

A PROGRAM FOR INDIVIDUALIZED
INSTRUCTION IN SENIOR HIGH SCHOOL PHYSICS

by

Frederick Eugene Tillisch

B. S., University of Kansas, 1971

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1975

Approved by:


Major Professor

LD
2668
R4
1975
T54
C 2
Document

ACKNOWLEDGEMENT

The author gratefully acknowledges the guidance and paitence of his major professor, Dr. Robert K. James, Associate Professor of Education. The assistance of Dr. Jackson A. Byars, Assistant Professor of Education is also appreciated.

TABLE OF CONTENTS

Chapter	Page
1. INTRODUCTION	1
INTRODUCTION TO THE PROBLEM	1
RATIONALE OF STUDY	3
PURPOSE OF STUDY	3
STATEMENT OF THE PROBLEM	3
PROCEDURES	4
2. REVIEW OF LITERATURE	5
3. CONCLUSIONS BASED ON LITERATURE	9
DEFINITIONS	10
4. THE PROGRAM	11
LIMITATIONS	11
POPULATION	11
INTRODUCTION TO THE PROGRAM	12
RATIONALE FOR STRUCTURE AND SEQUENCE	12
THE MODULAR ORGANIZATION	14
ANTICIPATED PROBLEMS AND SOLUTIONS	14
TRIAL MODULES	16
APPENDIX	40
FOOTNOTES	42
SELECTED BIBLIOGRAPHY	43

Chapter I

INTRODUCTION

INTRODUCTION TO THE PROBLEM

The physics course in the senior high school is usually composed of lecture and laboratory work. In this type of a course there are very few options for individual differences, such as; ability, aptitude, career preference, and interest. Using the same textbook and doing the same laboratory activities does not respect the individual differences that are known to exist. This lack of respect for individual differences is clearly seen in the results of Snider (1965) in that 70% of the physics "teacher talk" was either lecture or giving directions and only 8.3% of the "teacher talk" was devoted to asking questions.¹ In the opinion of the author, the result is very little feedback time for the amount of time used in giving out information. With this low amount of feedback there is also a very low rate of criticism, which is only 2.2%.² The laboratory-lecture course is a teacher centered system.

In the opinion of the author, this lack of flexibility is thought to be a factor in the decrease in enrollment in high school physics classes during the past twenty years. The first big change in this area was PSSC Physics, which was intended to upgrade the level of physics courses and to use well prepared movies and laboratory exercises in the laboratory-lecture method of instruction. Even though a large amount of money was used to

develop this program, the drop in physics-course enrollment continued.

Harvard Project Physics was the next major project to increase the relevance of physics. With the use of audio visual techniques, case histories, and relationships of physics with other endeavors, there was no complete system for individualizing instruction.

PSSC Physics did not change the existing method of teaching physics when it was developed. It is a laboratory-lecture course directed at the above average student. Harvard Project Physics uses a different approach. This is a humanistic and historical approach that tries to give the student a view of actual scientists at work and how they go about the process of science. The program is supposed to provide for any style of learning or teaching method. It is only individualized with programmed instruction booklets, optional laboratory exercises and tests.

Recently there have been several individualized physics courses offered, at best the entire package has to be purchased, and this expense is almost prohibited by a small budget.

In large high schools, many of the problems have been corrected by offering several different physics classes taught at different levels. At Moline High School, Moline, Illinois, a large high school, this method was used and there was an increase in enrollment from 104 physics students with a school enrollment of 2339 in 1966 to 270 physics students with a school enrollment of 2582 in 1969.³ The Boyertown Area Senior High School, Boyertown, Pennsylvania, using individualized instruction and optional activities had a 20% increase in enrollment from 86 to 103 physics students in the 1972-73 school year and in the 1973-74 school year there was a 22% increase from 103 students to 126. There is enough interest there to warrant the offering of a second year physics course.⁴

RATIONALE OF STUDY

There is a need to develop a physics course that will be useful to many different students, those with different aspirations, interests, and abilities. In a small school where only one section of physics is offered a year it is not possible to vary the material by offering different sections as many large high schools do. Thus any variety must be accomplished within the one class period. The traditional laboratory-lecture course has very little capability for such diversity. Therefore, it is necessary to use a method of instruction and materials management that will allow for the individual needs.

PURPOSE OF STUDY

The purpose of this study is to develop a senior-high-school physics course that will fit individual needs, use most of the existing hardware and software in the school, not require a large first year budget to adopt, provide variety for different interests, be suitable for small classes of under fifteen students, and be useful to the individual student. Primarily it is a search to find sources that have a variety of approaches. To fit individual differences such as reading levels, sources should be selected for a wide range of reading levels. For the nonreader sources of information that require very little reading are needed. For the student that wants a challenge laboratory experiments and problems that are difficult should also be included.

STATEMENT OF THE PROBLEM

The problem was to develop a senior-high-school physics course that is appropriate to a small high school with limited facilities and diverse student needs.

PROCEDURES

The outline of procedures for this study is as follows.

1. A review of the literature pertinent to the study;
2. Guidelines, drawn from the literature, for the development of a program;
3. Implementation of these guidelines in an organizational scheme and the preliminary materials necessary to begin the first semester of the course;

Chapter II

REVIEW OF LITERATURE

Enrollment in high school physics classes is dropping. This is a problem when there is a need for physics in the background of many technicians for their future jobs as well as for the engineers and scientists. People with these skills will be needed even more in the future.

During the 1948 to 1949 school year, 5.6% of the total high school enrollment was enrolled in a physics course. During the 1962 to 1963 school year, this had dropped to 4.0% of the total high school enrollment (Simon and Grant, 1967). This decrease occurred a time when the technical and science manpower needs were increasing.

Harvard Project Physics Curriculum Development in Physics is a sophisticated, well-financed program that was designed to meet the needs of students that PSSC and traditional physics did not satisfy. Using a humanistic and historical approach, it is still laboratory-lecture in the method of instruction.

Prior to Harvard Project Physics 67.6% of the physics teacher's time was devoted to lecture (Snider, 1965). After Harvard Project Physics had been used for several years, the amount of lecture-demonstration time was still 40% (American Institute of Physics, 1972). The typical PSSC physics course has an even higher amount of lecture time at 56% (American Institute of Physics, 1972). In the same study the amount of laboratory time, the student was free to investigate unscheduled activities was 27% in the PSSC course and 60% in Harvard Project Physics courses.

There are new programs that are to remedy this situation. The Project PLAN is: a well developed computer managed, individualized, modular pro-

gram which uses behavioral objectives. A major goal of project PLAN is to adapt education to the individual differences. Another goal is giving behavioral objectives for the learning materials (Flanagan, 1968).

A more practical program for the larger high schools is that which the Boyertown Area Senior High School, Boyertown, Pennsylvania, has developed. This program uses lecture, discussion, optional activities, remediation to individualize physics, and Harvard Project Physics Text as the basic text book. Pretesting was used to find the students entrance level (King and Szabo, 1974)

The Moline Plan is another large plan that approaches the problem of flexibility in a different way. There are several physics classes offered and each class is intended for a different group of students. There is an advanced course for brilliant students, a typical course for the person who needs a background in physics, and a special course for the student who is interested in physics for the "fun of it" and does not want to ruin a good grade average in competition with very good students (Goar, Fentem, and Bushman, 1970).

The results of individualized instruction in science are at least as good as the results the existing laboratory-lecture type of course. James found no significant difference in achievement between group instruction and individualized instruction (James, 1972). There are no significant difference between the mean scores of the test group or the control group (Hefferman, 1973). The application of these results to the study at hand is limited by the fact that they dealt with junior high age students. However, they do corroborate the results of other studies of individualized instruction in terms of the student achievement.

A significant element of most individualized programs has been the

Careful statement of objectives. Gatta in a study of behavioral objectives in a chemistry course found that there was a significant improvement in the student's achievement in chemistry and in the student's attitude toward chemistry (Gatta, 1974).

If this system can improve student success, there is a significant opportunity to improve the students satisfaction. This can result in an overall improvement in student performance (Beelick, 1973). With the below average student or slow learner in this situation, the amount of satisfaction can be increased by increasing the hands-on activities. This would result in better development for the slow learner (Milson, 1973).

With respect to individual differences in science teaching it is necessary to make allowances for the individual's stage of mental development. According to Piaget the final stage of development is not reached until the child is twelve years old. Adults show gaps in the complete development in this area (Stendler, 1965).

To adapt the educational system to individual differences, there are four aspects that must be varied. The most common variation in a traditional program is to make changes in the assignments. The second adaption is allowing for differences in the learning rates of the individual. Varying instructional methods and media is the third variation. The fourth and most important is to allow for different goals that fit different individuals (Flanagan, 1968).

Project PLAN (Program for Learning in Accordance With Needs) is an individualized program developed for kindergarten through twelfth grade. It uses objectives, modules, and objective evaluation. There are self checks built into the learning units for the student to evaluate his own progress. The two very important aspects to PLAN are the computer selected

assignments called TLU (Teaching-Learning Units) and individually selected objectives in some cases. The TLU's are unique in that there are several for each unit to allow for different students (Weisgerber and Rahmoow, 1971).

The FUSE (Federation for Unified Science Education) program is a different approach to science education. It is a modular arrangement that allows for individual differences in Alternative Modules. The program is developed to eliminate the individual science courses and replace these courses with one unified course to eliminate duplication that exists. The modules should be four to six weeks long. This is more directed at giving the learner a view of science as a single humanistic effort (Showalter, 1973).

The NPSP Physics-Chemistry (Nebraska Physical Science Project) is an integrated physics-chemistry course developed to eliminate duplication in physics and chemistry. It is also to use the basic principles of physics as a method for dealing with chemistry phenomena. Learning methods are multi-text approach, programmed learning materials, films, and auto-tutorial systems. Behavioral objectives are used to provide direction and simplify evaluation (NPSP, 1970).

Chapter III

CONCLUSIONS BASED ON LITERATURE

The present methods of teaching physics are not meeting all of the needs of the individual students in small schools. For this area there is a need for a different approach. There is no statistical evidence to indicate that either individualized instruction or the lecture instruction is significantly better. Therefore, the deciding factor might be to use the method that is the most efficient in the individual school. The physical limitations of a small school make large classes very difficult, but small classes could facilitate individualization. Since typically, small schools offer only one physics class per year, or every other year, individualization offers the only way to attempt to meet individual differences.

The modular organization of the material is a scheme of organization that facilitates optional learning experiences. This will also allow for conservation of equipment since not all students will be on the same activity at the same time. It is hoped that the one-day to ten-day duration of the module will give the student a sense of accomplishment.

The literature supports the conclusion that an appropriate program would include: individualized instruction, modular organization, and behavioral objectives. This course consists of modular-type assignment sheets based on standard sources such as text books and laboratory books. Demonstrations, laboratory experiments, and lectures can be inserted according to student's and teacher's preference.

Core Course: The basic modules for a two semester physics course.

Module: Instructional packet that includes assignments and instructions for a section. Behavioral objectives, rationale, assignments, pretest, post evaluation, and instructions are included.

Individualization: A program in which the individual can progress at his or her own pace, have options in some materials, and have options in the style of learning.

Behavioral Objectives: A statement in behavioral terms of the terminal ability of a student after completion of a module.

Pretest: The pretest is an evaluation to determine if the student has mastered the objectives of the module prior to starting the module and to determine if the student has met the prerequisites to accomplish the module.

Post Evaluation: This evaluation includes laboratory reports, problems or questions, and oral or a written objective test to determine if the student has accomplished the objectives.

Self Pacing: The student can progress at his or her own reasonable rate of learning.

Remediation: Remediation is the assignments and activities necessary to make up the deficiencies after an objective has not been satisfactorily accomplished.

Chapter IV

THE PROGRAM

LIMITATIONS

This program is untested in the field. The materials used are limited to those materials that are on hand in the Wakefield High School. There are no provisions for the size and design of the classroom and laboratory facility. Because outlived the facility in which the author teaches, there has been no research conducted for this report on the facilities available in the smaller high schools in Kansas. The ability to procure textbooks and audio visual materials is also a limit on the design of this course.

POPULATION

This program is intended for the students attending a rural high school. The classes are co-educational with a wide range of interests and abilities. Being in a rural area, there is an interest in agriculture. The students interested in agriculture are usually interested in mechanics and electricity. There are several students interested in engineering and they need a good background in physics for their college work. Those interested in a technical career such as electronics or mechanics, have a more practical interest in physics. There are several students who are taking physics for the background and they do not have a technical vocation or a technical field of interest. These are

the students that Harvard Project Physics was aimed at. The mathematics preparation is at least Algebra I. These students are very busy and need a course that can be adjusted to their needs.

INTRODUCTION TO THE PROGRAM

To better satisfy the needs of the student, the method of instruction and scheme for presentation is individualized instruction, using a behavioral objective, modular-approach for organization of materials.

This approach is used to give the course flexibility in learning materials, learning methods, and behavioral objectives. With this organizational scheme it is possible to adjust for the low reading ability, the bright student, and the average student in the same class. From Snider's (1965) results, there would be little lost in discussion because most of the time in a physics class is not devoted to discussion. Flexibility, with respect to the students' interest, is also built into the system with optional modules for more detailed study and challenge activities for short individual pursuits.

To take full advantage of the modular approach, it is necessary to use an individualized method of instruction. The advantages of self pacing, different instructional media, and individual interest would be lost by using any other method of instruction.

RATIONALE FOR STRUCTURE AND SEQUENCE

The course structure is typical of many physics courses. It is similar to many textbooks used for teaching physics at the high school level. There are several reasons for this structure other than the fact that it is used in many textbooks. The initial starting point

must be at a level the student can understand. Using distance allows the individual who is a "concrete operational thinker" in terms of Piaget's definition a good learning situation with a simple concrete model. The next step is an area that is closely related to the students everyday life. This is velocity. From velocity on, the least complicated concepts are delt with first. There are prerequisites built into the study of physics. As in the case of kinetic energy one must have a working definition of energy and one must also have the ability to measure and compute velocity to determine a kinetic energy. Therefore, velocity is studied before kinetic energy. Much of the material is related in this manner, where one must accomplish simple concepts first and then progress to the more difficult.

In selecting software materials for this type of instruction, the method to use is to insure that the materials have: a wide range of reading levels, different approaches from theoretical to practical, and film strips and other media besides the text book. An example of this is the text book reading range is from ninth grade to thirteenth grade. Modern Physics by Holt, Rinehart, and Winston has a ninth grade reading level, Physics by Genzer and Younger has a tenth grade reading level, Physics by Murphy and Smoot has a ninth grade reading level, Physics by PSSC has a college reading level, and The Project Physics Course Text has a twelfth grade reading level. These levels were evaluated by the author using Fry's Readability Formula.⁵ These texts also vary in approach from Physics by PSSC, which is very theoretical, to Modern Physics by Williams, Trinklein, Metcalfe, and Lefler which is very practical.

The hardware needed is present in most high school physics classrooms already, so very little expenditure would be needed for new equipment. The money normally spent on full classroom sets of equipment could then be directed toward replacing and upgrading old equipment.

THE MODULAR ORGANIZATION

Several different modular organizations were surveyed and it was found that the organization presented by Gerald D. Bailey in Competency Based Teacher Education was best fitted to the designer's needs.⁶

ANTICIPATED PROBLEMS AND SOLUTIONS

The program is not to be fixed and rigid, but a general scheme where parts can be removed and added as new methods, new discoveries, and different student interests dictate. There are many new problems built into the system and this is a short summary of how to deal with some of the problems such as classroom management, remediation, materials management, record keeping, and noise. These solutions will be useful for only a small class of fifteen students or less.

Classroom Management

There needs to be a laboratory where equipment can be set up for several days without being disturbed. Each student or student group should be responsible for keeping this area neat and uncluttered. There should be a quiet area where students can read and work out problems. Next to this quiet area should be the teacher-student conference area. These areas should be blocked off from the laboratory by a book shelf or a rolling cabinet.

Remediation

In the small class remediation will be developed after an objective has not been met so the makeup work can be individualized.

Materials Management

Textbooks and laboratory books will be shelved in the classroom in alphabetical order according to the code designation. The students will have access to this area during class and between classes. Materials will be stored in two areas. Small laboratory materials such as washers, string, and hardware will be stored in a cabinet in the classroom where students can obtain and replace materials by themselves. Painted outlines on shelves and boards will be used for quick visual inventory. Large pieces of equipment such as oscilloscope, force board, and static generator will be stored in a separate store room and the student will have to make arrangements to have these pieces of equipment in the laboratory on the day they are needed.

Record Keeping

Each student will have a folder with a list of the modules on a sheet of paper. When an assignment is handed in or a laboratory report is handed in the appropriate box will be checked. When an objective test is completed the percent score will be entered in the space provided for that module.

Noise

There is bound to be more noise and confusion in the classroom than one would expect in a laboratory-lecture classroom. The benefits of individualized instruction should outweigh the loss of serenity.

TRIAL MODULES

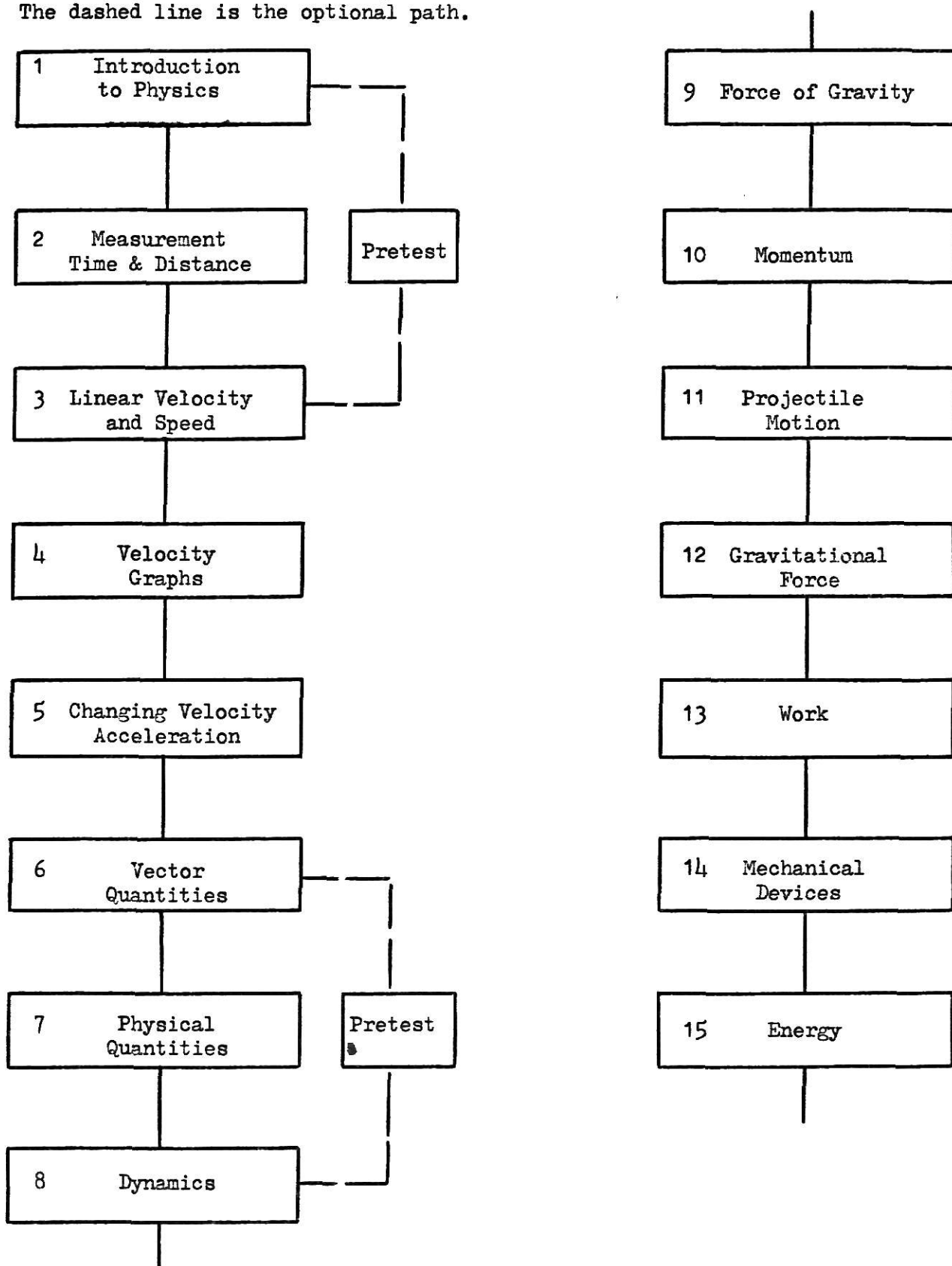
Following this page there are fifteen completed module assignments, for the first fifteen modules of the program. After these trial modules are used then the remaining thirty-two will be written for trial in the classroom.

Book Abbreviations

There is a list of student instructions in the appendix and the book abbreviations used in the modules is also in the appendix.

Flow Chart

The solid line is normally required.
The dashed line is the optional path.



Introduction to Physics
Module I

Rational

Physics is the study of a science and one should have an idea of what the professionals in this area have done, are doing, and are thinking.

Objectives

1. Demonstrate your attitude toward science.
2. Identify several methods of scientific research.
3. Identify conflicting views between scientists.
4. Find one's own answer to "What is science?".

Learning Activities

From the Project Physics Reader #1, read all of these selections.

1. "The Value of Science", pp. 1-8.
2. "On Scientific Method", pp.23-25.
3. "Four Pieces of Advice to Young People", pp. 29-30.

From Steps in the Scientific Tradition

4. Read at least one selection from this book.

Post Evaluation

1. Give an oral report to the instructor or write your answers to objectives 1 and 4.
2. Write your answers to objectives 2 and 3.

Challenge

1. Read another article from SST and give an oral report about this article.

Measurement, Time and Distance
Module II

Rationale

You will be expected to make measurements of both time and distance. Much of your success in this course will depend upon your ability to do this without difficulty. Much of all science depends on making accurate measurements. One may not use exotic equipment such as an electron microscope for this, but one may use a simple ruler if he were sampling the length of a pine tree needle.

Objectives

1. Measure distances in the metric system. Using units of millimeter, centimeter, and meter.
2. Measure distances in the English system, using units of inches and feet.
3. Convert distances in the English system. These conversions are inches to feet, feet to inches, feet to yards, and miles to feet.
4. Convert distances in the metric system. These conversions are mm to cm, cm to mm, m to cm, cm to m, m to km, and km to m.
5. Convert units of time. These conversions are hr. to min., hr. to sec., sec. to hr., min. to hr., min. to sec., and sec. to min.

Pretest: Take pretest from instructor if you can complete these objectives.

Learning Activities: From Refresher Math do activities 1-8.

1. Read pp. 434-435.
2. Do problems pp. 437-438, sets; 1, 4, 10, 11, 14, and 20.
3. Read pp. 298-299.
4. Do problems pp. 300, sets; 1a and 2.

5. Pp. 301 sets; 17 and 19.
6. Read pp. 408-9.
7. Problems p. 409, sets; 1, 3, and 4.
8. Problems p. 410, sets; 5, 6b, 7, 9, and 13.

Measurement

Check out a measurement box and meter stick. Measure the objects in the box and other objects as instructed.

Diagnostic Test, Measurements

1. Measure the length of this paper to the nearest centimeter.
2. Measure the length of this line to the nearest millimeter. ____
3. Measure the length of the lab table to the nearest tenth of a meter.
4. Measure the width of this page to the nearest inch.
5. Measure the length of the table in feet and inches.

Convert each of the following:

6. 25 mm = ____ cm.
7. 12 cm = ____ mm.
8. 5 m = ____ cm.
9. 330 cm = ____ m.
10. 2500 m = ____ km.
11. 1.5 km = ____ m.
12. 28 in. = ____ ft.
13. 5 ft. = ____ in.
14. 3 hrs. = ____ min.
15. 1.5 hrs. = ____ sec.
16. 5800 sec. = ____ hrs.
17. 90 min. = ____ hrs.
18. 380 sec. = ____ min.

Linear Velocity and Speed

Module III

Rationale

How fast does something happen? is a question that is often ask in many of the different sciences. One may be asking about the rate of a chemical reaction, the rate of growth of a rat, the rate of motion of a continent, the rate of blood flow, or any one of hundreds of questions about rate. In preparing yourself for some future task learning to calculate velocity, is the beginning step for more complicated problems you could face later in your life.

Objectives

1. Measure the average velocity of an object.
2. Calculate the average velocity of an object traveling a given distance in a length of time.
3. Calculate the distance an object will travel at a given average speed or velocity for a given time.
4. Calculate the time required for an object to move through a given distance at a given velocity.

Learning Activities

Select at least one from 1-3. Do assignments 4 and 5.

1. Read PPC pp. 9-18, Problems p. 32: 1.3 (a-h), 1.4, 1.5, 1.6, & 1.7.
2. Read MP pp. 73-77. Problems pp. 77 and 87: 1-6.
3. Read PSSC pp. 54-59. Problems p. 77: 1, 3a, 3b, and 4a.
Problems PPC p. 32: 1.3 (a-h)
4. Do lab. 2-1 in LIP.
5. Measure the velocity of four different objects, such as: a person walking or running, a car, a boat, or a river. The velocity of each object will be calculated in ft./sec., mi./hr., m/sec and km/hr.

Post-Assessment

1. Hand in results from LA numbers 4 and 5.
2. Take Module III quiz from instructor.

Challenge

1. Calculate the time it would take to cover a distance for each object in LA 4.
2. Devise your own challenge activity.
3. If you did not do this in LA 5, how fast do you walk, run, and jog. Find these speeds in English and metric units.

Velocity Graphs Module IV

Rationale

Because much information in the technical world and the scientific world is presented graphically one should be able to read graphs and construct graphs. These graphs will also help you to understand velocity and acceleration. The ability to construct and read graphs is a continuing demand of many modules to follow.

Prerequisites

The student must be able to do the following:

1. Plot points on a Cartesian coordinate system.
2. Plot a line given the equation of that line.
3. Determine the equation of a line given two points on the line.

Objectives

1. Interpret a distance vs. time graph.
2. Construct a distance vs. time graph.

Learning Activities: Do one from 1-4. Do no. 5.

1. Read PSSC pp. 63-66. Problems p. 79: 11, 12, 13, and 14.
2. Read P pp. 18-23. Questions p. 21: 6, 7, 8, and 9.
Questions p. 23: 10 and 11.
3. Read PPP pp. 40-45. Problems p. 47: 1(a-e).
Problems PPC, p. 21: 6 and 9.
4. Read P pp. 35-45. Problems p. 40: 1-3 and p. 48: 1-4.
5. Do Lab. 2-1, pp. 5-7 in LIP.

Evaluation

Hand in graph from learning activities 1-4. Interpret a given distance vs. time graph. Construct a distance vs. time graph. Construct a distance vs. time graph from an equation.

Challenge: Construct a distance vs. time graph from LA 5 Module III.

Changing Velocity, Acceleration

Module V

Rationale

The need to evaluate the rate of change of a rate is the next requirement. You must be able to understand acceleration before you can advance to a more difficult concept such as force. In a purely technical sense a pilot must understand acceleration and the best possible acceleration. This also applies to a race car driver. The problem is to find the best acceleration somewhere between a spin out and not driving fast enough to win.

Objectives

1. Calculate an average acceleration given the necessary data.
2. Measure an average acceleration.
3. Interpret a velocity vs. time graph.
4. Construct a velocity vs. time graph given the necessary information.
5. Define instantaneous velocity.
6. Find the instantaneous velocity from a velocity vs. time graph.
7. From a distance vs. time graph find the acceleration.

Learning Activities

Do one of the following activities.

1. Read PPC pp. 23-30. Problems p. 34: 1.15, 1.16, 1.17 (a-e) and 1.18.
2. Read PSSC pp. 64-74. Problems p. 77: 6(a & b), 7, and 8 (a-e).
3. Read PPP pp. 46-49. Problems pp. 48-50: 2, 3, 6, 8, 9, 10a, and 11 (a & b).
4. Read P pp. 45-47 and 51-73. Problems p. 56: a-b, p. 60: a-d, p. 62: a-c, and pp. 73-75: 1, 3, 5, 8, 10, and 12.

Post Evaluation

1. Hand in graph from LA 3.
2. Take objective test.

Challenge

1. In LIP do lab. 2-1.
2. Find the average acceleration of four objects such as a runner.
a car, a basketball, and a football when kicked.
3. Find the relationship between velocity distance and acceleration
and prove that this is true.

Vector Quantities
Module VI

Rationale

Vectors are tools to be used in solving problems. This is a symbol that you can use to help you understand how to solve problems and to understand concepts.

Objectives

1. Define vector.
2. Define scalar.
3. Solve problems using vectors in velocity and force.
4. Find the components of a vector.

Learning Activities: One is required of 1-3. One is required of 4-5.

1. Read PPP pp. 51-62. Problems p. 55: 1, 2, 3, & 9. p. 58: 11, & 12, & p. 61: 21 & 25. Questions pp. 64: 1-3.
2. Read P pp. 121-131. Problems pp. 144-5: 1-3, 6a, & 6b.
In PPP p. 65: 1-3, 5, & 7.
3. Read PSSC pp. 82-93. Problems p. 103: 1, 4 (a-b), 7, 10 (a-b), 11, & 12 (a-d).
4. Do Exp. 6, pp. 169-170, in EEP.
5. Do Lab. 6-2, pp. 34-39, in LIP.

Post Evaluation

1. Hand in results from LA 4 or 5.
2. Hand in problems.
3. Take post evaluation quiz.

Challenge

1. Do Lab. 6-1, pp. 29-34, in LIP.
2. Do Exp. 7, pp. 171-2 in PPC.
3. Find a vector force situation and write a report or give an oral report showing the vectors and their relationship.

Physical Quantities
Module VII

Rationale

You need to know how to measure the mass and density of an object as well as being able to measure the volume of a liquid. These are areas you need to be proficient in to complete some of the following modules.

Objectives

1. Measure the mass of an object.
2. Measure the volume of an object.
3. Calculate the density of an object.

Learning Activities:

Do one of the two.

1. In PWB do experiment number 4 pp. 11-14.
2. In EEP do experiment number 5 pp. 165-7.

Post Evaluation

1. Hand in lab report.
2. Schedule a performance test with the instructor. You will be required to measure several volumes of liquids, and determine the mass of several objects.

Dynamics

Module VII

Rationale

Now we are going to look at what makes things move and how quickly the rate of motion changes. This module gives you an excellent tool to study force and the resulting motion. The knowledge can help you simplify complicated systems.

Objectives

1. Determine the resulting acceleration on a given mass by a force.
2. Determine the mass of an object when a force causes an acceleration.
3. Determine the force that would cause a mass to accelerate at a rate.
4. Demonstrate a knowledge of mass.
5. Identify the acceleration of gravity in both systems.
6. Define weight in your own terms.

Learning Activities: From 1-5, do one. From 6-8, do one.

1. Read PPP pp. 67-76. Problems pp. 71-2: 1, 4, 5a, 8, 10, 11, & 14.
2. Read P pp. 81-95 & 101-9. Problems pp. 97-8: 6a, 6b, 12a, 12b, 15a, 15b, & 19. P. 118: 4a, 4b, 6a, & 6b.
3. Read PSSC pp. 318-331. Problems p. 332: 6, 8, 9, 13, 18, 22, & 26.
4. Read MP pp. 85-93 & 95-101. Problems p. 101-2: 1, 2, 4, 7, 9, & 12.
5. Read PPC pp. 75-92. Questions p. 78: 9, p. 83: 11-14, p. 94: 3.13, and p. 96: 3.33.
6. Do Lab, 4-1, pp. 19-23, in LIP.
7. Do Exp. 13-1, pp. 183-185, in EEP.
8. Do Exp. #.5, pp. 29-31, in PPCB.

Post Evaluation

1. Hand in questions or problems, lab report, and take quiz.

Challenge

1. Calculate the acceleration of gravity.
2. Do lab. 3-11, pp. 17-18, in LIP.
3. Do Exp. 5-1, pp. 25-28, in LIP.

Force of Gravity
Module IX

Rationale

This is a chance for you to prove to yourself how the gravitational force can be determined.

Objectives

1. Find the force between two objects from their mass and the distance between the centers of mass.
2. Determine experimentally the Universal Gravitational Constant.
3. Demonstrate an understanding of the change in gravitational force as a result of a change in the distance of separation of the centers of mass.

Learning Activities

Do either 1 or 2. Do 3.

1. Read PPC pp. 90-112. Problems p. 121: 8.11, 8.13 (a-b). and 8.14. Questions PPC p. 111: 21 & 22 (a-c).
2. Read PSSC pp. 368-375. Problems p. 377: 18, 23 (a-c) & 24 (a-b).
3. Read MP p. 104. Determine the force of gravitational attraction in this fashion and then determine the Universal Gravitational Constant.

Post Evaluation

1. Hand in problems from LA 1 or 2.
2. Hand in results from Lab in LA 3.

Momentum

Module X

Rationale

Understanding the actions and reactions in the real world can help you predict what is going to happen before an event occurs. In many other fields of activity this is a very useful tool in solving problems.

Objectives

1. Student can demonstrate an understanding of the conservation of momentum.
2. Describe a situation involving the collision of two objects where momentum is conserved.
3. Given any of the three quantities of a two body collision problem the student can find the fourth quantity.

Learning Activities

Do one from 1-5 and 6-8. LA 6 is optional.

1. Read PPC Unit 3 pp. 5-23. Problems p. 8: Q1. p. 11: Q5, pp. 15-16: Q6 & Q7 (a-d), p. 25: 9.11, p.26: 9.19, p. 27: 9.27 and 9.31.
2. Read MP pp. 78-83. Problems pp. 84-5: 1, 2, 5, 7, 8, 10, & 11.
3. Read P pp. 267-290. Problems p. 291: 3 (a-b), 8, 9, 10, 11 (a-b), and 13.
4. Read PPP pp. 78-86. Problems pp. 78-80: 1 & 3; and pp. 81-2 8, 9, 11, 13, 14, 17, and 20.
5. Read PSSC pp. 378-96. Problems p. 379: 1, 2, 4, 7, 15, 16(a-d) and p. 399: 24.
6. View film strip F 18.
7. Do experiment 11, pp. 179-80 in EEP.
8. Do Lab 3-8, pp. 56-7 in LPG.
9. Do p. 140. pp. 142-3, or pp. 144-5 in PPCB.

Post Evaluation

1. Hand in answer to problems.
2. Hand in results of lab.
3. Schedule an oral or written quiz.

Challenge

1. LGP, 3-10, pp. 59-61.
2. LGP, 3-11, p. 62.
3. PPCB, pp. 146-160.

Projectile Motion
Module XI

Rationale

This is one of the places we learn how something really happens from a lab situation.

Objectives

1. Determine the distance a projectile will travel.
2. Determine the path a projectile will take.
3. Calculate the range and height a projectile will reach.

Learning Activities

Do one from 1-4. Do 5.

1. Read PPP pp. 89-94. Problems pp. 92-4: 2, 5, 7, & 8 (a-b).
2. Read PPC pp. 101-6. Problems pp. 120-22: 4.6, 4.8 (a-f), & 4.10 (a-c).
3. Read PSSC pp. 338-40. Problems p. 354: 8 (a-e), 9 (a-b), 13, 14, & 15.
4. Read P. pp. 167-73. Problems p. 195: 5 (a-d), 6 (a-b), & 7.
5. Projectile Launcher Lab.
 - a. Use a projectile launcher to plot the path of a projectile.
 - b. Make a vector plot of velocities along a graph of "a".
 - c. Find the horizontal component of velocity.
 - d. Plot the paths of a light object and a heavy object.

Post Evaluation

1. Hand in problems and lab report.

Challenge

1. Lab. 8-1: pp. 47-9 in LIP.
2. Using a water jet find the velocity and distance the stream will travel at several different angles.

Gravitational Force

Module XII

Rationale

What keeps you on the Earth? The gravitational force is an interesting phenomena and it affects you every day.

Objective

1. Estimate the force of gravity given a changing distance.
2. Predict the change in force by suing the inverse square law, when the distance between two objects is varied.

Learning Activities

Do one activity.

1. Read PPP pp. 104-12. Read sample problem # 1 p. 107.
Problems p. 107: 1, 31 & 5.
2. Read Mp pp. 103-7. Questions pp. 107-8: 1-5 & 7.
3. Read PPC pp. 83-115. Questions p. 101: 12-14 and p. 105: 17, 18, 21 & 22.
4. Read PSSC pp. 358-375. Problems p. 375: 15, 16 (a-c) and p. 376: 18, 19, & 24.

Post Evaluation

1. Hand in questions or problems.
2. Take oral quiz.

Work

Module XIII

Rationale

So far you have only looked at events. Now we are going to look at what causes the event to continue to happen. This is called work and can be measured.

Objectives: The student can:

1. Define work in his own words.
2. Demonstrate an understanding of the relation between work, force, and time.
3. Demonstrate his or her ability to evaluate performance of a mechanical device.

Optional

4. Determine the amount of work necessary to move an object a distance against a constant force.

Learning Activities

Do activities 1 or 2. Do 3.

1. Read PPP pp. 113-16. Problems pp. 114-15: 1, 3, 5, 6a, and p. 116: 10 & 12.
2. Read P pp. 295-303. Problems pp. 315-16: 2 (a-c), 10, 12, & 13b.
3. Lab Activity
 - a. Find the amount of work you do in walking up from the first floor to the second floor.
 - b. Using a pulley set and an inclined plane determine the amount of work necessary to pull a loaded cart up to a height of 50 cm above the initial height.

Post Evaluation

1. Hand in problems or questions and lab report.
2. Write or record answer to objective 1 and 2.
3. How does a crew jack work?

Challenge

1. Find a mechanical device and determine how effective it is.

Mechanical Devices
Module XIV

Rationale

How a mechanical device gets a leverage advantage and how much this advantage costs in energy is useful knowledge.

Objectives

Choose any one of the objectives. The Student can:

1. Demonstrate the operation of a mechanical device in terms of work, force, and distance.
2. Evaluate the efficiency of a mechanical device.
3. Demonstrate a method for improving a mechanical advantage device.

Learning Activities

Do at least one activity.

1. View F1 and F3.
2. Pick any mechanical device, with the advise of your instructor, and evaluate this device with respect to input work, output work, and force applied.
3. Read MP pp. 145-47.

Post Test

You will be orally evaluated according to your objective and the device that you chose to evaluate.

Energy

Module XV

Rationale

You have now reached one of the biggest answers in physics, and an even bigger problem in the world. We are now experiencing an era of increased cost for energy with respect to the environment and money. A basic understanding of energy can also be a very effective tool in solution of technical problems.

Objectives

The student can:

1. Demonstrate an understanding of energy.
2. Evaluate a device according to its energy saving characteristics.
3. Distinguish between potential and kinetic energy.
4. Determine the amount of kinetic energy an object has.
5. Evaluate a change in potential energy.
6. Compare a potential and kinetic energy.
7. Determine the least expensive energy source with respect to the environment and actual money cost.
8. Demonstrate the basic knowledge of different energy sources and the efficiency of conversion from one energy to another.

Learning Activities

Do one reading assignment and one problem assignment.

1. Read PPC pp. 31-52.
2. Read PPP pp. 120-32. Questions p. 132: 1-7.
3. Read PPP pp. 120-32. Problems p. 133: 1, 2, 4, 7, 12, & 14.
4. Read MP pp. 131-43. Questions p. 143-4: 1-9.

5. Read MP pp. 131-43. Problems pp. 144-45: 1, 3, 7, 8, and 11.
6. Determine three ways that you can save energy, and in what form there would be a savings. (Note: Not doing your physics modules is not a good savings of energy, unless you intend to quit eating.)
7. Report on two recent articles about energy in a newspaper or on television. Reports should be either written or recorded on audio tape cassette.
8. Evaluate a mechanical device such as a rope and pulleys, hydraulic jack, screw jack, chain hoist, or inclined plane on energy input and energy output.
9. Using $\frac{1}{2}MV^2 = MGH$, find what the muzzle velocity of a projectile launcher is, with respect to the amount of energy that was given to the projectile by the launcher.

APPENDIX

MATERIALS

Textbooks

- MP-----Modern Physics. Williams, John E.; Metcalfe, H. Clark.;
Trinklein, Frederick.; and Lefler, Ralph W. Modern Physics
New York: Holt, Rinehart and Winston, Inc., 1972.
- PPC-----The Project Physics Course Text. New York, Holt, Rinehart
and Winston, Inc., 1970.
- PPP-----Physics, Principles and Problems. Murphy, James T. and
Smoot, Robert C. Physics, Principles and Problems. Columbus,
Ohio: Charles E. Merrill Publishing Co., 1972.
- PSSC-----Physics. Boston: D. C. Heath and Company, 1965.
- P-----Physics. Genzer, Irwin. and Youngner, Philip. Physics
Morristown, New Jersey, Silver Burdett Company, 1969.

Reading Books

- R1-----The Project Physics Course Reader 1. New York: Holt,
Rinehart and Winston, Inc., 1970.
- R2-----The Project Physics Course Reader 2
- R3----- 3
- R4----- 4
- R5----- 5
- R6----- 6

SST-----Steps in the Scientific Tradition. Westfall, Richard S.

and Thoren, Victor E., ed. Steps in the Scientific Tradition.

New York: John Wiley and Sons, Inc., 1968.

BNP-----The Birth of a New Physics. Cohen, I. Bernard. The Birth

of a New Physics. New York. Doubleday & Company, Inc., 1960.

Laboratory Books

EEP-----Exercises and Experiments in Physics. New York, Holt,

Rinehart and Winston, Inc., 1972.

LGP-----Laboratory Guide for Physics. PSSC, D. C. Heath and Company,

1960.

LIP-----Laboratory Investigations in Physics. Morristown, New Jersey,

Silver Burdett Company, 1969.

PWB-----Physics Work Book. Dull, Metcalfe, and Williams. New York:

Holt, Rinehart, and Winston, 1964.

PPCB-----The Project Physics Course Handbook. New York: Holt,

Rinehart, and Winston, Inc., 1970.

FOOTNOTES

1. Snider, Ray M. ERIC, ED 003-826, p. 116.
2. Ibid., p. 68.
3. Goar, Darrell F.; Fentem, Donald G.; and Bushman, Gary L.,
"The Moline Plan for Increasing Physics Enrollments" The Physics Teacher,
May 1970, p. 241.
4. King, Leslie A. and Sazabo, Michael. Individualization of Physics
for Increased Enrollment Through Modern Instructional Methods, ERIC
ED 093-669, 1970, p. 9.
5. Fry, Edward. "The Readability Formula That Saves Time" The Journal
of Reading, 11, 1968, p. 577.
6. Bailey, Gerald D. Competency-Based Education, (Manhattan, Kansas:
Kansas State University, 1974), p. 8-2.

SELECTED BIBLIOGRAPHY

- Bailey, Gerald D. Competency-Based Education. Manhattan, Kansas: Kansas State University, 1974.
- Beelick, Delbert B. "Sources of Student Satisfaction and Dissatisfaction" The Journal of Educational Research 67 (September 1974): 22.
- Capie, William. "Competency-Based Teacher Education the Concept" The Journal of the National Science Teachers 6 (September 1974): 50-55.
- Collins, Donald A. and Madden, Connie. "Individualized Project Physics" The Physics Teacher, November 1974, pp. 465-470.
- Cronk, Robert. "Campaign 71: Toward Increased Enrollment in High School Physics" The Physics Teacher, October 1971, p. 19.
- Davis Dell, Helen. Individualizing Instruction. Chicago: Science Research Associates, Inc., 1972.
- Flanagan, John C. "Individualizing Education" Education, February-March 1970, pp. 191-206.
- Fry, Edward. "The Readability Formula That Saves Time" The Journal of Reading 11 (March 1968): 576-77.
- Gatta, Louis A. An Analysis of an Objective-Based Curriculum in Chemistry. ERIC, ED 090-057, 1974.
- Goar, F. Darrell., Fentem, Donald G., and Bushman, Gary L. "The Moline Plan for Increasing Physics Enrollments" The Physics Teacher, May 1970, pp. 241-43.
- Heffernan, Daniel F. A Comparison of the Effects of Individualized Science Instruction with Traditional Science Instruction in Junior High Schools. ERIC ED 089-955, 1973.

144

Hughes and Associates. A Model of Good Teaching. ERIC, ED 002-844, 1958.

James, Robert K. "A Comparison of Group and Individualized Instructional Techniques in Seventh Grade Science." The Journal of Research In Science Teaching 9 (January 1972): 91-96.

Jordan, Thomas S. "Investigation into the Causes for Decreasing Enrollments in High School Physics." School Science and Math, November 1971, pp. 697-702.

Milson, James L. "Science and the Below Average Student" The Journal of Experimental Education 41 (Spring 1973): 135-39.

Nebraska Physical Science Project. Physics-Chemistry. Lincoln, Nebraska: University of Nebraska, 1970.

Parker, Laurence J. Factors Concomitant with Approach and Avoidance Behavior with Respect to Enrollment in High School Physics Courses. ERIC, ED 092-366, 1974.

Russell, James D. Modular Instruction. Minneapolis: Burgess Publishing Co., 1974.

Showalter, Victor M. "Symposium: Ways to Integrate Science, The FUSE Approach" The Science Teacher, February, 1973, pp. 25-27.

Simon, Kenneth A. and Grant, Vance W. Digest of Educational Statistics 1967. U. S. Department of Health Education and Welfare, Washington, D. C.: Government Printing Office, 1967.

Snider, Ray M. A Project to Study the Nature of Effective Physics Teaching. ERIC, ED 003-826, 1965.

Stendler, Celia B. Piaget's Developmental Theory of Learning and Its Implications for Instruction in Science, Edited by Edward

Victor and Marjorie S. Lerner. Readings in Science Education for the Elementary School. New York: The Macmillian Company, 1971.

Thompson, Raymond E. "A Survey of the Teaching of Physics in Secondary Schools" School and Society, April 1970, pp. 243-44.

Van Koevering, Thomas E. "The Distinguishing Characteristics of High Schools with High and Low Enrollments in Physics" The Journal of Research in Science Teaching 8 (January 1971): 37-39.

Weisgerber, Robert A. and Rahmlow, Harold F. The Process of Learning in PLAN, Edited by Robert A. Weisgerber. Developmental Efforts in Individualized Learning. Itasca, Illinois: F. E. Peacock Publishers, Inc., 1971.

A PROGRAM FOR INDIVIDUALIZED
INSTRUCTION IN SENIOR HIGH SCHOOL PHYSICS

by

Frederick Eugene Tillisch

B. S., University of Kansas, 1971

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

COLLEGE of EDUCATION

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1975

ABSTRACT

The physics course in the senior high school is usually a lecture and laboratory course. This type of instruction does not provide options for individual differences. This problem has a greater effect in small high schools where only one section in physics can be offered each year. Therefore, it is necessary to use a method of instruction and materials arrangement that will allow for individual needs. The problem was to develop a senior-high-school physics course that is appropriate for a small high school that features individualized instruction and behavioral objectives.

In the Review of Literature it was found that individualized instruction methods yield student achievement that is as good as the achievement from a laboratory-lecture type of course. In some schools individualized physics is being tried on a small scale and the results are very encouraging. With respect to the individual's mental development, individualized instruction can provide for different individual's mental processes. This program is limited to fifteen students in a section. With this limit it is possible for the teacher to work with students on a one to one basis. This type of course can provide the framework for a highly successful physics course.

There are fifteen modules completed for this report. This is the first fifteen from a total of forty six for the complete course that are to be completed after evaluation and use of the first fifteen. Student instructions are also included.

There is a need for continued improvement and testing of this program to eliminate bad spots and add new materials as they are developed.