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## A Study of the Use of the Computer as a Problem-Solving Tool in an Introductory Course in College Physics

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A PROBLEM-SOLVING TOOL IN AN INTRODUCTORY  
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Roland L. Meade

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## CHAPTER 1

### THE PROBLEM AND IT'S BACKGROUND

#### Introduction

Since the first electronic computer, ENIAC, became operational in 1945, the development and use of computers have had a major impact on society. To most people the computer is a tool, solving in seconds, problems that otherwise would take many years to solve. A few, perhaps in ignorance, fear the computer, viewing it as an evil spirit lurking in wait for unwary humans. But almost everyone, to some degree, is aware of some of the impacts that the computer has had.

To the educator the computer holds forth many promises. It was not difficult to learn from the business world how to use the computer to ease administrative chores. In addition, in the last few years the computer has played an increasingly important role in the classroom. Some of these uses are described in the following sections.

The computer has proven useful in the drill and practice and the tutorial modes as means for individualizing instruction. In a paper by Fletcher, Suppes, and Jamison (1972) 18 studies were



cited in which the effectiveness of computer-assisted instruction (CAI) was described. The various studies included students from kindergarten to the college level, encompassed many regions of the country, and ranged across many academic disciplines. The use of the computer in this mode, of course, depended on the development of time-sharing systems, with the high cost spread out over many users. Two other major educational uses of the computer are simulations and problem solving. In simulations many students can be involved, in some cases a whole class. In problem solving, much of the work can be done away from the computer, with the student only going "on line" to run the program with his data. Consequently the cost per student for these purposes is lower than for the drill and practice or the tutorial modes.

A computer simulation can be described as a computer program which incorporates a mathematical model of some physical reality. This might be an experiment which cannot be conducted in the classroom or laboratory because it is dangerous, expensive, or otherwise impractical to perform. Or it might be an environment which is inaccessible for classroom study. With some simplification of the model and proper programming, one can simulate these experiments or environments.

There are two methods in which the computer is commonly used for problem solving. In one the instructor supplies the

program and the student simply executes it, supplying only the data. In the second, the student must write, test, and debug the program to solve the problem. This study is concerned with the latter, since the goal was to teach students to write programs, and not merely provide them with a handy tool to solve problems.

Problem solving has long been a concern of science educators. Bloom (1950) thought that the study of problem-solving processes in students was linked to individual differences. He stated, "We are convinced . . . that a study of problem-solving processes is basic to an understanding of individual differences--their measurement and control" (p. 103).

Mathematics and science courses are allegedly designed to develop in the student the necessary skills to solve problems in the "real" world. What teacher has not despaired of teaching students how to solve "word problems"? Introductory courses in college physics, in particular, commonly include much problem solving in their content.

If properly programmed, the computer is a powerful problem-solving tool. If many problems of a certain type must be solved, or numerous and/or complicated calculations made, the computer can be an invaluable aid. For example, a common problem in physics is the computation of the resultant of two vectors. It is not a difficult procedure, but the details are easily forgotten, and the calculations

become fertile ground for errors. The student may be assigned the task of writing a program that accepts the input data, namely, the magnitude and direction for two vectors, and computes the resultant vector's magnitude and direction. In an introductory physics text by Bueche entitled Principles of Physics, four of the problems in chapter 1 can be solved by this program. By modifying the program, or by running it twice, four more of the problems may be solved. Writing the program requires the student to specify, clearly and without ambiguity, the steps needed to solve the problem, and so he must understand how to solve it. Usually, trials with sample data are necessary to debug his program, reinforcing the student's initial understanding of the process needed to solve the problem.

Gagne (1966) suggested the following definition of problem solving:

Problem solving is an inferred change in human capability that results in the acquisition of a generalizable rule which is novel to the individual, which cannot have been established by direct recall, and which can manifest itself in applicability to the solution of a class of problems. (p. 132)

If this definition is accepted, the "generalizable rule" can be considered to be the computer program. Once written, the program can be used to solve "a class of problems". It may be hypothesized then that writing a computer program to solve a problem will require a student to understand how to solve the problem. If the student, in the

introductory course in college physics, can develop a logical approach to solving a class of problems by writing computer programs, perhaps he can use this approach to solve this type of problem on an examination or a quiz. Hatfield and Kieren (1972) cited various mathematics educators as follows:

[They] have suggested that the activity of writing, processing, and studying the output of computer algorithms should promote the development of mathematical concepts and principles, computational skills, and problem-solving abilities of the student. (p. 99)

The National Council of Teachers of Mathematics Committee on Computer Oriented Mathematics (1965) stated, "students who write computer programs acquire a better understanding of the mathematics concepts involved" (p. 395).

Donaldson (1972) said the following:

Through CSI problem-solving certain students acquire a greater understanding of the principles and processes of science than would be expected in the absence of the PS/CSI approach. (p. 4)

The acronym CSI used by the author is Computer Supplemented Instruction; PS is Problem Solving. One of the students in his study supported this viewpoint with these words:

In order to "teach" the computer to perform a certain manipulation it was necessary that I gain a workable knowledge of the processes included. I found that as I built and elaborated upon my programs I greatly increased my own knowledge and understanding of the problems included. I find that, even now, I understand the concepts I used while working with the computer much better than the ones I learned by doing

the home work problems assigned involving them.

Some researchers have looked for parallels between human problem-solving processes and the design of computer programs to solve problems. Davis (1973) made this statement:

A successful program will provide a detailed, unambiguous description of a problem-solving sequence that parallels, point by point, the strategic way a human might solve the same problem. (p. 73)

This statement received support from work reported by Paige and Simon (1966) on the use of a computer program as a model for investigating the processes that humans use in solving such problems. They found that the processes used by a good problem-solver closely paralleled those used in the computer program. This would lend support to the idea that writing a computer program to solve a problem would help develop in the student the ability to apply a process that could be used to solve other problems of the same type.

Requiring students to write programs to solve problems in physics raises a host of questions. First, since most of the students have not previously learned to use the computer, one may ask, "Can they be taught to program during the course?" and "Will the students complete the programming assignments?"

Attitudes can have an important bearing on the achievement of the students in a course. Instruments to measure attitudes toward problem solving, physics, and the course could be developed by the

researcher. However, such instruments are available, for example, in Scales for the Measurement of Attitudes by Shaw and Wright (1967). Hopefully, to allow comparisons in a study, both control and experimental groups would begin the course with similar attitudes toward problem solving and physics. To determine if this were the case, instruments to measure the student's attitudes toward problem solving and physics could be administered at the beginning of the course. At the end of the course, the same instruments could be administered again to determine if any changes had taken place during the course of the experiment. Also, the attitudes of the students toward a course could be measured when the course is completed. The attitude scales used in this study are described in chapter 2.

There were some other concerns regarding use of the computer.

1. "Will the use of the computer require an inordinate amount of time on the part of the students and the instructor?" If the use of the computer placed undue demands on the time of the students or instructor, its use would be inappropriate.
2. "Will the computer be sufficiently reliable and available for student use during the course?" If the computer is down or not readily available at hours during which the students are able to use it, they will not be able to complete the assignments.
3. "Will some parts of the course lend themselves more readily to the use of the computer than other parts?" The course covers 15 chapters ranging over many topics in physics, and one could reasonably assume that the computer's usefulness would vary among the units.

In summary, it was hoped to discover the relationships that might exist among the following factors: the writing of programs by students to solve problems in an introductory course in college physics, student performance on course quizzes and tests, and student attitudes toward the course. It was also hoped to learn if it were feasible to use the computer regularly in the course.

A pilot study with one class of 14 students was conducted during the Summer Session 1973 at Western Michigan University. The computer programming assignments were developed and tested during this Session. The students were taught to program in BASIC and were able to complete the assignments without great difficulty. Surveys of attitude were administered to determine how much time was needed to complete them. In general, the attitudes of the students toward the writing of programs for the computer were found to be favorable.

#### Related Literature

The use of the computer in classrooms is relatively new. Most studies to date have concentrated on the development of materials and techniques to use the computer as an instructional tool. There have been few studies comparing the effectiveness of using the computer with other means of instruction in the area of problem solving. The following studies were useful in suggesting areas to be

researched and in developing techniques to be used in this study.

Hatfield and Kieren (1972) conducted a study of the use of the computer as a problem-solving tool in seventh-grade and eleventh-grade classes in mathematics. Their study extended over two school years, each year being treated as a separate experiment.

They considered these questions:

1. Does the activity of writing, executing, and studying the output of computer programs related to problems in the regular mathematics curriculum affect mean student achievement?
2. Is there a differential effect of computer use on students of varying levels of prior mathematics achievement?
3. Are there curricular areas where the use of the computer particularly contributes to or detracts from mathematics achievement?

Each year students in the two grades participated as shown in Table I on page 10. Both computer and non-computer groups studied from the same textbook. The computer groups, however, were given instruction in the computer language BASIC, whereas the non-computer groups did not use the computer or computer programs in their study of the same mathematical content. The students in the computer group then wrote programs in BASIC to solve problems presented in the mathematics curriculum.

Various performance measures of mathematical achievement were used that reflected the objectives of the regular mathematics



TABLE I  
Sample Size for Each Experiment

Treatment	Grade Seven		Grade Eleven	
	Year 1	Year 2	Year 1	Year 2
Computer	26	25	18	22
Non-computer	27	25	18	23

curriculum. At the end of each unit a test involving a sample of the concepts, principles, and processes from the unit was given. A comprehensive test, constructed by the authors, was given to assess the students' performances over the year. Standardized mathematics achievement tests were also given: COOP Structure of The Number System, Contemporary Mathematics Test, STEP Mathematics 3B, and the Iowa Test of Basic Skills. Items related directly to the computer, programming, or computer output were not used.

On each test, for grade seven, a two-way analysis of variance was run to test hypotheses related to relationships among treatment, previous achievement, and their interaction. Using the mean scores of the STEP Mathematics 3A as a pretest, the two groups, computer and non-computer, were partitioned into low, average, and high mean-score categories. This resulted in a 2 x 3 design for each

year. A similar design was used for grade eleven, but only two categories of mean scores on the STEP Mathematics 2B were used, high and average, resulting in a 2 x 2 design.

The authors found that even low achievers in the seventh grade were able to learn to program mathematical problems. That finding was important for the present study, since most of the subjects had not previously written computer programs or used a computer.

The authors tested a null hypothesis of no interaction between treatment and levels of prior achievement. The hypothesis could not be rejected for any of the measures in either experimental year. However, on almost all measures they noted a trend in which the differences between the two treatment groups were greater for the average-achievement students than for the high-achievement students.

In year one, grade seven, in only one area was a significant difference found between the two groups. The non-computer group scored higher on "numeration systems". For year two, the computer group scored significantly higher in the categories of "elementary number theory", "contemporary mathematics", and "thought problems". The differences for "thought problems" have implications for this study, since Physics 110 is considered to be a problem-solving course. The course contains a great number of problems that one might consider to be "thought problems".

It was noted by the authors that unit one, year one, for grade

seven in which the non-computer group scored significantly higher, the computer group received their introductory instruction in BASIC. The authors thought that this detracted from the learning of the mathematics and caused the lower scores on the first unit. In the second unit, the computer group had evidently "recovered" and achieved scores that were approximately equal to those of the non-computer group. This point will be mentioned later in the discussion of the results of this study in which a similar relationship was noticed. In year two, the first unit was revised and less emphasis was placed on using the computer during that unit. This seemed to correct the problem since in year two the mean scores of the two groups were about the same on unit one.

For the experiments in grade 11, none of the comparisons evidenced a difference that was significant at the .05 level. In summary, the Hatfield and Kieren study suggests it should be possible to teach college students to program in BASIC as part of a course. This was supported by the pilot study mentioned above. The findings may be interpreted as showing a differential effect of the treatment between low-ability and high-ability students. The use of the computer seemed to enhance the ability of the students in the experimental group to solve word problems.

Kelsey (1967) developed 18 laboratory exercises in physics and mathematics that involved the computer in areas of data analysis and

interpretation, graphing, computation, prediction, and formula derivation. Eight of the experiments required a knowledge of simple programming. In a pilot study the students who were the subjects had completed a year of high-school physics. The author sampled the students' attitudes with a student reaction inventory to help make a subjective evaluation of the laboratory exercises. The author reported the results of this analysis as follows:

The students felt that they had gained in understandings and learnings of "how science is done", in data interpretation and analysis, and that the computer was helpful in gaining these understandings and learnings. (p. 122)

The students strongly recommended the author's type of laboratory exercise over the more conventional types of exercises. The students did not believe the exercises were too difficult to perform.

Shafer (1971) reported on the use of the computer as a reinforcement tool in the chemistry laboratory. He found that the students using the computer showed significantly greater gains between the pretest and posttest of the Test on Understanding Science (TOUS) than did the students who did not use the computer. Evidence was not found that the subjects differed significantly on their gain scores for the Cooperative Chemistry Test or the Watson-Glaser Critical Thinking Appraisal.

Wallace (1968) reported a study of three classes, in grades 11 and 12. The first was taught trigonometry conventionally; the

second, a one-semester course in computer mathematics, then trigonometry in the same manner as the first class; the third class, 15 weeks of trigonometry and then three weeks of flow charting and elementary computer programming as another means of learning trigonometric relationships and problem-solving. The third class showed a significantly greater gain in knowledge of trigonometry than did the first and second classes. He also reported that 10 of 60 physics students had completed in the same semester, the course in computer mathematics. The analysis failed to indicate that the two groups differed significantly in gain in knowledge of physics during the semester. The author concluded that "the use of flow charts and algorithmic methods in teaching mathematics appears to fortify conventional teaching methods, with the result that higher learning rates are achieved."

#### Conclusion

The reported results of the above papers prompted the author to undertake a research project to gain some insight into the use of the computer as a problem-solving tool in the physics classroom.

The purpose of this study was to explore the relationships among the following factors: students learning to program the computer and student achievement in physics; and attitudes toward problem solving, physics, and the course. The objectives of the study are

stated in the following section.

### Objectives

The primary objectives of the study were as follows:

1. To determine if students in the introductory course in college physics who are taught problem-solving by the computer approach can solve more problems on quizzes and examinations administered in the course than students who are taught by the traditional approach.
2. To determine if students react more favorably to learning problem-solving by the computer approach, than by the "traditional" approach.

The secondary objectives of the study were:

1. To determine the relationship between levels of ability, as measured by SAT and ACT scores, and scores obtained on examinations and quizzes by the control and experimental groups.
2. To determine the problems that are encountered in teaching computer programming as part of a physics course.

To measure the attainment of the objectives, the following

research hypotheses were proposed:

1. Students who are taught problem-solving by the computer approach will achieve higher scores on the examinations and quizzes in the course than students who do not use the computer.
2. Students who are taught the introductory course in college physics by the computer approach will have a more favorable attitude toward the course than those who are taught by the conventional approach.
3. There will be greater differences between course examination scores of high-ability students, as measured by ACT scores, in the control and experimental groups, than in the scores of the low-ability students in the two groups. It is

expected that high-ability students in the experimental group will have higher scores than the corresponding students in the control group.

In addition, the answers to the following questions were

sought:

1. How many class hours are required to teach computer programming to enable the student to use the computer as a problem-solving tool?
2. What additional work is required on the part of the instructor in implementing the computer approach as compared with implementing the traditional approach?
3. What difficulties will students encounter in gaining access to the computer and running their programs?
4. Will the student invest more time with the computer approach than with the traditional approach in learning problem solving in introductory physics? If so, will the students be willing to devote this extra time to the course?
5. Will some parts of the course in introductory college physics lend themselves more readily to the computer approach than other parts of the course?

## CHAPTER 2

### DESIGN AND METHODS

The purpose of this chapter is to describe the population and sample, the procedure for gathering data, the data collected, and the instrumentation used in the study.

#### Population and Sample

The population in this study consisted of those students taking an introductory course in college physics at Western Michigan University during the Fall semester, 1973. The course was essentially oriented toward problem solving. The sample contained two sections, CZ and DZ. CZ was chosen as the control group, DZ the experimental. The students were assigned to the sections by the computer on the basis of requests submitted by the students during registration. It was assumed that this was a random process, although there was no assurance that this was true. Most of the students in the course were either science majors or minors but were not majoring or minoring in physics, since the course could not be used toward a major or minor in physics. Section CZ had 89 students, DZ 46. The scores of some students were not included in the analyses for various reasons, including students missing the



examinations and not completing the survey forms.

### Procedure

The experimental group received assignments that required them to write and execute computer programs based on the problem assignments given to the control group. These assignments were developed by the researcher and reviewed by the course instructor. They had been used in the pilot study in the Summer Session 1973, and revised where necessary. They consisted of problems from the text used in the course, with instructions to write a computer program that would lead to a solution to the problem. The programs were graded and the grades were part of the course evaluation. Copies of these assignments may be found in Appendix C.

Both groups had the same instructor, and received the same quizzes and examinations. But, the experimental group received two hours of instruction in computer programming in addition to the regular lectures. This two-hour session was conducted by a colleague of the researcher, who had programming experience and teaching experience at the college level. The elements of BASIC programming were covered including PRINT, DATA, READ, LET, and END statements. These five BASIC language statements were sufficient for most of the student programs. Additional help in computer programming was available in special sessions.

## Data and Instrumentation

Data collected included the results of the three attitude surveys, quiz and examination scores, scores from the student records for the American College Testing (ACT) program and the Scholastic Aptitude Test (SAT) when the scores for these two tests were available, and observations of problems that students had in programming the computer.

The quizzes and examinations were those given by the instructor to evaluate the students in the course. The quizzes consisted of problems, whereas the examinations were multiple-choice and consisted mainly of problems, although some questions were included to measure knowledge of concepts. The quizzes and examinations were judged to have content validity since they consisted of problems, based directly on those found in the course text, that had been assigned to the students as homework. The reliability coefficients of the four examinations were calculated using the Kuder-Richardson Formula 21. The coefficients were: Examination 1, 0.83; Examination 2, 0.88; Examination 3, 0.91; Examination 4, 0.89. Copies of the course examinations and quizzes are found in Appendix A. Examination scores were converted to T scores and totalled to allow a comparison between the means of the two groups for all four examinations.

Three attitude surveys were administered to each group. One was designed to measure the attitudes of the students toward physics. The second was designed to measure their attitudes toward problem-solving activities. These two instruments were administered on a pretest and posttest basis. Finally, a posttest was administered consisting only of a survey of attitudes toward the course. This instrument is regularly administered by the Physics Department at the end of all courses. Copies of the three attitude surveys appear in Appendix B.

The scale to measure the attitudes of the students toward physics was developed by modifying a scale reported by Shaw and Wright (1967). The original instrument was a mathematics attitude scale that was modified by substituting the word "physics" wherever the word "mathematics" was used. The original scale used a Likert scaling procedure and was developed from paragraphs describing attitudes toward mathematics written by 310 college students. Validity estimates were based on a sample of 160 female college sophomores in a Southeastern women's college. The authors of the scale reported a test-retest reliability coefficient of 0.94. Scores on the scale were found to be significantly related to final course grades of 67 females but not to the grades of 60 males. Scores were positively correlated with numerical ability. From scores on the scale, it was possible to predict the change in scores from the

initial to final administration of a mathematics achievement test when training intervened. The authors also claimed a degree of discriminant validity since they state:

A test of independence between the scores on the attitude scale and scores on four items designed to measure attitudes toward academic subjects in general suggested that attitudes specific to mathematics were being measured.

The problem-solving attitude scale was adapted from another scale reported by Shaw and Wright (1967). Two items in the original scale were deleted and the word "mathematics" was replaced with "problem-solving" in another item. This was done to make the items more specific and improve the content validity of the items. Since the scores on the scale were found to have a positive relationship to performance in experimental problem-solving situations, the scale was assumed to have predictive validity. The author of the scale reported an equivalent-forms reliability of 0.94 based on a sample of 32 males and 100 females and a reliability of 0.83 based on another sample of 59 women and 50 men.

Reliability and validity data were not available for the course attitude survey that was developed locally. The items on the instrument are brief and each item appears to be unambiguous. The items directly question the student on a representative set of constructs applicable to the course. Thus the instrument appears to have content validity.

ACT and SAT scores were obtained from the students records. In many cases these scores were not available. The numbers of scores included in the analyses are indicated wherever these scores are used in the statistical analyses.

The mathematical ability score of the SAT battery was used to compare the two groups. This was accomplished using a "t"-test of the mean scores for the two groups on the mathematical ability section. However, only a limited number of scores was available for this analysis.

The correlation coefficients between the total T scores for all four examinations and each of three of the ACT test scores were computed. The three ACT scores used were the mathematics usage, natural science reading, and the composite score. The scores for the test with the highest correlation with the T scores were used to partition the sample into high and low ability groupings. Those students with scores above the median score were called high ability and those with scores below the median were called low ability. These groupings were then used for a two-way analysis of variance with ability as one factor and the two groups as the other factor.

## Data Reduction

The data were reduced by using computer programs written to perform the various statistical analyses. Most of these can be found in any statistical text. These were a chi-square test, "t"-test between means, correlation coefficients, and two-way analysis of variance. The procedure used in the "t"-test followed that given by Edwards (1972). The two-way analysis of variance was accomplished using a program developed for the computer at Western Michigan University. It is based on a procedure from Bancroft (1968). The program produced a preliminary ANOVA table to be used to test the equality of the row and column cell means. In addition, a least squares ANOVA table and a weighted means ANOVA table were produced by the program. The least squares table is used if the interaction of rows and columns is not significant; the weighted means table is used if the interaction is significant. This procedure was used since the row-column sample sizes were not equal.

## CHAPTER 3

### DATA AND RESULTS

The purpose of this chapter is to describe the data that were collected, and the statistical treatment of those data. These include numbers of science and non-science students; the mean scores for SAT tests, ACT tests, course quizzes, course tests; and scores obtained on the three attitude surveys. Narrative data were collected to help answer the questions posed in chapter 1.

#### Similarity of the Two Sections

Data in school records were used to determine if any obvious differences between the two troupes were evident. The first comparison involved the type of curriculum, science or non-science, in which the students were enrolled.

Table II on page 25 contains the numbers of science and non-science students in each section. Science students are those listed on the course roster as majoring in biology, chemistry, physics, or geology. Non-science students were all others.

Numbers of science and non-science students

TABLE II  
 Numbers of Science and Non-science Students

Section	Non-science	Science
CZ	51	42
DZ	23	24

A chi-square test used with these data with one degree of freedom gave a value equal to 0.53, which is less than the value of 3.84 considered significant at the .05 level.

ACT scores

The next comparison of the two sections involved scores the students obtained on the ACT battery.

The ACT battery consists of scores in four subcategories, English, social science, mathematics, and natural science, and a composite score. A "t"-test was used to determine if the means for the composite scores of the two groups differed significantly. The results appear in Table III on page 26.

On this measure the data failed to show that the two groups differed significantly.



TABLE III

Comparison of Means of ACT Composite Scores

Sample	Size	Mean	S. D.	"t" value	Prob.
CZ	58	24.9	4.9	1.25	.11
DZ	28	23.6	4.4		

SAT scores

Scores of students on the SAT mathematics usage test were compared for the two groups. The results of a "t"-test between means for these scores are found in Table IV. Students in the two groups for whom scores were available were not found to differ significantly at the .05 level on this measure.

TABLE IV

"t"-test for SAT Scores, Mathematics Category

Sample	Size	Mean	S. D.	"t" value	Prob.
CZ	23	539	100	.073	.47
DZ	9	542	93		

## Tests of Hypotheses Related to Achievement

### Course quizzes

The mean score for each group was computed for each quiz. The control group scored higher than the experimental group on 10 of the 14 quizzes. On each of the other four, the difference between the means for the two groups is small. The means and the sample size for each quiz appear in Table V on page 28. On the basis of these results, the hypothesis that the experimental group will score higher on the course quizzes than the control group can be rejected.

### Course tests

The scores on the course tests were analyzed in two ways. First, the means for the two groups were computed. The results are found in Table VI on page 29.

In every case the mean for the control group is higher than for the experimental group. The hypothesis that the experimental group will score higher on course examinations than the control group is therefore rejected.

Since the numbers of available student scores are larger for the ACT measure than for the SAT, it was decided to use the ACT scores as an independent measure to partition the groups into low and high ability subgroups.

TABLE V  
Comparison of the Means for Quiz Scores

Quiz	CZ		DZ		DZ - CZ
	Mean Scores	Size	Mean Scores	Size	
1	15.7	86	15.5	46	- .2
2	14.8	86	15.1	46	+ .3
3	12.2	86	11.3	46	- .9
4	12.0	85	9.9	45	-2.1
5	13.9	85	10.5	45	-3.4
6	12.7	87	11.0	45	-1.7
7	15.2	85	15.1	44	- .1
8	13.3	84	11.7	46	-1.6
9	13.0	85	13.2	46	+ .2
10	12.8	84	12.2	45	- .6
11	14.5	84	14.7	45	+ .2
12	14.0	82	12.0	45	-2.0
13	17.0	84	16.3	46	- .7
14	13.9	80	14.5	46	+ .6

TABLE VI  
Means of Test Scores

Test	CZ		DZ	
	Mean	Size	Mean	Size
1	58.7	86	54.1	45
2	53.9	86	53.0	45
3	55.4	86	51.2	45
4	56.5	86	54.3	45
All	203.0	82	194.0	41

Coefficients of correlation were computed between each of the ACT sub-category scores, and the total test T-score for each student in both groups. ACT scores were available for 77 students in the two sections. The results appear in Table VII.

TABLE VII  
Coefficients of Correlation Between ACT Scores  
and Total T-score for Each Student (N=77)

Sub-category	Math.	Nat. Sci.	Comp.
Coefficient	.401	.586	.529

The natural science reading score would seem to be the best predictor of course examination scores, although none of the scores reduced the error of prediction more than 19 per cent beyond chance.

The second analysis consisted of separating each group into two sub-groups called "low" and "high". These categories were obtained by classifying all students with an ACT natural science reading score of 27 or above as "high" and those below 27 as "low". The results of a 2 x 2 two-way analysis of variance for this comparison appear in Table VIII. The value of 27 was selected so that approximately one half of the students fell in each category. The numbers in parentheses are the number of students in each cell.

TABLE VIII  
Analysis of Variance  
ACT Scores (Factor 1) and Section (Factor 2)

		Factor 2	
		CZ	DZ
Factor 1	Low	198 (29)	186 (10)
	$F(1, 73) = 8.46, p = .005$		
	High	217 (26)	212 (12)
	$F(1, 73) = 1.36, p = .247$		
Interaction		$F(3, 73) = 3.38, p = .023$	

Note: Scores are average T-scores; numbers in parentheses are number of students in each cell.

The row by column interaction is found to be significant in the preliminary analysis of variance. Therefore a weighted means analysis of variance is used. For Factor 2 a null hypothesis of no difference cannot be rejected. Factor 2 is the groups, control and experimental. For Factor 1 the means were significantly different and a null hypothesis of no difference can be rejected. An inspection of the means shows that the high achievement groups scored higher than the low achievement groups in each section. A significant difference occurs between the low achievement groups with the experimental section (DZ) scoring an average twelve points lower than the control section (CZ), whereas the spread between the high achievement groups only averages five points. There does seem to be a differential effect from the experimental treatment, but it is in the opposite direction from that hypothesized and it is evident with the low achievement group rather than the high achievement group.

#### Tests of Hypotheses Related to Attitude

Two of the attitude surveys were analyzed with a two-way analysis of variance. Factor 1 in each case was pretest versus posttest; Factor 2 was control versus experimental. The results of the analysis for the problem-solving survey are shown in Table IX on page 32.

Inspection of the means show they are almost identical. The

analysis failed to elicit any significant  $F$  ratios. All  $F$  ratios obtained were less than 1.

TABLE IX  
Analysis of Variance for Problem-Solving Attitude Survey

Factor 2			
Factor 1		CZ	DZ
	Pretest	58.3 (83)	57.2 (43)
	$F(1, 196) = .49, p = .483$		
	Posttest	57.9 (48)	57.9 (26)
	$F(1, 196) = .92, p = .34$		
Interaction $F(3, 196) = 0, p = .967$			

Note: Scores in the table are the average score for the cell. The number in parentheses is the sample size.

The results of analyzing the scores obtained from the administration of the physics attitude scale appear in Table X on page 33. The row by column interaction was not significant. Therefore the least squares analysis of variance was used to test means for Factors 1 and 2. Only for Factor 1 eliminating 2 was the  $F$  ratio greater than 1. An inspection of the means shows that the scores were slightly higher for the control group than for the experimental group on the pretest. Both were lower on the posttest with nearly the

same average score. During the course the scores for attitudes toward physics had declined in both sections.

TABLE X  
Physics Attitude Scale Two Way Analysis of Variance

Factor 2			
Factor 1	CZ		DZ
	Pretest	69.4 (86)	66.8 (43)
	$\underline{F}(1, 99) = 4.99, p = .027$		
	Posttest	64.8 (50)	64.1 (24)
	$\underline{F}(1, 199) = 1.05, p = .308$		
Interaction $\underline{F}(3, 199) = 2.08, p = .104$			

The course attitude scores were obtained only at the end of the course and the means were compared with a "t"-test. Table XI contains the results.

TABLE XI  
Course Attitude Survey, "t"-test Between Means

	CZ	DZ	"t"	Probability	Significant
Mean	74.6 (54)	83.0 (28)	2.8	0.003	Yes

The course attitude scale included comments. One may note



that although eight of the twenty-eight students mentioned the computer as the most disliked part of the course, overall their ratings of the course were significantly higher.

#### Data Related to Questions Posed in Chapter 1

1. Initially two class hours were used to introduce programming in BASIC. The students were asked to follow a sample run in which they logged on the computer and typed in and executed a program. Many of the students required additional help with programming techniques during the first and second assignments. This additional help required an average of 15 minutes per student.
2. The instructor in the course was not familiar with BASIC and did not spend time in implementing the computer approach. He did spend some time helping collect data and implement the research study. If the computer approach were used regularly in the course, it is estimated that two class hours would be needed to introduce programming. Additional help could be given during the regular office hours when the instructor would be available to help students. This assumes of course that the instructor is competent in programming skills.
3. The students reported little difficulty in accessing the computer and running their programs. However, many of the students postponed the assignments until the last day, and were pressed for time to complete the assignment.
4. The students did find it necessary to spend more time with the computer, than with the non-computer, approach. Many resented spending this extra time in writing and executing the programs. Some thought that it took away time they needed to study the course material. Unfortunately, many were aware that the students in the control group were not required to complete computer assignments and thought that this was unfair.

5. The use of the computer was appropriate when the course covered material that involved problem-solving. The use of the computer to solve problems involving vectors was thought likely to be useful. However, vectors were covered at the beginning of the course when the students were learning to program. The programming of problems involving vectors was more difficult than later programming. It would seem desirable to move the study of vectors to later in the course if the computer is to be used to solve problems involving vectors.

#### Summary

In only three of the statistical analyses were significant differences detected at the .05 level.

1. The experimental group scored lower than the control group on the first course examination.
2. Students in the experimental group who were classified as lower ability on the basis of ACT scores achieved lower examination scores than similar students in the control group.
3. Students in the experimental group rated the course higher than did the students in the control group.

All other statistical tests failed to detect any significant differences between the two groups.

## CHAPTER 4

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

#### The Problem

The purpose of this study was to determine the relationships among the use of the computer as a problem-solving tool by students in an introductory course in college physics, the students' performance on course quizzes and examinations, and attitudes toward the course. Also, it was hoped to learn if it is feasible to use the computer on a regular basis in the course. The following research hypotheses were proposed:

1. Students who are taught problem-solving by the computer approach will achieve higher scores on the examinations and quizzes in the course than students who do not use the computer.
2. Students who are taught the introductory course in college physics by the computer approach will have a more favorable attitude toward the course than those who are taught by the conventional approach.
3. There will be greater differences between course examination scores of high-ability students, as measured by ACT scores, in the control and experimental groups, than in the scores of the low-ability students in the two groups. It is expected that high-ability students in the experimental group will have higher scores than the corresponding students in the control group.

In addition, answers to the following questions were sought:

1. How many class hours are required to teach computer

programming to enable the student to use the computer as a problem-solving tool?

2. What additional work is required on the part of the instructor in implementing the computer approach as compared with implementing the traditional approach?

3. What difficulties will students encounter in gaining access to the computer and running their programs?

4. Will the student invest more time with the computer approach than with the traditional approach in learning problem solving in introductory physics? If so, will the students be willing to devote this extra time to the course?

5. Will some parts of the course in introductory college physics lend themselves more readily to the computer approach than other parts of the course?

#### Methods Employed

The subjects of the study were students enrolled in sections CZ and DZ, Physics 110, at Western Michigan University in the Fall Semester, 1973. Section CZ was selected as the control group. This group was taught the course in the conventional manner. In particular they received homework assignments of problems selected from problem sets found at the ends of the chapters in the course text. Section DZ was given the additional assignment to write computer programs to solve problems selected from the same problem sets. These assignments were collected and graded by the researcher. Both groups were administered the same course quizzes and examinations and attended lectures and laboratory sections taught by the same instructor, a regular member of the

physics department. Additional help in computer programming was made available to the students in the experimental group. Data collected included quiz scores, examination scores, responses to three attitude surveys, and SAT and ACT scores when available. Also the observations of the researcher and the course instructor were recorded.

#### Analysis of Data

The analyses of the data included correlation coefficients, "t"-tests between means, and two-way analysis of variance. The results of these analyses follow:

1. The students who were taught problem-solving by the computer approach did not achieve higher scores on course examinations and quizzes than those who were taught by the non-computer approach.
2. The students in the experimental group who were taught the introductory course in college physics by the computer approach did not have more favorable attitudes at the end of the course, toward problem-solving or physics, than did the students in the control group. The students in the experimental group did rate the course itself significantly higher on the end of the course evaluation than did the students in the control group.
3. Higher-ability students in the experimental group, as measured by ACT scores, did not score higher on the course examinations than higher ability students in the control group.
4. Other non-numerical observations were made. The students in many cases reported that the computer programming required too much time. It is estimated that the assignments took one or two hours per week to complete. Some students who needed extra help took somewhat longer to complete the

earlier assignments. Two hours were used to introduce the computer language BASIC to the experimental group. Two or three students required help on a weekly basis.

### Conclusions

Insofar as the techniques used in this study are defensible, the following conclusions seem valid. The control group (DZ) appeared to be slightly superior to the experimental group in all measures reported in this study. Except for scores on Test 1 the differences were small, but all hypotheses that predicted greater achievement on course examinations and quizzes by the experimental group must be rejected.

The students did not seem to react unfavorably to the computer assignments as such, but they did express a dislike for the extra work required for the computer assignments.

The results of the course attitude survey administered to the subjects need some comment. It is difficult to attribute the higher scores in the experimental group to the use of the computer, particularly when approximately one-third of the students indicated in their comments that they disliked the computer assignments. Perhaps, even with the difficulties, the students were in fact stimulated somehow by the challenge of programming. Since the experimental group was smaller, namely, half as large as the control group, perhaps the opinions of the students in the course

were influenced by their being in a smaller class. In any event, the experimental group rated the course significantly higher than did the control group.

There is some evidence that introducing computer programming in the course may be responsible for lower achievement on course examinations and quizzes, especially in the case of lower-ability students. Since programming skills are not traditionally included in the study of physics, such inclusion may be regarded as undesirable.

#### Recommendations

On the basis of the findings of this study, the following recommendations seem reasonable:

1. If the use of the computer as a problem-solving tool is incorporated into a course, it should be integrated into the activities so that it does not place undue demands on student time. It would be desirable for the student to have some knowledge of computer programming prior to taking the course. Since many high schools are now teaching computer programming, the day is not far off when many students will enter the physics class with programming skills.
2. The use of the computer should be introduced gradually to alleviate the reactions noted in this study, and in the Hatfield and Kieren study, in which the experimental group had low achievement as the students coped with learning to program the computer.
3. Research is needed to determine the proper role of the computer in education. The scope and power of the computer is so great that one must exercise the utmost in ingenuity and imagination if the full potential of the machine is to be realized.

The computer is certain to be an important influence in science education in the coming years. But, its use must not overwhelm and alienate the students who are being educated. If used properly, the computer may become a powerful tool in education. If not, it may serve to further polarize scientist and non-scientist.



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## APPENDICES

## APPENDIX A

## COURSE EXAMINATIONS AND QUIZZES

110 General Physics I, 10/5/73

Test #1, Chapters 1, 2, 3, 4

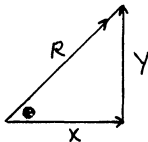
Name \_\_\_\_\_

Multiple Choice. Place the capital letter that represents the best answer in the ( ) at the left. Total =  $25 \times 4 = 100\%$

- ( ) 1. How many of the following are scalar quantities: acceleration, displacement, distance, speed, time, velocity and volume.  
 (A) one  
 (B) two  
 (C) three  
 (D) four  
 (E) five
- ( ) 2. A force of 8 lbs is to be combined with, or added to, a force of 12 lbs. The resultant R could be:  
 (A) 3 lbs  
 (B) 10 lbs  
 (C) 21 lbs  
 (D) 24 lbs  
 (E) more than one of the above
- ( ) 3. Several forces are acting on a point. After the sum of the X-components and the sum of the Y-components have been determined, it is possible to determine the angle  $\theta$  and the resultant R by using the first relation for  $\theta$  and then using  $\theta$  in the second relation for R:

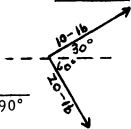
To Det.  $\theta$   
 (A)  $\tan \theta = Y/X$   
 (B)  $\sin \theta = Y/X$   
 (C)  $\tan \theta = Y/X$   
 (D)  $\tan \theta = X/Y$   
 (E)  $\sin \theta = X/Y$

To Det. R  
 $R = X/\cos \theta$   
 $R = Y/\tan \theta$   
 $R = X/\cos \theta$   
 $R = X/\sin \theta$   
 $R = Y/\tan \theta$



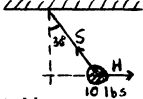
- ( ) 4. A body is acted upon by two forces as shown in the diagram. The vertical component of the resultant is given by:

- (A)  $10 \sin 30^\circ + 20 \sin 60^\circ$   
 (B)  $10 \sin 30^\circ - 20 \sin 60^\circ$   
 (C)  $10 \cos 30^\circ + 20 \cos 60^\circ$   
 (D)  $10 \cos 30^\circ - 20 \cos 60^\circ$   
 (E)  $\sqrt{10^2 + 20^2 - 2(10)(20) \cos 90^\circ}$



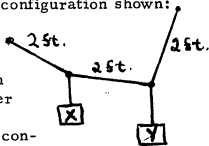
- ( ) 5. What is the tension in the string S if the ball in the diagram weighs 10 lbs? ( $\sin 30^\circ = 0.5$ ;  $\cos 30^\circ = 0.87$ ;  $\tan 30^\circ = 0.58$ )

- (A) 8.66 lbs  
 (B) 10 lbs  
 (C) 11.5 lbs  
 (D) 17.3 lbs  
 (E) cannot be calculated because the string length is not given



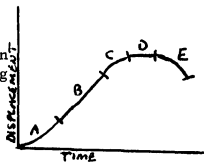
- ( ) 6. The weights X and Y are hung from three strings, each 2 feet long. In order to have the configuration shown:

- (A) X must be smaller than Y  
 (B) X must be equal to Y  
 (C) X must be larger than Y  
 (D) there is no definite relation between X and Y (i. e. either can be the larger)  
 (E) it is impossible to get this configuration with any values of X and Y



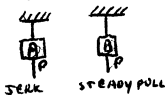
- ( ) 7. A car has the displacement or distance vs. time relation shown in the graph. Which one of the following statements is correct concerning the motion of the car?

- (A) in region A the car has a constant speed  
 (B) in region B the car has a constant positive acceleration  
 (C) in region C the car is slowing down or decelerating  
 (D) in region D the car has a constant speed  
 (E) in region E the car is standing still

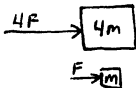


- ( ) 8. The speedometer on an automobile records the following:  
(A) the average speed  
(B) the instantaneous speed  
(C) the average acceleration  
(D) the instantaneous acceleration  
(E) the distance covered during the past hour
- ( ) 9. How long does it take an object having an acceleration of  $5 \text{ m/sec}^2$  to change its speed from  $40 \text{ m/sec}$  to  $60 \text{ m/sec}$ ?  
(A) 2 sec  
(B) 4 sec  
(C) 5 sec  
(D) 20 sec  
(E) 100 sec
- ( ) 10. A car covers a distance of 100 ft while going from rest to a speed of  $20 \text{ ft/sec}$ . The acceleration of the car is:  
(A)  $0.1 \text{ ft/sec}^2$   
(B)  $1 \text{ ft/sec}^2$   
(C)  $2 \text{ ft/sec}^2$   
(D)  $5 \text{ ft/sec}^2$   
(E)  $32 \text{ ft/sec}^2$   
(F)  $400 \text{ ft/sec}^2$
- ( ) 11. A ball is thrown downward from a bridge with an initial speed of  $20 \text{ ft/sec}$ . How long does it take before the ball is traveling with a speed of  $148 \text{ ft/sec}$ ?  
(A) 0.62 sec  
(B) 3.2 sec  
(C) 4 sec  
(D) 4.6 sec  
(E) 10 sec
- ( ) 12. A bullet is shot upward with an initial velocity of  $1200 \text{ ft/sec}$ . At the highest point in its flight:  
(A) the bullet has no acceleration  
(B) the bullet's acceleration changes direction from up to down  
(C) The bullet has an instantaneous acceleration of zero which quickly becomes  $32 \text{ ft/sec}^2$   
(D) the bullet has a downward acceleration of  $32 \text{ ft/sec}^2$   
(E) the bullet has an acceleration which varies directly with its height

- ( ) 13. Two identical weights are hung on two identical strings, as shown. Both are pulled down by a force applied at points P. If A is given a sudden jerk while B is given a slow steady pull, the following occurs:
- (A) the strings break above A and above B  
 (B) the strings break above A and below B  
 (C) the strings break below A and above B  
 (D) the strings break below A and below B



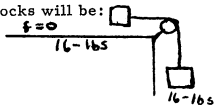
- ( ) 14. Which of the following pairs of forces are NOT an example of Newton's third (action-reaction) law?
- (A) bullet fired from a gun  
 (B) man standing on scales checking his weight  
 (C) exhaust coming from a rocket  
 (D) punter kicking a football  
 (E) fence post held by two wires with equal and opposite tension
- ( ) 15. A block of mass  $4\text{ m}$  is acted on by a force of  $4\text{ F}$ ; a block of mass  $\text{m}$  is acted on by a force of  $\text{F}$ . The acceleration of the larger mass is the following multiple of the acceleration of the smaller:
- (A)  $1/16$   
 (B)  $1/4$   
 (C) 1 (i. e. the same acceleration)  
 (D) 4  
 (E) 16



- ( ) 16. A force of  $1\text{ lb}$  will give an acceleration of  $32\text{ ft/sec}^2$  to a mass of:
- (A)  $1/32\text{ slug}$   
 (B)  $1/32\text{ lb}$   
 (C)  $1\text{ slug}$   
 (D)  $1\text{ lb}$   
 (E)  $32\text{ slugs}$   
 (F)  $32\text{ lbs}$
- ( ) 17. A  $5\text{-lb}$  iron ball falls at practically the same speed in air that a  $1\text{-lb}$  iron ball falls because:
- (A) air friction causes it to  
 (B) the ratio of force to mass is the same for both  
 (C) the earth's attractive force is the same for both  
 (D) if two unequal objects have the same potential energy they will fall at the same rate  
 (E) the inertia at any point is the same for both

- ( ) 18. A 16-lb block rests on a frictionless table with a cord tied to a hanging 16-lb block, as shown. The acceleration of the system of two blocks will be:

- (A) zero  
 (B)  $1 \text{ ft/sec}^2$   
 (C)  $16 \text{ ft/sec}^2$   
 (D)  $32 \text{ ft/sec}^2$   
 (E)  $64 \text{ ft/sec}^2$



- ( ) 19. A block of wood rests on a horizontal table and it is found that a force of 10 lbs applied horizontally is required to move it at a constant velocity of 5 ft/sec northward. The block weighs 80 lbs. The coefficient of friction between the block and the table is:

- (A)  $1/16$   
 (B)  $1/8$   
 (C)  $5/16$   
 (D)  $10/16$   
 (E)  $1/4$

- ( ) 20. A person weighs 180 lbs on the earth's surface, which is 6,000 km from the earth's center. This same person weighs the following at a distance of 12,000 km from the earth's surface:

- (A) 20 lbs  
 (B) 45 lbs  
 (C) 60 lbs  
 (D) 90 lbs  
 (E) 180 lbs (same)

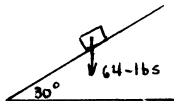
- ( ) 21. Comparing the acceleration due to gravity on earth to that on another planet having  $1/4$  the radius of the earth and  $1/80$  the mass of the earth, one finds that the ratio of the acceleration due to gravity on the planet to that on the earth is:

- (A)  $1/20$   
 (B)  $1/3$   
 (C)  $1/4$   
 (D)  $1/5$   
 (E)  $1/6$

- ( ) 22. A 64-lb block rests on a frictionless  $30^\circ$  incline, as shown. With what acceleration will the block slide down the incline: ( $\sin 30^\circ = 0.5$ ,  $\cos 30^\circ = 0.87$ ,  $\tan 30^\circ = 0.58$ )



- (A) zero  
 (B)  $0.5 \text{ ft/sec}^2$   
 (C)  $16 \text{ ft/sec}^2$   
 (D)  $27.8 \text{ ft/sec}^2$   
 (E)  $32 \text{ ft/sec}^2$



- ( ) 23. A cord runs over a frictionless pulley and connects two masses,  $M_1$  and  $M_2$ .  $M_1$  weighs 10 lbs and  $M_2$  weighs 6 lbs. The plane on which  $M_1$  rests is frictionless and makes an angle of  $60^\circ$  with the horizontal. Find the acceleration of  $M_1$  in  $\text{ft/sec}^2$  and its direction. ( $\sin 60^\circ = 0.866$ ,  $\cos 60^\circ = 0.500$ ,  $\tan 60^\circ = 1.732$ )

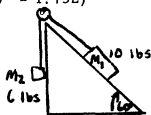
(A) 7.8 (up plane)

(B) zero

(C) 0.244 (down plane)

(D) 5.67 (down plane)

(E) 5.32 (down plane)



- ( ) 24. A projectile is shot horizontally from a height  $h$  with a speed of  $V_0$ . Which of the following is true of its motion at point P where it has an elevation of  $h/2$ ?

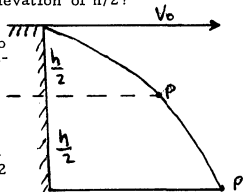
(A) the vertical component of its velocity equals  $V_0$

(B) the resultant of its horizontal and vertical velocities is  $V_0$

(C) its horizontal displacement is  $1/2$  its range  $R$

(D) The projectile has been in the air more than  $1/2$  time required to reach the ground at  $R$

(E) the vertical component of its velocity at P is  $1/2$  the vertical component of its velocity as it reaches  $R$



- ( ) 25. A projectile is fired with a velocity of 1,600 ft/sec at an angle of  $30^\circ$  above the horizontal. It will remain in the air:

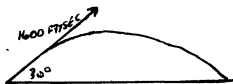
(A) 25 sec

(B) 30 sec

(C) 50 sec

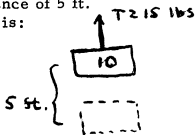
(D) 60 sec

(E) 86 sec



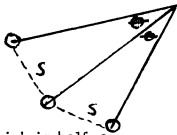
**Multiple Choice.** Place the capital letter that represents the best answer in the ( ) at the left. Total =  $25 \times 4 = 100\%$

- ( ) 1. A force  $T = 15$  lbs is used to lift a 10-lb object through a vertical distance of 5 ft. The work done by the force  $T$  is:
- (A) 25 ft-lbs  
(B) 50 ft-lbs  
(C) 75 ft-lbs  
(D) 125 ft-lbs  
(E) 750 ft-lbs

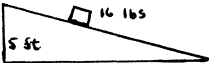


- ( ) 2. When a 50 kg (110 lbs) woman climbs to a fourth story office 20 meters above the street in 3 minutes and 16 seconds (196 sec), she develops an average power of:
- (A) 0.091 Watts  
(B) 1.82 Watts  
(C) 5.1 Watts  
(D) 17.8 Watts  
(E) 50 Watts

- ( ) 3. A hockey puck which weighs 0.64 lbs slides a distance of 40 ft in two seconds. The average kinetic energy of this puck is:
- (A) 4 ft-lbs  
(B) 16 ft-lbs  
(C) 128 ft-lbs  
(D) 1,600 ft-lbs  
(E) 51,000 ft-lbs



- ( ) 4. For a pendulum bob which is halfway along the arc between its highest and lowest positions, the following is true:
- (A) the potential energy = the kinetic energy, or  $E_p = E_k$   
(B)  $E_p$  is less than  $E_k$   
(C)  $E_p$  is greater than  $E_k$   
(D) there is no exact relation between  $E_p$  and  $E_k$  as both depend upon the mass of the bob  
(E) there is no exact relation between  $E_p$  and  $E_k$  as both depend upon the actual speed of the bob

- ( ) 5. A 16-lb block slides down an incline from a vertical height of 5 ft. At the bottom it is traveling 10 ft/sec. The work done against friction in sliding down the incline is:
- (A) 25 ft-lbs  
 (B) 55 ft-lbs  
 (C) 80 ft-lbs  
 (D) 105 ft-lbs  
 (E) the work against friction cannot be determined without knowing either the angle or the length of the incline
- 
- ( ) 6. Which one of the following is FALSE? Machines may be used to:
- (A) gain force  
 (B) gain speed  
 (C) gain work  
 (D) change the direction of a force  
 (E) change the direction of a force and at the same time gain force
- ( ) 7. The efficiency of a machine is defined as:
- (A)  $\frac{\text{resistance force}}{\text{effort force}} \times 100$   
 (B)  $\frac{\text{effort force}}{\text{resistance force}} \times 100$   
 (C)  $\frac{\text{resistance distance}}{\text{effort distance}} \times 100$   
 (D)  $\frac{\text{effort distance}}{\text{resistance distance}} \times 100$   
 (E)  $\frac{\text{work input}}{\text{work output}} \times 100$   
 (F)  $\frac{\text{work output}}{\text{work input}} \times 100$
- ( ) 8. Impulse may be equated to:
- (A) the increase in the kinetic energy given a body  
 (B) the product of the mass and velocity of a body  
 (C) the change in momentum given a body  
 (D) the average force acting on a body  
 (E) the acceleration per unit mass

- ( ) 9. The statement, "Force is the time rate of change of linear momentum.", is a re-statement of the following:  
 (A) Newton's second ( $F = ma$ ) law  
 (B) Newton's third (action-reaction) law  
 (C) Newton's law of universal gravitation  
 (D) the law of conservation of momentum  
 (E) the law of conservation of energy
- ( ) 10. If a gun is fired that weighs 100 times as much as its bullet, the "kickback" velocity of the gun is the following multiple of the velocity of the bullet:  
 (A)  $1/10,000$   
 (B)  $1/200$   
 (C)  $1/(\sqrt{2} \times 100)$   
 (D)  $1/100$   
 (E)  $1/10$
- ( ) 11. A heavy cart of weight  $W$  is moving with a speed of 6 miles/hour. Two men, each weighing 200 lbs, drop directly onto the cart from vertically above. The cart with the two men now moves with a speed of 5.4 mph. The weight  $W$  of the cart is:  
 (A) 112.5 lbs  
 (B) 125 lbs  
 (C) 1,720 lbs  
 (D) 3,600 lbs  
 (E) 4,000 lbs
- ( ) 12. A 2-lb ball moving 24 ft/sec collides centrally with a 1-lb ball moving 12 ft/sec in the opposite direction. The collision is perfectly elastic. Determine the speeds of the two balls immediately after the collision:
- | Speed 2-lb Ball        | Speed 1-lb Ball    |
|------------------------|--------------------|
| (A) $v_1 = +12$ ft/sec | $v_2 = +12$ ft/sec |
| (B) $v_1 = -12$ ft/sec | $v_2 = +24$ ft/sec |
| (C) $v_1 = -24$ ft/sec | $v_2 = +12$ ft/sec |
| (D) $v_1 = 0$          | $v_2 = +36$ ft/sec |
| (E) $v_1 = -36$ ft/sec | $v_2 = 0$          |
- 
- BEFORE
- AFTER
- ( ) 13. An electric motor requires 4 sec to reach its operating speed of 1,800 rpm (30 rev/sec) starting from rest. In reaching this speed the motor will make about the following number of revolutions:  
 (A) 30  
 (B) 45

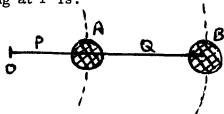
- (C) 60  
(D) 75  
(E) 90

- ( ) 14. Through how many radians does a wheel turn as it speeds up for 5 sec from an angular speed of 10 rad/sec, if it has an angular acceleration of 2 rad/sec<sup>2</sup>?  
(A) 2 radians  
(B) 20 radians  
(C) 25 radians  
(D) 30 radians  
(E) 75 radians
- ( ) 15. A wheel 1 ft in radius speeds up from 2 rps to 5 rps in 1/2 sec. What is the angular acceleration and what is the linear acceleration of a point on the rim during the interval?

	<u>Angular Accel</u>	<u>Linear Accel Rim</u>
(A)	$2\pi \text{ rad/sec}^2$	$4\pi \text{ ft/sec}^2$
(B)	$3\pi \text{ rad/sec}^2$	$4\pi \text{ ft/sec}^2$
(C)	$3\pi \text{ rad/sec}^2$	$12\pi \text{ ft/sec}^2$
(D)	$6\pi \text{ rad/sec}^2$	$6\pi \text{ ft/sec}^2$
(E)	$12\pi \text{ rad/sec}^2$	$12\pi \text{ ft/sec}^2$



- ( ) 16. An automobile is rounding a turn in an unbanked highway.  
(A) the single unbalanced force acting on the car is the frictional force of the road on the tires  
(B) the only forces acting on the car are the weight of the car downward and the frictional force of the tires on the road  
(C) a single force, the weight of the car, is acting  
(D) the car is acted on by a set of balanced forces  
(E) the resultant of all forces acting on the car is zero
- ( ) 17. Two bodies A and B of equal mass are fastened to identical strings P and Q as shown, with mass A halfway between point O and mass B. When the bodies are whirled about point O, the tension in the string at P is:  
(A) equal to the tension at Q  
(B) 2 times the tension at Q  
(C)  $\sqrt{2}$  times the tension at Q  
(D) 4 times the tension at Q  
(E) 3/2 times the tension at Q

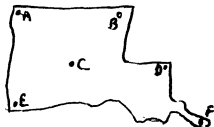


- ( ) 18. Which of the following is NOT in a condition of apparent weightlessness:

- (A) a 5-lb weight falling freely  
 (B) a satellite circling the earth  
 (C) a space ship halfway to the moon  
 (D) a rocket leaving its launch pad with an upward acceleration of exactly  $g$  ( $32 \text{ ft/sec}^2$ )  
 (E) a baseball en route from the batter's bat to an outfielder

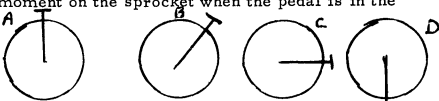
- ( ) 19. The drawing is a map of the state of Louisiana. The center of gravity of the state is located at the point:

- (A) A  
 (B) B  
 (C) C  
 (D) D  
 (E) E  
 (F) F



- ( ) 20. A boy exerts his entire weight on the pedal of a bicycle when he "stands" on the pedal. He exerts the greatest torque or moment on the sprocket when the pedal is in the position:

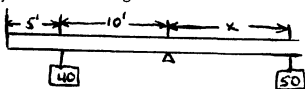
- (A) A  
 (B) B  
 (C) C  
 (D) D



- (E) the torque is the same in each case since his weight is constant and the pedal arm is of constant length

- ( ) 21. A uniform rod 30 ft long is balanced at its center on a cross bar as shown in the figure. The 40-lb weight will be balanced by the 50-lb weight if the distance  $x$  is:

- (A) 10 ft  
 (B) 8 ft  
 (C) 7.5 ft  
 (D) 6 ft  
 (E) 5 ft



- ( ) 22. A wheel revolves at  $240\pi$  radians per minute ( $4\pi \text{ rad/s}$ ). Its moment of inertia is  $2 \text{ kg}\cdot\text{m}^2$ . If the wheel is brought to rest in 5 sec, the required torque in newton-meters is:  
 (A)  $1.6\pi \text{ N}\cdot\text{m}$   
 (B)  $0.8 \text{ N}\cdot\text{m}$   
 (C)  $96\pi \text{ N}\cdot\text{m}$

- (D) 48 N·m  
(E) 480 N·m
- ( ) 23. Select the true statement from the following. The moment of inertia of any object is:
- (A) maximum for an axis through the center of gravity
  - (B) dependent upon the axis around which the object rotates
  - (C) the same for all objects having the same mass
  - (D) the same for all objects having equal radii
  - (E) zero if the object rotates about an axis through its center of gravity
- ( ) 24. A solid cylinder, a ring or hoop, a solid sphere, and a hollow sphere, all having the same radii and the same masses, are rotating about axes through their centers, all with the same speeds. The one of the four which is the hardest to stop rotating is:
- (A) the solid cylinder
  - (B) the ring or hoop
  - (C) the solid sphere
  - (D) the hollow sphere
  - (E) the four are equally hard to stop rotating since they all have the same  $mr^2$
- ( ) 25. A platform with a moment of inertia of  $4 \text{ kg}\cdot\text{m}^2$  rotates about a vertical axis with a uniform speed of 0.2 radians/sec. A 100 kg man jumps onto the center of the platform. If the man's radius of gyration is 0.1 m, what will be the platform's new speed?
- (A) same as before, that is 0.2 rad/sec
  - (B) 0.05 rad/sec
  - (C) 0.16 rad/sec
  - (D) 0.50 rad/sec
  - (E) 0.57 rad/sec

110 General Physics I, 11/19/73

Test #3, Chapters 10, 11, 12

Name \_\_\_\_\_

Multiple Choice. Place the capital letter that represents the best answer in the ( ) at the left. Total =  $25 \times 4 = 100\%$

- ( ) 1. Ice melts in a warm room, butter softens and eventually melts. This shows that:  
 (A) ice is crystalline with a definite melting point; butter is amorphous or glassy and does not have a definite melting point  
 (B) ice is crystalline with no definite melting point; butter is amorphous with a definite melting point  
 (C) ice is amorphous with no definite melting point, butter is crystalline with a definite melting point  
 (D) ice is amorphous with a definite melting point, butter is crystalline with no definite melting point
- ( ) 2. A rod of elastic material is elongated 2% by a stress of  $10^{10}$  dyne/cm<sup>2</sup>. If this is within the elastic limit, Young's modulus, in dyne/cm<sup>2</sup>, is equal to:  
 (A)  $2 \times 10^{10}$   
 (B)  $2.5 \times 10^{10}$   
 (C)  $5 \times 10^{11}$   
 (D)  $4.9 \times 10^{12}$   
 (E)  $2 \times 10^{12}$
- ( ) 3. The reciprocal of the bulk modulus is called compressibility. If the compressibility of water is  $50 \times 10^{-6}$  per atmosphere, what pressure in atmospheres will reduce a given volume of water by 0.001%?  
 (A) 0.05  
 (B)  $2 \times 10^4$   
 (C) 0.20  
 (D)  $50 \times 10^{-9}$   
 (E)  $50 \times 10^9$
- ( ) 4. A vessel such as shown in the figure is filled with glycerine of density  $d_1$  to a height  $h_1$ . Oil of density  $d_2$  is now poured onto the glycerine to an additional height  $h_2$ . The additional pressure at all points in the liquid is:  
 (A)  $h_1 d g$   
 (B)  $(h_1 + h_2) d_2 g$   
 (C)  $h_2 d_2 g$   
 (D)  $(h_1 + h_2 - h_3) d_1 g$   
 (E)  $h_2 d_1 g$





- ( ) 5. In a hydraulic press the force in the small piston is 42 lb. The diameter of the small cylinder is 3.16 in and that of the large cylinder is 10 in. The force on the large piston is:
- (A) 42 lb/in<sup>2</sup>
  - (B) 133 lb
  - (C) 420 lb
  - (D) 1,330 lb
  - (E) 4,200 lb
- ( ) 6. A wooden rod serving as a hydrometer is floated in various liquids and the distance it sinks in the liquid is noted in each case. Which of these statements is true?
- (A) the length of the rod is proportional to the density of the liquid in which it is immersed
  - (B) the portion submerged is proportional to the density of the liquid
  - (C) the weight of the portion submerged equals the weight of the displaced liquid
  - (D) the density of the submerged portion is inversely proportional to the buoyant force
  - (E) the length of the submerged portion is inversely proportional to the density of the liquid
- ( ) 7. A cylinder of aluminum has a mass of 270 gm and a volume of 100 cm<sup>3</sup>. If suspended on a string and lowered into carbon tetrachloride, a liquid of specific gravity 1.6, it will displace the following mass of the liquid (displaced liquid, not tension in the string):
- (A) 60 gm
  - (B) 100 gm
  - (C) 110 gm
  - (D) 160 gm
  - (E) 270 gm
- ( ) 8. A mercury barometer on a high mountain has a height of only 40 cm (instead of 76 for normal atmospheric pressure). If the specific gravity of mercury is 13.6, and for a certain liquid is 2.0, a barometer containing this liquid would show the following height:
- (A)  $40 \times .5 = 20$  cm
  - (B)  $13.6 \times 2 = 27.2$  cm
  - (C) 40 cm, same as mercury barometer
  - (D)  $40 \times 13.6 \times .5 = 272$  cm
  - (E)  $40 \times 13.6 = 544$  cm

- ( ) 9. Bernoulli's equation states that the pressure + the P E per unit mass + the K E per unit mass is constant for a flowing liquid. (i. e.  $P + dgh + 1/2 dv^2 = \text{const}$ ) If a liquid flows from a constriction to a lower level as shown, the pressure at position 1 compared to position 2 is:

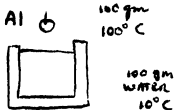
- (A)  $P_1$  is greater than  $P_2$   
 (B)  $P_1$  is the same as  $P_2$   
 (C)  $P_1$  is less than  $P_2$   
 (D) not enough data given



- ( ) 10. On a special thermometer, the freezing point of water is  $20^\circ \text{N}$ ; the boiling point of water on this thermometer is  $110^\circ \text{N}$ . What is the N-temperature which corresponds to  $70^\circ \text{F}$ ?
- (A)  $19^\circ \text{N}$   
 (B)  $35^\circ \text{N}$   
 (C)  $39^\circ \text{N}$   
 (D)  $50^\circ \text{N}$   
 (E)  $128^\circ \text{N}$
- ( ) 11. The pressure of a gas as read on a gauge is  $30 \text{ lb/in}^2$ . If the volume of the gas is reduced to one half its original value and the temperature of the gas is not changed, the gauge will read approximately: (the gauge reads 0 for atmospheric pressure)
- (A)  $15 \text{ lb/in}^2$   
 (B)  $60 \text{ lb/in}^2$   
 (C)  $75 \text{ lb/in}^2$   
 (D)  $90 \text{ lb/in}^2$   
 (E)  $105 \text{ lb/in}^2$
- ( ) 12. Air enters a hot-air furnace at  $7^\circ \text{C}$  and leaves the furnace through the hot-air pipe at  $77^\circ \text{C}$ . If there is no change in pressure, each cubic foot of cold air expands to a volume of:
- (A)  $0.8 \text{ ft}^3$   
 (B)  $1.25 \text{ ft}^3$   
 (C)  $1.91 \text{ ft}^3$   
 (D)  $7 \text{ ft}^3$   
 (E)  $11 \text{ ft}^3$
- ( ) 13. According to the kinetic theory for a perfect gas, the temperature of a given mass of the gas is directly proportional to:
- (A) the rms velocity

- (B) the most probable velocity  
 (C) the kinetic energy of the molecules of the gas  
 (D) the square of the number of molecules per cubic centimeter  
 (E) the average velocity
- ( ) 14. The atomic mass, or molecular weight, for a particular isotope of mercury is 200. A tank containing a mass of 100 gm of this isotope has the following number of atoms or molecules: ( $N_A = 6 \times 10^{23}$ )  
 (A) 11.2  
 (B) 100  
 (C) 200  
 (D)  $6 \times 10^{13}$   
 (E)  $3 \times 10^{23}$
- ( ) 15. An iron rod, 1 sq in in cross-section, is mounted in a massive frame so arranged that it cannot change its length when heated. If the rod is heated through a change of  $500^\circ\text{F}$ , what is the force (in lbs) of compression produced in it? (Young's modulus for iron is  $30 \times 10^6$  lb/sq in; the coefficient of linear expansion for iron is  $6.1 \times 10^{-6}$  per degree F)  
 (A) 40.75  
 (B) 30,500  
 (C) 91,500  
 (D) 183,000  
 (E) 30,500,000
- ( ) 16. The fact that a pond freezes at the surface and not at the bottom is due to the following phenomenon for water:  
 (A) high specific heat capacity  
 (B) high heat conductivity  
 (C) maximum density is at a temperature of  $4^\circ\text{C}$ , or  $39^\circ\text{F}$ , instead of  $0^\circ\text{C}$   
 (D) high heat of fusion of ice  
 (E) high coefficient of volume expansion
- ( ) 17. If, without loss of heat to the surroundings, 100 gm of aluminum of specific heat capacity  $0.2$  cal/gm C at  $100^\circ\text{C}$  are dropped into 100 gm of water at  $10^\circ\text{C}$ , the final temperature must be:

- (A)  $25^\circ\text{C}$   
 (B)  $55^\circ\text{C}$   
 (C)  $65^\circ\text{C}$   
 (D)  $70^\circ\text{C}$   
 (E)  $85^\circ\text{C}$



- ( ) 18. If two equal masses of the same gas are heated from  $15^{\circ}\text{C}$  to  $20^{\circ}\text{C}$ , the first being kept at constant pressure, the second at constant volume, the heat required for the first mass is:
- (A) less than the heat required for the second
  - (B) the same as the heat required for the second
  - (C) greater than the heat required for the second
  - (D) either greater or less, depending on the kind of gas
  - (E) either greater or less, depending on the actual mass of gas
- ( ) 19. A fat mountain climber with a mass of 100 kg eats a chocolate candy bar, deriving 234 kilocalories of energy from it. If his bodily mechanism could use this energy efficiently for vertical climbing, about how high would it raise him?
- (A) 1
  - (B) 9.8
  - (C) 100
  - (D) 9,800
  - (E) 1,000 meters
- ( ) 20. A metallic object of mass 1,800 grams at  $25^{\circ}\text{C}$  is placed in steam at  $100^{\circ}\text{C}$ . When 15 grams of steam condenses on the object, its temperature rises to  $100^{\circ}\text{C}$ . Calculate the specific heat capacity of the object. ( $H_v = 540\text{ cal/gm}$ )
- (A)  $.012\text{ cal/gr-}^{\circ}\text{C}$
  - (B)  $.06\text{ cal/gm-}^{\circ}\text{C}$
  - (C)  $.12\text{ cal/gm-}^{\circ}\text{C}$
  - (D)  $.18\text{ cal/gm-}^{\circ}\text{C}$
  - (E)  $.36\text{ cal/gm-}^{\circ}\text{C}$
- ( ) 21. When a liquid is heated in an open vessel, its temperature rises until:
- (A) it is completely evaporated
  - (B) its critical temperature is reached
  - (C) its vapor pressure equals atmospheric pressure
  - (D) the latent heat is all absorbed
  - (E) the kindling temperature is reached
- ( ) 22. If 50 gm of ice at  $0^{\circ}\text{C}$  are placed in a thermos bottle containing 100 gm of water at  $6^{\circ}\text{C}$ , the water will melt: ( $H_f = 80\text{ cal/gm}$ )
- (A) 2 gm of ice
  - (B) 7.5 gm of ice

- (C) 8.3 gm of ice  
 (D) 17 gm of ice  
 (E) 50 gm of ice
- ( ) 23. If the temperature difference between the faces of a copper metal plate is doubled, its thickness increased 4 times, and its area made 3 times as great as before, the heat it will transfer per sec is:  
 (A) reduced by a factor of 3  
 (B) increased by a factor of  $3/2$   
 (C) decreased by a factor of 6  
 (D) increased by a factor of  $8/3$   
 (E) decreased by a factor of  $2/3$
- ( ) 24. Two black bodies are maintained at absolute or Kelvin temperatures of  $A = 200^\circ \text{K}$ , and  $B = 300^\circ \text{K}$ , in surroundings having a constant temperature of absolute zero,  $0^\circ \text{K}$ . The ratio of the rate of radiation of heat from body B to that radiated by body A is:  
 (A)  $3/2$   
 (B)  $9/4$   
 (C)  $27/8$   
 (D)  $81/16$   
 (E) 1 (i. e. both radiate at the same rate)



- ( ) 25. Given:

Temperature	$0^\circ \text{C}$	$5^\circ \text{C}$	$10^\circ \text{C}$	$15^\circ \text{C}$	$20^\circ \text{C}$	$25^\circ \text{C}$	$30^\circ \text{C}$
Water vapor per cubic meter of saturated air	4.9 g	6.8 g	9.4 g	12.8 g	17.3 g	23.0 g	30.0 g

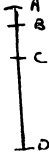
- If the air at  $25^\circ \text{C}$  has a relative humidity of 30%, what will be the dew point of the air? (approximately)  
 (A)  $2^\circ \text{C}$   
 (B)  $5^\circ \text{C}$   
 (C)  $8^\circ \text{C}$   
 (D)  $11^\circ \text{C}$   
 (E)  $17^\circ \text{C}$

110 General Physics I, 12/18/73

Test #4, Chapters 13, 14, 15, 7

Name \_\_\_\_\_

Multiple Choice. Place the capital letter that represents the best answer in the ( ) at the left. Total =  $25 \times 4 = 100\%$

- ( ) 1. A body is vibrating between positions A and D in the figure. The restoring force is zero at the position labeled:
- 
- (A) A, the end of the swing  
 (B) B, halfway between the end position and the midposition  
 (C) C, the midpoint of the swing  
 (D) the restoring force is never zero  
 (E) the restoring force is a constant
- ( ) 2. If a spring, having a spring constant  $k$ , is stretched a distance  $y$ , the work done on the spring is:
- (A)  $k$   
 (B)  $ky$   
 (C)  $ky^2$   
 (D)  $\frac{ky^2}{2}$   
 (E)  $\frac{ky^2}{4}$
- ( ) 3. A 10-gm weight stretches a helical spring of negligible mass 1 cm, the distortion being well within the limits of elasticity. The period of vibration of the suspended weight is:
- (A)  $2\pi$  sec  
 (B)  $2\pi / \sqrt{980}$  sec  
 (C)  $2\pi \sqrt{980}$  sec  
 (D) 10 sec  
 (E) 1/10 sec
- ( ) 4. A mass of 1 kg executes SHM in a period of 1 sec with an amplitude of 1 cm ( $10^{-2}$  m). Its velocity at the midpoint of its swing in m/sec is:
- (A)  $0.02\pi$  m/sec  
 (B)  $0.2\pi$   
 (C)  $2\pi$   
 (D)  $2\pi^2$   
 (E)  $4\pi^2$

- ( ) 5. A certain long pendulum is found to have a period of 3 seconds on earth where  $g = 32 \text{ ft/sec}^2$ . This same pendulum is found to have a period of 6 seconds on another planet. The value of  $g$ , the acceleration of gravity, on this other planet is:
- (A)  $8 \text{ ft/sec}^2$   
 (B)  $16 \text{ ft/sec}^2$   
 (C)  $64 \text{ ft/sec}^2$   
 (D)  $128 \text{ ft/sec}^2$   
 (E)  $g$  cannot be determined without knowing the length of the pendulum

- ( ) 6. The wavelength of a transverse wave is 20 cm and its amplitude is 4 cm. At point A the displacement is 4 cm. At point B, .25 cm away in the direction of propagation of the wave, the displacement in cm is:
- (A) 0 cm  
 (B) 1 cm  
 (C) 2 cm  
 (D) 4 cm  
 (E) 8 cm

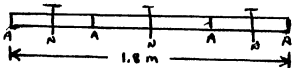
- ( ) 7. To increase the speed of a wave in a stretched string, the following changes could be made to the tension and to the mass per unit length:
- |     | <u>Tension</u> | <u>Mass/Length</u> |
|-----|----------------|--------------------|
| (A) | increased      | increased          |
| (B) | increased      | decreased          |
| (C) | decreased      | increased          |
| (D) | decreased      | decreased          |

- ( ) 8. A pulse of the type shown traveling to the left comes to a fixed boundary and is reflected. Which of the diagrams below correctly represents the returning pulse?



- (A) (B) (C) (D) (E)

- ( ) 9. In order to set up a standing wave, for example in a string, one must have:
- two waves traveling in the same direction
  - two waves traveling in opposite directions
  - two waves traveling at right angles
  - two waves from one source traveling different distances
  - none of the above gives rise to standing waves
- ( ) 10. A string in which standing waves are produced is 8 ft long and vibrations are being sent into it near one end at the rate of 15 per second. Five complete loops are produced. The velocity of the waves in the string is (in ft/sec):
- 48
  - 36
  - 24
  - 16/5
  - 8/5
- ( ) 11. A longitudinal wave is set up in a glass rod 1.8 m long so that there are 3 nodes and 4 anti-nodes, the ends being anti-nodes. A computation using Young's modulus and the density of the longitudinal waves in glass shows the speed of the longitudinal waves in glass to be 4,800 m/sec. The frequency of the sound coming from the glass is:
- 2,670 Hz
  - 4,000 Hz
  - 4,450 Hz
  - 8,000 Hz
  - it is impossible to get a longitudinal wave in a glass rod



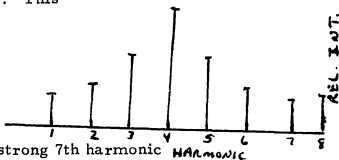
- ( ) 12. The compressibility  $k$  of water is 13 times the compressibility of mercury, i. e.  $k(\text{water}) = 13 k(\text{mercury})$ , where  $k = 1/\text{Bulk Modulus } E$ . The mass density  $d$  of mercury is 13 times the mass density of water, i. e.  $d(\text{mercury}) = 13 d(\text{water})$ . This means that the speed of sound  $v$  in mercury is the following multiple of the speed of sound in water:
- 169
  - 13
  - 1, or the same speed in both
  - 1/13
  - 1/169



- ( ) 13. An extreme drop in the temperature of air will cause the following change in the wavelength associated with a particular sound pitch:
- (A) the wavelength will increase since the velocity of sound decreases with a drop in temperature
  - (B) the wavelength will increase since the velocity of sound will increase
  - (C) the wavelength will remain unchanged
  - (D) the wavelength will decrease since the velocity of sound decreases with a drop in temperature
  - (E) the wavelength will decrease since the velocity of sound will increase
- ( ) 14. The ratio of the intensities of 2 sounds, whose loudnesses in decibels are respectively 80 and 30 dB above the threshold of hearing, is:
- (A)  $8/3$
  - (B)  $10^3$
  - (C)  $10^5$
  - (D)  $10^8$
  - (E)  $10^{50}$
- ( ) 15. The three characteristics of a sound are said to be pitch, quality, and loudness. These are subjective interpretations by the human brain of the following physical characteristics of the sound:
- | <u>Pitch</u>  | <u>Quality</u> | <u>Loudness</u> |
|---------------|----------------|-----------------|
| (A) frequency | intensity      | waveform        |
| (B) frequency | waveform       | intensity       |
| (C) waveform  | intensity      | frequency       |
| (D) waveform  | frequency      | intensity       |
| (E) intensity | waveform       | frequency       |
| (F) intensity | frequency      | waveform        |
- ( ) 16. If the ninth (9th) harmonic of a note has a frequency of 810 cps, the fourth (4th) harmonic has a frequency of:
- (A) 90 cps
  - (B) 202.5 cps
  - (C) 360 cps
  - (D) 1,822.5 cps
  - (E) can't tell without knowing the name of the tone having a frequency of 810 cps

- ( ) 17. The spectrum shown at the right is for a piano playing  $C_1$  (33cps). This sound spectrum shows:

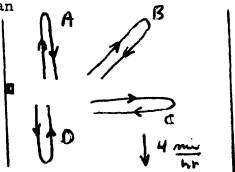
- (A) strong fundamental, weak 4th harmonic  
 (B) weak fundamental, strong 4th harmonic  
 (C) strong 2nd harmonic, strong 3rd harmonic  
 (D) strong fundamental, strong 7th harmonic  
 (E) that all the harmonics have the same intensity



- ( ) 18. Two wave trains start out in phase. They travel unequal paths and are brought back together again. If they are to produce destructive interference when they come together, their path difference must be:
- (A) any whole number of half wavelengths  
 (B) any odd number of wavelengths  
 (C) any even number of wavelengths  
 (D) any even number of half wavelengths  
 (E) any odd number of half wavelengths
- ( ) 19. Two identical tuning forks vibrate at 256 vib/sec. One of them is loaded with a drop of wax, after which 6 beats per second are heard when the forks are sounded. The period of the loaded fork in sec is:
- (A) 0.003 sec  
 (B) 0.004 sec  
 (C) 0.005 sec  
 (D) 0.006 sec  
 (E) none of these
- ( ) 20. If the five organ pipes described below have equal diameters, the one whose fundamental tone has the highest pitch is:
- (A) an open pipe 8 ft long  
 (B) an open pipe 10 ft long  
 (C) a closed pipe 5 ft long  
 (D) a closed pipe 9 ft long  
 (E) a pipe in which the anti-nodes are 16 ft apart

- ( ) 21. Each of four men who can row a boat 5 mi/hr in still water start out in the directions shown in a stream flowing at 4 mi/hr. If each travels the same distance, the man winning the race is:

- (A) A  
 (B) B  
 (C) C  
 (D) D  
 (E) there will be a four-way tie (i. e. all four take the same time)



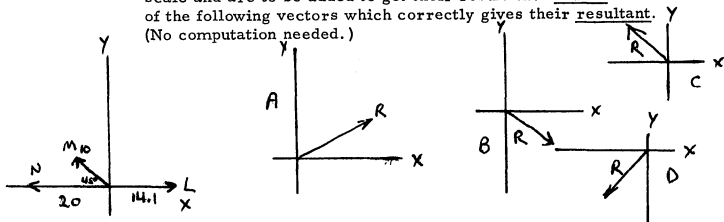
- ( ) 22. At a speed of 98% of the speed of light (i. e.  $0.98c$ ) the factor  $\sqrt{1 - (v^2/c^2)} = 1/5$ . A clock moving at this speed is observed by a stationary observer, who claims the following:
- (A) the mass of the clock is increased by a factor of 5; the time interval shown on the moving clock is decreased to  $1/5$  the time interval on a laboratory clock
- (B) mass increases by factor of 5; time interval increases to 5 times
- (C) mass decreases to  $1/5$ ; time interval increases to 5 times
- (D) mass decreases to  $1/5$ ; time interval decreases to  $1/5$
- (E) both mass and time are the same as on the stationary clock
- ( ) 23. For a speed  $v$  that is 98% of the speed of light  $c$ , the relation  $1/\sqrt{1 - v^2/c^2}$  has the value of 5. If a stationary observer (on Earth, say) measures a meter stick passing him at a speed of  $0.98c$ , he will claim that the moving meter stick (compared to his stationary scale) has a length of:
- (A) 20 cm  
 (B) 50 cm  
 (C) 80 cm  
 (D) 100 cm (i. e. no change)  
 (E) 200 cm  
 (F) 500 cm
- ( ) 24. Two particles, each of rest mass  $m_0$ , approach each other at equal high speeds, collide, and stick together to form a third particle of rest mass  $M_0$ . It is certain:
- (A) that  $M_0$  is greater than  $2m_0$   
 (B) that  $M_0$  is equal to  $2m_0$

- (C) that  $M_0$  is less than  $2 m_0$
  - (D) that  $M_0$  may be larger or smaller than  $2 m_0$ , depending on the actual speed  $v$
- ( ) 25. If one kilogram of mass of any substance were completely annihilated, it would release the following energy:
- (A) none, since the mass of a body is constant
  - (B)  $6.66 \times 10^{-11}$  Joule
  - (C) 9.8 J
  - (D)  $4.5 \times 10^{16}$  J
  - (E)  $9.0 \times 10^{16}$  J

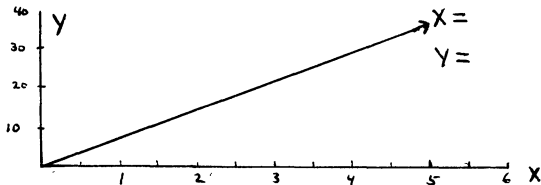
## 110 General Physics I, 9/11/73

## Quiz #1, Chapter 1

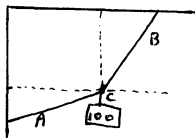
1. (3 pts) The three force vectors  $L$ ,  $M$ , and  $N$  are shown drawn to scale and are to be added to get their resultant. Circle the one of the following vectors which correctly gives their resultant. (No computation needed.)



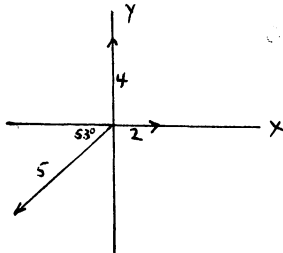
2. (3 pts) Determine graphically the magnitude of the X and Y components of vector  $V$ .



3. (6 pts) Three forces  $A$ ,  $B$ , and  $C$  are shown. Using the method of resolving into X and Y components, determine the resultant force  $R$  (magnitude and direction). Leave the angle as a trig function, if necessary. ( $\sin 53^\circ = 0.8$ ,  $\cos 53^\circ = 0.6$ ,  $\tan 53^\circ = 1.3$ )

ForcesA = 2 lbs at  $0^\circ$ B = 4 lbs at  $90^\circ$ C = 5 lbs at  $233^\circ$ X-ComponentsY-Components

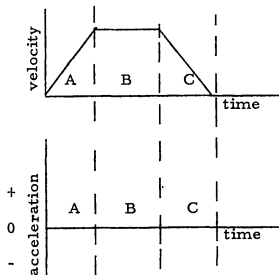
PROB. 4



4. (3 pts) Three ropes A, B, and C meet at a knot with C holding a 100 lb weight. Which of the three ropes has the greatest tension? (No computation needed.)

110 General Physics I, 9/18/73  
Quiz #2, Chapter 2

1. (4 pts) A body has a motion described by the velocity vs. time graph having three parts A, B, and C as shown. Draw the acceleration vs. time graph associated with the motion of this body for the three parts A, B, and C.



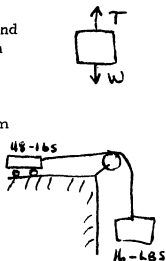
2. A car traveling with a speed of 20 ft/sec accelerates uniformly to a speed of 80 ft/sec in a time of 15 seconds.
- (4 pts) Determine the acceleration of the car.
  - (4 pts) How far does the car travel during the 15 sec?

3. A ball thrown vertically upward stays in the air for 6 seconds (3 sec up, 3 sec back down).  
 (a) (4 pts) With what initial velocity  $v_0$  is the ball thrown?  
 (b) (4 pts) How high does the ball rise?



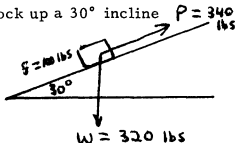
110 General Physics I, 9/25/73  
 Quiz #3, Chapter 3

1. (3 pts) Define either (not both) of the following:  
Newton of force, or Dyne of force.
2. (3 pts) Define either of the following:  
Slug of mass, or Kilogram of mass.
3. (4 pts) A freight elevator weighs 2,400 lbs. Find the tension in the cables when it ascends with an acceleration of  $4 \text{ ft/sec}^2$ .
4. A 48-lb block lies on a flat table and is attached by means of a cord to a 16-lb block hanging from a pulley at the edge of the table, as shown.  
 There is no friction.  
 (a) (3 pts) Determine the acceleration of the system.  
 (b) (2 pts) Determine the tension  $T$  in the cord.

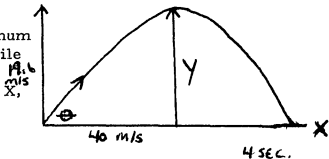


110 General Physics I, 10/1/73  
 Quiz #4, Chapter 4

1. (4 pts) A man who weighs 200 lbs on Earth would weigh how much on the planet Neptune, which has a mass that is 16 times the Earth's mass (i. e.  $M_N = 16 M_E$ ) and has a radius that is 4 times the Earth's radius (i. e.  $R_N = 4 R_E$ ). Show work.
2. A force  $P = 340 \text{ lbs}$  accelerates a 320 lb block up a  $30^\circ$  incline against an opposing force of friction of 100 lbs. ( $\sin 30^\circ = 0.5$ ,  $\cos 30^\circ = 0.87$ ,  $\tan 30^\circ = 0.58$ )  
 (a) (2 pts) Determine the component  $F_x$  of the weight  $W$  which is parallel to the incline.

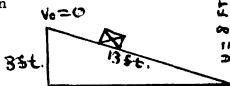


- (b) (3 pts) Determine the acceleration  $a$  of the block up the incline.
3. A projectile, fired at an angle  $\theta$ , has a velocity whose X component is 40 m/sec, and whose Y component is 19.6 m/sec. A stopwatch shows the projectile to be in flight for 4.0 seconds (i. e. up + down = 4 sec). (Remember  $g = 9.8 \text{ m/sec}^2$ .)
- (a) (3 pts) Determine the maximum height Y to which the projectile rises.
- (b) (3 pts) Determine the range X, or the distance to the point where the projectile hits.



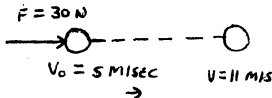
110 General Physics I, 10/9/73  
Quiz #5, Chapter 5

1. (5 pts) A 25-lb block is pulled 5 ft at a constant speed along a horizontal table by a force of 6 lbs. Determine the work done against the forces of friction (magnitude and unit).
2. (5 pts) A man having a mass of 60 kg (or a weight of  $60 \times 9.8 \text{ N}$ ) climbs 3 meters up a vertical ladder in 6 seconds. Determine his power in watts.
3. (5 pts) A 32-lb block slides from rest down an incline 3 ft high and 13 ft long and has a speed of 8 ft/sec at the bottom. Determine the work done against friction in ft-lbs. (Hint: use the interconversion of kinetic and potential energies.)



110 General Physics I, 10/15/73  
Quiz #6, Chapter 6

1. (4 pts) How long (in sec) would a force of 30 N (30 newtons) have to act on a mass of 6 kg to change its momentum from  $30 \text{ kg}\cdot\text{m/sec}$  to  $66 \text{ kg}\cdot\text{m/sec}$ ?

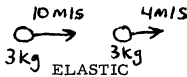




2. (5 pts) A mass of 16 kg traveling 4 m/sec makes a completely inelastic collision with a mass of 4 kg traveling 5 m/sec in the opposite direction. Determine the velocity of the two masses after the collision (magnitude and direction).



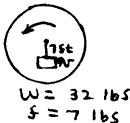
3. (6 pts) A mass of 3 kg traveling 10 m/sec makes a completely elastic collision with an identical mass of 3 kg traveling in the same direction with a speed of 4 m/sec. Determine the velocities of the two masses immediately after the collision.



110 General Physics I, 10/19/73

Quiz #7, Chapter 8

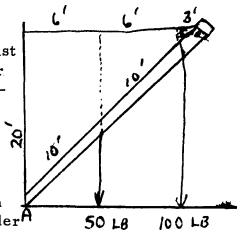
1. A rotating flywheel speeds up from an angular speed of 8 radians/second to 44 rad/sec in 6 seconds.  
 (a) (3 pts) Determine the angular acceleration  $\alpha$  in rad/sec<sup>2</sup>.  
 (b) (3 pts) Through what angle  $\theta$  in radians does it turn during this 6 seconds?
2. (5 pts) The frictional force between a 32-lb block and a rough turntable is 7 lbs. Determine the fastest speed  $v$  with which the table can move the block so that it will stay on the table at a distance of 7 ft from the center.



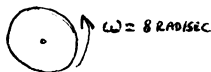
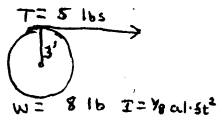
3. (4 pts) A 200-lb man, if stationary above the Earth at an altitude of 600 miles, would weigh 150 lbs. This same man in a circular satellite orbit at this altitude would have an apparent "weightlessness". Explain.

110 General Physics I, 10/26/73  
Quiz #8, Chapter 9

1. (6 pts) The foot of a ladder rests against a vertical wall and on a horizontal floor as shown. The top of the ladder is supported from the wall by a horizontal rope 15 ft long which is 20 ft above the floor. The ladder is 25 ft long, weighs 50 lbs, with its center of gravity 10 ft from the foot, and a 100-lb man is 5 ft from the top. Use the second condition for equilibrium with the foot of the ladder as axis and determine the tension  $T$  in the rope.



2. (5 pts) An 8-lb wheel has a radius  $r = 0.3$  ft and a moment of inertia of  $1/8 \text{ al}\cdot\text{ft}^2$ . A rope around the rim is pulled with a steady force of 5 lbs. Determine the angular acceleration  $\alpha$  of the wheel in  $\text{rad}/\text{sec}^2$ .
3. (4 pts) Compute the rotational kinetic energy of a 3-kg flywheel having a radius of gyration  $K = 1/4 \text{ m}$  which is rotating on a fixed axle with a constant angular speed  $\omega = 8 \text{ rad}/\text{sec}$ . (Answer in Joules)



110 General Physics I, 11/5/73  
Quiz #9, Chapter 10

1. An aluminum post 3 inches by 4 inches and 10 ft long supports a load of 24,000 lbs. Under this load it is found to be compressed by 0.024 inch.
- (4 pts) Determine the stress to which the aluminum post is subjected.
  - (4 pts) Determine the strain set up within the post.
  - (4 pts) Determine the value for Young's modulus for aluminum.

2. An aluminum cylinder having a specific gravity of 2.7 weighs 540 gm in air. When immersed in carbon tetrachloride, it weighs 220 gm.
- (a) (4 pts) Determine the volume of the cylinder in  $\text{cm}^3$ .
- (b) (4 pts) Determine the density of the  $\text{CCl}_4$  in  $\text{gm}/\text{cm}^3$ . (the mass density of water is  $1 \text{ gm}/\text{cm}^3$ )

110 General Physics I, 11/9/73

Quiz #10, Chapter 11

1. (4 pts) A temperature scale has the freezing point of water at  $20^\circ$  and the boiling point of water at  $620^\circ$ . Determine the temperature on this scale that corresponds to  $40^\circ$  on the Celsius scale.
2. (3 pts) By what factor must the mass of a gas be changed if its pressure  $P$ , volume  $V$ , and absolute temperature  $T$  are to be simultaneously tripled?
3. (4 pts) By what factor must the absolute temperature  $T$  of a gas be multiplied if the average velocity of the molecules is to be tripled?
4. (4 pts) A mass of 1,360 grams of mercury at  $0^\circ \text{C}$  occupies  $100 \text{ cm}^3$  of volume. The coefficient of thermal volume expansion is  $\gamma = 2 \times 10^{-4}/\text{C}^\circ$ . What volume does 1,360 gm of mercury occupy at  $300^\circ \text{C}$ ?

110 General Physics I, 11/16/73

Quiz #11, Chapter 12

1. (5 pts) Determine the final temperature when 20 gm of ice at  $0^\circ \text{C}$  are mixed with 80 gm of water at  $50^\circ \text{C}$ . ( $H_f = 80 \text{ cal}/\text{gm}$ )
2. (5 pts) How many calories of heat are released when 20 gm of steam at  $100^\circ \text{C}$  are converted to ice at  $0^\circ \text{C}$ ? ( $H_v = 540 \text{ cal}/\text{gm}$ )
3. (5 pts) A brass plate of  $25 \text{ cm}^2$  area and thickness 5 cm conducts 20 cal/sec of heat when there is a temperature difference of  $20^\circ \text{C}$  between its faces. Determine the coefficient of thermal conductivity, including the units.

110 General Physics I, 11/27/73  
Quiz #12, Chapter 13

- (5 pts) Describe the velocity changes and the acceleration changes as a body vibrating on a spring goes from its lowest position to its highest position.
- A 2 kg mass on a spring vibrates with a period of  $\pi$  seconds, and an amplitude of  $10^{-2}$  m. (Note that 2 kg does not stretch the spring 10 cm.)
  - (5 pts) Determine the force constant  $k$  of the spring in N/m.
  - (5 pts) Determine the maximum velocity  $v_0$  as the mass goes through its equilibrium position or midpoint.  
(Hint:  $PE_{\max} = KE_{\max}$ )
- (5 pts) A certain pendulum has a frequency of 2 vibrations/second on Earth where  $g = 32 \text{ ft/sec}^2$ . What would be the frequency of this same pendulum on a massive planet where  $g = 9 \times 32 = 288 \text{ ft/sec}^2$ ?

110 General Physics I, 12/4/73  
Quiz #13, Chapter 14

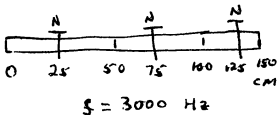
- How large a weight must be hung on the end of a thread 200 cm long if the speed of transverse waves in it is to be 40 cm/sec? The thread weighs 0.50 gm for each 100 cm of length. You do not have to obtain a numerical answer to this problem.

Given:  $v = \sqrt{\frac{T}{m/L}}$

Answer the following:

- (1 pt) Write down the symbol of the variable to be found.
  - (3 pts) Write down the given quantities with their numerical values and units.
  - (3 pts) Solve the equation for the variable which is to be found (in terms of the symbols, not numbers).
  - (1 pt) The answer will be in what units?
- (5 pts) Describe briefly the film Tacoma Bridge seen during class last Thursday.

3. A bar or rod 150 cm (1.5 m) long is clamped as shown so as to vibrate longitudinally in its 3rd mode of vibration with a frequency of 3,000 cycles/sec (Hz).



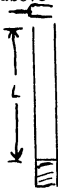
- (a) (3 pts) Determine the wavelength  $\lambda$  of the waves in the bar.
- (b) (4 pts) Determine the speed  $v$  of the longitudinal waves in the bar.

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Quiz #14, Chapter 15

1. (4 pts) Doubling the intensity of a sound increases its intensity level or loudness by 3 dB (decibels). Determine the intensity level in dB for eight (8) singers if each is singing 70 dB above the threshold of hearing.

2. A man wishes to find how far down the water level is in a pipe leading into an old well. He finds that the lowest frequency sound that resonates in the pipe is 55 Hz (cycles/sec). Assume the speed of sound to be 1,100 ft/sec.



- (a) (2 pts) Determine the wavelength  $\lambda$  of the 55 Hz sound.
- (b) (3 pts) Determine the depth  $L$  to the water in the pipe.
3. The siren on a fire truck has a true frequency of 2,090 Hz (cps). A stationary observer says the approaching fire truck has an apparent frequency of 2,200 Hz. If the speed of sound is 1,100 ft/sec, what is the speed of the fire truck? You do not have to obtain a numerical answer to this problem.

Given:  $f' = f \frac{v}{v - v_c}$ .

- (a) (1 pt) From the above equation, write down the symbol of the variable to be found, and give its units.
- (b) (2 pts) From the above equation, write down the symbols of the given variables and their values.
- (c) (3 pts) Solve the equation for the variable which is to be determined in terms of symbols (not numbers).

APPENDIX B  
ATTITUDE SCALES

Problem-Solving Scale

Directions: Please write your name in the upper right-hand corner. Each of the statements on this opinionnaire expresses a feeling which a particular person has toward problem-solving. You are to express, on a five-point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling. The five points are: Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), Strongly Agree (SA). You are to encircle the letter(s) which best indicate how closely you agree or disagree with the feeling expressed in each statement AS IT CONCERNS YOU.

1. I am more interested in the theoretical than the applied aspects of my major field.  
SD          D          U          A          SA
2. Problem-solving is one of my favorite subjects.  
SD          D          U          A          SA
3. When a problem arises that I can't immediately solve, I stick with it until I have the solution.  
SD          D          U          A          SA
4. I like to try new games.  
SD          D          U          A          SA
5. I am more interested in the physical sciences than humanities.  
SD          D          U          A          SA
6. I find it helpful to count on my fingers when doing problem-solving.  
SD          D          U          A          SA
7. I prefer fiction to non-fiction.  
SD          D          U          A          SA
8. Every college student should take at least one problem-solving course.  
SD          D          U          A          SA

9. I like puzzles.  
SD      D      U      A      SA
10. English is one of my favorite subjects.  
SD      D      U      A      SA
11. I would like to do scientific research.  
SD      D      U      A      SA
12. I am challenged by situations I can't immediately understand.  
SD      D      U      A      SA
13. I enjoy problem solving of many kinds.  
SD      D      U      A      SA
14. I avoid games which involve intellectual problems.  
SD      D      U      A      SA
15. I would rather be a philosopher than an artist.  
SD      D      U      A      SA
16. I am as good at solving puzzles as most of my friends are.  
SD      D      U      A      SA

#### Physics Scale

Directions: Please write your name in the upper right-hand corner. Each of the statements on this opinionnaire expresses a feeling which a particular person has toward physics. You are to express, on a five-point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling. The five points are: Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), Strongly Agree (SA). You are to encircle the letter(s) which best indicate how closely you agree or disagree with the feeling expressed in each statement AS IT CONCERNS YOU.

1. I am always under a terrible strain in a physics class.  
SD      D      U      A      SA
2. I do not like physics, and it scares me to have to take it.  
SD      D      U      A      SA
3. Physics is very interesting to me, and I enjoy physics courses.  
SD      D      U      A      SA

4. Physics is fascinating and fun.  
SD            D            U            A            SA
5. Physics makes me feel secure, and at the same time it is stimulating.  
SD            D            U            A            SA
6. My mind goes blank, and I am unable to think clearly when working physics.  
SD            D            U            A            SA
7. I feel a sense of insecurity when attempting physics.  
SD            D            U            A            SA
8. Physics makes me feel uncomfortable, restless, irritable and impatient.  
SD            D            U            A            SA
9. The feeling that I have toward physics is a good feeling.  
SD            D            U            A            SA
10. Physics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.  
SD            D            U            A            SA
11. Physics is something which I enjoy a great deal.  
SD            D            U            A            SA
12. When I hear the word physics, I have a feeling of dislike.  
SD            D            U            A            SA
13. I approach physics with a feeling of hesitation, resulting from a fear of not being able to do physics.  
SD            D            U            A            SA
14. I really like physics.  
SD            D            U            A            SA
15. Physics is a course in school which I have always enjoyed studying.  
SD            D            U            A            SA
16. It makes me nervous to even think about having to do a physics problem.  
SD            D            U            A            SA



17. I have never liked physics, and it is my most dreaded subject.  
SD            D            U            A            SA
18. I am happier in a physics class than in any other class.  
SD            D            U            A            SA
19. I feel at ease in physics, and I like it very much.  
SD            D            U            A            SA
20. I feel a definite positive reaction to physics; it's enjoyable.  
SD            D            U            A            SA

## WESTERN MICHIGAN UNIVERSITY

\_\_\_\_\_  
 Instructor's Name  
 \_\_\_\_\_  
 Physics  
 \_\_\_\_\_  
 Course Number

\_\_\_\_\_  
 Date  
 \_\_\_\_\_  
 Section

The information on the response sheet will be tabulated for departmental use and returned to the instructor only after final grades have been submitted. Answer only those questions for which your knowledge is sufficient to judge. Rate the following statements on a scale 1-5 with the interpretation:

USE BLACK PENCIL ONLY	poor	below	average	above	excellent
	1	average	3	average	5
	disagree	2	neutral	4	agree
	strongly	disagree		agree	strongly
		strongly	somewhat	somewhat	

## I. THE COURSE (excluding lab)

- |   |           |
|---|-----------|
| 1. Catalog accurately describes course                          | 1 2 3 4 5 |
| 2. Work required was appropriate for college-level credit given | 1 2 3 4 5 |
| 3. Text was helpful to me                                       | 1 2 3 4 5 |
| 4. Pace of the course was reasonable                            | 1 2 3 4 5 |
| 5. Level of difficulty was reasonable                           | 1 2 3 4 5 |
| 6. Value or usefulness of the course to me                      | 1 2 3 4 5 |
| 7. Course increased my interest in physics                      | 1 2 3 4 5 |
| 8. General evaluation of the course                             | 1 2 3 4 5 |

## II. THE INSTRUCTOR

- |   |           |
|---|-----------|
| 9. Grading of tests was done fairly             | 1 2 3 4 5 |
| 10. Presentation of material was well organized | 1 2 3 4 5 |

- |   |           |
|---|-----------|
| 11. Gives enough examples to illustrate concepts                | 1 2 3 4 5 |
| 12. Has thorough knowledge of the subject                       | 1 2 3 4 5 |
| 13. Communicates satisfactorily (speaking, writing, etc.)       | 1 2 3 4 5 |
| 14. Stimulates thinking about the course content                | 1 2 3 4 5 |
| 15. Presents ideas in an interesting and understandable fashion | 1 2 3 4 5 |
| 16. Gives tests that are representative of the material covered | 1 2 3 4 5 |
| 17. Shows interest in the course material                       | 1 2 3 4 5 |
| 18. Has been willing to help me outside of class upon request   | 1 2 3 4 5 |
| 19. Makes clear how course grade will be determined             | 1 2 3 4 5 |
| 20. I would like to take another course from this instructor    | 1 2 3 4 5 |
| 21. General evaluation of instructor                            | 1 2 3 4 5 |

III. Please respond to the following questions. (Use back of sheet, if necessary.)

1. What did you particularly like about the course and/or the instructor?
2. What did you particularly dislike about the course and/or the instructor?
3. Do you have any specific suggestions for improvement of the course and/or the teacher's methods of presenting the course?

APPENDIX C  
COMPUTER HOMEWORK ASSIGNMENTS

Homework Assignment 1

- I. Using east as an angle of  $0^\circ$  and north as  $90^\circ$ , use the computer program vector to solve problems 1 and 2, chapter 1 (Bueche).
- II. Write a computer program to add three vectors. This should be a modification of the program to add two vectors, vector. Use the program to solve problems 9, 10, and 17, chapter 1 (Bueche).

Note: In all assignments turn in the problem labeled properly and a copy of the program. Write in the appropriate units for the answer.

Homework Assignment 2

- I. Write a computer program to solve problem 1, chapter 3. Check your program by using this sample data. If the weight of a car = 1,600 lbs, and the required acceleration =  $1 \text{ ft/sec}^2$ , then the load will be 50 lbs. Solve problem 1, chapter 3. Find the acceleration in problem 4, chapter 3, then use your program to find the force required. (You may use the program from part VI of the previous homework to find a.)

- II. Write a program to compute the force of gravitational attraction between two bodies. Given the masses of the bodies and the separation of their centers of mass, use your program to find the gravitational force of attraction between the proton and electron if they are separated by  $1 \times 10^{-8}$  cm. (This is approximately the radius of the Bohr atom.) Use your program to solve problems 1 and 2, chapter 4. Use your program from part I above to find the weight of a neutron at the Earth's surface.

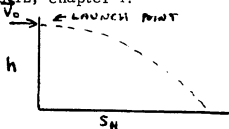
#### Homework Assignment 3

- I. Write a program to solve Illustration 5.6, method 2 (page 94). Use your program to solve problems 3, 10 (first part), and 15, in chapter 5.
- II. Write a program to input  $F$ ,  $s$ ,  $\theta$ , and solve Equation 5.2 (page 84). Solve problem 1, chapter 5, using your program. If the tension in the rope in Fig. 5.3 is 20 lbs and  $\theta$  is  $45^\circ$ , how much work is done pulling the sled 100 ft? (Be sure to convert degrees to radians in your program before taking cosine.)
- III. Problems 3, 4a, and 5, chapter 6, are of the same type; one body collides with a body at rest, the two bodies stick together after the collision. The velocity of the first body is given, the common velocity of the bodies after the collision is

required. Write a program to compute final velocity given the masses and initial velocity. Solve the three problems. In problem 3, use 1 gram for the mass of ball 1. Repeat using 10 grams. Does the mass matter if the balls are identical? In problem 4, input masses, not weights.

#### Homework Assignment 4

- I. A projectile is shot horizontally (at the Earth's surface) with a velocity  $v_0$  from a height  $h$ . Write a program to calculate the distance traveled  $s_h$ , and time of flight  $t$ . (Hint:  $s_h = v_0 t$  and  $h = 1/2 g t^2$ ) Check your program by solving the example on page 77. Then use your program to solve problems 11 (1st part) and 12, chapter 4.



- II. Problem 7, chapter 4, can be solved by using Equation 4.7 to find the acceleration and then using Equation 2.10d,  $S$  may be computed. Write a program to compute  $a$  and then  $S$ . Note: Friction acts down the incline, in the opposite direction of the block in the example (page 70), where Equation 4.7 is developed. Therefore the friction force is negative (-200 lb). Also note you must use either the numerical value of  $\sin 37^\circ$  or

convert  $37^\circ$  to radians before taking the sine in the program. You may wish to input the angle as part of your data so that your program can solve problems of various angles.

#### Homework Assignment 5

- I. Write a computer program which will solve for the pressure if a (0) is input, volume if (1) is input, and temperature if you type in a (2). The equation required is  $\frac{P_1 V_1}{P_2 V_2} = \frac{T_1}{T_2}$ . Use your program to solve Illustrations 11.3, 11.4, 11.5, and problems 4 (in atmospheres only), 5, 6, and 7, chapter 11.
- II. Select a problem from the set at the end of chapter 12. Write a program to solve the problem. Clearly label the problem you selected, your answer, and the answer computed by hand. If you can find an illustration in the chapter or another problem, use your program to solve it. Otherwise make up a set of data and use your program to solve the problem.

#### Homework Assignment 6

- I. Write a program to solve Equation 13.7. Use your program to solve Illustration 13.2. Then starting with a mass of 1.0 kg and increasing by 1 kg each time, obtain the period of masses from 1 to 10 kg. Plot on a graph  $t$  vs.  $m$  ( $m$  on the  $x$ -axis). Comment on the relationship of  $t$  to  $m$ .

- II. Write a program to solve for  $f'$  (the frequency of sound one hears) in Equation 15.2. Use your program to solve problem 19, chapter 15.
- III. Select a problem or illustration from chapter 13, 14, or 15. Write a program to solve the problem. Compare the answer from the program to the answer obtained by solving the problem by hand. Select another problem of the same type (or manufacture a set of data) and use your program to solve this problem. Clearly label the problems which you solve.

#### Homework Assignment 8

- I. In Illustration 9.7,  $mgh = 1/2 mv^2 + 1/2 Iw^2$ . Since  $I = mK^2$  we find  $mgh = 1/2 mv^2 + 1/2 mK^2w^2$ ;  $m$  divides out and  $w = v/r$ . This gives  $gh = 1/2 v^2 + 1/2 K^2 \frac{v^2}{r^2}$ . Solving for  $v = \sqrt{2gh / (1 + \frac{K^2}{r^2})}$ . Putting in  $K$  for a hoop, solid disk, or a solid sphere (from Table 9.1) leads to three equations. Write a program to solve the proper equation (one of the three) after typing in a 0, 1, or 2 for a hoop, disk, or sphere respectively. (Use the same technique as in part II, Assignment 7.) Use your program to solve problems 30 and 31, chapter 9. (You must find  $h$  from data in the problem.) Also use values of  $r$  and  $h$  (which you select) to answer Question 7, page 185. (Plug in the same values for each item and see which rolls fastest.)



Past experience indicates that most difficulties in this assignment arise in solving for  $v$  for the hoop, disk, or sphere. You may wish to check your three equations with a friend or the instructor before writing the program.

#### Homework Assignment 9

- I. Write a computer program which will solve for the pressure if ( $\emptyset$ ) is input, volume if (1) is input, and temperature if you type in a (2). Required is  $\frac{P_1 V_1}{P_2 V_2} = \frac{T_1}{T_2}$ . Use your program to solve Illustrations 11.3, 11.4, 11.5, and problems 4 (in atmospheres only), 5, 6, and 7, chapter 11. (Note:  $\emptyset$  = zero)
- II. Select a problem from the set at the end of chapter 12. Write a program to solve the problem. Clearly label the problem you selected, your answer, and the answer computed by hand.

#### Homework Assignment 10

- I. Write a program to solve Equation 13.7. Use your program to solve Illustration 13.2. Then starting with a mass of 1.0 kg and increasing by 1.0 kg each time, obtain the period of masses from 1 to 10 kg. (You will need to run your program ten times.) Plot a graph of  $t$  vs.  $m$  ( $m$  on the  $x$ -axis). Comment on the relationship of  $t$  to  $m$ .

## Homework Assignment 11

- I. Write a program to solve for  $f'$  (the frequency of sound one hears) in Equation 15.2. Use your program to solve problem 19, chapter 15.