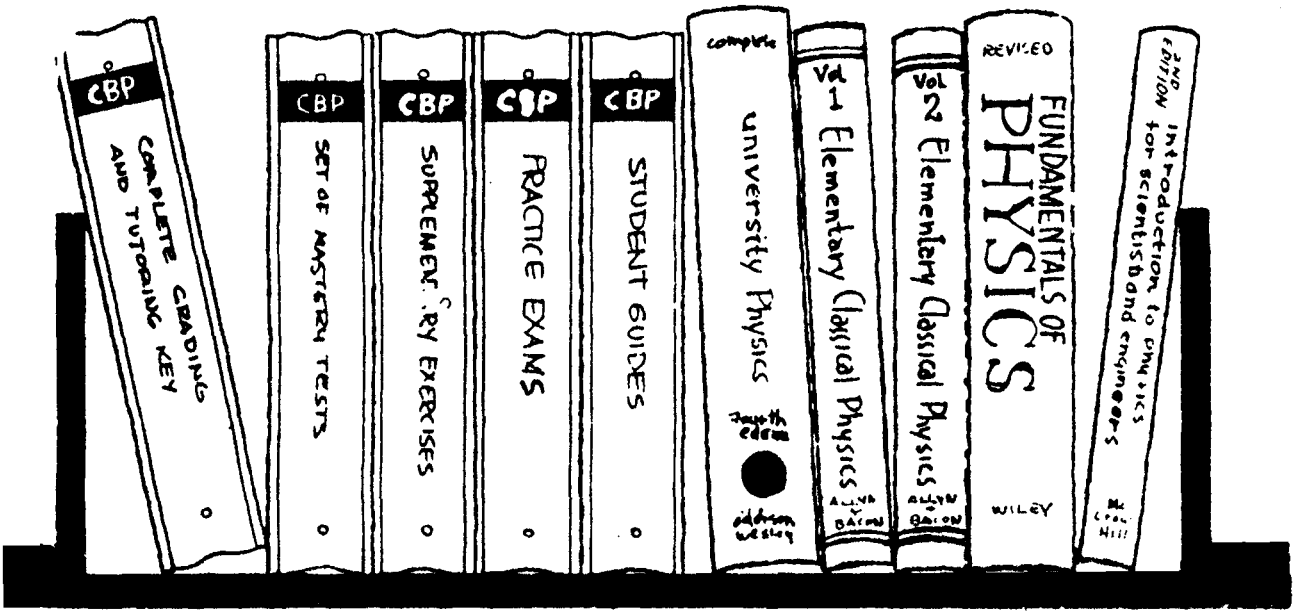
1975

0 Introduction to STUDY MODULES FOR CALCULUS-BASED GENERAL PHYSICS

STUDY MODULES FOR CALCULUS-BASED GENERAL PHYSICS*



CBP Workshop
Behlen Laboratory of Physics
University of Nebraska
Lincoln, NE 68508

* Supported by the National Science Foundation
Second Printing February 1976

Comments

These modules were prepared by fifteen college physics professors for use in self-paced, mastery-oriented, student-tutored, calculus-based general physics courses. This style of teaching offers students a personalized system of instruction (PSI), in which they increase their knowledge of physics and experience a positive learning environment. We hope our efforts in preparing these modules will enable you to try and enjoy teaching physics using PSI.

Robert G. Fuller
Director
College Faculty Workshop

MODULE AUTHORS

OWEN ANDERSON	Bucknell University
STEPHEN BAKER	Rice University
VAN BLUEMEL	Worcester Polytechnic Institute
FERNAND BRUNSCHWIG	Empire State College
DAVID JOSEPH	University of Nebraska - Lincoln
ROBERT KARPLUS	University of California - Berkeley
MICHAEL MOLONEY	Rose Hulman Institute of Technology
JACK MUNSEE	California State University - Long Beach
GARY NEWBY	Boise State University
IVOR NEWSHAM	Olivet Nazarene College
WILLIAM SNOW	University of Missouri - Rolla
WILLARD SPERRY	Central Washington State College
ROBERT SWANSON	University of California - San Diego
JAMES TANNER	Georgia Institute of Technology
DAVID WINCH	Kalamazoo College

These modules were prepared by the module authors at a College Faculty Workshop held at the University of Colorado - Boulder, from June 23 to July 11, 1975.

Workshop Staff

Albert A. Bartlett	University of Colorado
Thomas C. Campbell	Illinois Central College
Harold Q Fuller	University of Missouri - Rolla

Calculus-Based Physics (CBP) Modules Production Staff

Robert G. Fuller	Editor
Thomas C. Campbell	Assistant Editor
William D. Snow	Illustrator
Catherine A. Caffrey	Production Editor

Dear Colleague:

This is the second printing of the CBP modules. We have tried to remove all of the errors from this material. No doubt, we missed a few, please write to us and tell us any that you find.

In this printing we have added the review tests at the end of the material, just in front of Appendix A. We have also inserted ---- several forms of additional mastery tests supplied to us by the University of Missouri-Rolla.

CBP Modules Staff

Robert Fuller
Thomas Campbell
Stella Moline
Carole Robel
(402) 472-2790
Behlen Laboratory
University of Nebraska-Lincoln
Lincoln, NE 68588

WHY TRY PSI?

The personalized system of instruction (PSI)[1-3] has been used in physics courses in a number of colleges and universities for several years. Studies have shown that in some cases the students in a PSI physics course learn physics better than students in a lecture course. In almost all cases, a majority of the students prefer the PSI course to the lecture course, yet they report working harder in the PSI course. Why is it that this system of instruction is not more widely used? At least one reason is the large effort required of the PSI instructor to develop the study modules for his course. We have written these modules to enable you to use PSI in your calculus-based physics course. With these modules we believe the effort required to use PSI will be greatly reduced. We hope you will give PSI a try.

---

[1] For study modules on the use of these CBP Modules, see Appendix A.

[2] J. Gilmore Sherman, (ed.) Personalized System of Instruction, 41 Germinal Papers, A Selection of Readings on the Keller Plan, (W. A. Benjamin, 1974)

[3] Fred S. Keller and J. Gilmore Sherman The Keller Plan Handbook, Essays on a Personalized System of Instruction, (W. A. Benjamin, 1974)

NOTE TO THE INSTRUCTOR

You need to make several specific decisions as you prepare for the student use of these materials.

1. You must select a textbook. These materials are not intended to be used independent of other reading and study materials. In fact, these modules have been keyed to four different calculus-based general physics textbooks.[1-4] If you wish your students to read only one of these books, you may remove the pages in each module that refer the students to the other textbooks. We intend that these materials can be easily adaptable to any other general physics textbook that you choose, but you will have to provide the suggested study procedures for such a text.

2. You should select a sequence in which you wish your students to study these modules and your selected text. We have labeled these modules by their physics content and provide a flow chart for you on pp. 2 and 3 of Preparation of Your Orientation Module. You may wish to give them numbers to suggest a learning sequence for your students. In general, your students will find a sequence that follows your selected textbook preferable to other sequences.

3. You may need to prepare an orientation module for your students. We have provided a study guide to assist you in the preparation of an orientation module. (See the next page.) If you have never taught using the self-paced, mastery-oriented, student-tutored style of instruction, known as the personalized system of instruction (PSI) or Keller Plan, you will find it useful to read the references given on the previous page.

4. You may wish to provide additional learning activities for your students. We have found that film loops and audio tapes can be very useful to students. We have provided in our modules some references to film loops. You can provide audio-tape instructions about problem solving as you wish. The task of working a problem while listening to suggestions from you on a cassette tape can be a good learning experience for your students.

These modules, each of which includes a student study guide with worked problems and a practice test, as well as equivalent mastery tests and grading keys, provide the basic written ingredients for a PSI calculus-based general physics course. You can also use these materials to improve a traditional lecture-recitation course, through the use of enriched homework assignments, repeatable testing, or in other ways.

---

[1] Frederick J. Bueche, Introduction to Physics for Scientists and Engineers (McGraw-Hill, New York, 1975), second edition.

[2] David Halliday and Robert Resnick, Fundamentals of Physics (Wiley, New York, 1970; revised printing, 1974).

[3] Francis Weston Sears and Mark W. Zemansky, University Physics (Addison-Wesley, Reading, Mass., 1970), fourth edition.

[4] Richard T. Weidner and Robert L. Sells, Elementary Classical Physics (Allyn and Bacon, Boston, 1973), second edition, Vols. 1 and 2.

PREPARATION OF YOUR ORIENTATION MODULE

INTRODUCTION

Perhaps you have walked into a large shopping center and wandered around looking for the items you came to purchase. The feelings of lostness you had may be similar to the feelings of students as they wander into a self-paced, mastery-oriented, student-tutored physics course. As the instructor, you need to provide them with the assurance that all is well because you know where everything is (if you don't, please read Appendix A). You also need to provide your students with a road map and catalog for your physics course. This combination road map-catalog is often called the orientation module. (If you want your orientation module to match the CBP modules have it typed on an IBM Selectric 12 pitch typewriter with letter gothic type.)

PREREQUISITES

Before you begin this module you should be familiar with the personalized system of instruction (See Appendix A) and the content structure of the physics textbook you have chosen for student use.

LEARNING OBJECTIVES

After you have mastered the content of this module, you will be able to write an orientation module for your course which contains:

1. A description of the organization of the physics modules and the format of each module.
2. A suggested procedure for student progress in completing the modules.
3. An identification of the resources for learning and of their availability.
4. A statement of the requirements and responsibilities of students.
5. An explanation of the grading policy.

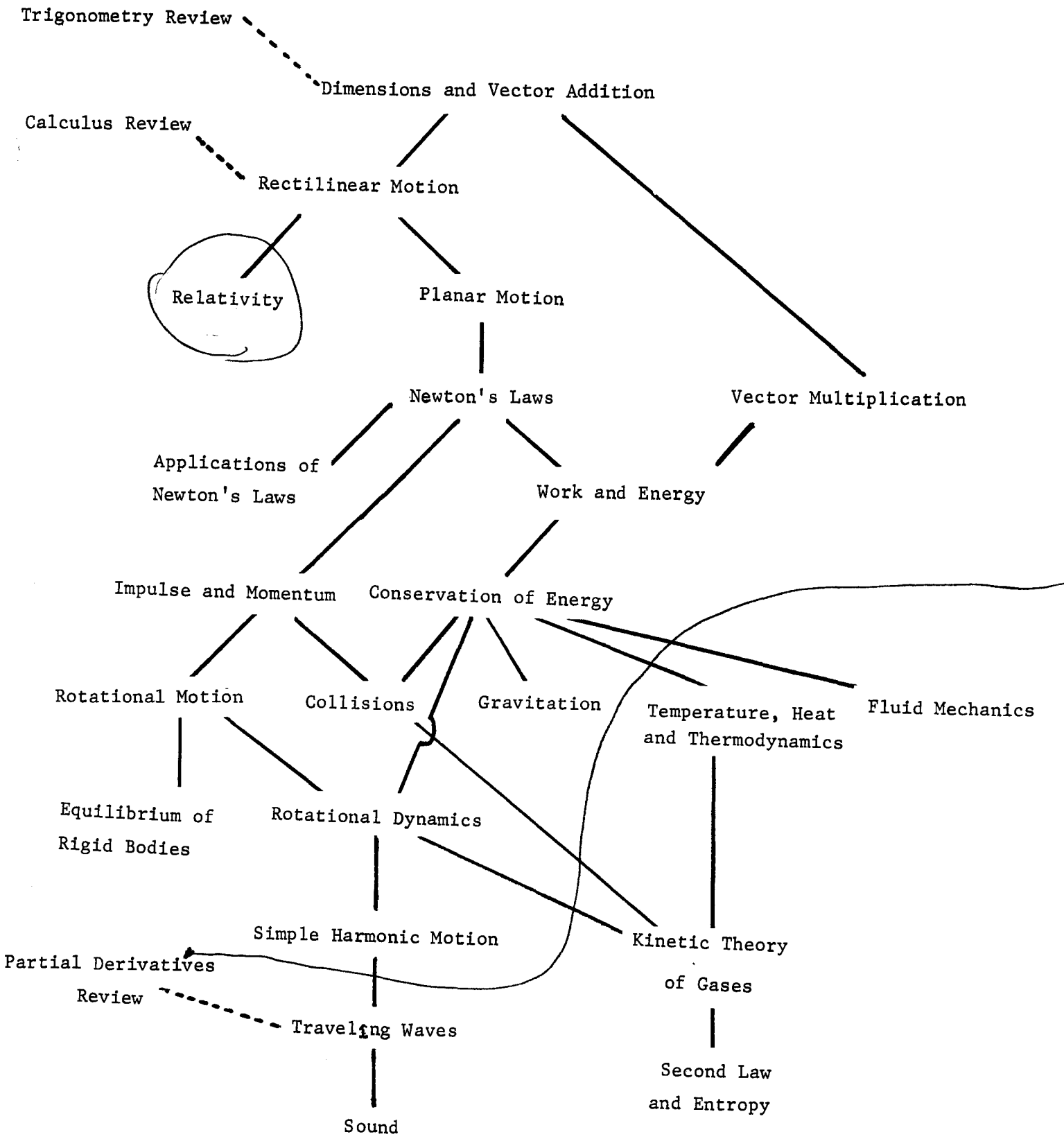
GENERAL COMMENTS

The orientation module you must prepare serves as the introduction of your students to your PSI physics course. For many students this may be their first experience in a course that requires so much active involvement from them. The self-pacing feature of PSI will demand that each student take responsibility for the effective use of his study time. The repeated testing enables students to perfect their problem solving skills. Your orientation module is to encourage your students to develop these personal attributes.

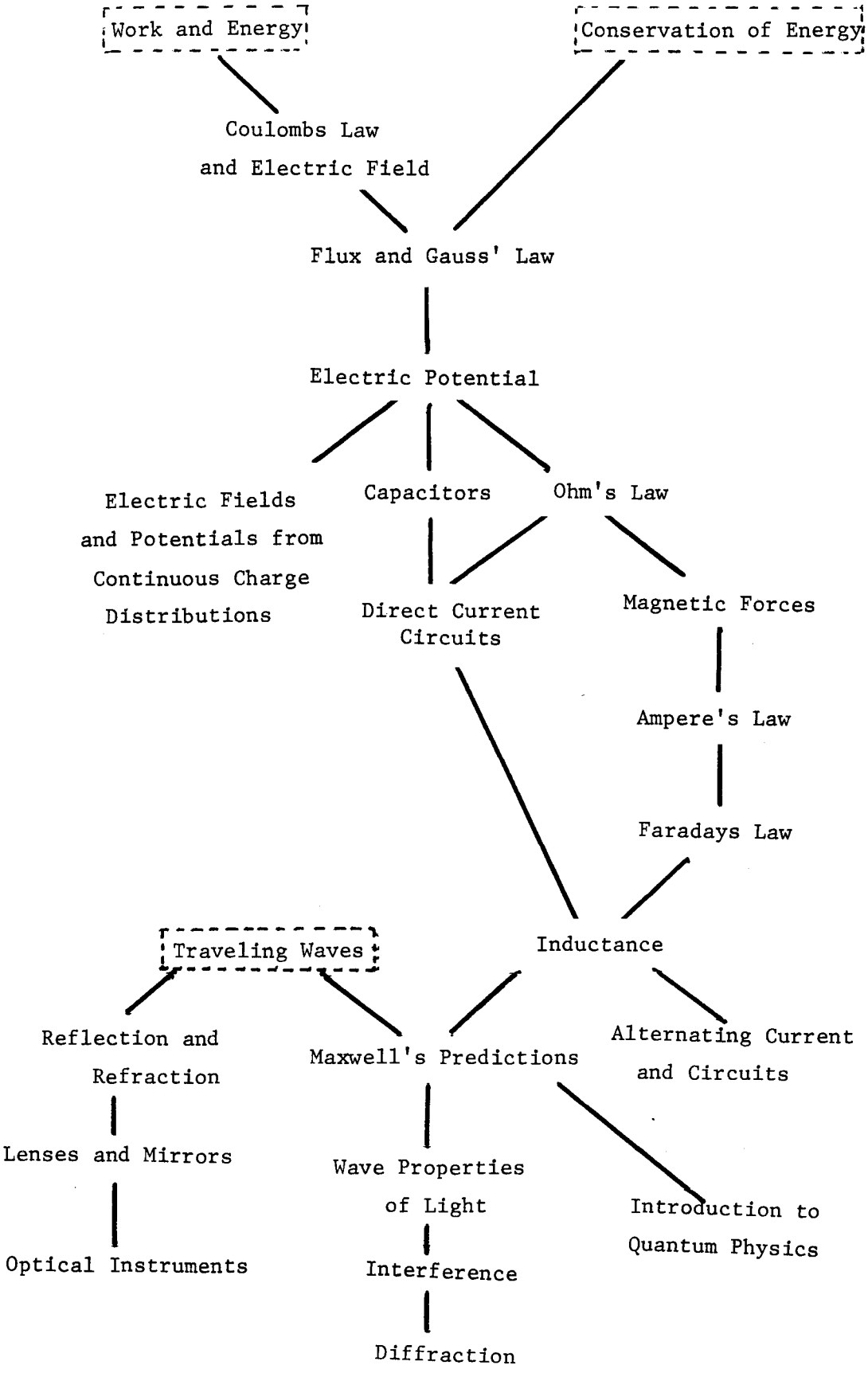
SUGGESTED STUDY PROCEDURE

To complete Objective 1, you must become familiar with the structure of the physics textbook you have chosen. You need to know what the prerequisites are for the various textbook chapters. The CBP study modules we have prepared are a compromise between the sequence of physics topics in four textbooks. You may wish to rearrange the sequence in which you use these modules or you may change the sequence of topics in the textbook. Examine the following prerequisite charts for the CBP modules.

CBP Content and Prerequisite Description



CBP Content and Prerequisite Description



SUGGESTED STUDY PROCEDURE (Continued)

For example, you wish your students to study the CBP module on Work and Energy, they should previously completed the modules on Newton's Laws, Vector Multiplication, Planar Motion, Rectilinear Motion, and Dimensions and Vector Addition. The Mathematics skills required are treated in the trigonometry review and the calculus review modules. You will notice that the CBP modules permit some branching, e.g. after the student has completed the Newton's Laws module, he can do any one of three modules, Applications of Newton's Laws, Work and Energy, or Impulse and Momentum.

Decide how you want your students to proceed through the materials. You can allow branching if you wish. Fill out the sequence chart below.

Module Sequence Number	Textbook Chapter(s)	CBP Module
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Examine the format of several of the study modules. You will notice that each module contains sections labeled: introduction, prerequisites, learning objectives, general comments, four separate suggested study procedures (one for each textbook), problem set with solutions, practice test (with answers), at least three forms of mastery tests and grading keys. You need to remove the mastery tests and grading keys from each module for use during the usual class testing times. You need to remove the suggested study procedures that do not relate to your textbook. Then you have a study guide in the format that you will give your students. Prepare a short description of the study guide to put in your orientation module.

To complete Objective 2 you need to write a suggested procedure for your students to progress through your course. Below is an example.

"How the course will be run. Since you are to do the work, I shall not lecture but provide you with reading assignments, study hints, and exercises. You work where and when you wish, at your own rate within the ten week limit of the course. I have divided the subject matter into fifteen modules, nine basic ones required for a C grade, and six advanced ones leading to B or A. Thus, each basic module covers about a week's work at a basic level."

"Prepare yourself through study at home. Whenever you feel you have mastered the material in a module, you present yourself for a test during class hours. If you are successful, you go on to another module; if not, you go back for more work on the module on which you were tested."

"DO NOT GO ON TO THE NEXT MODULE UNTIL YOU HAVE PASSED THE TEST ON THE PREVIOUS ONE: IT IS MORE IMPORTANT TO KNOW A FEW THINGS WELL THAN TO KNOW A LOT BADLY."

"If you do not understand something, use the class time to get tutorial help. If you wish to attend lectures, you can go to those given for Section 1 or 2."

(Karplus, UC-B)

An additional example is found as Exhibit A, page 9.

For Objective 3, you need to identify the resources available to assist your students in their learning of physics. An example of resources for students use is shown below.

"The materials you should have for this course are:

A. Elementary Classical Physics, Vol. 1, by R. T. Weidner and R. L. Sells, hereafter called "W & S".

B. Study Guide in Physics, Vol. 1, Mechanics, by Victor Namias, hereafter called "Namias".

C. A three-ring binder in which to keep:
Information and notices concerning this course
Study guides to the units as they are issued to you
Your notes on the reading
Your solutions to the problems
Your progress chart
Other miscellaneous material, such as Physics 111 quizzes and solutions, etc."

(Baker, RU)

Additional examples of student resources are found as Exhibit B, pages 10 and 11.

For Objective 4, you may wish to offer a general statement of the responsibilities of the students, provide a list of student responsibilities, or to prescribe proper problem solving performance. Examples are shown as Exhibit C on pages 11 - 13.

A progress chart or student record sheet can be helpful as a guide for students. They can then guage their pace according to a long term performance goal. An example is shown as Exhibit D on page 13.

For Objective 5, finally, your orientation module provides the written grading contract with the student. In the orthodox Keller Plan course the grade is determined by the number of modules that a student masters.

"2. Grading in Physics 111

The final grade in Physics 111 will depend on the number of units completed by the end of the semester. The relation between semester grade and unit completed is given on the progress chart that each student receives."

(Baker, RU)

By now, the Keller Plan has been adapted to fit a wide variety of grading systems: a final examination may be used for part of the grade.

"Grading: The term grade will be determined largely by how many units are completed by the end of the semester (Friday of Review Week). The number of units completed out of 24 will count 90% of the term grade. The comprehensive final exam may be taken at the option of the student and will count an additional 10%. The A range is 90-100%, B is 80-90%, C is 70-80%, D is 60-70% and F is less than 60%. Completing less than 14 units will result in a term grade of F."

(Fuller, UN)

Two levels of mastery may be required.

"The two examinations on each unit are designed to be of increasing difficulty, which reflect the increasing mastery of the subject area by the student. (The examinations are not intended to be a test of a high level of intelligence or sophisticated physical understanding, just mastery).

Exam P	Average Mastery of unit	(To pass the course this exam must be passed in all units.)
Exam S	Complete Mastery	

"Course grading will go as follows:

A - all 25 examinations passed

B - 20 examinations passed, 15P + 5S

C - 15 examinations passed, 15P

No D grades will be assigned except by failure of the final exam. To pass the course, the first "P" unit examination is each of the 15 subject areas must be passed."

(Snow, UMR)

A small bonus may be given for keeping ahead of schedule.

"Grading policy. Your final grade will be based on your work, as follows:

For each module completed "pass"	1 point
For each module completed "partial"	.7 Points
For each module completed "pass" ahead of "slow pace" (Modules 1-9 only)	.12 points bonus
Final exam	0 to 5 points
Maximum possible	21
For grade of A	19
For grade of B	15
For grade of C	12
For grade of D	9
For grade of F	8 or less"

(Karplus, UC-B)

PROBLEM SET WITH SOLUTIONS (The number in parenthesis is the number of the learning objective that is covered by the question.)

A(1) Are the CBP modules in the same sequence as your textbook?

SOLUTION: Check the CBP prerequisite diagrams. In particular, notice the location of the module - Equilibrium of Rigid Bodies. In many texts equilibrium is treated much earlier in the book than as shown in CBP. Plan your strategy to avoid difficulty with this problem and look for other possible sequence troubles.

B(2) Are you going to regularize student progress by the use of deadlines?

SOLUTION: The original Keller article (see Reference in Appendix A) suggested unlimited time and minimal punishment for procrastination. Many physics teachers find that suggestion incompatible with their institution's rules or with their own teaching style. Deadlines can subvert the intentions of a PSI course and need to be carefully considered. A PSI physics course can teach physics and help students learn about the logical consequences of irresponsible behavior.

C(3) What additional learning resources are you going to make available to your students?

SOLUTION: The use of audio tapes or video tapes to augment the textbook reading and problem assignments has been successfully used in a number of colleges. Talking a student through physics problems, by means of an audio casette tape can be very effective. You can prepare your own audio tapes quite easily and add another dimension to your interaction with your students.

D(4,5) Have you described clearly what you are requiring of your students?

SOLUTION: Just as the learning objectives in each module show what physics content must be learned by the student, so your orientation module shows what the students must do to pass mastery tests and how their grade is to be determined. An essential ingredient in a successful PSI course is an open grading contract. A student must be able to decide what tasks he must do to obtain the grade he desires.

PRACTICE TEST

Write your orientation module and try it on your students. (We are interested in how you use the CBP modules. Please send us a copy of your orientation module - CBP Workshop, Behlen Laboratory of Physics, University of Nebraska, Lincoln, NE 68508)

MASTERY TEST

Write a short test over your orientation module and check it before a student is permitted to take the first mastery test. It is a good way to reward a student for reading your orientation material.

Exhibit A - Suggested Procedure

The Teaching Method

"Unlike courses which have a rigid pace locked to a series of lectures, and which too often leave most of a class either bored or confused, this course allows you to proceed at a pace of your own choice. You will not be held back by slower students, or forced to go ahead when you are not ready. Some of you will finish the course in 5 or 6 weeks, but fast may not be best."

"The material of this quarter is divided into 14 units, each of which covers somewhat less than one chapter of the text (Halliday and Resnick). You have enrolled in sections of about 10 students led by a tutor whose job is to help you learn the material of each unit in sequence. For each unit we have written a sheet which spells out objectives of the unit, indicates relevant sections of the text and in some cases contains supplementary material, and includes a set of problems to help you learn and to test your understanding."

"After you have completed the objectives of a unit by self study, working with other students, help from your tutor, or any other method which works, go to your tutor. The tutor will provide you with a written quiz which you should be able to work in about a half hour by yourself (no book) in the quiz room. Immediately after taking the quiz, you and the tutor go over the quiz in order to decide how well you understand the material. If your quiz is correct, or if you understand things well enough to find and correct your errors on the spot without help, you pass on to the next unit. If you cannot do the quiz by yourself, the tutor will help you find your difficulties and suggest some review work which should enable you to pass the next quiz. We do not care how many quizzes you take to pass a unit; the important thing is the number of units passed. Most students pass most units on the first or second try, but once in a while someone needs three or four quizzes to understand a unit. You can't lose; a passed quiz advances you in the course and the others get you some individual tutoring where you need it most. The important thing is to avoid putting off a quiz; you should take at least two or three quizzes per week to finish the course."

"The results will surprise you. You will learn a remarkable amount of science very well, well enough to discuss it with your tutor and with other students. You will acquire the ideas needed to develop positions of your own on scientific aspects of some problems of public concern, and you will get some experience with the most powerful decision making tool we know; the making of a mathematical model which approximates the real world and can be used to make predictions regarding real situations."

(Swanson, UC-SD)

Exhibit B - Learning Resources

"Learning Materials You are required to purchase these items (approximate costs):

1. Complete set of Physics 5A Study Guides $ 2.50
   (purchase syllabus cards from Physics Department, Room 154 LeConte)

2. Resnick and Halliday, PHYSICS I or PHYSICS I & II 11.50
   (1966 Edition) PHYSICS I is used in 5A and 5B, (20.50)
   PHYSICS II in 5C and 5D. One part of the two-volume edition is easier to carry around with you.

The following are recommended--you may use them in the Physics library or Moffitt on 2-hour reserve, buy them for yourself, or share them with friends:

3. Young, FUNDAMENTALS OF MECHANICS AND HEAT (1974) 12.00
   (referred to for additional reading and text for some advanced modules; more readable and insightful than #2, but fewer worked-out examples)

4. Karplus, INTRODUCTORY PHYSICS, A MODEL APPROACH 14.00
   (qualitative background material, especially if your high school physics course was weak)

5. Taylor, PROGRAMMED STUDY AID FOR INTRODUCTORY PHYSICS I 4.00
   (step-by-step worked out physics problems, keyed to Resnick and Halliday; very good if you have difficulty)

6. Feynmann, THE FEYNMANN LECTURES ON PHYSICS
   (excellent advanced supplementary reading)

7. Helmholz and Moyer, BERKELEY PHYSICS COURSE (rev.)
   Sears and Zemanski, UNIVERSITY PHYSICS, Vol. I
   (alternate references, in case you get bogged down)

The following are provided for your use and are NOT for sale:

1. Worked-out solutions to Exercises in all modules
   (in classroom, Physics Library, and T.A. Office)

2. Audiotape supplements to some modules
   (in Physics Library, cassette players available there also)"

(Karplus, UC-B)

"MINI-LECTURES AND DISCUSSIONS
ON T.V. TAPE"

"The tapes listed below are available for your viewing in the library. Just go past the Audio-visual desk and ask the T.V. secretary for the number and title you want. Additional titles will be posted on the bulletin board in room 202B as they become available.

1. Problem 4, Page 708, Cooper. Describes how to use vector methods to solve projectile problems.

2. Problem 5, page 708, Cooper. Shows how to use vectors to analyze motion.

3. Circular Motion. Why is Acceleration Towards the Center of the Circle? Page 41, Cooper. Explains the rather abstract material in Cooper. This tape shows the difference between velocity and speed..."

(Sperry, CWSC)

Exhibit C - Student Responsibilities

"1.4 Class time will be used for studying, test taking, asking the instructor and/or tutors and/or fellow students questions about those things that you don't understand. You may also meet the tutors, the instructor, and fellow students outside regular class time in the Keller Plan Study Hall - Room SC3-207."

"1.5 Thus the pattern for this semester should be as follows: Study the material indicated in your study guide, work some of the suggested problems, and answer some of the suggested questions. When you feel that you have mastered the material you will then take a test. When you pass the test, you will go on to another unit. If you do not pass, you will study the suggested material again, and take another test when you feel ready, and so forth."

(Munsee, SCU-LB)

"Your responsibilities. Your principal responsibility, of course, is learning about Newtonian mechanics. To make this possible for all students in a class using the PSI format, I have found certain specific requirements very helpful:

1. Honor system: all tests must be treated confidentially. You should never take a test paper from the classroom, communicate the content of a test to another student (though we encourage you to help fellow students master the material in other ways), or have the assistance of other students, the text, or notes during any of the tests except for Module 4 and the final exam, as described there.

Exhibit C - Student Responsibilities - continued

2. Attendance: You are required to attend one weekly conference with your tutor during a mutually determined class period to discuss your progress, until you have completed the nine basic modules. Beyond this, attend classes as needed for your progress, to take tests, get help, or confer with other students.

3. The final examination is required. It will take place Tuesday, March 8, 1:30 - 4:30.

4. Your Progress Sheet must be kept up-to-date by bringing it to class so completed modules can be recorded.

5. Bulletin Board: consult the bulletin boards in Room 60 at least once a week to get information concerning any special situations, changes in procedure, corrections to the study guides, or other matters that you need to know.

6. Errors: If you find mistakes in the study guides, especially in Exercise answers or solutions, tell your tutor immediately so they can be checked and announced on the bulletin board for the benefit of other students.

7. Use your initiative: there will be no planned group activities in Room 60 after the first meeting. We will respond to your questions and suggestions. If you procrastinate, we recommend you change to Section 1 or 2."

(Karplus, UC-B)

"PROBLEM SOLVING PERFORMANCE PRESCRIPTIONS
FOR KELLER PLAN TESTS

THUS SPAKE ZARATHUSTRA...in order to receive a "pass" mark on the KELLER PLAN EXAMINATIONS a student must satisfy the following prescription for problem solving and provide the information noted.

1. SKETCH your interpretation of a word problem in the form of a figure and define all symbols that you employ.

2. Define a coordinate system and sign convention appropriate for the problem.

3. Write and identify by name, if appropriate, any physical and mathematical laws or theorems that you employ in the solution.

4. If you simply employ a formula derived by mathematically manipulating physical laws, specify any approximations involved in the derivation or any physical conditions that must be satisfied in order to use the formula.

5. Be specific in distinguishing between vector quantities, components of vectors, magnitudes of vectors, and scalar quantities.

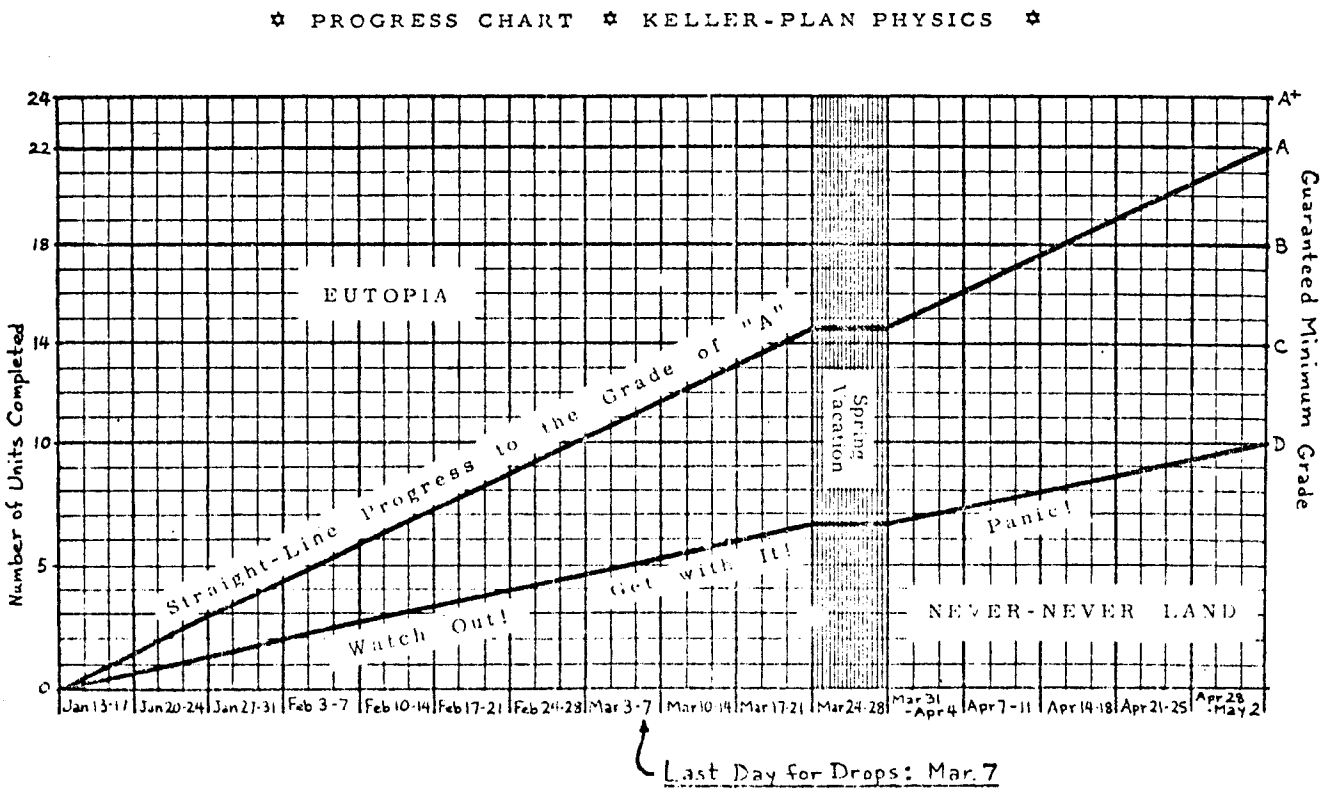
Exhibit C - Student Responsibilities - (continued)

6. When you reach that point in your solution where you substitute numerical quantities for the symbols in your equations, include the units associated with each numerical value and carry these units or the resultant set remaining after appropriate cancellations, until you arrive at a solution. NUMERICAL ANSWERS WITHOUT UNITS OR WITH INCORRECT UNITS HAVE NO MEANING AND DO NOT CONSTITUTE A SOLUTION. ZERO CREDIT.

7. Write legibly and proceed in an orderly manner toward your solution. You are not under a time constraint, so the opportunity for an orderly presentation is available to you. USE IT."

(Snow, UMR)

Exhibit D - Progress Chart



(Joseph, UN-L)