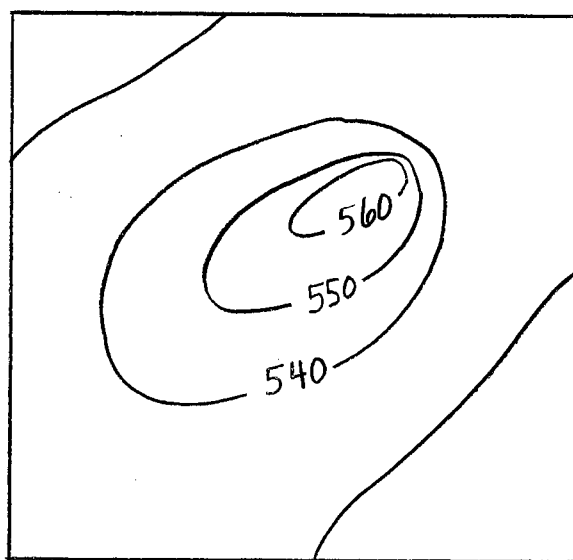


Figure 2

The height of the above hill is some figure between 20 feet and 40 feet. As we do not know how much above the 560 contour the top of the hill is, neither do we know how much below the 540 contour is the base of the hill. Hence the base of the hill starts somewhere between 530 and 540 feet. There must be a 0 to 10 feet allowance for the base of the hill. Since there are two closed contours, the hill is at least 20 feet high. The top of the hill is 0 to 10 feet above the last contour (560 ft). Therefore, the minimum height of the hill is 20 feet; maximum height possible is 40 feet.

In the hill in Figure 2, assume a contour interval of 25 feet instead of a 10 foot contour interval. Assume the lowest contour

INTRODUCTION TO TOPOGRAPHIC MAPS page 4

line on the map is 600 feet.

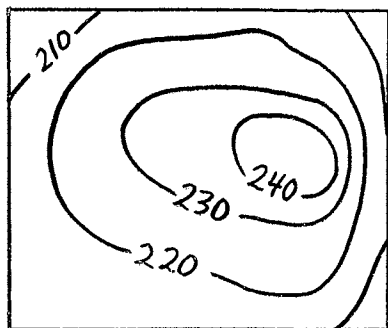
What is the elevation of the top of the hill?

What is the elevation of the base of the hill?

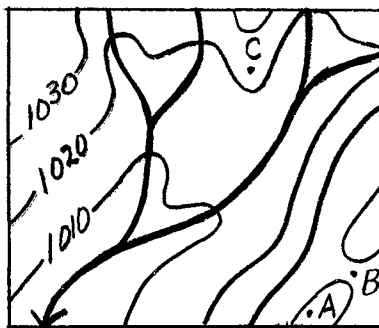
What is the height of the hill?

Assuming a contour interval of 100 feet, what is the height of the hill?

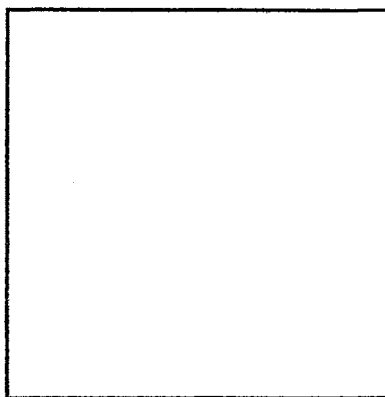
What is the significance of the fact that the contours are more closely spaced on the eastern side of the hill?



What is the elevation of the top of this hill?
What is the height of the hill?

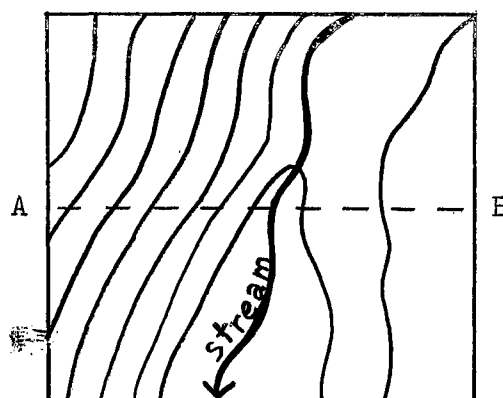


What is the elevation of:
Point A? _____
Point B? _____
Point C? _____

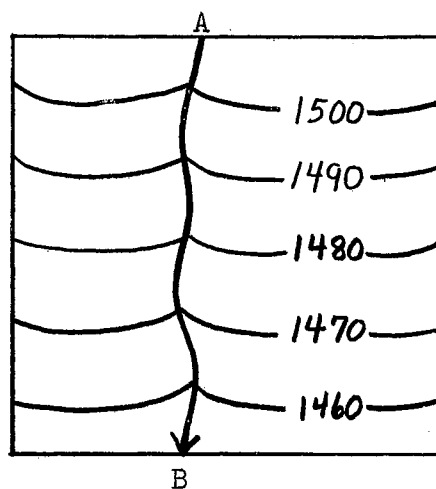


By means of contour lines, draw a hill which is steep on N. side and gentle slope on S. side. Use 20 ft C. I.

INTRODUCTION TO TOPOGRAPHIC MAPS page 5



Sketch a cross section in the box below along line A-B to show the slope of the land.



Assume it is 2 miles from A to B.
What is the fall of the stream in feet per mile?

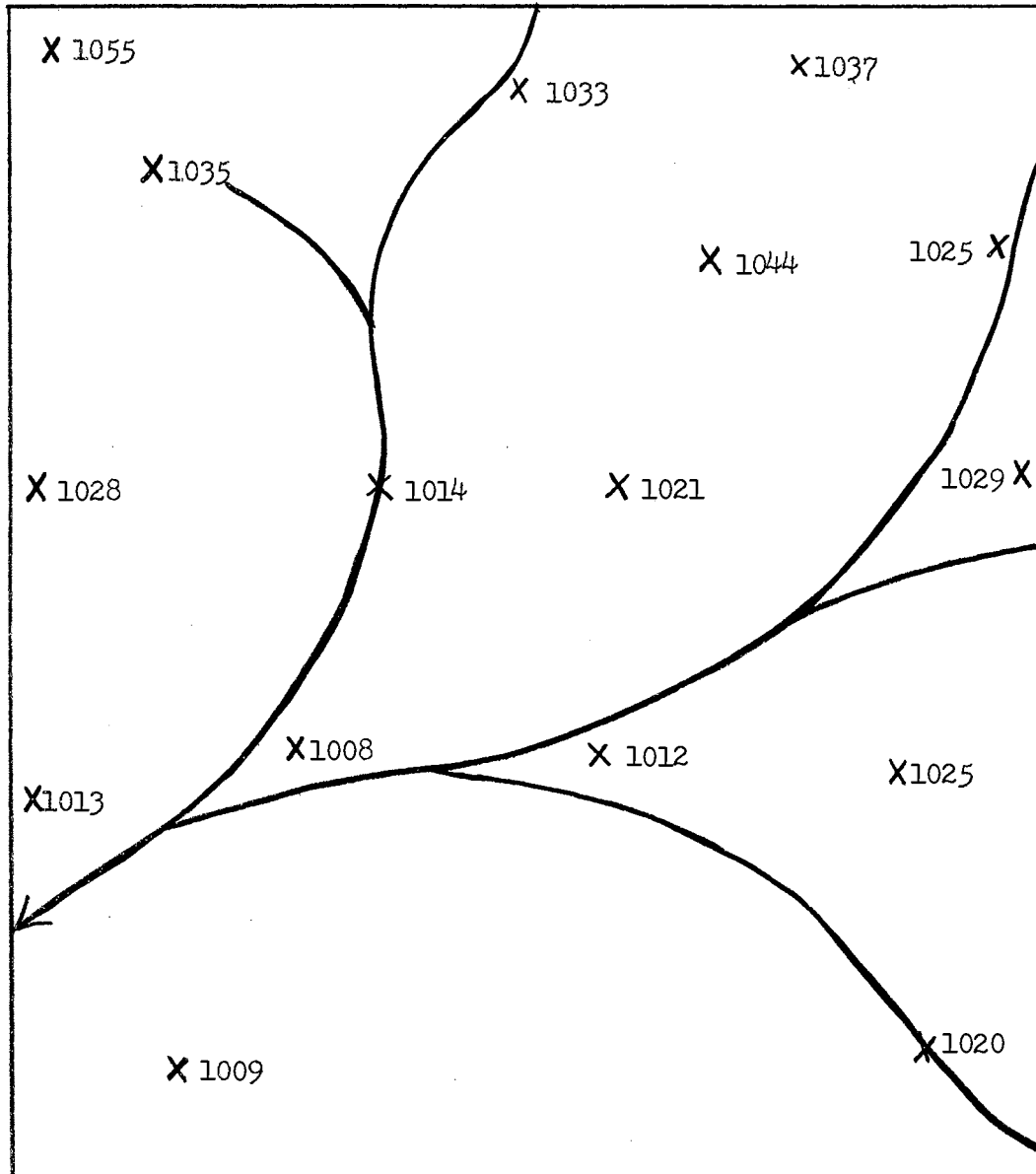
INTRODUCTION TO TOPOGRAPHIC MAPS page 6

Summary of Principles Governing Contour Lines.

1. All points on any one contour line have the same elevation.
2. Contour lines never intersect or cross unless they are merged in a vertical or overhanging cliff.
3. Contour lines never split.
4. Contour lines bend up valleys and point upstream. Why?
5. Closed contours represent hills. Closed contours with hachures (short lines perpendicular to contour line) represent depressions. Every contour line closes on itself, either within or beyond the limits of the map. If beyond the limits of the map the contour line will run to the edge of the map.
6. Evenly spaced contour lines indicate a uniform slope; uneven spacing indicates an uneven slope.
7. Closely spaced contours indicate a steep slope, widely spaced contours indicate a gentle slope.
8. Usually every fifth contour line is heavier than the others and has the elevation printed at intervals throughout its length.
9. The contour interval (C. I.), given on the bottom margin of a map, is usually the same over the entire map.
10. The land on one side of a contour line is higher than the line and the land on the other side is lower.
11. The highest contours on a ridge or the lowest contours in a valley are always in pairs; that is, there cannot be one higher contour line between two lower ones or one lower contour line between two higher ones.

INTRODUCTION TO TOPOGRAPHIC MAPS page 7

Using a contour interval of 10 feet, draw in the contour lines on the map below. The points marked "x" are points of known elevation.



INTRODUCTION TO TOPOGRAPHIC MAPS page 8

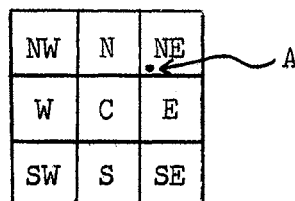
Methods of Designating Points on a Map. There are four principal means of designating some particular points on a map.

1. With reference to some prominent feature.

Any point on a map may be designated as so many miles in a certain direction from a city, mountain, lake or other prominent feature on the map.

2. By rectangles.

The topographic maps of the United States Geological Survey are commonly divided into nine rectangles by meridians of longitude and parallels of latitude. The drawing below shows the method of identifying these rectangles. Point A, for example, is in the southwest part of the northeast rectangle.



3. By longitude and latitude.

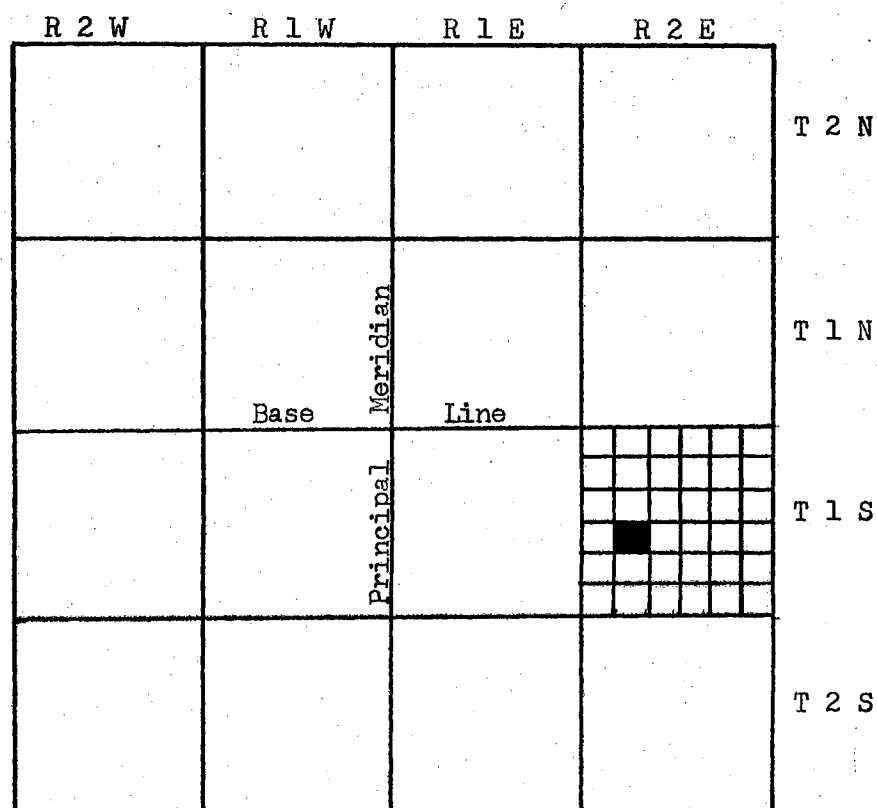
Since the quadrangles are bounded by lines of longitude and latitude a point may be located by giving its longitude and latitude.

4. By the land division system of the United States.

In much of the United States, the land is divided into townships and sections. An arbitrary parallel of latitude is chosen as a Principal Meridian. Distances that are multiples of six miles north and south of the base lines are called Townships. Distances that are multiples of six miles east and west of the principal meridians are called Ranges. The intersections of these sets of parallel lines make a series of squares six miles on a side called Townships. The township is further divided into smaller units one mile square. These are called Sections. It can be seen that every square mile in the United States has an entirely different description. Sections are numbered in the various townships in a particular way as shown on page 9. Also sections may be further subdivided into $1/4$ sections.

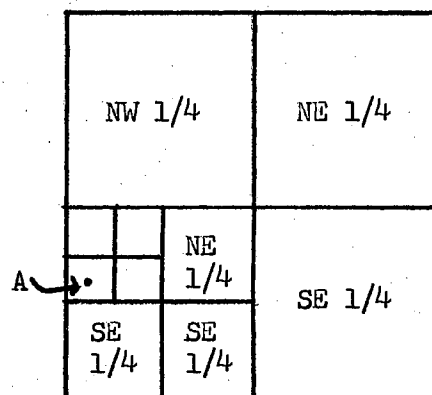
Other parts of the United States are divided into Ranchos, Mission Lands, Towns, and Parishes.

INTRODUCTION TO TOPOGRAPHIC MAPS page 9



6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

T 1 S, R 2 E



T 1 S, R 2 E, Sec 20

Give the location of point A in the drawing above.

TOPOGRAPHIC PROFILES

It is often necessary for geologists to construct a cross-section or profile of an area shown by a topographic map. This accomplished by three steps.

First Step. Assume that Figure 1 represents a topographic map. You are to draw a cross-section of the area along the line A-B.

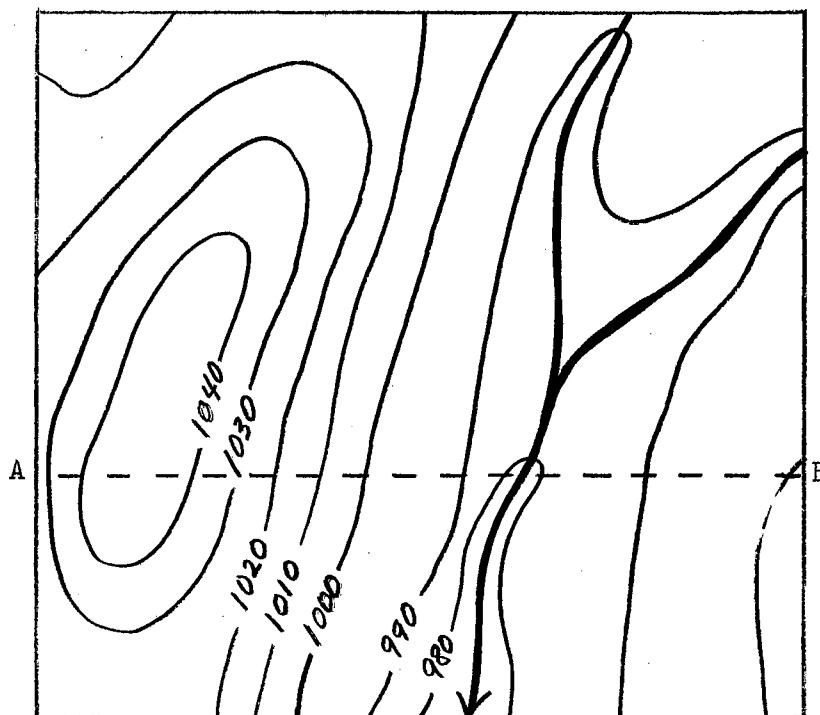


Figure 1

The first step is to place a strip of paper along the line A-B as shown in Figure 2. Mark the limits of the X-section on this paper. Next, mark and label each point at which a contour line intersects the line of cross-section in the manner shown in Fig. 2.

TOPOGRAPHIC PROFILES page 2

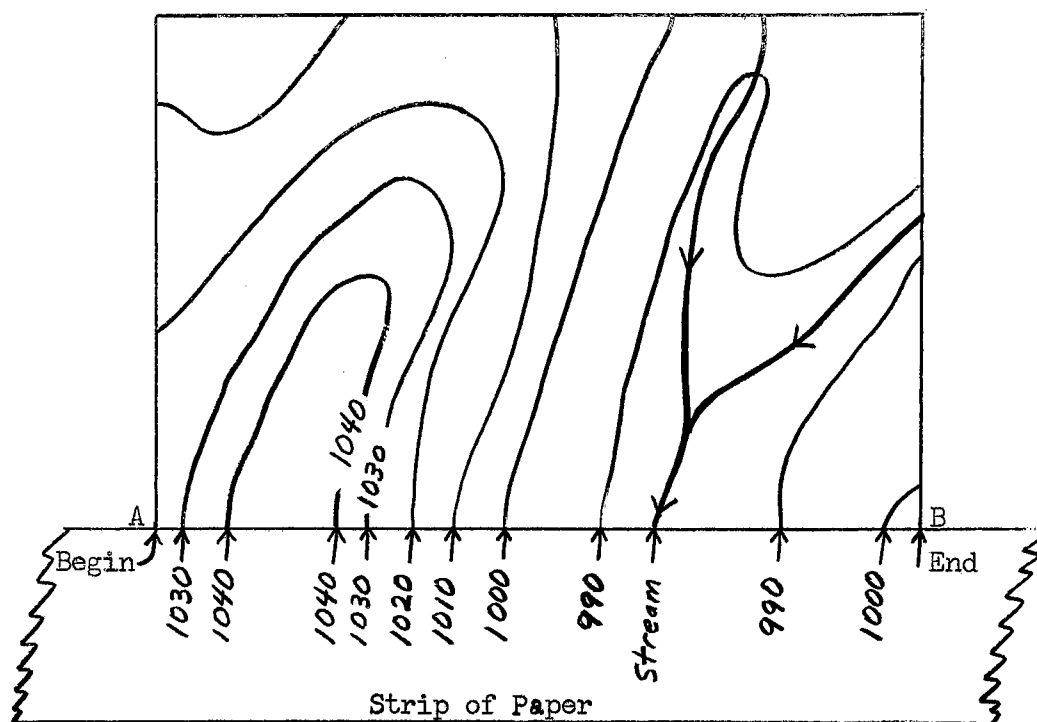


Figure 2

Second Step. Determine the highest and lowest elevations encountered by the cross-section. Then construct a series of lines as shown in Figure 3. Each line represents a contour line. The distance between the lines is constant for a given map. This distance is determined by the vertical scale. In Figure 3, the vertical scale is $1/4$ inch equals 10 feet (the contour interval). Label each line with a contour number. The lowest line should be the next contour below the lowest contour marked on the strip of paper. In our example, the lowest contour is 990 feet; hence, lowest contour on cross-section is 980 feet. Similarly, the highest line should be the next contour above the highest on the cross-section. Highest line on Figure 2 is 1040 feet; hence, top line of cross-section will be 1050 feet.

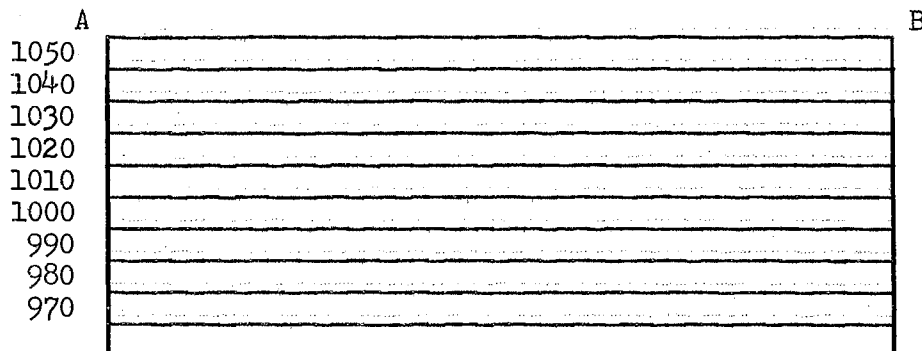


Figure 3

TOPOGRAPHIC PROFILES page 3

Note: In construction of the cross-section, for a horizontal scale you have used that of the map. For a vertical scale you have assumed an arbitrary scale in which the distance between two points is much greater than in the horizontal scale. As a result, there is much exaggeration in the vertical direction and the profile is not a true, accurate profile of the surface. Accurate profiles which are true representations of the surface of the ground are constructed on a "natural scale" - one in which the vertical and horizontal scales are identical.

Third Step. The last step consists entirely of transferring the data on the strip of paper to the series of lines drawn and assigned contour numbers in Step 2.

This is accomplished in the manner shown in Figure 4.

Note: Highest point 1040-1050; Lowest point 990-980.

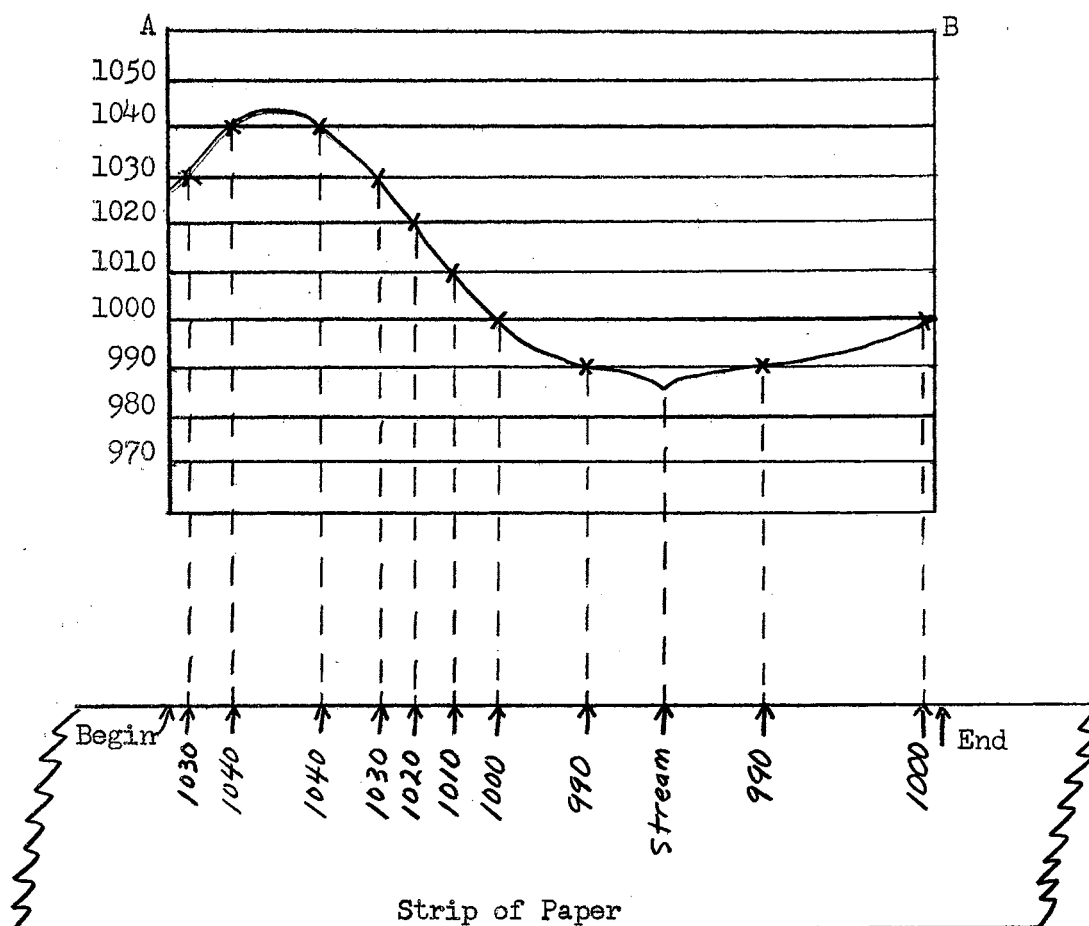


Figure 4

TOPOGRAPHIC PROFILES page 4

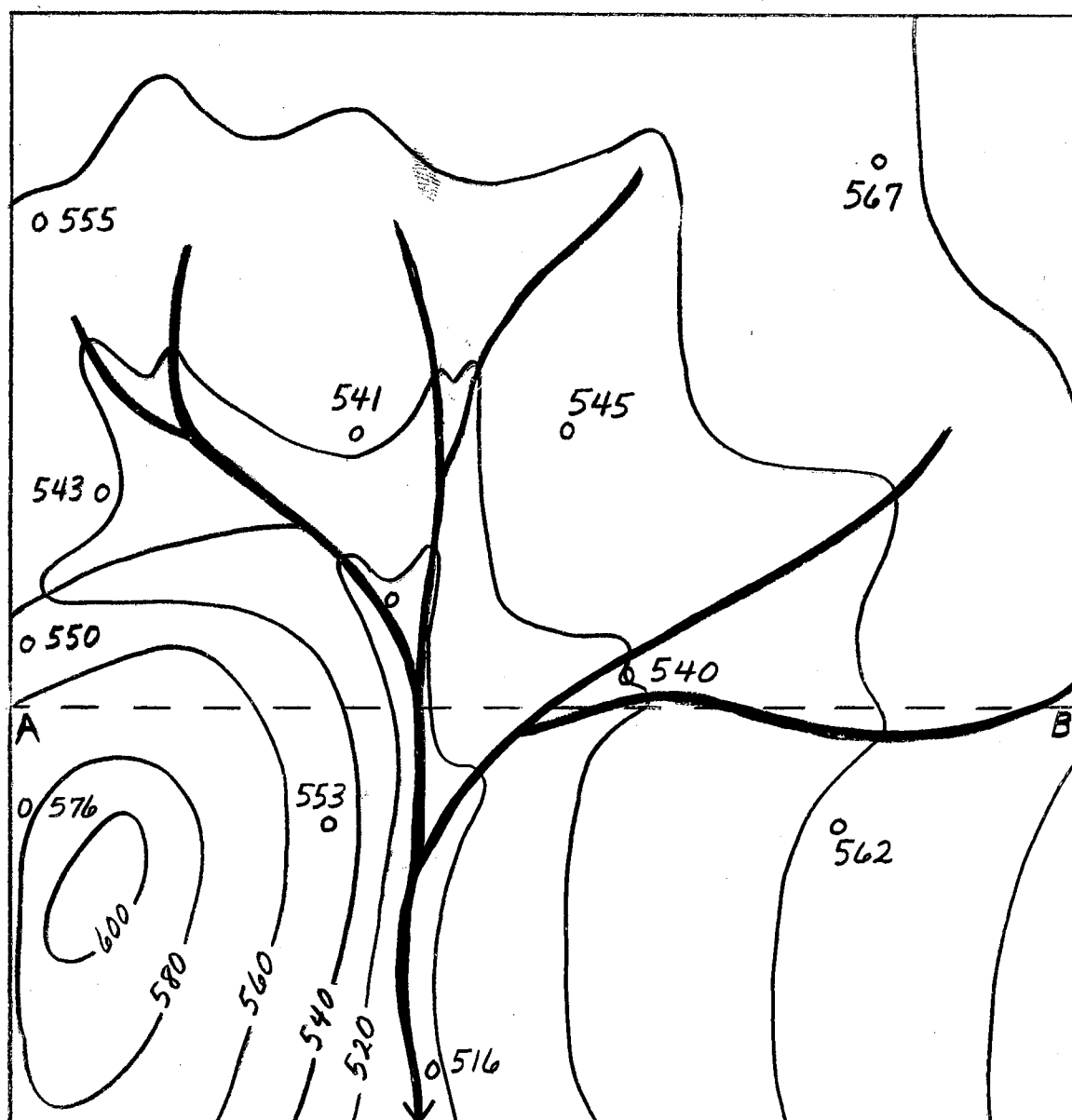
When actually completing this step, the strip of paper should be placed on top of the cross-section with the left side of the strip marked "Begin" directly on the left edge of the graph (cross-section) marked "A".

For example, to plot the profile points which are at an elevation of 1040, place the strip of paper on the line numbered 1040. The 1040 contour is marked at a distance of $\frac{1}{4}$ inch from the left margin of the strip of paper. Therefore, mark the 1040 line on the graph or profile $\frac{1}{4}$ of an inch from the left margin. Another 1040 elevation is located $\frac{3}{4}$ of an inch from the left margin on the strip of paper. Mark this point on the graph.

Then make similar points on the other appropriate graph lines for each contour shown on the strip of paper. The profile is completed when a line is drawn connecting these points you have marked on the graph.

Using the map on the next page, construct a topographic profile along line A-B.

TOPOGRAPHIC PROFILES page 5

[illegible]

APPENDIX D

APPENDIX D

Physical Science 114 Laboratory Examination NAME _____

Use Figure 1 to answer questions 1-5.

1. The barometric pressure at this station is 31 OKC
 (A) 942.0 millibars (B) 953.0 millibars
 (C) 995.3 millibars (D) 1095.3 millibars 10 953
2. The relative humidity is probably 30 + 28
 (A) extremely low (B) moderately low
 (C) moderately high (D) extremely high
3. An anemometer and weather vane located at this station would give which of the following information.
 (A) 31 knots, North (B) 30 knots, South
 (C) 15 knots, North (D) 15 knots, South
4. The sky is completely overcast and the horizontal visibility is
 (A) 1.0 miles (B) 2.8 miles (C) 3.0 miles (D) 10 miles
5. During the past three hours the barometer has probably
 (A) not changed (B) dropped slightly
 (C) risen slightly (D) impossible to answer because of insufficient data
6. When a liquid changes to a gas
 (A) heat is liberated from the system
 (B) heat is absorbed by the system
 (C) the temperature of the system must rise
 (D) the temperature of the system must fall.
7. The dew point is
 (A) the amount of water vapor in the air
 (B) the relative amount of water vapor in the air
 (C) the temperature of the air when water boils
 (D) the temperature at which the air is saturated with water vapor.
8. The period of a simple pendulum depends primarily upon
 (A) the length of the pendulum
 (B) the mass of the pendulum bob
 (C) the arc through which the pendulum swings
 (D) the size of the pendulum bob.
9. Which of the following groups of data gives sufficient information to determine g , the acceleration due to gravity. (simple pendulum)
 (A) $\pi = 3.14$, 10 cycles/sec, 50 cm
 (B) $\pi = 3.14$, 3 seconds, 10 grams
 (C) $\pi = 3.14$, 3 cm, 70 cm
 (D) $\pi = 3.14$, 50 degrees, 4 grams.

Figure 1

Physical Science 114 page 2

10. A simple pendulum could be used best as which of the following:
- (A) an instrument to measure mass
 - (B) an instrument to measure velocity
 - (C) an instrument to measure length
 - (D) an instrument to measure time.

Refer to the chart of solar system data to answer questions 11-13.

11. An astronomical unit is the average distance from the earth to
- (A) the north star
 - (B) the nearest planet
 - (C) the farthest planet
 - (D) the sun.
12. Venus is the brightest planet because
- (A) its surface temperature is very high
 - (B) it is the closest planet to the earth
 - (C) it is larger than the earth
 - (D) its surface is solid rock.
13. If you were to make a scale drawing of the solar system showing the relative size and location of the planets, a different scale size of planets and distance between planets should be used because
- (A) the planets are so large
 - (B) the distances between planets is very great
 - (C) the distance between planets is very great compared to the size of the planets
 - (D) the earth could not be shown.
14. You determined by experiment that 1 inch is approximately equal to 2.5 centimeters. The method used indicates that
- (A) distances can be measured with extreme accuracy
 - (B) volume measurements are more accurate than distance measurements
 - (C) a unit of length is a completely arbitrary quantity
 - (D) the metric system of measurement has been used for many years.
15. Which of the following data groups is just sufficient to allow the determination of the volume of a cube.
- (A) the cube weighs 3 pounds and is made of wood
 - (B) the cube weighs 2 pounds and will float on water
 - (C) the cube has a diagonal length of 3 centimeters on a face and its density is 4 grams/cubic centimeter
 - (D) the cube has a cross-sectional area of 100 square centimeters.
16. A major advantage of the metric system over the English system of measurement might be
- (A) metric units are in multiples of 10
 - (B) metric units are more convenient in size
 - (C) the metric system is more widely used
 - (D) the English system is too old.

Physical Science 114 page 3

Use Figure 2 to answer questions 17-18.

17. The elevation of point A is
 (A) less than point B
 (B) greater than point B
 (C) the same as point B
 (D) may be greater or less than point B.

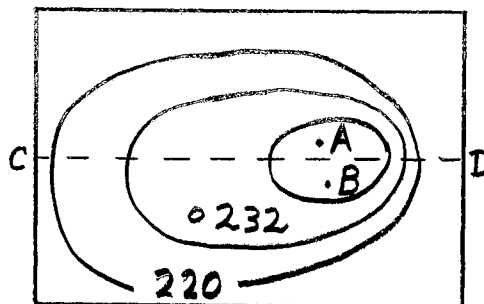
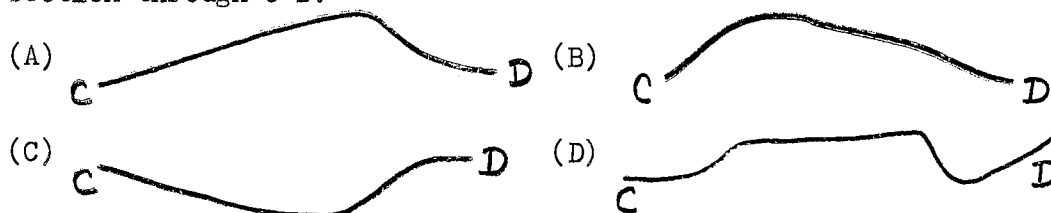


Figure 2

18. Which of the following is the best representation of a cross-section through C-D?



19. Which of the following is NOT true concerning contour lines?
 (A) Contour lines bend up valleys and point upstream.
 (B) Closely spaced contours indicate gentle slopes; widely spaced contour lines indicate a steep slope.
 (C) The land on one side of a contour line is higher than the line and the land on the other side is lower.
 (D) All points on any one contour line have the same elevation.
20. Which of the following ideas or observations could NOT be classified as scientific.
 (A) Living things are made of cells.
 (B) The earth moves around the sun.
 (C) The law of gravity applies to all known things.
 (D) Life exists in other parts of the universe.
21. Scientific theories are accepted primarily because they
 (A) are true (B) can be proved conclusively
 (C) are useful (D) are the results of the work of great men.

Use Figure 3 to answer question 22.

22. A vibrating tuning fork (550 cycles/sec) is placed above a cylinder which contains water. The loudness of the sound from the fork is found to increase when the water level is at A and also at B. If the velocity of sound in air is 1100 feet per second, what is the distance between points A and B?
 (A) 1 ft (B) 2 ft (C) 3 ft (D) 4 ft

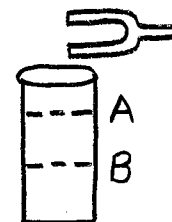


Figure 3

Physical Science 114 page 4

23. A stationary observer hears the sound of an approaching object. Which of the following best describes the situation?
(A) The observer will hear a higher pitch than if the source were not moving.
(B) The observer will hear a lower pitch than if the source were not moving.
(C) The pitch heard may be higher or lower.
(D) None of the statements are true.
24. Which of the following terms would NOT be used to describe a sound wave?
(A) wavelength (B) frequency (C) transverse (D) longitudinal
25. In a vacuum the acceleration of a freely falling body
(A) increases as the object falls
(B) decreases as the object falls
(C) remains the same as the object falls
(D) may increase or decrease as the object falls.
26. Two bodies of the same shape and size, but of different mass are thrown upward with the same initial velocity. Neglecting air resistance, the heavier body will be found to rise
(A) to the same height as the lighter
(B) higher than the lighter
(C) unnaturally because of the lighter
(D) less high than the lighter.
27. If it only takes a bullet fired horizontally from a gun 2 seconds to hit the ground, the muzzle of the gun is:
(A) 32 ft above the ground
(B) 64 ft above the ground
(C) 128 ft above the ground
(D) 4 ft above the ground.
28. Problem (Show method of solution)

If eggs cost 36 cents per dozen; it takes 8 eggs to make 3 cakes; and a cake can be cut into 20 pieces; find the cost of the eggs in 80 pieces of cake.

APPENDIX E

APPENDIX E
ANATOMY OF THE TEST

N = 64

Item	H	L	H + L	H - L	% Diff.	% Disc.
1	12	4	16	8	25	38
2	9	5	14	4	22	19
3	20	10	30	10	47	47
4	28	25	53	3	83	14
5	29	15	44	14	69	65
6	17	10	27	7	42	32
7	30	22	52	8	81	37
8	27	21	48	6	75	28
9	26	15	41	11	64	52
10	25	21	46	4	72	19
11	32	23	55	9	86	42
12	22	22	44	0	69	0
13	31	20	51	11	80	52
14	25	14	39	11	61	52
15	19	9	28	10	44	46
16	27	13	40	14	63	65
17	19	13	32	6	50	28
18	29	17	46	12	72	56
19	28	18	46	10	72	46
20	31	29	60	2	94	9
21	11	5	16	6	25	28
22	7	6	13	1	20	5
23	24	9	33	15	52	70
24	22	14	36	8	56	37
25	19	9	28	10	44	46
26	22	12	34	10	53	46
27	19	11	30	8	47	37
28	21	11	32	10	50	46

H = the number of "highs" who got the item right.

L = the number of "lows" who got the item right.

$$\text{Difficulty} = \frac{H + L}{N}$$

$$\text{Discrimination} = \frac{3(H - L)}{N}$$

APPENDIX F

APPENDIX F

RATING SCALE FOR TEACHING EFFECTIVENESS

Your instructor is anxious to secure a frank and honest rating from the members of this class as an aid to his growth in effectiveness as a teacher. Since it is desired that all ratings be anonymous, please do not place your name or any other identifying mark on your copy of this scale.

You are asked to rate your instructor on each of the qualities listed below by placing on the horizontal line a check in the position that most accurately indicates your judgment. The higher ratings will, of course, trend toward the left and the lower ratings toward the right.

It is not necessary to check every item.

1. Preparation for Class Meetings

.
Meetings regularly planned with care	Planning sometimes seems inadequate	Little planning evident

2. Teacher's Interest in Subject

.
Marked interest and enthusiasm	Only mild interest	Apparent tendency toward boredom and indifference

3. Reaction of Students

.
Most students alert and attentive	Many students seem only slightly interested	Much inattentive- ness and general lack of interest

4. Classroom Management

.
Active attention to comfort of students as to light, temperature, ventilation, etc.	Some concern with comfort of students	Practically com- plete indiffer- ence to comfort of students

5. Scholarship

.
Knowledge of subject seems broad and accurate	Knowledge seems de- ficient at times	Knowledge seems seriously defi- cient

6. Ability to Express Thought

Excellent mastery of language; meaning always clear	Some hesitation; meaning not always clear	Much verbal hesitation and uncertainty; meaning often obscure
---	---	---

7. Voice

Voice well adapted to classroom; speech distinct and audible	Voice at times unsatisfactory; some students do not hear easily	Voice often inaudible; students irritated by inability to hear
--	---	--

8. Spirit of Growth

Presentation always fresh and vital	Some apparent effort to keep subject matter fresh	Apparent following of a familiar outline, with little freshness
-------------------------------------	---	---

9. Assignments

Assignments clear and carefully given	Sometimes vague, indefinite, or hastily given	Usually vague and hastily given
---------------------------------------	---	---------------------------------

10. Class Discussion

Class discussion highly valuable	Class discussion often unprofitable	Class discussion largely a waste of time
----------------------------------	-------------------------------------	--

11. Feeling between Teacher and Class

Strong atmosphere of mutual goodwill	Neither marked goodwill nor marked antagonism	Class too often antagonized
--------------------------------------	---	-----------------------------

12. Sense of Humor

Keen and appropriate sense of humor	Occasional touches of humor	Practically no humor
-------------------------------------	-----------------------------	----------------------

13. Self-Confidence

Always sure of himself; meets difficulties with poise	Fairly confident but occasionally disconcerted	Hesitant, timid, uncertain; disturbed by trifles
---	--	--

14. Tolerance and Mental Flexibility

Welcomes differences of opinion and treats them with respect	Somewhat impatient with opinions of students	Dogmatic; easily irritated by any disagreement or opposition
--	--	--

15. Personal Appearance

Good grooming; clothing neat and in good taste	Some carelessness about details of personal appearance	Definitely careless and untidy in grooming and dress
--	--	--

16. Personal Mannerisms

Substantial freedom from annoying or distracting personal mannerisms	Mannerisms not serious or objectionable	Mannerisms a serious detriment to effectiveness
--	---	---

17. Conduct of Class

Class conducted in competent, business-like manner	Some looseness in conduct of class; occasional confusion and disorder	Little order or method in conduct of class
--	---	--

18. Efficiency in Procedure

Prompt beginning and ending of class; time fully utilized	Reasonable promptness and use of time	Carelessness about time
---	---------------------------------------	-------------------------

19. Approachability

Teacher welcomes conferences and exerts himself to be understanding and helpful	Teacher tolerates conferences and is sometimes helpful to students	Teacher seems to be too busy to afford much time or thought to the students' problems
---	--	---

20. Stimulus to Thinking

Abundance of novel and stimulating ideas and viewpoints	Occasional new and stimulating ideas	Little attempt to develop and stimu- late new ideas
---	---	---

21. Validity of Examinations

Examinations closely related to course material	Examinations sometimes not closely related to course materials	Examinations seem to have little re- lation to course material
---	--	---

22. Major Objectives of Course

Major objectives clearly explained and made obvious through- out course	Major objectives vaguely expressed and rarely emphasized	Major objectives never mentioned or made apparent
--	--	---

23. General Rating of Teacher

If all teachers with whom I have taken work were divided into three groups, all qualities considered, I should place this one

In the top third	In the middle third	In the lowest third
------------------	---------------------	---------------------

The following is a list of suggestions for the teacher. Place checks before those items which to you seem pertinent, leaving the other blank.

The effectiveness of the teacher's work might be increased by:

- ☐ A - more visual aids
- ☐ B - more tests and examinations
- ☐ C - fewer tests and examinations
- ☐ D - more required outside reading
- ☐ E - less required outside reading
- ☐ F - less emphasis on memorizing in examinations
- ☐ G - a mimeographed outline of the course for the student

The teacher should:

- ☐ A - use English of a higher standard
- ☐ B - reduce the monotony of his speaking
- ☐ C - use fewer unfamiliar words
- ☐ D - present material more slowly
- ☐ E - do less moving about while lecturing
- ☐ F - make chalkboard writing more legible
- ☐ G - be less hasty in erasing useful material from the chalkboard

Additional suggestions:

- ☐ A - work demanded in this course is excessive for the amount of credit
- ☐ B - work demanded in this course is lighter than average for the amount of credit
- ☐ C - effectiveness of teaching in this course would be helped by the setting up of more rigorous prerequisites
- ☐ D - more time should be devoted to answering the questions of students

In the space below, please write any specific suggestions not provided for above which you believe might help your teacher to do more effective work.

APPENDIX G

APPENDIX G
STUDENT COMMENTS

Control Group

1. More experiments.
2. Relate the subject like pendulums to something else, not just skip around. The lab experiments are interesting.
3. Explain and give more notes.
4. Many students are not acquainted with the sciences when they enroll in GPS. Should spend more time discussing the fields of science and stimulate interest. Try and get the student interested in a science. Most are waiting for the opportunity, but feel unsure because of weak background.
5. Show more pronounced interest in student's work and problems.
6. I believe you should give more small tests.
7. Don't try covering so much. Explain on a lower level.
8. I think the idea of an outline is very good.

Experimental Group

1. Present more class experiments. Let students out of class once in a while.
2. Speak louder when giving an assignment or some important material.
3. For some students I feel that the course was too general and did not explain in enough detail. For those who had background in science it was just right.
4. A more outlined criteria of work for semester.
5. No suggestions--just keep up the good work.
6. Material covered not clear.
7. It has been great! You are a wonderful teacher!
8. The relation of general physical science to everyday life should be emphasized more.
9. Most of the students don't understand physics. You should take that into consideration and explain the material in simpler terms and formulas.

10. The class is real interesting and presented well. I believe I would have learned more if I would have been given more tests. I would have done better because it is easier to learn a little at a time.
11. I think there should be more tests during the semester.
12. Be more specific about which assignments you want handed in and when they are due.
13. Very good job--I learned something.
14. It would be better if the course was more comprehensive in the fields even if some fields had to be left out. Course accomplished much and was interesting in general.

VITA

Ronald Eugene Appleman

Candidate for the Degree of

Doctor of Education

Thesis: A COMPARATIVE STUDY OF THE COGNITIVE EFFECTS OF THE USE OF
TAKE HOME LABORATORY MATERIALS ON STUDENT ACHIEVEMENT IN
COLLEGE LEVEL PHYSICAL SCIENCE CLASSES

Major Field: Higher Education

Biographical:

Personal Data: Born in Ponca City, Oklahoma, July 30, 1933, the
son of Stratton B. and Edna Appleman.

Education: Attended elementary and secondary school in Alva,
Oklahoma; graduated from Alva High School, Alva, Oklahoma,
in 1951; received the Bachelor of Science degree from
Oklahoma State University in 1955 with a degree in geology;
attended Northwestern State College summer session in 1956;
attended the University of Oklahoma summer sessions in 1957
and 1958; received the Master of Education degree from the
University of North Carolina in August, 1959, with a major
in physical science; attended Texas A & M University summer
sessions in 1965; completed requirements for the Doctor of
Education degree in July, 1967.

Professional experience: Taught general science, biology, and
chemistry in Comanche High School, Comanche, Oklahoma, from
1955-58; accepted position of physics instructor at Northern
Oklahoma College, Tonkawa, 1959, and have served as Chairman
of the Science and Mathematics department since 1960 with
the exception of a one year sabbatical leave to Oklahoma
State University in 1966; worked as a graduate assistant in
the Physics department during the year of residency.