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ABSTRACT

This evaluative report summarizes the objectives, costs, and outcomes of a project undertaken by South Oklahoma City Junior College to develop 50 computer-based tutorial lessons to assist students in mastering the requirements of a competency-based physics course. A rationale for the project is presented first, based on the inordinate amount of time required of the instructor to individually tutor students; the unsatisfactory nature of commercially prepared workbooks; and the positive results of an initial pilot study. The report then outlines specific project goals: to reduce the dropout rate and the number of attempts students needed to demonstrate competency for each course objective; to improve student attitudes toward physics; and to leave the instructor with more time to help the students with the most serious difficulties. The report then describes the special features of the tutorial lessons, which are programmed on micro-computer cassettes and which require the student to establish problem-solving methodologies with gradually decreasing amounts of assistance. Implementation problems posed by time constraints and limited memory capacity are examined prior to an evaluation of the system based on a comparison of student progress using the system with the progress registered by students prior to its implementation and student evaluations of the system. The report concludes with a summary of project funding and expenses. (JP)

Micro-Computer Tutorial Assistance Project

Steven D. Kamm

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Oklahoma City, OK 73159

1981

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I—PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. NSF Program / 4. Award Period	3. NSF Award Number / 5. Cumulative Award Amount
South Oklahoma City Junior College 7777 South May Avenue Oklahoma City, OK 73159	LOCI 4. Award Period: From 4-1-79 To 6-30-81	SER-7900773 5. Cumulative Award Amount: $24,450

6. Project Title
Micro-Computer Tutorial Assistance Project

PART II—SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

This college uses a system of competency-based instruction which requires students to master each course objective before they proceed. In calculus-based Physics courses, over forty separate objectives requiring the application of physical concepts and mathematical rules must be completed without error. Recycling, an integral part of the system, consists of tutoring and retesting over missed objectives. While this method insures that students acquire necessary knowledge and skills, it leaves the instructor little time to help individual students.

The objective of this project was to develop 50 tutorial lessons for use on the Apple II micro-computer which would provide assistance to students having minor trouble with specific types of physics problems, freeing the instructor to work with others experiencing serious conceptual, intellectual or language difficulties.

Established techniques of individualized instruction were used to create programs which concentrate on developing methods of problem solution, identifying problem variables, and pointing out areas where errors are common. Thus, the programs were designed primarily to tutor problem solving rather than to teach physics concepts, and were to be used by students after classroom instruction. Micro-computers and programs were made available through the open physics laboratory so students could obtain assistance at their convenience even when the instructor was not available.

Students who used the lessons indicated the programs were quite helpful. Also, the instructor expressed a subjective belief that his time was more effectively utilized. Most importantly, there was a reduction in the average number of objective tests retaken when the lessons were made available. Improved performance was particularly noted when students were required to utilize the tutorials before retesting. Finally, the course completion ratio increased more than 12 percent.

The tutorial lessons are being made available to other institutions free of charge.

PART III—TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM: Check (✓)	Approx. Date
a. Abstracts of Theses	X				
b. Publication Citations The Physics Teacher				X	June, 1981
c. Data on Scientific Collaborators		X			
d. Information on Inventions	X				
e. Technical Description of Project and Results		X			
f. Other *(specify)* 4 - Computer Diskettes		X			

2. Principal Investigator/Project Director Name *(Typed)*	3. Principal Investigator/Project Director Signature	4. Date
STEVEN D. KAMM		

NSF Form 98A (5-78) Supersedes All Previous Editions

Form Approved OMB No. [illegible]

INSTRUCTIONS FOR FINAL PROJECT REPORT
(NSF FORM 98A)

This report is due within [illegible] the expiration of the award. It should be submitted in two copies to:

National Science Foundation
Division of Grants and Contracts
Post-Award Projects Branch
1800 G Street, N.W.
Washington, D.C. 20550

INSTRUCTIONS FOR PART I

These identifying data items should be the same as on the award documents.

INSTRUCTIONS FOR PART II

The summary (about 200 words) must be self-contained and intelligible to a scientifically literate reader. Without restating the project title, it should begin with a topic sentence stating the project's major thesis. The summary should include, if pertinent to the project being described, the following items:

- The primary objectives and scope of the project.
- The techniques or approaches used only to the degree necessary for comprehension.
- The findings and implications stated as concisely and informatively as possible.

This summary will be published in an annual NSF report. Authors should also be aware that the summary may be used to answer inquiries by nonscientists as to the nature and significance of the research. Scientific jargon and abbreviations should be avoided.

INSTRUCTIONS FOR PART III

Items in Part III may, but need not, be submitted with this Final Project Report. Place a check mark in the appropriate block next to each item to indicate the status of your submission.

a. Self-explanatory.
b. For publications (published and planned) include title, journal or other reference, date, and authors. Provide two copies of any reprints as they become available.
c. Scientific Collaborators: provide a list of co-investigators, research assistants and others associated with the project. Include title or status, e.g. associate professor, graduate student, etc.
d. Briefly describe any inventions which resulted from the project and the status of pending patent applications, if any.
e. Provide a technical summary of the activities and results. The information supplied in proposals for further support, updated as necessary, may be used to fulfill this requirement.
f. Include any additional material, either specifically required in the award instrument (e.g. special technical reports or products such as films, books, studies) or which you consider would be useful to the Foundation.

MICRO-COMPUTER TUTORIAL ASSISTANCE PROJECT
NSF GRANT 7900773

INTRODUCTION

PROBLEM STATEMENT: South Oklahoma City Junior College utilizes a systems approach to education in which student achievement is measured against behavioral objectives developed for each course. This structure allows students to learn in groups, individually, or in some combination of the two through the use of learning packets in which objectives are specified by the faculty. The student's evaluation is criterion-referenced, based upon successful completion of stated objectives rather than upon a traditional norm-referenced evaluation.

Instead of taking two or three major examinations which require a certain percentage of correct responses, students in the calculus-based College Physics series must complete, without error, approximately 40 separate objectives per course to earn a passing grade. The typical objective for this course requires a student to apply physical concepts and mathematical rules to solve a given type of problem. The College's use of competency-based instruction is ideal for promoting subject mastery, but reduces the amount of time instructors have available to tutor students.

One feature of the competency-based system is the "recycling" of students who have not mastered an objective. Recycling normally consists of tutoring, restudy and retesting. Although the method effectively insures all students have acquired the knowledge and skills necessary to continue in their respective fields, it places unique demands on the instructor. This is particularly true

in the calculus-based physics series where there is only one full-time instructor available to students. Individual tutoring and retesting of students who do not master an objective on the first attempt requires more of the instructor's time than is normally available. While many students will master an objective on the first attempt, slower students may need 3 or 4 tries, and even the best students need to repeat some of the objective tests. The lack of graduate assistants or upper division students to aid in tutoring has meant that the instructor is frequently unable to provide all the individual attention students need. Simply asking them to restudy the material usually does not help; whatever blocked learning the first time continues to block learning. Assigning additional problem sets without a joint review of the material by the instructor and the student does not alleviate the situation; the student still does not have the feedback necessary to identify the source of his difficulty.

The solution to this problem envisioned by the instructor was an automatic personalized tutor which could help students who do not master objectives after "normal" teaching.

INITIAL ACTIVITY: An attempt to solve the problem was made utilizing commercially prepared workbooks and student guides. This solution, however, proved to be unsatisfactory from the standpoint of student performance and satisfaction. In addition to burdening the student with the expense of another text, the worked-out sample problems seemed to be of little help, primarily because they did not involve the student in decision-making processes. The form that student-teacher interactions often took during tutorials suggested to the instructor that a programmed training aid incorporating student decision-making might be appropriate.

The advent of inexpensive micro-computers provided a possible technology for presentation of course materials. Although computer-assisted instruction (CAI) is certainly not new, it has, for the most part, been reserved for those institutions with both resources and expertise to implement large and costly systems. The affordability of micro-processors, also called home or personal computers, made them an attractive possibility. In order to test the feasibility of using a micro-computer to tutor students having difficulty, the instructor conducted a pilot study. This study involved completing a course in individualized instruction at a local university, borrowing a micro-computer (Radio Shack TRS-80), learning the programming language, and preparing a tutorial lesson. The results of this study, reported in the Oct. 1978 issue of The Physics Teacher, were sufficiently positive for the college to justify the purchase of a micro-computer (Apple II) and to include initial program development as part of the instructor's contractual goals. Subsequently, a National Science Foundation Grant Proposal was prepared under the Local Course Improvement for Undergraduate Science Education (LOCI) program. The Grant (SER-7900773), awarded effective April 1, 1979, provided released time for the instructor as well as additional micro-computer equipment.

GOALS

The original goal of the project was to develop 50 tutorial lessons for College Physics students having difficulty with specific types of problems. The intent was to tutor problem solving rather than teach physics concepts. Consequently, the lessons were designed for use after classroom instruction had occurred. Micro-computers were to be available in the open physics laboratory so students could obtain assistance even when the instructor was not available.

The instroduction of micro-computer tutorials was expected to impact the physics program. Assumptions to be tested included:

1. The number of repeat assessments should be reduced. By receiving guided assistance, students should increase their problem solving skills and therefore reduce the number of attempts at mastering course objectives.
2. The attitude of students should improve. Having directed, self-controlled, and non-judgmental help available should affect the students in a positive manner.
3. The number of drop-outs should be reduced. As the students' abilities and therefore success on assessments are promoted, feelings of frustration which eventually lead to dropping the course should be reduced.
4. Shifting some of the tutorial load from instructor to machine should leave the teacher with more time. This should allow greater coverage, ideally, help for <u>all</u> students who need assistance. Additionally, this project, when implemented, should allow the instructor to concentrate on students encountering the most serious difficulties.

The tutorial lessons were to incorporate the following features:

1. Hardware - The programs were to operate on an unmodified 16K Apple II micro-computer.
2. Cassette Tapes - The programs were to be recorded on cassette tapes to be loaded into the computer by the student at his convenience.

3. *Learner Decisions - The programs would require the learner to make decisions for himself and his progress was to be controlled by the correctness of his decisions.*
4. *Fading - The programs would gradually reduce the amount of help provided so that the learner would become self-sufficient.*
5. *Random Problem - The programs would end with one problem for which the computer would generate random data to be solved and turned in to the instructor for grading.*
6. *Areas of Concentration - The programs would concentrate on establishing a method of problem solution, identifying known and unknown variables in the problem, and pointing out areas where student errors are common.*
7. *Time - The programs would not require the student to be at the computer console for more than 25 minutes.*

DEVELOPMENT

Work on the project was begun early in the summer of 1979. A review of student records covering previous years provided base line data for a pre-post comparison. The number of retests by objective and by student were recorded. This data also provided information useful in selecting topics for the tutorials. A preliminary list of topics was made using the following criteria:

1. *Need: Subjects for which there was a high rate of repeat testing.*
2. *Graphics: Subjects for which the excellent color graphics of Apple II would help clarify meaning.*

3. Motion: Subjects for which moving displays would help clarify meaning.

4. Language: Subjects for which displays and user control of information presentation rate would benefit international students.

5. Transference: Subjects which would be encountered in other courses.

Funding from the National Science Foundation and the College allowed the purchase of two new 16K Apple II systems for student use and a line printer for developmental/documentation purposes. As a result of receiving a vendor educational-institution discount, the College was able to purchase, in addition, one Disk Drive unit. This unit required a 32K system; consequently, the College purchased a 16K memory expansion kit. Since the original acquisition, the College has also purchased a second Disk Drive, two ROMPLUS+ cards (see below) and memory expansion units for all Apple II systems.

Twenty-four weeks were allotted for program development. Thus, each of the 50 programs was to be produced in about 20 hours--considerably less than the generally accepted standard ratio of 100 production hours per student interaction hour. Shortly after programming started, it became obvious that time restrictions would limit the sophistication and complexity of the programs. It was also found that computer memory restrictions would further reduce the desired scope of the lessons. The computer's 16K RAM was found insufficient in many cases to handle the desired amount of material. This restriction became severe in the case of programs using Apple II High Resolution Graphics. 8K of RAM is required to utilize this feature, leaving only 8K for programming.

It was necessary, therefore, to limit the amount of program branching (computer direction to various parts of the program based on student response), and to produce some programs in multiple parts. The desired feature of random problem generation was dropped altogether, although computer generated, individualized homework will be developed at a later date.

In the end, fifty program parts comprising 42 individual titles were produced. A list of titles and program descriptions is attached as Appendix I. While the programs still require student input and decision-making, less than desired sophistication in computer response was incorporated. For example, many questions are of the yes/no variety, and correct responses are often provided regardless of student response. As is true for all CAI, the computer can never interpret why students choose certain responses.

Two changes in hardware affected the outcome of the project. While it was originally intended that all programs would be recorded on cassette tape, the fortuitious chance of obtaining a Disk Drive provided an opportunity for comparison. Difficulties of loading programs into memory from cassette tapes (Apple II is extremely sensitive to volume settings and the brand of cassette recorder used) were serious enough to force a decision in favor of the disk. Also, programs can be loaded much faster from disk, and programs in parts may be chained (linked by the computer) to load automatically. Only the disk version operating on 32K systems is being used by students.

One major disadvantage of Apple II graphics is that alpha/numeric characters cannot be mixed in a pictorial display--only four lines of print at the bottom of the screen are available. Thus graphs, vectors, and pictorials cannot be adequately labeled. An initial attempt to overcome this problem

was made using SHAPE tables--generation of specific shapes in machine language. This method is, to say the least, laborious, time consuming, and uses up valuable memory space. A solution to the problem was found in the ROMPLUS+ card produced by Mountain Hardware, Inc. Although the addition of a ROMPLUS+ card (which simply plugs into the Apple II) entailed an additional expense of $169 per system, the programmer then had available a complete set of upper and lower case alpha/numerics in various colors which could be used in graphics displays at no cost in memory space. Twenty-one of the programs make use of this feature.

By the end of the allotted developmental time plus a few extra weekends, the first editions of all but one program were ready for student use. Twenty-seven programs deal with classical mechanics, five with thermodynamics, seven with electricity/magnetism, and two with optics. At the end of the first semester of implementation, a final program dealing with graphing data was added. In addition, a MENU feature was incorporated, enabling students to select programs on the disk by typing a number rather than the title. Other features designed to improve the ease of use were added, and necessary corrections were made at this time.

IMPLEMENTATION

The tutorial programs were first used by physics students during the Spring 1980 semester. Participation was voluntary; the instructor introduced the material to his College Physics I and II classes and suggested at several intervals that the programs might be helfpul. In addition, the Introductory Physics instructors directed their students to the tutorial lessons. Utilization data was collected along with student evaluations (Form attached as Appendix II). Para-professional laboratory personnel

maintained all materials and assisted students with the operation of the computer.

A "Second Edition" of the tutorials incorporating corrections and improvements was made available to students in the Fall 1980 semester. A procedural change was incorporated at this time. As before, students were encouraged to use the lessons before the test as a study aid. However, if they failed to pass an objective assessment, they were required to work through the appropriate CAI lesson (if available) before retesting. No other observed differences between semesters were noted by the primary investigator.

RESULTS & EVALUATION

The question to be asked at this point is, "Was the project successful?" Did the projected outcomes materialize sufficiently to justify the effort, time and financial resources expended?

Usage logs maintained in the Science Center reveal that students used the tutorial programs 212 times during the Spring 80 semester and 261 times during the Fall semester. These values are known to be low--some students did not record their activities. Thus, at the minimum, the programs were utilized, and their effect on performance was positive in all aspects as shown below. Data in this chart applies only to assessments in College Physics I for which there was a corresponding CAI tutorial lesson.

	PRE-CAI*	SPRING 1980	FALL 1980
Average number of assessments retaken by students who completed the course	5.00	4.81	4.11
Average number of attempts per assessment by all students	1.46	1.42	1.25
Average number of attempts per assessment by students who completed the course	1.35	1.33	1.27
Average number of retakes on repeated assessments by all students	1.23	1.22	1.10

*Combined Spring 78, 79

As can be seen, average student performance did improve. Fewer assessments were repeated, and the number of attempts per assessment was reduced. An unspecified outcome was that students were more likely to pass an assessment the first time. The last fact is attributed to a tendency of many students to utilize the tutorials as a study aid before their first attempt at an assessment.

In order to determine if the changes noted were significant, performance data was analyzed using the non-parametric Mann-Whitney II-Test. This test was chosen in preference to the t-test because: 1) The sample size was small; 2) The samples were drawn from different parent populations and the

comparison was being made on a single criterion to determine whether the populations differed; and 3) This test does not require homogeneity of variance or normality. Results of the analysis show a statistically significant reduction in the number of attempts per assessment for all students.

Is there a difference in:	Pre CAI vs SPRING 80	SPRING 80 vs. FALL 80	PRE CAI vs. FALL 80
1. Number of assessments retaken by students who completed the course	NO	NO	NO
2. Number of attempts per assessment by all students	NO	YES	YES
3. Number of attempts per assessment by students who completed the course?	NO	NO	NO

Although this analysis shows a significant difference in only two categories, this is felt to be a consequence of the small sample sizes (<20). With small samples, only very large differences would result in statistical significance. The consistent positive pattern of changes in performance for all categories may warrant a more lenient interpretation of the results.

It must be noted, however, that the improved performance of students may be due to factors other than the availability of CAI tutoring. It may be that students simply spent more time studying by using the computer and that performance increases reflect this effort.

Considering all of the above, the first goal of the project, reduced repeat assessments, seems to have been accomplished.

No direct measure of the second goal, improved student attitude, was conducted. Students were, however, polled about the helpfulness of the tutorial lessons with the following results:

CATEGORY	RESPONSES	RATING VALUE
Not helpful	1	1
Little helpful	6	2
Helpful	100	3
Very helpful	79	4
Extremely helpful	39	5
AVERAGE		3.7

These data, combined with the many positive verbal comments made directly to the instructor, seem to indicate a favorable student attitude towards the computer tutorials.

Additional information was obtained through student evaluations. First, use-time varied considerably--from 10 minutes to 5 hours. The long use-time reflects two factors: if there was no waiting line, students would often copy and/or translate most of the screen displays. Second, some students had minor initial difficulties adapting to this instructional mode (e.g. how to operate and respond to the machine). By the end of one session, these difficulties disappeared. Finally, the only negative comments received reflect that in the programs one cannot "turn back the page" at random. In other words, a student cannot go back to review previous portions of the program. As a result of these comments, most of the tutorial lessons have been modified. Students may, at selected points in the programs, choose to look back and review without going through the entire tutorial a second time.

The third goal of the project, a reduced drop out rate, was also realized. The percent of students completing the course, initially 69.6% remained the same in the Spring of 1980. The Fall 1980 completion rate, however, increased to 81.8%.

The final goal, more effective use of instructor time, was also realized. Although no objective data was recorded, it can be seen that fewer repeat tests were given and consequently fewer "in office" tutorial sessions were conducted. This was particularly true for the better students. The instructor did therefore have more time available to work with students having serious difficulties. Higher completion ratios may be a direct result of this redistribution of instructor time.

An overall evaluation, based on the initial goals, shows the project to have been successful. Even though the scope of the tutorial lessons was somewhat reduced and the hardware requirements were expanded, the primary goal of improved instruction was realized.

DISSEMINATION

The cost of this project when viewed against the returns for one year seems excessive: $34,995.00 for about 35 students.

The material dealt with, however, is classical physics, a subject which changes little from year to year. Thus, as time passes and enrollments continue expanding, the cost per student will greatly decrease.

Equally important, these materials are not restricted in their use to one institution. As a result of the initial journal article, awarding of the grant, American Association of Physics Teachers meetings, on-site visits, and word of mouth, other institutions are learning of the availability

of the tutorial lessons (see Appendix III). To date, fifteen sets of tutorials in disk format have been sent to instructors at other institutions (see Appendix IV). Instructors have been asked to send this college four blank diskettes; the programs are recorded and the diskettes returned free of charge. Thus, for an institutional investment of approximately $2,400 other schools can have ready-made tutorials. Many schools are already purchasing Apple II systems; their cost of implementing this project will be negligible. The overall benefit to science education in this country is, then, judged to be worth the initial investment.

Future dissemination plans include a follow-up article for The Physics Teacher, and listing with the American Association of Physics Teachers, the Apple Corporation, and the ACCTion Consortium. Future plans for the project itself include new programs covering additional topics and programs for generating printed sets of homework/study problems.

(See Appendix V for aticles appearing in local newspapers.)

FINANCIAL STATUS

NSF FUNDING	BUDGETED/ALLOCATED	EXPENDED	BALANCE
PERSONNEL			
Salaries	$14,018.74	$14,018.74	-0-
Benefits	1,916.24	1,916.24	-0-
EQUIPMENT	$ 3,576.02	$ 3,576.02	-0-
MATERIAL & SUPPLIES	0.00	0.00	-0-
INDIRECT COSTS	$ 4,939.00	$ 4,939.00	-0-
TOTAL	$24,450.00	$24,450.00	-0-

SOCJC MATCH FUNDING	BUDGETED/ALLOCATED	EXPENDED	BALANCE
PERSONNEL			
Salaries	$ 6,826.00	$ 6,826.00	-0-
Benefits	819.00	819.00	-0-
EQUIPMENT	$ 1,250.00	$ 1,250.00	-0-
MATERIALS & SUPPLIES	$ 300.00	$ 300.00	-0-
OTHER COSTS	$ 300.00	$ 300.00	-0-
INDIRECT COSTS	$ 2,730.00	$ 2,730.00	-0-
TOTAL	$12,225.00	$12,225.00	-0-

(Please refer to Appendix VI for Form SF272)

APPENDIX

APPENDIX I

NSF LOCI PROJECT - PHYSICS CAI

Disk Title	Program Title and Description
	Volume 1
Vector 1	VECTOR RESOLUTION Resolving a vector into two right-angle components graphically and trigonometrically.
Vector 2 Vector 3	VECTOR ADDITION: PART I AND II (Chained) Adding vectors in magnitude/direction form by adding components.
Vector 4	DOT PRODUCTS: M/D FORM Finding the scalar product of two vectors in magnitude/direction form.
Vector 5	CROSS PRODUCTS: M/D FORM Finding the vector product of two vectors in magnitude/direction form.
Vector 6	DOT AND CROSS PRODUCTS: UNIT VECTORS Finding the scalar and vector product of two vectors in unit vector form.
Vector 7	VECTOR AND SCALARS QUIZ Tests ability to identify physics quantities as vectors or scalers.
Kinematics 1	ONE-DIMENSIONAL KINEMATICS Solving one-dimensional, constant acceleration kinematics problems, translational and rotational.
Kinematics 2	KINEMATICS AND GRAVITATIONAL ACCELERATION Solving one-dimensional kinematics problems for objects moving under the influence of gravity.

GRAPHING MOTION: PARTS I, II, III & IV (Chained)

Graphing 1 Graphing 2 Graphing 3 Grahing 4	Developing complimentary graphs of displacement, velocity or acceleration when given a graph of either displacement, velocity or acceleration.

Volume 2

	PROJECTILE MOTION
Projectile	Solving projectile mction problems.
	CIRCULAR MOTION: CONSTANT SPEED
Circle 1	Discussion of velocities and accelerations associated with constant angular velocity.
	CIRCULAR MOTION: CHANGING SPEED
Circle 2	Discussion of velocities and accelerations associated with changing angular velocity.
	*STATICS: METHOD
Statics 1	Method for analyzing systems in static equlibrium.
	*STATICS: BEAM PROBLEMS
Statics 2	Analyzing problems involving static beams supported by cables and hinges.
	*STATICS: LADDERS
Statics 3	Analyzing problems involving inclined ladders supporting loads.
	*STATICS: INCLINED PLANES
Statics 4	Analyzing problems involving static systems of masses on inclined planes.
	*DYNAMICS: METHOD
Dynamics 1	Method for analyzing dynamic systems with constant acceleration.

Dynamics 2	**DYNAMICS: TRANSLATION* *Analyzing multiple-body systems moving with constant translational acceleration.*
Dynamics 3	**DYNAMICS: TRANSLATION & ROTATION* *Analyzing multiple-body systems moving with constant translational and/or rotational acceleration.*
Energy 1	**CONSERVATION OF ENERGY: METHOD* *Method for analyzing dynamic systems using energy considerations.*
Energy 2	**CONSERVATION OF ENERGY: CONSERVATIVE FORCES* *Analyzing dynamic systems acting under the influences of conservative forces only.*
Energy 3	**CONSERVATION OF ENERGY: NON-CONSERVATIVE FORCES* *Analyzing dynamic systems acting under the influence of conservative and non-conservative forces.*
Momentum 1	*CONSERVATION OF LINEAR MOMENTUM* *Using the conservation law to analyze one and two dimensional recoil problems.*
Momentum 2	*CONSERVATION OF ANGULAR MOMENTUM* *Using the conservation law to analyze rotating one and two body systems.*
	VOLUME 3
Collisions X	*ONE-DIMENSIONAL COLLISIONS* *Using the conservation laws to analyze elastic and inelastic collisions in one-dimension.*
Collisions 1 Collisions 2 Collisions 3	*INELASTIC COLLISIONS: PARTS I, II, AND III (Chained)* *Using the conservation law to analyze two-dimensional inelastic collisions.*

SHM & THE REFERENCE CIRCLE: PARTS I & II (Chained)

SHM 1
SHM 2

Analyzing simple harmonic motions using the concept of a reference body moving with constant angular velocity.

CALORIMETRY

Calorimetry

Analyzing calorimetry (mixing) problems using conservation of energy approach. Includes heat of fusion for water and water equivalent of calorimeter cup.

THERMODYNAMIC PROCESSES

Thermo Process

Displays and requires recognition of isothermal, isobaric, isometric and adiabatic processes on P-V, P-T, and V-T diagrams.

THERMODYNAMICS CYCLES

Thermo Cycles

Combining thermodynamic processes to produce thermodynamic cycles. Develops concept of net work.

HEAT ENGINES: METHOD

Engines 1

Method for analyzing ideal heat engines and heat pumps.

HEAT ENGINES: APPLICATIONS

Engines 2

Analyzing ideal heat engines and heat pumps.

VOLUME 4

*GAUSS' LAW: PART I & II (Chained)

Gauss I
Gauss II

Finding the electric field inside and outside a sphere filled with a non-uniform charge distribution.

*CAPACITORS IN CIRCUITS

Capacitor

Finding the charge on and potential difference across multiple capacitors in a series/parallel network.

*RESISTORS IN CIRCUITS

Resistor

Finding the current through and potential difference across multiple resistors in a series/parallel network.

Lorentz

LORENTZ RELATION

Graphic displays and questions about the direction of electric and magnetic forces on moving charges.

Ampere

AMPERE'S LAW

Finding the magnetic field inside and outside a co-axial cable.

RC Response

RC CIRCUIT RESPONSE

Mathematic solution of transient response for series resistor/capacitor circuit. Automatic plotting of charge and current curves (student selects various values of R and C) to investigate transient response.

RCL Analysis

RCL CIRCUIT ANALYSIS

Mathematical solution of series resistor/capacitor/inductor circuit with alternating current source. Automatic computation of reactances, inductance, current and phase angle. Student selects frequencies to maximize current and discovers that reactances are equal and the phase angle is zero.

Mirrors

RAY DIAGRAMS: MIRRORS

Finding images by ray tracing for concave and convex mirrors.

Lenses

RAY DIAGRAMS: LENSES

Finding images by ray tracing for converging and diverging lenses.

Datagraph

GRAPHING DATA

Finding the linear equation for plotted data using $y = Mx + b$.

*Indicates need for Mountain Hardware's ROMPLUS+ Board.

APPENDIX II

NSF TUTORIAL ASSISTANCE PROJECT

STUDENT EVALUATION

1. PROGRAM TITLE: ______________________________

2. How much time did you spend at the computer? ______________

3. Why did you use this program (check one)?

   ________a. Didn't pass objective test

   ________b. Reviewing for test

   ________c. Reviewing for Final Exam

   ________d. Other ______________________________

4. How helpful was the program to you (check one)?

   ________a. Not very helpful (a waste of time)

   ________b. Only a little helpful

   ________c. Helpful

   ________d. Very helpful

   ________e. Extremely helpful (a BIG help)

5. What difficulties did you have in understanding and/or operating that program?

6. What suggestions for improvement can you make?

7. Did you use the disk or cassette tape version? ______________

8. What course are you enrolled in? ______________________

APPENDIX III

DISSEMINATION ACTIVITIES

ARTICLES

1. "Using Personal Computers as Physics Tutors - A Feasibility Study", The Physics Teacher, October, 1978.
2. A follow-up article will be submitted to The Physics Teacher in the near future.

VISITS TO SOCJC: staff members from the following institutions visited SOCJC to view the tutorial project:

1. Murray State College, OK
2. Westark Community College, AR
3. Oklahoma State University, OK
4. Tri-County Technical College, SC
5. University of Oklahoma, OK
6. Central State University, OK

VISITS TO OTHER INSTITUTIONS: the principal investigator visited the following institutions to demonstrate the tutorial project:

1. Kansas State University, KS
2. Oscar Rose Junior College, OK
3. University of Central Arkansas, AR

MEETINGS: the principal investigator attended or sent tutorial materials to the following:

1. AAPT - AOK Regional Meeting, KSU, 1979
2. Staff Development Workshop, ORJC, 1979
3. AAPT National Meeting, Chicago, 1980
4. Staff Development Workshop, SOCJC, 1980
5. NSF LOCI Directors' Meeting, Detroit, 1980
6. AAPT, AOK Regional Meeting & Computer Workshop, UCA, 1980
7. ACCTion Consortium, CAI Workshop, Dallas, 1981

APPENDIX IV

DISTRIBUTION OF TUTORIAL MATERIALS

Jacqueline D. Spears
Marymount College of Kansas
Salina, KS

Mike Hightower
Westark Community College
Fort Smith, AR

Dewey Dykstra
Oklahoma State University
Stillwater, OK

Eugene B. Fuchs, Jr.
Mehlville Senior High School
St. Louis, MO

Joseph E. Lang
Thomas More College
Ft. Mitchell, KY

L. Dwight Farringer
Manchester College
North Manchester, IN

James C. Wood
Tri County Technical College
Pendleton, SC

Austin R. Brown, JR.
Colorado School of Mines
Golden, CO

Robert G. Fuller
University of Nebraska
Lincoln, NE

Mark Cross
Ruston, LA

A. T. Bell
Hall High School
Little Rock, AR

George Kolodly
Bloomfield College
Bloomfield, NJ

John R. Merrill
Hendrix College
Conway, AR

Phillip Cloud
Central State University
Edmond, OK

Charles Brownlee
Seward County Community College
Liberal, KS

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Dr. Annmarie Shirazi - Director of Institutional Research

James A. Bibler - Science Laboratory Assistant

Gloria F. Carson - Institute Typist