

NEW HIGH SCHOOL PHYSICS COURSES -  
DO THEY ANSWER THE PROBLEMS?

by

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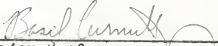
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## CHAPTER I

### INTRODUCTION

The successful launching of Sputnik I on October 4, 1957, caused many people to wonder why the United States had not yet launched a satellite. Aren't our scientists intelligent enough to do this? Doesn't America have enough manpower in science to keep up with the Russians? These questions exemplify the anxiety of the American people.

In relation to this, the physics courses offered by the public school systems came to the front. Physics is an important subject in the training of physicists, chemists, and engineers who are the trained persons needed in space research. When the scientists and educators examined the high school physics courses, they found them to be inadequate in subject matter and the physics classes were not attracting very many students. An outgrowth of this situation was the development of PSSC physics. After this physics text was developed, several groups began developing other texts.

### THE PROBLEM

The purpose of this paper is to analyze three high school physics texts in relation to the general problems facing high school physics courses. The three courses analyzed are (1) Modern Physics, a traditional physics text, (2) Physics, the text developed by the Physical Science Study Committee,

and (3) An Introduction to Physics, the text being developed by Harvard Project Physics.

#### DEFINITION OF TERMS

The traditional physics text refers to the book that has been the most widely used high school text.

To avoid using the lengthy group names of the groups Physical Science Study Committee and Harvard Project Physics, the terms PSSC and HPP will be used respectively throughout this paper.

#### TIMELINESS OF THIS PAPER

This paper is pertinent because in the seven years since PSSC published their physics text, there has been much controversy over the various high school physics courses. Many have criticized one program or other, and many have praised the same programs. But, few have tried to view them in the perspective of the high school situation. This paper first presents a brief description of the three physics courses mentioned above. Second, there is a discussion concerning the students and physics teachers found in the high schools today and a discussion of the scientific and technical manpower situation. Lastly, there is an evaluation of the degree to which the physics courses fit the present situation.

## CHAPTER II

### THE THREE PHYSICS COURSES

This section will briefly describe the course content, objectives, and means of accomplishing these objectives for each of the three physics courses. Many sources and viewpoints are cited in the descriptions.

#### MODERN PHYSICS

The authors of Modern Physics are Charles Dull, H. Clark Metcalfe, and John Williams. All three men are or were high school physics teachers. In the preface to their book they state that "the objective in Modern Physics has always been to present physics with a directness and a simplicity that will enable every student to achieve maximum comprehension."<sup>1</sup>

The text is indeed written in a direct manner. The subject matter is divided into nine units: (1) Matter and Energy, (2) Force and Motion, (3) Structure of Matter, (4) Heat, (5) Sound, (6) Light, (7) Direct Current Electricity, (8) Alternating Current Electricity, and (9) Electronics. Each chapter begins with an historical statement to introduce the material. This informs the student of the work that has been done by different scientists in developing the concepts.

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<sup>1</sup>Dull, Metcalfe, and Williams, Modern Physics, (New York: Holt, Rinehart and Winston, Inc., 1960), p. v.

that are presented in the succeeding chapter.

The main body of the chapters are written in a direct manner. The important terms and concepts are emphasized by italics, bold print, etc. Also these terms are placed in a vocabulary list at the beginning of each chapter and are again defined in the chapter the first time the term is used. The text includes sample problems, color diagrams, and color picture to aid the student to comprehend the material. The authors state that they have used ". . . the concept of energy to tie together all the traditional branches of the science."<sup>2</sup> However, this is not obvious to the writer.

A workbook is available for use with the text. The first half consists of exercise sheets for each chapter. These can be used by the teacher to test the student's understanding of the chapter, or used by the student as a study guide, review sheet, or self-test on a given chapter. The last half is the lab manual. Instructions are given as to how the student should set up the experiment; questions are asked about each step executed by the student; and space is provided for the student to record his observations. The laboratory is constructed such that the student can complete an experiment in a minimal amount of time. The questions are to help direct

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<sup>2</sup>Ibid.

the student's thinking along the lines of an experimental scientist. Actually the students tend to do the experiments in "cookbook" fashion; that is, the students just follow directions and answer the questions instead of trying to analyze what is being done.

The 1960 revision of Modern Physics has eliminated much of the introductory, qualitative material of the earlier editions on the assumption that the junior high schools have better prepared the students in general concepts of science.<sup>3</sup> Hence much new material dealing with new developments in physics is included in the 1960 edition.

A review of the latest edition to go on the market notes that the word "modern" in the title of the book is best interpreted as including all physics to date. The reviewer says that the new physics is "skillfully intermingled with the old,"<sup>4</sup> and that the authors of the book "give straightforward exposition of facts, unafraid to use algebraic equations and numerical problems."<sup>5</sup>

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<sup>3</sup>Ibid.

<sup>4</sup>Noel C. Little, Everet J. Ford, and Lester G. Paldy, "Book and Film Reviews," The Physics Teacher, IV (February, 1966), 90.

<sup>5</sup>Ibid.

## PSSC PHYSICS

PSSC physics is the first physics course written by a research committee. The Physical Science Study Committee, composed of a group of university and secondary school physics teachers, was organized in 1956. The research was financed by grants from the National Science Foundation. Professor Jerrold R. Zacharias headed the project from beginning to end.

The stimulus for the PSSC project was ". . . to get around the shortage - and mediocrity - of high school physics courses by producing a large number of teaching films in physics along with all the other classroom paraphernalia such a course would require."<sup>6</sup> In a recent publication the committee summarizes their goals as follows:

- "(a) to present physics as a unified yet living and ever-changing subject
- (b) to demonstrate the interplay between experiment and theory in the development of physics
- (c) to have the student learn the basic principles and laws of physics by interrogating nature itself, thus learning not only the laws but also evidence for them as well as their limitations
- (d) to extend the student's ability to read critically, to reason and to distinguish between the essential and the peripheral; thereby improving his learning skills in general
- (e) to provide a sound foundation for those students who plan to study science or engineering at the college level."<sup>7</sup>

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<sup>6</sup>Paul E. Marsh and Ross A. Gortner, Federal Aid to Science Education: Two Programs, (New York, 1963), 18.

<sup>7</sup>Uri Haber-Schaim, "The PSSC Course," Physics Today, XX (March, 1967), 26.



Zacharias, in an interview with Time in 1957, stated that he believed that one of the reasons high school physics courses were so bad was because the textbooks are based on the physics of 50 years ago instead of present day physics. Also the books carelessly tack the new knowledge onto the end of the text instead of incorporating the material into the body of the text. In addition, Zacharias noted that practical applications and macrophysics, such as Archimede's principle, is over emphasized while microphysics, the study of the atom, has been neglected.<sup>8</sup> The textbook developed in the PSSC program concentrated on basic laws and included major discoveries of the last few years. Zacharias indicated further that the program would emphasize that physics is still an open field and that the students may elect one of the paths of physics to follow.<sup>9</sup>

The first edition of the text was published in 1960 by D. C. Heath and Company of Boston. A year or so later a complete line of film strips and a very detailed teacher handbook became available. The course had been developed scientifically with many students, teachers, and schools experimenting with the materials during the four years of preparation. In order to hasten the adoption of the new text, summer institutes

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<sup>8</sup>"Razors at the Frontiers," Time, LXXVIII, (July 29, 1957), 40.

<sup>9</sup>Ibid.

were held across the country in order to teach the prospective high school physics teachers how to teach the new Physics.

In the preface to the text, James R. Killian, Jr., chairman of the Board of Trustees, Educational Services Incorporated, summarized the course noting the structure of the material and the learning path along which the student is to be led. In part he says:

"The PSSC course consists of four closely interconnected parts. Part I is a general introduction to the fundamental physical notions of time, space, and matter: how we grasp and how we measure them."

". . . In this first examination of matter, we develop the concepts of mass and of its conservation."

"Throughout, the student is led to realize that physics is a single subject of study. In particular, time, space, and matter cannot be separated. Furthermore, he sees that physics is a developing subject, and that this development is the imaginative work of men and women like him."

"The topics in the PSSC course are selected and ordered to progress from the simple and familiar to the more subtle ideas of modern atomic physics. In Part I we have looked at a broad picture of the universe. Now as we examine certain fields of physics in more detail, we start in Part II with Light."

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 "During the first half of the course, the principal emphasis is on the kinematics of our world: where things are, how big they are, and how they move, not why. In Part III we turn to a closer look at motion, this time from a dynamical point of view."

"The laws of conservation of momentum and of energy are introduced through a combination of theory and laboratory exploration. These laws form a substantial portion of Part III."

"Part IV introduces the student to electricity and through it to the physics of the atom."<sup>10</sup>

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<sup>10</sup>Physical Science Study Committee, Physics, (Boston: D. C. Heath and Company, 1960), pp. v-vi.

One must agree with the authors of the text that they have come up with a new physics course. Much comment about it has resulted. O. L. Brauer, Professor of Physics and Chemistry, Emeritus at San Jose State College, is very critical of PSSC physics. Some of his comments include the following:

"In 1960 their text came out. It is a freak among physics texts. It omits all the physics needed to understand our civilization. It ranges in difficulty from elementary general science to college level physics with most of the time spent at the college level. It assumes the background of the scientist instead of that of the teen-age student. It wanders far afield from physics into pure mathematics, chemistry, and astronomy. It is not a teachable text."<sup>11</sup>

Brauer also dislikes the "indoctrination" and pressure put on teachers to use the text, and the amount of money behind the project. In his article in Science Education he quotes numerous teachers' comments about PSSC physics, most of whom feel that the book is too difficult for the average high school student taking physics, although a few also note some good points in the book. To further aid his dislike for the new text, Brauer wrote a dramatization to emphasize that PSSC physics does not answer the practical questions kids want to know: What makes a baseball curve? Why a power line has three wires? How planes fly? Brauer is of the opinion that

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<sup>11</sup>Oscar L. Brauer, "Something Dangerously New in Physics Teaching," Science Education, XLVII (October, 1963), 365.

high school students are interested in practical applications of physics and that this is a major reason many take the subject.<sup>12</sup>

Some insight into the teachability of the PSSC text may be obtained through D. D. Rathe's doctoral dissertation, Certain Physics Generalizations Desirable for Students to Attain Before Taking Physical Science Study Committee's High School Physics Course. Rathe states:

"The word generalization was restricted to a comprehensive objective statement that may (a) describe, interpret, and make order out of our experience with the physical world; (b) help recognize commonalities involved with hitherto unknown physical phenomena; and (c) formalize rather inclusively certain experiences with the physical world which have the essential attributes of a class or logical species."<sup>13</sup>

In the dissertation Rathe lists 223 generalizations agreed upon by himself and a number of other teachers as desirable for the students to know before taking PSSC Physics. The teachers also rated the generalizations as to whether they strongly agreed, agreed, undecided, disagreed, or strongly disagreed with the necessity of having the particular generalization. Approximately the first one hundred generalizations were agreed to be most desirable for the student to know, with

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<sup>12</sup>Oscar L. Brauer, "Conventional Physics Against PSSC Physics," Science Education, XLIX (March, 1965), 170-171.

<sup>13</sup>D. D. Rathe, "Certain Physics Generalizations Desirable for Students to Attain Before Taking the Physical Science Study Committee's High School Physics Course," Science Education, XLIX (March, 1965), 128.

the rest not being as necessary.

This list of 223 generalizations range from (1) "Electrons, protons, and neutrons are basic units of an atom" to (223) "Waves rebound from media boundaries if impedances are not matched." The writer questions whether many of these generalizations could possibly be known to the students without a course in physics offered by most high schools or an outstanding general science course. How many students enroll in high school physics knowing that an electrical current is accompanied by a magnetic field (#104) or that the force of repulsion between like charges depends upon the size of these charges and their distance apart (#88)?

On the contrary a representative of PSSC insists that PSSC physics is aimed at the student normally taking physics (the student who plans to take physics because of scientific interest or future need in college) and that the textbook assumes a background of junior high school general science. Also the mathematics requirements are to be minimal.<sup>14</sup>

One point often emphasized by critics of PSSC physics is that parts of the text are unnecessarily wordy and complicated. Mr. Clinton Kaufman, Coordinator of the Science Department of Wichita High School Southeast, in conjunction with this says that the authors have some times gone too far

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<sup>14</sup>Uri Haber-Schaim, "The PSSC Course," Physics Today, XX (March, 1967), 30.

afield before coming to the point in order to make students think. He also finds that the first nine weeks work is difficult to motivate, but it must be taught first in order to maintain continuity.<sup>15</sup>

The laboratory for PSSC physics has resulted in the first development of student apparatus. The labs were originally set up to be uninstructed. However, "A happy medium had to be found between providing students with detailed cookbook instructions on equipment use and turning them loose without any instructions to fumble along with the hope that at least some would be able to reach some useful conclusions before they were entirely discouraged and lost."<sup>16</sup> Mr. Kaufman cites the laboratory as the central focus of PSSC physics. He says the students are sent into the laboratory with only simple directions and equipment - not with pre-established conclusions. In the laboratory, the student is to discover the principles for himself. Data is supplied for him only if it would be too difficult to obtain under normal high school conditions. He further indicates that the text is a supplement to the laboratory and is to help the student find the specific principle

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<sup>15</sup>A letter from Mr. Kaufman. See the appendix.

<sup>16</sup>Uri Haber-Schaim, "The PSSC Course," Physics Today, XX (March, 1967), 30.

and its ramifications. The number of topics is limited but allows greater depth of exploration of those presented.<sup>17</sup>

"The problems expand the concept and permit the student to analyze the assumptions of conditions and arrive at conclusions, rather than looking for the right formula to 'plug into.'"<sup>18</sup>

To accompany the basic textbook, laboratory, and four volume teacher guide, PSSC requested several physicists to write a series of books to supply outside reading for the students interested in additional information. These books were published in paperback by Doubleday of New York as the Science Study Series. Some of the titles are The Birth of a New Physics by I. Bernard Cohen, How Old Is the Earth? by Patrick M. Hurley, Echoes of Bats and Men by Donald R. Griffin, Soap Bubbles by C. V. Boys, Crystals and Crystal Growing by Singer and Holden, Waves and the Ear by David, Pierce and Van Bergeijk, The Physics of Television by Lutyens and Fink, Magnets by Francis Bitter, The Neutron Story by Donald Hughes, The Restless Atoms by Alfred Romer, and Horns, Strings, and Harmony by Arthur Benade.

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<sup>17</sup>A letter from Mr. Kaufman. See the appendix.

<sup>18</sup>Ibid.

## HARVARD PROJECT PHYSICS

A second agency now developing a new physics course is Harvard Project Physics. This group began with a grant from the Carnegie Corporation in 1962 and is headed by Dr. James Rutherford, an experienced high school science teacher and administrator in California and now at Harvard Graduate School of Education; Professor Watson, a science educator in the Harvard Graduate School of Education; and Gerald Holton, a physicist working in the history of science at Harvard. The other members of this group include not only physicists and high school teachers, but also chemists, historians of science, philosophers of science, science educators, and experts in scientific manpower problems.<sup>19</sup>

The group was inspired mainly by the decline in physics enrollment. Harvard Project Physics cites three major reasons for trying to increase physics enrollment: (1) High school juniors and seniors are making career decisions and they will probably pass up physics as a career if they have no introduction to the subject; (2) Some acquaintance with science and scientific thinking is becoming increasingly essential; and (3) It is important to show the students who go on to college to study the humanities or social sciences that

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<sup>19</sup>Gerald Holton, "Project Physics. A Report on Its Aims and Current Status," The Physics Teacher, V (May, 1967), 198.



"physics is neither an isolated bloodless body of facts and theories with mere vocational usefulness nor a glorious entertainment restricted to an elite of specialists."<sup>20</sup>

HPP is in the process of developing a course with a cultural approach to physics, attempting to present the subject as an interesting, dynamic field. In their first Newsletter, HPP indicated that the purpose of their course was to ". . . catch the interest of the large, untapped group of students who do not enroll in a physics course at all, perhaps because their inclinations and talents are not focused on what they may regard to be narrowly pre-professional physics courses."<sup>21</sup>

The first draft of the HPP textbook was based on the college text, Introduction to Concepts and Theories in Physical Science by Gerald Holton. The first draft was used by one public and one private secondary school during the 1963-64 school year.<sup>22</sup> Since then, the revised texts have been tested. The group hopes to have most of the course materials available by late next year or early 1969.<sup>23</sup>

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<sup>20</sup>Gerald Holton, "Harvard Project Physics," Physics Today, XX (March, 1967), 31-33.

<sup>21</sup>Harvard Project Physics, Newsletter 1, (Fall, 1964), 4.

<sup>22</sup>Ibid., p. 5.

Serious work on the new physics course did not begin until June, 1964. The plan was to write, test, and rewrite the materials every year during a four-year cycle.<sup>24</sup> During the progress of HPP's work they have moved away from the text as the major source of information for the student to a heavier dependence on films, guides, readings, and transparencies. There have been approximately ten transparencies per unit and eighty film loops prepared to accompany the six unit student guide or text.<sup>25</sup>

Holton describes the course content as follows:

"We have divided the basic course material into six units, each of which is meant to occupy the average class for one to two months. The Student Guide for Unit 1 - Concepts of Motion has four chapters. . . . The main theme is how to know a great deal while being practically ignorant of details. . . . Here we have a chance to let students learn about motion. . . .

"Entitled Motion in the Heavens Unit 2 deals with the dynamics of our planetary system. . . .in this unit we . . .set the achievement of an understanding of the motions in its historical context as well as raise such methodological questions as how one is to decide between rival theories.

"Unit 3 is the triumph of the mechanistic point of view throughout physics: the laws of conservation of mass and momentum; mechanical energy and the first law of thermodynamics (with the second law to be treated only qualitatively); kinetic theory, with some explicit attention

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<sup>23</sup>Gerald Holton, "Project Physics. A Report on Its Aims and Current Status," The Physics Teacher, V (May, 1967), 198.

<sup>24</sup>Ibid.

<sup>25</sup>Gerald Holton, "Harvard Project Physics," Physics Today, XX (March, 1967), 33.

to the great power and limits of the model, and the new theme of our ability to master chaos; finally, going further from the discussion of two-body problems, a chapter on mechanical waves. . . .

"We are now ready for the treatment of electricity, magnetism, and light - in short, the failure of the mechanistic view and the beginning of a new physics. This is the subject of Unit 4. . . .

"Unit 5 deals with the models of the atom: the chemical basis of atomic theory; electrons and quanta; the quantum-theoretical model of the atom; and some introduction to subsequent theories, particularly wave-particle dualism.

"Unit 6 is on the nucleus: radioactivity; isotopes; the nucleus and elementary particles; nuclear energy and nuclear forces."<sup>26</sup>

HPP labs are not committed to having the students "discover" laws and physical relationships in the laboratory, although the group does believe that "discovery" is an effective method of learning given ample time in the lab.<sup>27</sup> HPP has written 25 experiments which they have labeled as "basic" to the course.

"The exact emphasis that the teacher places on the experiment will depend upon his own predilections and experience, on the ability of his class, and on the physical conditions in his school. The experiments are coupled to the text, but rather loosely, so that neither should depend upon the other for its understanding."<sup>28</sup>

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<sup>26</sup>Gerald Holton, "Project Physics. A Report on Its Aims and Current Status," The Physics Teacher, V (May, 1967), 206-208.

<sup>27</sup>John Harris, "The Laboratory in Project Physics," The Physics Teacher, V (May, 1967), 224.

<sup>28</sup>Ibid.

Besides the student guide and laboratory manual, HPP is developing about twenty supplemental units such as Accelerators and Reactors, Biophysics, The Physics of Music, Physics for the Airplane Passenger, Particle Physics, etc.<sup>29</sup> In their publications HPP emphasizes that the project has

" . . .planned to produce a course that can be finished in one year in any school. An experienced teacher or one with an above-average class should be able to finish the material of the six basic units in six to eight months leaving one to three months for enrichment by means of units chosen by the teacher himself."<sup>30</sup>

This is done because HPP believes that any successfully taught course must involve the teacher. "It must be teacher-centered, not so much in having the teacher take class time in lecturing, but rather in the choices that the teacher will make to find a course and a role congenial to him."<sup>31</sup>

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<sup>29</sup>Gerald Holton, "Project Physics. A Report on Its Aims and Current Status," The Physics Teacher, V (May, 1967), 208.

<sup>30</sup>Gerald Holton, "Harvard Project Physics," Physics Today, XX (March, 1967), 33.

<sup>31</sup>Ibid.

## CHAPTER III

### THE HIGH SCHOOL PHYSICS SITUATION

Before any group can write a successful physics course the group must be aware of the students and teachers who will use the course. The writers of these courses cannot assume that the average high school senior knows calculus when this is not the case. A high school text using calculus today would not be acceptable in the majority of the high schools.

#### STUDENT ENROLLMENT IN PHYSICS

There has been a steady decline in the percentage of high school students enrolling in physics since the turn of the century, while there has been a dramatic increase in biology enrollment. Since 1910 the chemistry enrollment has been fairly constant. This is all shown clearly in figure 1. A closer look at the situation since 1948 is presented in figure 2. In figure 2 the percentages are in reference to the total number of students in the grade that normally enrolls in biology, chemistry, or physics respectively. Again the trend is upward for biology enrollment, steady to slight increase for chemistry, and downward for physics. Looking strictly at the number of students enrolled in physics since 1948, the enrollment has increased slightly, but the number of students in the twelfth grade has more than doubled as seen in figure 3.

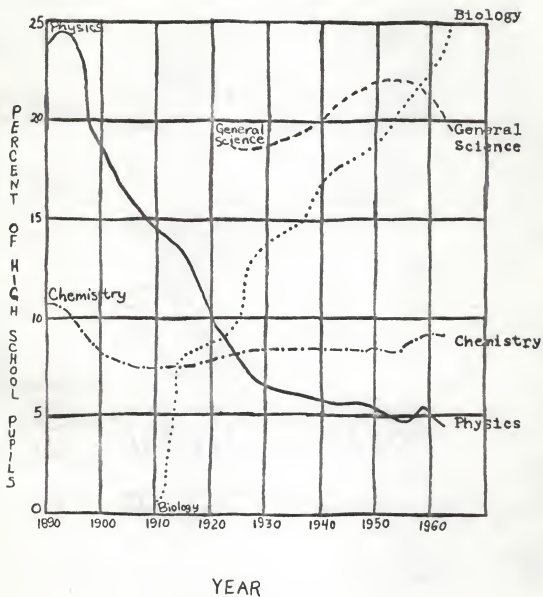


FIGURE 1

NUMBER OF STUDENTS ENROLLED IN SCIENCE. (FROM HARVARD PROJECT PHYSICS, NEWSLETTER 1, FALL, 1964, p. 1.)

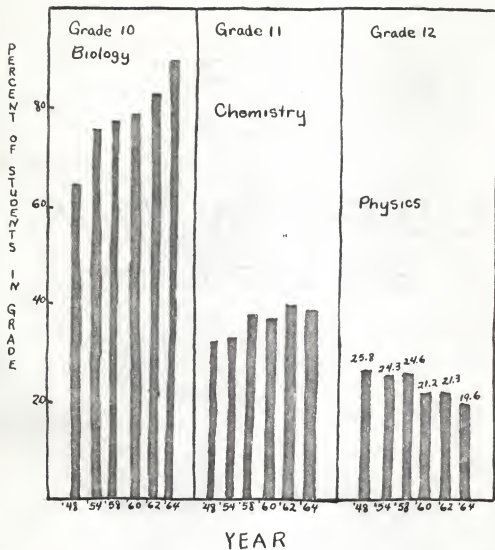


FIGURE 2

PERCENTAGE OF STUDENTS ENROLLED IN VARIOUS INTRODUCTORY SCIENCE COURSES IN U. S. PUBLIC HIGH SCHOOLS, 1948-1964. (FROM THE PHYSICS TEACHER, MAY, 1967, p. 213.)

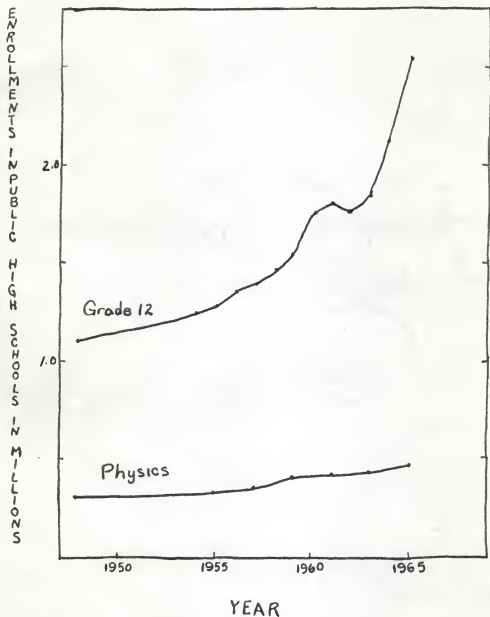


FIGURE 3

A COMPARISON OF TRENDS ON PHYSICS ENROLLMENT WITH NUMBER OF PUPILS IN TWELFTH GRADE IN PUBLIC SCHOOLS. (THE PHYSICS TEACHER, MAY, 1967, p. 213.)



Viewing the statistics in another way, one can (perhaps) convince oneself that physics enrollment has increased! Kleinman argues in this manner. Consider a four-year high school today with an enrollment of 500. Probably only one hundred of the students would be seniors of whom probably only 25 would be eligible to take physics. Those 25 represent only five percent of the entire high school. If one further considers that the typical ages of high school students are 14-17, one can find from census surveys that only 80 percent of this group attend high school. Therefore only four percent ( $80\% \times 5\% = 4\%$ ) of the 14-17 year olds are now taking high school physics. On the other hand, in 1900, only about ten percent of the 14-17 age group attended high school. Of this ten percent, 19 percent took physics; therefore less than two percent of the total high school age population took physics in 1900. Using this reasoning the enrollment in physics has doubled.<sup>1</sup>

In sum, the number of students going to high school has drastically increased. The result is that more "average" students are in the high schools; that is, the public schools are trying to educate all 14-17 year olds, not just the intelligent and financially able persons. Therefore, groups

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<sup>1</sup>Gladys S. Kleinman, "All Is Not Lost: The High School Physics Enrollment Picture Is Not as Black as It Seems!" The Physics Teacher, III (March, 1965), 120-121.

concerned with physics courses in the high school will have to decide which students should take physics or if all students should take the subject before writing "their" physics course.

#### PHYSICS TEACHERS IN THE HIGH SCHOOL

Few high schools throughout the nation are large enough to have five classes of physics and therefore employ a teacher who teaches only physics.<sup>2</sup> Thus the physics teacher has to be prepared in at least one other field which he must also teach. Furthermore, most high school teachers do not complete 28 or 30 hours of physics which is required for a physics major in most physics departments.

". . . by the National Association of State Directors of Teacher Education and Certification and the American Association for the Advancement of Science for the National Science Foundation found that 26 percent of the high school physics teachers had taken fewer than nine semester hours of college physics, 41 percent had taken between nine and seventeen semester hours, and only 32 percent had taken eighteen or more hours of physics."<sup>3</sup>

This indicates that only 32 percent of the physics teachers in the United States have the number of college physics hours that is required for a minor or major in physics.

Another critical factor related to this situation is that the annual number of college graduates in the United

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<sup>2</sup>Winston Cram, "Prospective Physics Teacher Development," a lecture given April 3, 1967, at Kansas State University.

<sup>3</sup>Fred Boercker, "Education and Manpower in Physics," Physics Today, XVII (September, 1964), 43.

States certified to teach physics has stayed less than 500 since 1950 and then only 60 percent of these enter the teaching profession after graduation. Thus, this yearly input of 300 qualified teachers is merely "a drop in the bucket." To put it into figures, this group is only two percent of the 16,700 persons who teach physics in high school. This does not come close to providing adequate replacements for the normal turnover in high school physics teachers.<sup>4</sup> Without qualified teachers, the schools are forced to hire the "... kind of science teachers who have never studied science or who have taken a couple of general science courses and are put in to fill an 'emergency' and then retained because they have 'experience.'"<sup>5</sup>

In upgrading the quality of physics taught in the high school, it cannot be so advanced that the poorly prepared teachers are not able to understand the text the agencies want them to teach.

#### NEED FOR SCIENTIFIC MANPOWER

In 1961, the Bureau of Labor Statistics conducted a study for the National Science Foundation investigating the

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<sup>4</sup>Ibid.

<sup>5</sup>"Science Teachers," New Republic, CXLII (January 4, 1960), 6.

long-range demands for scientific and technical personnel. The bureau found that there is a demand for 106,000 new workers each year in scientific and technical fields. Eighty-five thousand of the 106,000 are for newly created jobs, while the other 21,000 workers are for replacements; that is, persons to replace the workers who have retired, taken a new job outside this field, or died. The need as viewed by fields is for 81,000 engineers and 25,000 scientists.<sup>6</sup>

The demand being established, from where will the supply of workers come? Looking first for the supply of 81,000 new engineers per year, the bureau reports that 19,000 will probably come from other fields and the remaining 62,000 workers will have to come from the engineering colleges. However, to compensate for the current fact that one in seven engineering graduates do not enter the profession,<sup>7</sup> the colleges will have to graduate 70,000 engineers per year in order to meet the needs. At present the colleges graduate only 45,000 engineers including those with master and doctoral degrees. This leaves 25,000 engineers unaccounted for.

In the sciences the report finds a closer balance between demand and supply. However, Mr. Trytten believes

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<sup>6</sup>M. H. Trytten, "Advances in Science - and the Need for Scientists," School Life, XLV (October, 1962), 6.

<sup>7</sup>Ibid.

that the report ". . . does not reflect the substantial demands that will be made in certain accelerated programs in which the national interest is involved and the Federal Government is leading in its support."<sup>8</sup> Trytten sites the National Space and Aeronautics Agency as an example. "In three or four years its annual budget may go up to five billion and conservative estimates say this will mean 1,000 additional staff members at the doctoral level."<sup>9</sup>

A more recent study completed, which is a follow up to the one mentioned above, shows that a sufficient number of scientists will enter the labor market, but there will be a drastic shortage of engineers.<sup>10</sup>

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<sup>8</sup>Ibid.

<sup>9</sup>Ibid.

<sup>10</sup>"Scientists and Engineers, 1960-70: Supply and Demand," Monthly Labor Review, (November, 1963), 1282.

## CHAPTER IV

### EVALUATION AND CONCLUSIONS

Chapter II presented a brief description of three high school physics courses. Chapter III presented some facts concerning the high school physics situation. Before one can determine which course should be taught in the high school or even determine the outstanding points of each physics course, one has to decide upon the aim or role of the high school physics course and physics teaching.

Peter Thompson cites two reasons for teaching high school physics: (1) Colleges expect the science majors to have had it; and (2) The general college student needs high school physics because most liberal educations omit science, and physics helps the student to reason and helps him with mathematical thinking.<sup>1</sup> Drozin also cites a need to teach physics to non-college bound students, since this would be their last chance to take such a course.<sup>2</sup>

### EVALUATION

Based on the above reasons for teaching high school

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<sup>1</sup>Peter Thompson, "An Argument for Physics at the Secondary Level," The Physics Teacher, V (March, 1967), 133.

<sup>2</sup>V. G. Drozin, "Need for Multiplicity of Physics Courses," The Physics Teacher, III (November, 1965), 371.

physics, it is logical to assume that one physics course would not fulfill all the demands placed upon it by the three various student groups. PSSC and Modern Physics could best be used for science oriented groups. PSSC supporters believe their course is best. PSSC has developed student lab equipment and have emphasized basic unifying principles in physics. A study by Heath further indicates that PSSC students acquire a cognitive style measured by the Concealed Figures Test to a greater degree than the traditional physics student. Also this cognitive style is related to achievement scores of the PSSC classes. However in the control group, this "use of objects in a new way" was not related to achievement on the traditional test.<sup>3</sup> Hence, the traditional course, such as Modern Physics needs to be taught in a different manner if the students are to develop as much reasoning power as the PSSC students.

Although the average student is supposed to be able to achieve in PSSC physics, this writer believes that HPP has a more reasonable program for the students interested in a college major other than science. HPP would fit Hounshell's goal of science teaching which is to help the student

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<sup>3</sup>R. W. Heath, "Comparison of Achievement in Two Physics Courses," Journal of Experimental Education, XXXII (Summer, 1964), 348.

understand the meaning, significance and potential of science and scientific processes so they will be able to accept and appreciate change.<sup>4</sup> In fact one of HPP's main goals is to reach the non-science major, and from the information available to date the writer believes that HPP is developing an excellent course. The major innovation that particularly appeals to the writer is that HPP is preparing a "Basic course" with a lot of supplementary materials so the teacher can still develop his own individual course to suit his individual course to suit his individual class.

A physics course for the non-college bound student could be any of the three physics courses described. The class may be composed of students going into trade fields such as auto mechanics, printing, farm labor, etc., who may be interested in the practical applications that are associated with a traditional course in physics. Or, they may be students who just want to be able to discuss science and current science events, such as the space program, intelligently. In this case HPP may be the desirable program. Matthews has taught PSSC physics to "low ability students."<sup>5</sup>

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<sup>4</sup>P. B. Hounshell, "What Knowledge Is of Most Worth in Science," High School Journal, XLVIII (February, 1965), 348.

<sup>5</sup>Richard E. Matthews, "PSSC and the Low Ability Student," The Physics Teacher, V (January, 1967), 34-35.



So it is possible that this course could have a place in a class of non-college bound students.

Although there are a variety of physics texts from which to choose, this does not help the small high school meet the needs of the variety of student interests and abilities when the enrollment in physics is enough to justify only one physics class. For this situation, a flexible course is needed which can offer numerous possibilities to satisfy the variety of student interests and capabilities. Drozin also identifies this need and has suggested that such a variable textbook consist of four parts: (1) the Core, (2) an Advanced Supplement, (3) an Historical and Cultural Supplement, and (4) a Technical Supplement.<sup>6</sup> HPP has done this to an extent by developing a "basic course" with supplementary units, but the materials are all in line with part three of Drozin's suggestion.

#### CONCLUSIONS

It may well be that the whole high school physics problem is reducible to the realization that no physics textbook can constitute a successful physics course. Hence, there needs to be a teacher who knows enough physics to be able to make the course satisfy the interests, needs, and

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<sup>6</sup>V. G. Drozin, loc. cit.

capabilities of the individuals in the classes. Drozin's suggestion for a flexible text probably would make the teachers' job much easier, but still it would not fit every class. One of the major weaknesses of PSSC physics is that the group tried to write a self-contained text. They admit that this turned out not to be desirable.<sup>7</sup> Further Goldfarb asks for a syllabus which is not written by those long removed from the high school scene.<sup>8</sup>

Perhaps HPP has learned from the mistakes of PSSC, since HPP has emphasized in their news releases that theirs is a "teacher - centered" course.<sup>9</sup> Modern Physics has not changed its philosophy of physics presentation, although the text does have a more or less complete coverage of physics from Newton to the twentieth century physics. Therefore the teacher has the liberty to choose whichever sections of the book he teaches, and has the further opportunity to de-emphasize the need of working numerical problems for students who would not benefit from them.

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<sup>7</sup>Uri Haber-Schaim, "The PSSC Course," Physics Today, XX (March, 1967), 27.

<sup>8</sup>Melvin I. Goldfarb, "Students and a Third Course," The Physics Teacher, III (September, 1965), 272.

<sup>9</sup>Gerald Holton, "Project Physics. A Report on Its Aims and Current Status," The Physics Teacher, V (May, 1967), 210-211.

Many high school physics teachers expressing their views of the physics problem in The Physics Teacher indicate much the same view, Matthews illustrates what can be done with PSSC physics when a teacher modifies the original course.<sup>10</sup> Hutchisson says it is the responsibility of the teacher to make sure the physics course is appropriate for the class.<sup>11</sup> Brother Shamus declares that ". . . physics will be a popular subject when physics teachers show the students that physics is such an interesting subject that it is well worth any difficulty involved."<sup>12</sup>

Others when writing about the quality of physics courses also speak of the teacher not the text.

"The science teacher must transmit to the student the ability to determine what is essential and what is non-essential to the thought experiment. He the teacher needs to be well acquainted with the history of science and with the history of ideas to enable him to help the student develop this ability. The student should be encouraged to find further historical examples of his own. Perhaps this is the real goal of a physics teacher rather than to try to teach a student details of a particular set of experiments and claim that this is the providence of physics."<sup>13</sup>

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<sup>10</sup>Matthews, loc. cit.

<sup>11</sup>Elmer Hutchisson, "Physics in Our High Schools - A National Problem," The Physics Teacher, II (November, 1964), 386.

<sup>12</sup>Brother Shamus, C.F.X., "A High School Physics Survey," The Physics Teacher, III (March, 1965), 124.

<sup>13</sup>John K. Wood, "Aristotle and the Physics Student," American Journal of Physics, XXVI (March, 1958), 178.

Buchta mentions that the quality of teaching could be improved.<sup>14</sup> Miller stresses that the teachers should pass out less facts and teach the students to ask the right questions needed to analyze problems.<sup>15</sup> HPP commits themselves to the statement:

"We hold that, despite the embattled state of high school physics teaching as a profession, a successfully taught course must deeply involve the teacher. It must be teacher-centered, not so much in having the teacher take class time in lecturing, but rather in the choices that the teacher will make to find a course and a role congenial to him."<sup>16</sup>

Thus others also believe that a textbook does not constitute a physics course; the teacher plays a very important part in a successful course.

It is not unreasonable to believe that high school physics courses will not improve until the quality of high school physics teachers have improved. Since Young reports that physics majors tend to be the best high school physics teachers,<sup>17</sup> graduating more physics teachers with more semester hours of college physics than his present counterparts seems to be one step in the right direction. Most teachers do not

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<sup>14</sup>J. W. Buchta, "Improvement of Teaching as a Factor in the Production of Physicists," American Journal of Physics, XXIV (March, 1956), 155-156.

<sup>15</sup>J. S. Miller, "It Is Important to Know What Questions to Ask," American Journal of Physics, XXVIII (January, 1960), 38.

<sup>16</sup>Holton, op. cit., 210.

<sup>17</sup>Victor J. Young, "A Report on Pre-College Physics," The Physics Teacher, LV (January, 1966), 20.

seem to have had enough physics education to enable them to make the changes needed in established textbooks. On the other hand, how much physics is enough for the teacher is a difficult question to answer. Perhaps eighteen hours is the minimum requirement, as this would allow the teacher to complete a basic two semester introductory physics course (8-10 hours), an introductory atomic physics course (3 hours), and one or two physics courses beyond this of the teacher's choice (4-6 hours) such as mechanics, nuclear physics, optics, thermodynamics, or electricity and magnetism.

Such an emphasis on the teacher is not to deny the fact that many believe that the improved physics laboratory apparatus, films, and other teaching aids are useful. Tomer,<sup>18</sup> Shamus,<sup>19</sup> and Potter<sup>20</sup> are just three who believe the materials PSSC developed are helping to improve physics. Perhaps the HPP materials will also help. The point is, however, that a teacher well versed in his subject can probably improvise equipment where needed, but a fine set of teaching materials cannot replace a qualified teacher. This, then, is the case

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<sup>18</sup>D. W. Tomer, "High School Physics Courses," The Physics Teacher, V (January, 1967), 39-40.

<sup>19</sup>Brother Shamus, C.F.X., "A High School Physics Survey," The Physics Teacher, III (March, 1965), 121-124.

<sup>20</sup>J. G. Potter, "Comments on Results of the Physics Teacher Survey," The Physics Teacher, III (March, 1965), 118-119.

with Modern Physics, PSSC, and HPP. With a choice of programs, the competent teacher can alter the basic physics course to fit the classroom situation, even though the resulting course might not be the same as the original structure and purpose of any one of them in particular.

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APPENDIX

Copy

February 2, 1966

Miss Bernadine L. Hale  
1500 N. Manhattan  
Manhattan, Kansas 66502

Dear Miss Hale:

Your letter arrived during our last week of the semester. I was busy with tests, averaging grades, and the other multitude of things that come up at the close of one and beginning of another semester. I hope this reply is not too late to be of some value to you.

Sheryl Alloway is right in assuming that I prefer PSSC to the more conventional approaches in physics. However, the contrast is not as distinct as it was six years ago when I first started with PSSC. Two new texts,

Physics by Taffel, Allyn, and Bacon  
Foundations of Physics by Lehrman, Swartz, and Holt

both incorporate a great deal of the philosophy of the PSSC approach. Others have selected some ideas but their basic approach is still to teach a major principle, do problems to fix the method of solution in the student's mind, and finally send him into the laboratory to see if he can get data that will corroborate the principle. The laboratory manual for expediency's sake has every detail worked out, and all that is necessary is to write the numbers in the designated place.

PSSC, on the other hand, sends the student into the laboratory with simple instructions and equipment, but no conclusions. There he is to discover the principles for himself. Sometimes the data is supplied if it would be too difficult to obtain in the average high school laboratory.

The text then supplements the laboratory to help find the specific principle and its ramifications. The number of

topics is greatly reduced but those presented are explored in much greater depth. The problems expand the concept and permit the student to analyze the assumptions or conditions and arrive at conclusions, rather than looking for the right formula to "plug into."

Conventional courses usually present mechanics, heat, sound, light, electricity, and something they normally call modern physics. Each unit is independent and they can be taught in any order with only a very little planning. In PSSC there are some themes, for example, measurement, momentum, energy, the particle structure of matter, that run throughout the course and thus present physics as a unified whole.

There is a set of films especially made to supplement the course that are exceptionally well done. The teacher's manual comes in four volumes that not only show how to work the exercises, or problems, but give many suggestions for things to do and what pitfalls to avoid in the planning of each lesson.

Now let me enumerate some of the less desirable things. The first nine weeks work is difficult to motivate, but must be taught first because of continuity. Parts of the text are unnecessarily wordy and complicated. In order to make students think the authors sometimes go too far afield before coming to the point. Some of the problems are very difficult. The new edition of the text has improved in many of these areas, but, in my judgment, did not change as much as is desirable. However, in Wichita, we did adopt the new addition for the next 4-5 years.

Any student that can do conventional can do PSSC physics. For the slower ones the teacher must depend on the laboratory even more than for those who read easily with good comprehension. The course is designed for the non-science major to give him an understanding of how scientists work and think, and of the cultural contributions of science to man's knowledge. At the same time, it lays an excellent foundation for those preparing to take calculus and more physics and chemistry.

PSSC does very little in specific utilitarian value for the student who will go directly into a garage, machine shop, or radio shop after graduation. The course will reveal the student with an accurate memory but who does not understand basic principles. This oftentimes means students with preciously very high grade averages do not show up well. I think that is a good thing. They often do not agree.

All members of the American Association of Physics Teachers receive the magazine Physics Today. In the last 4 to 5 years it has had some excellent articles on the status of PSSC physics in the high schools throughout the nation. The Science Teacher may have had some. My files are incomplete or I would try to find some of these articles. However, rather than delaying this reply any longer, I will send it as is.

Sincerely yours,

Clinton Kaufman  
Coordinator,  
Science Dept.

NEW HIGH SCHOOL PHYSICS COURSES -  
DO THEY ANSWER THE PROBLEMS?

by

BERNADINE LOUISE HALE

B. S., Kansas State University, 1966

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AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE  
PHYSICAL SCIENCE TEACHING

Department of Physics

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

1968



NEW HIGH SCHOOL PHYSICS COURSES -  
DO THEY ANSWER THE PROBLEMS?

The purpose of the report was to analyze three high school physics texts in relation to the general problems facing high school physics courses. The three courses analyzed were (1) Modern Physics by Dull, Metcalfe, and Williams, a traditional text, (2) Physics, the text developed by the Physical Science Study Committee, and (3) An Introduction to Physics, the text being developed by Harvard Project Physics.

In the report the analysis of the three physics texts is followed by a section describing the high school physics teachers, the high school physics enrollment, and the scientific manpower situations. After an evaluation of the problems based upon goals of physics courses stated by current teachers of high school physics, the following points were made: (1) The teaching materials and laboratory apparatus developed by PSSC have been useful in the improvement of physics, but there seems to be a limit, beyond which, improved teaching materials are of little value; (2) A physics textbook alone can not constitute a successful physics course since the teacher plays a very important role in the successful course; (3) It is unlikely that further improvements in high school physics courses will occur until the training of high school physics teachers has improved.