A REPORT ON THE PREPARATION OF A TEACHING UNIT ON MOTION: AN INTEGRATED APPROACH TO INSTRUCTIONAL DEVELOPMENT

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A REPORT ON THE PREPARATION OF A TEACHING UNIT ON MOTION: AN INTEGRATED APPROACH TO INSTRUCTIONAL DEVELOPMENT

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John William Walsh

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To my wife

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for her patience and forebearance

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BACKGROUND

Introduction

The process of curriculum development in this Province has too often been carried out on a crisis-management basis. Curriculum changes and revisions have occurred as a defensive response to a rising tide of teacher criticism about a particular course or text that has become antedated, or was too long, or too short, or which overlapped too much with another course. The standard response to such criticisms was either the deletion of parts of the course or a replacement of the text with another, generally of the same kind.

In recent years, however, mainly through the auspices of the special-interest councils of the Newfoundland Teachers' Association, with assistance from faculty members of Memorial University and curriculum consultants at the Newfoundland Department of Education, some concerted efforts at curriculum reform have been undertaken. Efforts on the part of graduate students undertaking the development and piloting of course units have also helped in the growing understanding of the processes involved in curriculum development soundly based on educational theory.

Unfortunately, the major problem with many of these attempts has been a basic lack of follow-up. These reforms, like the old, are completed, instituted in the schools and all too often forgotten about. Such new programs often fail to produce significant improvement because teachers revert to traditional methods, applied in many instances to programs unsuited to the old instructional procedures.

It is the writer's contention that curriculum revision and alteration should be instituted and carried on in such a way as to promote instructional improvements. It is not sufficient to pilot and gain acceptance of a new course or unit without following through with the development and dissemination of instructional strategies, materials and devices which will promote the teaching of such a course or unit in the way in which it was designed to be applied.

In various capacities with the Newfoundland Teachers' Association Science Council (NTASC) over the past decade, the writer has observed the piloting of various science courses by many interested and diligent teacher groups. In many instances the courses were approved only to be given to other teachers as a new textbook, with little information on supplementary instructional materials and methods. Such a procedure often results in the failure of teachers to accept the new course or else their grudging compliance resulting in a new course that is a carbon copy of the old. The failure of many teachers to grasp the concepts and instructional requirements of the New Math is a case in point.

The basic tenet of any curriculum or instructional developments in the school should be the active involvement of the majority of teachers affected in the implementation of the scheme. Only through a system of mutual cooperation and consultation can such development be effective. The lines of communication between the originators of the scheme and the teachers who are to use it must be maintained at all times. As Margaret Gillett (1973) states:

> When substantial change is imposed from the top without full and frank consultation with teachers, success can hardly be assured. This holds true whether the change involves educational technology, or an organizational innovation such as a switch to modular scheduling, or a question of curriculum. Teachers, the very people expected to work most closely with the new situation, whatever it is, may not want it, may not approve it, may not understand it. (p. 94)

Physics in Newfoundland

Physics has been an important part of the high school program in Newfoundland since the late nineteenth century. It was not until 1962, however, that the physics curriculum took its present form, for until that time several textbooks were recommended from which schools could choose to teach the prescribed course. In 1964 the textbook Modern Physics by Dull, Metcalf and Brooks (1956) was selected for high school use and a later edition by Dull, Metcalf and Williams (1964) continues to be used to this day.

Newfoundland public examination figures show that enrollment in physics reached over two thousand in 1967, spurred by interest in physical science occasioned by Sputnik. By 1972, however, the enrollment in physics in Newfoundland had dropped to one-half the 1967 figure, while enrollment in other sciences, notably biology, increased rapidly.

This enrollment trend was the same all over North America. As Watson (1967) points out:

> Thus we see that, despite much public concern, effort, and expense, an increasing fraction of our children are completing secondary school without any systematic study of physics on the high school level. At present, four out of five high school graduates have taken no physics. Furthermore, very few of those who avoided physics in school will ever study physics in college. If we want any sizable segment of the future population to have some introduction to physics, that study must be done in the secondary school. (p. 213)

Thus, the declining enrollment problem had struck in the United States first, and, due to local factors, hit Newfoundland about five years later. Extrapolation from this decline could have led to the prediction that by 1976 there would be little, if any, high school physics in the Province. Several smaller schools did, in fact, discontinue the presentation of a physics course due to lack of enrollment.

Physics enrollment in Newfoundland has levelled off at the 1973 level but is still drastically low if this Province is to produce a sufficient number of engineers and technicians to meet its needs into the twenty-first century. However, the need for a higher physics enrollment in our schools goes deeper than just Newfoundland's need for engineers and technicians. Physics is the basic science. Its content is not only fundamental to the study of all other sciences, but also to a thorough understanding of philosophy, religion, history and contemporary society. Its importance as the basis of the other sciences is readily apparent in its wide range of subdivisions. Physical chemistry, biophysics, geophysics, astrophysics and other arms of this science show its all-embracing compass.

Less readily understood, perhaps, is the importance of concepts developed in physics to disciplines referred to as the humanities. The mechanistic designs of Newton, Einstein's relativity and Bohr's concept of complementarity, to name just a few physical concepts, have had important implications in philosophy and epistemology. Ruth Moore (1966) quotes Oppenheimer's remarks regarding a debate between Bohr and Einstein on the concept of complementarity:

> Oppenheimer called Bohr's report on the continuing twenty-eight year long discussion, "The richest and deepest" dialogue since Plato's Parmenides. Only Socrates debating his theories with the great Eleatic Philosophers Parmenides and Zeno had explored reality as profoundly and subtly. (p. 397)

Knowledge of contemporary physical theories also plays an important role in understanding history and sociology. The Newtonian system of a mechanism run by a constant set of "checks and balances" to sustain equilibrium was embodied in the Constitution of the United States of America. The concept of atomism pointed Locke in the direction of an atomistic society which later lead to theories asserting that, "government should have no function except to protect the freedom and property of the individual" (Paul, Peirce & Stief, 1974, p. 74). These are but two of many such examples of the role physical theories play in history and sociology.

A knowledge of physical science is also important for a thorough understanding of our technological society. The advent of new technological wonders such as thermonuclear armaments, nuclear reactors, the energy crisis, microcircuitry, cryogenics, laser technology and many other manifestations of the technology derived from physical science and their impact on society can hardly be overemphasized. In all areas of our lives the influence of physics and the technology based on it is felt. Citizens are asked to make decisions on policies based on this new technology with little if any knowledge of how or why it operates.

As the basic science, then, physics has an important and some say central role to play in the secondary school curriculum. Some of the facets of this role were outlined in 1960 by the Subcommittee on the Physics Curriculum set up by the Newfoundland Department of Education. The aims of physics instruction stated by this committee are to be found in the report of the Provincial Science Curriculum Committee (PSCC) Physics Subcommittee (1976).

> The following objectives are embodied in the teaching of physics in Newfoundland schools:
>
> To stimulate in the student a curiosity about the physical world and an interest in the study of physics.
>
> To acquaint the student with some parts of the body of knowledge of physics and so develop in the student a better understanding and appreciation of the many contributions which science has made to mankind.
>
> To promote an understanding of the importance of the broad underlying, unifying principles and laws of nature.

> To develop in the student the ability to analyze problems and situations critically so that he may arrive at logical conclusions and explanations.
>
> To promote an appreciation of physics and of its international character through study of the historical development of some of the underlying ideas.
>
> To point out the importance of precise methods of measurement in the development of a better understanding of nature.
>
> To lay emphasis on the fact that physics is a mathematical science.
>
> To assist in keeping the student's mind free of popular fears and superstitions involving science.
>
> To provide opportunity for the student to experience the satisfaction which arises from intellectual accomplishment.
>
> To participate in the preparation of the best minds for advanced education. (p. 17)

A more modern but general list of science objectives was drawn up by Mr. S. Norris (1975, p. 3). This list was included in the first of what was to be a series of papers to guide curriculum development in science in Newfoundland. Among the guiding principles included were the emphasis on student activity, individualization of instruction and promotion of student interest.

Holton (1976) outlines a more specific modern concern of physics educators:

> A problem common in most countries is how to deal effectively with those who do not necessarily have the motivation or preparation to do very well in the classical, narrowly conceived physics course. (p. 332)

The problem has become to reach a greater proportion of the student population in order to reverse the declining enrollment trend of the late sixties and early seventies. However, as Dietrich (1973) points out:

> The concern appears to stem from the assumption that high school physics can and does contribute to the development of individual scientific literacy rather than from the concern for attracting more people into the profession of physics or physics related areas. (p. 5)

In order to meet this concern, however, many publishers of physics texts have produced a series of new physics courses of the 'physics is phun' variety. These texts attempt to make physics more palatable by stripping from it the mathematics by which it was built and replacing it with some sort of theme. Such books, interspersed with 'quippy quotes', cartoons and simplistic explanations, are supposed to provide the arts or non-science student with a new outlook on the physical sciences. Clifford Scwarts (1976) comments on this new phenomenon in physics education in an editorial entitled Physics can be Phun and also Phony:

> The addition of theme does not necessarily unify the subject for the beginner. Nor does leaving out mathematics reduce the conceptual difficulties involved in physics. (p. 198)

He goes on to say that instead such courses run the risk of giving unsophisticated high school students a misleading impression of the concepts of physics and their development while ill-preparing them for future studies in the sciences or technology. A more effective procedure for meeting this need is outlined by Holton (1976):

> But if one wishes to engage a great variety of individuals, with all their 'chemical properties', one must have a course which will be meaningful in a variety of ways, each of which is actually rewarded. Some students will excell in the mathematical or laboratory part, others in the more verbal reports, perhaps connected with their interest in the social sciences or history. Hence, the assigned work, and of course the tests, must allow some choices or options, to permit different kinds of excellence to show up. (p. 333)

This philosophy is the essence of the Project Physics course and the avenue that physics teachers in Newfoundland have chosen to follow. The objectives for the teaching of physics compiled in 1960 are still valid and should be upheld in any new physics course introduced into our high schools. The emphasis might change from one to the other of the objectives, and new insights, based on educational theory, may add a new one from time to time, but these standards and criteria should remain.

Most physics teachers in Newfoundland now agree, however, that the text Modern Physics is not meeting this challenge. A physics teachers' workshop held in 1972 at Memorial University established the extent of teacher discontent with the Modern Physics course. Weir and Walsh (1976) describe the consensus reached at that meeting:

> This rather traditional "problem solving oriented" course is based on the textbook Modern Physics by Dull, Metcalf and Williams. The workshop participants felt that this book was not matched to the mathematical abilities and learning levels of the students in grades X and XI in this province, and it did little to help teachers create and sustain student interest in physics. (p. 3)

A poll conducted by Mr. Harvey Weir of ten physics teachers from across the island in 1976 reinforced this view. A report prepared for the PSCC (1976) states:

> Nine teachers expressed considerable dissatisfaction with Modern Physics by Dull, Metcalf and Williams. Comments such as "Not readable", "Dull" and "Outdated" were common. The overall feeling was that it ought to be replaced. (p. 4)

At least four efforts to replace this course have been undertaken with varying degrees of success over the past ten years. The first such attempt was the introduction of PSSC Physics in 1966 at Prince of Wales Collegiate by Mr. Phillip Williams. The course was presented by Mr. Williams after attending a summer school presented by the Curriculum Division of the Faculty of Education at Memorial University. Despite the preparation, the conclusion drawn from this pilot course was that it was not suitable for local schools, the main reason being that the mathematical content was too advanced for most of our grade ten students.

Mr. Williams was not alone in his conclusion. Arnold Moore (1968) states:

> PSCC Physics was one of the innovations with a high abandonment rate. Although 43.2 per cent of the schools had adopted PSCC materials, 3.2 per cent of the respondent schools had abandoned the materials. The predominant reason given for discontinuance was that the materials were considered most suitable for the high ability college bound student. (p. 338)

The second course was introduced in 1970-71 by Mr. Joseph Sheppard at J.R. Smallwood Collegiate in Wabush (Labrador). Mr. Sheppard is still using the Project Physics course and is very enthusiastic about using it. However, no other teacher has decided to undertake this program.

The third attempt was the introduction in 1972-73 of The World of Physics in Glovertown by Mr. A. Stewart. The course was dropped after a half-year.

The fourth and possibly the most successful attempt at introducing a new course was the piloting by Mr. Lloyd Gill of Conceptual Physics. This course was continued in grade eleven in 1973-74 at Queen Elizabeth High School, Foxtrap and subsequently several other schools undertook to teach it. This course was given alternate course status in 1974. Conceptual Physics was chosen more as a student reader and study guide since the mathematical content was very low. It is in fact classifiable as a "physics is phun" text mentioned earlier, but was redeemed by the fact that Mr. Gill prepared two comprehensive supplement booklets to accompany the course. As Mr. Gill (1973) states:

> An important point to remember, however, is that the student has a non-mathematical text, and the teacher can now control exposure to mathematical techniques. It is assumed that examinations both in school and on the provincial level will be putting less stress on mathematical type questions. In this way the Physics (sic) course should offer itself to more students than at present. It is therefore necessary to stress an understanding of the scientific principle rather than the mathematical application. At the same time, this supplement will allow the advanced student to benefit from additional material that the teacher can provide. (p. iv)

Despite these efforts, however, several of the teachers using this book reverted to the Modern Physics text and no new teachers undertook to try it. This course is now in use in only a few schools and is slated to be replaced with the PHE course.

This, then, was the extent of attempted curriculum reform in the decade preceding 1974. However, during this time, one event of overriding significance took place. This was the revitalization and reorganization of the Newfoundland Teachers' Association Science Council (NTASC). Under the impetus gained from the introduction of the CHEM Study course, a group of science teachers decided to rehabilitate the almost completely defunct NTASC. To quote a report of the Biology Committee entitled Program 76: A Biology Program in Preparation (1975)

> During the past three years there has been a notable increase in the activity of the Science Council of the Newfoundland Teachers' Association. There are perhaps several discernable causes for this: a growing sense of professionalism among science teachers, an increasing awareness of the role of the classroom teacher in curriculum development, a genuine concern about the quality of science education among educators generally and finally a greater demand for science skills and concepts by students and the labor market. (p. 1)

Thus the new NTASC was split up into four groups, each to deal with one of the four major high school sciences. Each group or committee elected its own executive and the chairperson of each committee was to serve also on the central executive. Under this new organization, interest and enrollment in NTASC has increased greatly. The Council has grown to include a committee on junior high school science and an elementary science committee is contemplated. Most of the meaningful developments in the science curriculum at the high school and junior high school level in the past three years have come as a direct consequence of the work of members of NTASC.

It was at the first general conference of NTASC in 1974 that the physics teachers present organized to meet the challenge of setting up a new and viable course in physics. At the 1974 conference a talk by Mr. J. Sheppard on his experiences with Project Physics prompted Mr. R. Anthony, Mr. S. Norris and the writer to do some detailed research on this course. This led to the discovery that a Canadianized and slightly simplified version called Physics: A Human Endeavour was being published. At that time only the first two modules of the course entitled Motion and Motion in the Heavens were available but perusal of these two booklets convinced those teachers that it offered some advantages over the PP program. It was subsequently decided to prepare a detailed proposal for the Curriculum Division of the Department of Education, asking for permission to pilot this course beginning September 1974.

The results of this two-year pilot were promising enough for the teachers involved to present a report to the Department of Education in 1976 recommending that PHE be given alternate course status for Newfoundland high schools for the 1976-77 school year. This report was sent to the PSCC and resulted in the formation of a subcommittee on high school physics. The report of the PSCC - Physics Subcommittee (1976) cites its main objectives as:

> ... to establish criteria for evaluating physics textbooks, and to make recommendations pertaining to same. In doing this it was to take into account the piloting of Physics: A Human Endeavour during 1974-75 and 1975-76, as well as existing textbooks and courses either piloted or existing under alternate textbook or course status. (p. ii)

Among the recommendations of this committee were:

> 1. That Physics: A Human Endeavour be phased in a maximum of a four-year period for Grade XI and a three-year period for Grade X, and that Modern Physics and Conceptual Physics be phased out over the same period. During this phase-in period it is recommended that Physics: A Human Endeavour be granted an "alternate course" status, starting in 1976-77....
> 3. That copies of Physics: A Human Endeavour and copies of Mr. W. Walsh's list of laboratory materials [see Appendix H] be placed in the hands of all high school physics teachers in this Province before the end of this school year (1975-76).

Other recommendations included the setting up and financing of workshops for potential users of the course, the presentation of a summer institute at Memorial University on both the pedagogical aspects and physics content of the course, the provision of a special equipment grant by the Department of Education for schools using the course, and the establishment of a special committee to monitor the course during its implementation and to undertake the planning and running of in-service workshops (op. cit., pp. 11-14).

As can be seen from these recommendations, the committee was very cognizant of several factors involved in curriculum development in physics in Newfoundland high schools. These are:

1. The wide disparity of laboratory and other facilities for the teaching of physics. This disparity has been increasing rather than decreasing over the past few years with the opening of well equipped DREE schools, while older schools are still limited to approximately two hundred dollars per year for their physics laboratory supplies. This has been further aggravated by the fact that physics teachers are a very mobile group, and teachers who are leaving a school or are going to teach a different subject in the coming year rarely take the time to order supplies for the course they are leaving.

2. The need for a carefully organized implementation period during which teachers could be made aware of the nature of the new course and become involved in its adoption.

3. The wide disparity in educational background of physics teachers which ranges from a low of four semester courses in physics to a high of a Master's degree or equivalent.

This project report is based on a recognition of a fourth factor, the need for teachers to become involved in instructional development. The lab-lecture method which was suitable to the old course is not as suitable for PHE, and should be supplemented with a research-discovery approach. The philosophy engendered in the new course requires new instructional patterns to be implemented and this project suggests one method for such implementation.

The Project Physics Course

In order to gain a thorough understanding of the philosophy engendered in PHE it is necessary to examine its origins in the Project Physics (PP) course.

The development of the Harvard Project Physics course began officially in late October, 1963 at a meeting of the United States National Science Foundation. Discussions centered around the purposes of founding new approaches to introductory physics. The purposes were twofold. Firstly, although the PSSC program had been available for some time, there was an argument for a strategy of pluralism. Secondly, and more fundamental, was the fact that PSSC had done nothing to reverse the serious decline in physics enrollment in the United States, and many physics educators believed that it was actually contributing to physics' reputation of elitism. Dahlgren (1971) describes this aspect of PSSC physics in a highly satirical article:

> People everywhere respect an ex-PSSC student physicist; they know he's the best available. They also know that his breeding was extremely selective and that there are few of his caliber. At last count there were only eight in my class. Although PSSC do not produce their physicists in quantity, they do produce quality in their physicists. (p. 536)

After three years of intensive effort under the guidance of the three directors, Gerald Holton, F. James Rutherford and Fletcher G. Watson, PP course materials were ready for piloting. The development of the course was funded by several major national foundations and involved a large advisory council consisting of scientists, science historians and educators at all levels. The materials were piloted in 1967 in more than fifty schools across the United States, and revisions and additions in the program, in the light of a comprehensive evaluation system, have continued to this day. The first version available for general use was ready by 1970.

The PP course, as it currently exists, consists of six text modules, each dealing with a major topic in physics. Each module consists of a student guide (text) and a handbook containing experiments and activities. The Teacher Resource Book is very comprehensive, containing suggestions for organizing instruction, background to particular topics, description of learning materials, suggestions on demonstrations, experiments and activities, equipment notes, answers to problems and tests, and an annotated edition of the text. Other materials include: student readers, films, filmloops, transparencies, programmed instruction materials, tests, and special laboratory equipment. The PP program is accepted to be one of the most comprehensive physics programs ever developed.

The basic aims of this program are outlined by Holton (1967).

> First, we wish to create a coherent, tested course for use on a national scale alongside the others that have been developed previously; but it is to be a course that accentuates those aspects of physics and pedagogy which have so far not been prominently incorporated into course developments in physics on the high school level,

> although they are widely held to be desirable. We can hope, in this way, to provide variety of choice in the physics teacher's arsenal.
>
> Second, we hope to help stem the decline in proportionate enrollment in physics at the high school level--a decline which, in fact, is now reaching into the college years. Professor Watson writes, on page 212, about this deeply troublesome situation, one which is nothing less than a national educational emergency.
>
> Third, is the obvious and necessary decision to provide teachers with all the necessary aids for teaching good physics in realistic classroom situations as they now exist and are likely to exist...... Here we define good physics in the widest, most humanistic way possible, rather than in professional terms only.
>
> And fourth, our course development requires thinking entirely afresh through some quite basic questions, such as the new role of the teacher and his involvement with the class, the new desire to allow greater diversity and flexibility, and the new opportunities opened up by the developing technology of education. (pp. 201-202)

Underlying all these materials and aims is a philosophy that physics should show its diversity in the classroom. As Holton (1976) states:

> Education is achieved by imparting a point of view that allows generalization and application in a wide variety of circumstances in one's later life. This difference explains why the older, linear kind of science course, though perhaps easier to teach, is not appropriate for classes that contain students interested in the power and meaning of science, but who do not all necessarily think themselves ready to be trained as future physicists.
>
> Teachers and scientists, being members of a group that plays a key role in the total cultural life of a nation, should be proud of the existence of this tapestry of interlinking ideas, the more so as their field, physics, has a central place in the total organic structure of intellectual history. (p. 335)

E.D. Hobb (1974) describes the PP course in the following way:

> Project Physics aims at transmission of a culture to the student. Physics is seen to be an essential and significant part of the human quest for knowledge, a "beautifully articulated and yet always unfinished creation at the forefront of human ingenuity". Knowledge is a network of dispassionate facts which result from a continuing human activity, while science is itself that activity, a chronologically developing train of discovery, an exciting story in its own right. (p. 154)

This philosophy, and the aims outlined for the course, underline many aspects of its content, application and organization. The first consequence of this philosophy is the effort of the PP course and materials to reach a more varied audience. As Winter and Welch (1967) point out:

> Project Physics has developed its course to encourage diversity. It has produced a variety of materials to allow the teacher to adapt the course to his personal interest. Moreover, it has produced materials that can be used by individual students for more extensive explorations of their own particular interests. These things have been done in recognition of the existence of differences among teachers, among schools and among students, and in the belief that diversity should be fostered rather than suppressed. A logical concomitant of this view is that achievement testing must allow for differences in styles and interests. (p. 230)

The second consequence is that of updating teaching. Project Physics has been inordinately successful in enticing teachers to experiment with new instructional techniques. Educational journals are replete with reports on such experimentation by teachers. The PP course, by its built-in diversity, leads teachers to attempt to use the materials in a way which best suits their own specific circumstances. Thus, teachers are led to think of a physics program, rather than a physics text or physics course. In this way PP promotes instructional development on the part of the teacher.

Lang, Klein and Ingoldsby (1975) state:

> The development of such a program has involved experimentation with many educational strategies such as team teaching, individualized instruction, varying instructional systems, and peer teaching. (p. 409)

Other reports on such experimentation include those by John Payne (1972), LaBrecque (1973) and many others.

The third consequence is what Holton (1976, p. 334) calls the "connective approach". It is by this means that the content of Project Physics is structured. This structure involves a chronology--an historical development of content combined with sections that show physics in its relationship to other disciplines such as the arts, religion, philosophy and the other sciences.

The fourth consequence revolves around the role of physics in general education rather than simply the training of future physicists. This is what Holton (1967) calls the "social mission of physicists and teachers". He goes on to state:

> Now that jobs of the more menial kind are being eliminated at the rate of about 100,000 a year, even the simpler industrial or business jobs in our more and more technological society will require some knowledge of the physical sciences and of the elements of scientific thinking. Without this, young people will find it increasingly difficult to profit from in-plant training, from technical home study, and all other opportunities which in the 1970's and 1980's will allow them to be adequate wage earners and, indeed, citizens and parents.

> An equally important mission lies with another group which now says no to all existing high school physics courses: the larger and larger numbers who go on to college and who there concentrate in the humanities or social studies. They also have been avoiding college physics courses and usually take, at most, a general college science course, with some reluctance and little benefit. (pp. 202-203)

Holton continues, stating that such students need physics in order to fully understand the influences shaped by physics on the humanities and their everyday lives.

This, then, was the basic philosophy which guided the developers of the PP program. In summary, the major pedagogic changes brought about by this course were:

1. An undertaking that the elitism associated with physics be eliminated and an acknowledgement that physics should be open to a greater variety of students.

2. A movement away from the traditional, mathematically based, pre-college course to one based on a humanistic orientation more suitable to a wider range of student.

3. An integration of new educational technology and a resultant lessening of dependence on a text-lecture approach.

4. A recognition of the important role teachers have to play in instructional development and a fostering of an experimental approach to teaching by teachers.

5. A movement away from total test evaluation to one involving mastery learning strategies and a more broadly based evaluation system.

6. Greater stress on the student as a learner rather than the text as an authoritarian dispenser of knowledge.

Despite the successes of the PP program, no one believes that it is the final or only answer to the physics curriculum. The people involved in PP believe that a multiplicity of courses is required if physics is to reach the broad spectrum of students in our schools. It is readily understood that the wholesale adoption of the PP program in other countries may not be feasible and that some adaptation is required. Holton (1976) describes this attempt in Canada:

> In Canada, too, we insisted on a thorough adaptation to the local cultural and educational context. Hence Canadian groups made two separate adaptations, one in French (published in Quebec) and the other in English (published in Toronto). A good deal of pure and applied science is, of course, entirely international; yet I see no reason why a student should be deprived of seeing the historical connections and present applications of physical science in his or her own country. (p. 332)

Physics: A Human Endeavour

The English adaptation of the Project Physics course in Canada is Physics: A Human Endeavour. The PHE course consists of six modules: Motion, Motion in the Heavens, Energy and the Conservation Laws, The Nature of Light and Sound, Electricity, and The New Physics. Each module contains from three to five chapters on the title topic, and the student texts contained in each module run from a minimum of 84 pages to a maximum of 118 pages. Each module consists of a student text and a student handbook. The handbook contains the experiments for the module, many of which have several alternate procedures suggested, as well as student activities, filmloop notes and the answers to the end of chapter problems. These texts are clearly student oriented. The style is familiar and great pains are taken to give full and adequate explanations.

The PHE course, while maintaining the basic framework and philosophy of the PP program, differs in several important areas:

Firstly, the PHE course consists solely of a set of six modules which parallel in most cases the content of the PP modules. The lack of specially developed, supplementary materials is therefore offset somewhat by the fact that many of the PP materials are directly applicable to the PHE course. However, the lack of a teachers' manual is one of the most serious drawbacks of the course. Indeed, in choosing between PP and PHE the Physics Subcommittee of the PSCC (1976) states:

> The subcommittee has had a great deal of difficulty in choosing between these two textbooks. However, after taking into account all of the items mentioned, and after taking account of our local conditions and needs, it has decided to give top rating to Physics: A Human Endeavour. (p. ii)

The remaining differences, then, were sufficient to sway the committee in favor of PHE.

The second difference is that the PHE course is distinctly Canadian. Frequent references are made to the interaction of physical science with Canadian society and history. Examples include the story of two Canadian scientists in the prologue of each module to exemplify the work of physicists. References to Canadian places, such as

Mosport Park racing circuit, the David Dunlap Observatory, Pickering Nuclear Power Station, and the Bay of Fundy, are made frequently. Canadian contributions to the physical sciences and technology, such as the experiments carried out by Rutherford at the MacDonald Laboratory at McGill, the development of the first practical, commercial electron microscope in Canada and the CANDU nuclear reactor, are discussed. The interaction of science and society is dealt with in sections on the energy crisis and scientific freedom.

Thirdly, the PP text does not have as many solved problems and examples for student direction as the PHE text.

Fourthly, the PP course tends to carry the development of concepts well beyond the level required for our high school students. This probably arises from the fact that the PP course was developed for schools in the United States, many of which continue to Grades twelve and thirteen. It can also be seen from a short perusal of the texts that the mathematical requirements of the PP course are higher than those of the PHE course.

Fifthly, the text is new. The final module was not available until early 1976. This weighed as a positive factor in favor of the PHE course. For example, all modules are now fully metricated and bear the seal of the Canadian Metrication Commission.

Despite these differences, the indebtedness of the authors of PHE to the PP program is readily apparent. The PHE course draws heavily on PP for its structure and most of its content arrangement. Parts of the text, many tables, lists, problems, photographs, filmloops, experiments, activities and equipment are drawn directly from PP. Other materials developed for PP, such as films, programmed instruction materials, parts of tests, some of the transparencies and the student readers, are readily adaptable to the PHE course.

Most important of all, however, is that the philosophy of PP has lost nothing in the transition. If anything, for our purposes, this course might be more acceptable to a wider variety of students than is the PP program. Douglas Paul, one of the authors, echoes this philosophy. Mr. Paul (1975) states:

> The physics story is one of an interaction between nature (in the form of matter and energy), a most interesting cast of characters, called scientists, and the era in which they lived. Physics is a dynamic human endeavour, not a bunch of unchanging truths for the purpose of solving idealistic problems. It is by placing some emphasis on the human element in physics that we can better understand both the nature of science and the nature of man. (p. 54)

The need for teacher experimentation with new instructional procedures and emphases is apparent. Most teachers will readily recognize that this course, with its many suggested activities, open-ended questions, multiple-procedure experiments, and humanistic approach, cannot be easily taught using traditional lecture-lab methods. All three teachers who piloted this course found themselves adapting teaching methods and evaluation procedures to deal with it. Indeed, it was this aspect of the course which led the writer to seek some procedure whereby a rational and carefully planned instructional system could be developed to meet these needs.

The first module of the PHE course was the most logical place to start on such an undertaking, not simply because it is the first module, but for several other reasons as well. These reasons include:

Firstly, the introduction of students to the procedures involved in the LAP program would form an integral part of their overall introduction to the physics course and would establish rather than disrupt the students' study habits.

Secondly, this module contains all of the aspects of the course in general. It combines a mathematical approach in some chapters with a historical approach in others. It therefore provides a range of objective types to be dealt with.

Thirdly, this module contains the most difficult of the mathematical concepts dealt with in the course, including the introduction of graphical, algebraic and vector techniques.

Fourthly, it provides an opportunity to study the effects of the LAP program at a point where students' opinions about the study of physics were not well formed. Many of the students entering Grade ten physics have little idea of what the science is about. Thus, introducing the LAP program at this stage provided an opportunity to studying not only the students' acceptance or rejection of the learning procedures involved, but also, how their attitudes toward physics developed under this type of instruction.

A Brief Overview of the Report

Chapter I. This chapter has attempted to provide the reader with background information concerning the state of physics instruction in Newfoundland. A brief history of curriculum developments in physics, with special reference to their adoption in Newfoundland, has also been dealt with.

Chapter II. This chapter contains a review of the educational literature associated with instructional design and various instructional strategies as they affect the production and use of learning activity packages (LAPs).

Chapter III. This chapter outlines the nature of the problem to be dealt with by this project, the purpose of the project, its rationale and its limitations.

Chapter IV. This chapter describes the procedures used to develop the LAPs for the project. The development of special instructional management procedures and materials, as well as materials used to evaluate the effectiveness of the LAPs, is also described.

Chapter V. The implementation and evaluation of the LAP program on "Motion" is described in this chapter.

Chapter VI. This chapter contains an analysis of the data obtained from the evaluation procedures.

Chapter VII. In this chapter, the project is summarized, conclusions are drawn and some recommendations regarding the revision and extension of the work done are made.

CHAPTER II

A REVIEW OF THE LITERATURE

Factors in Instructional Design

A great deal has been written over the past two decades on instructional design and development. Many writers have offered strategies or models which can be adapted to make instructional development more systematic and logical. One of the basic tenets of these writers is the need for individualization of instruction in order to meet the individual differences found among students. The movement has been away from the traditional, teacher-dominated, instructional patterns to one in which the student is the focus. A second major influence on these developments has been the roles that educational technology and the teacher have to play in the new system.

Doll (1964) discusses the role of psychological, social and subject-matter influences on decision making in the whole curriculum field. He states that, before there can be curriculum improvement, there must be consideration given to the philosophy of education. This should be done with constant revision rather than a lengthy formulation at the expense of action. He gives four actions that facilitate curriculum and instructional improvement: cause the climate and working conditions in the institution to encourage curriculum development, achieve and maintain appropriate tempo; arrange for a variety of activities; and build evaluation procedures into each improvement project.

Mager (1962) makes a good case for the inclusion of behavioral objectives when planning instruction, giving reasons for their inclusion and guidelines for writing them. Glaser (1962), on the other hand, warns against total reliance on behavioral objectives. He states:

> If the end products of the learning process can be rather precisely specified, then it can be said that the student is being trained.... On the other hand, if the behavioral end products are complex and present knowledge of the behavior makes them difficult to specify, then the individual is educated by providing a foundation of behavior which represents approximations to the behavior it is wished that the student will eventually perform. (pp. 4-5)

Bloom (1965) states that there are several levels of objectives which should be evaluated. The educational system tends to emphasize the simpler types of objective, such as knowledge out of all proportion to its usefulness while tending to neglect the higher-order cognitive and affective objectives. Bloom's taxonomy tends to present to the educator the need for the inclusion of these higher-order objectives in the educational framework.

Gagné (1965) identifies in detail eight ways in which learning occurs and describes the optimal conditions for each. The structures of learning outlined by Gagné are very important considerations when selecting and organizing instructional sequences.

Piaget (1952) describes the abilities of students at various levels of their development, stating that most students are in their late junior high school years before they can reason abstractly. This is another factor in learner analysis and in the selection of instructional modes for individual students.

Bruner (1960) believes that four themes must be considered when developing instruction: the role of the structure which makes a subject more comprehensible, increases retention, aids transfer of learning and narrows the gap between advanced and elementary knowledge; analysis of readiness for learning (consideration of Piaget's work); consideration of the role of intuition and analytical thinking; and motivational considerations (including the nature of reenforcement).

Schwab (1960) states that there is a need for better scientists and a more informed public because science at present is erroneously regarded as conclusive and unalterable. To rectify the situation, he advocates more self-learned segments of courses through which the student can learn to fully understand formulation and application of new concepts.

Gillett (1973), Kinder (1973), Trow (1963) and many others point to the role of educational technology in fulfilling the need for self-learning, individualized, and small- and large-group instruction. They point to the need for the integration of educational media into the instructional scheme rather than its use as a mere adjunct to instruction.

Bloom (1971) and Carrol (1963) point out the possibility that over 90 percent of our students can learn what we have to teach them, given the optimal conditions of learning for each student and a proper evaluation system based on predetermined criteria rather than competition for a place on the normal curve.

While there may be some debate among professional instructional designers as to whether the teacher has a role to play in this area, among progressive teachers there is no doubt. The teacher not only designs his own instructional materials, but is left to manage and orchestrate the materials produced by the professional designer so that they will fit into a course. The literature contains a great deal of information on the procedures to follow in producing instructional materials. Needs analysis, learner analysis, task analysis, systems analysis, behavioral objectives, norm-referenced testing, criterion-referenced testing, formative and summative evaluation, computer-assisted marking, cybernetic-instructional systems, inputs, outputs, modifiers, and so on, are all dealt with in great detail. Such writers often give carefully analysed bits of a course as examples of how this or that model works, but rarely are these ideas transposed to the less sterile environment of the secondary school classroom.

Instead, what the teacher is exposed to is glowing reports on instructional media by the manufacturers of such media and a great deal of "armchair philosophizing" about how and when such media should be used. The teacher is left in an overcrowded and underfinanced situation where the time when courses are carefully designed as self-teaching modules which integrate many of these concepts and materials, and which adapt themselves to the individual student, appears to be receding into a far distant future. In Newfoundland, the situation, while improving rapidly, still is a long way from allowing even a single, remote computer terminal in most schools. Yet, as Cronbach (1967) states:

> My conception of strategy for adapting instruction has much in common with Cooley's (1964) proposal for "programmed experiences" in guidance. He suggests that students can be diagnosed quasi-mechanically with the aid of a computer, which can use empirically validated rules to suggest activities appropriate to the student's interests and abilities. (p. 39)

It appears, then, that students will be analysed by computers and taught by teaching machines, but while this is happening teachers still search for some less esoteric means of meeting the needs of their students now, in the time and with the facilities available. While there is no doubt that some of the models and paradigms developed by the professional educational designers and psychologists may bear fruit at some later date, and that the new wonders of electronic wizardry may some day allow us to quantify all aspects of education, today's teachers have to face several unpleasant realities:

1. Teachers at the secondary school level in Newfoundland teach an average of six out of seven periods per day. Must of their after-class time is taken up with correcting, student interviews and meetings of one kind or another. This leaves very little time for instructional planning.

2. Teachers have very little, if any, clerical assistance. Most of the larger schools average one full-time and one part-time secretary to which classroom teachers have little, if any, access.

3. Teachers rarely have access to computer terminals, let alone computer time.

4. Few schools have full-time library or media specialists. This particular deficiency is rapidly being improved as school boards set up centralized media centers to serve several schools from a single location.

5. The practise of hiring teacher aides is not carried out in this Province. Occasionally, teachers are blessed (or sometimes cursed) with student teachers who may, for a time, help in the preparation and delivery of instruction, but even this assistance is confined to the St. John's area.

6. In many instances schools are not equipped with such fundamental media hardware as filmloop or filmstrip projectors. That is to say nothing of the software which is generally too expensive for most schools to contemplate obtaining in quantity.

7. In most instances the extent of instructional design seen by teachers is the textbook on his desk at the beginning of the school year and the curriculum bulletin outlining which sections are to be covered.

8. Despite recent government undertakings to reduce the student-teacher ratio, most teachers at the secondary school level still face classes of up to forty-five students and

deal with between 150 and 200 students during a school year.

9. Secondary school teachers in this Province are not free to select the evaluation system for their course. The Provincial evaluation system is norm referenced, and, while the school sets 50 percent of a student's final mark in Grade eleven, teachers are not expected to have marks which vary much from those obtained by his students in the provincial exams.

Despite these factors, however, most teachers do orchestrate good courses for their students, often despite outdated textbooks and lack of facilities. Notwithstanding the debate as to whether teachers are really instructional designers, in many instances it is the teacher alone who carries out many of the steps given by Merrill (1971). Who else can establish the really relevant characteristics of the student to be taught at the classroom level? Who else can specify media in terms of what the school has available? Who else is there to make decisions regarding the modification of such displays? Burr (1973) describes the role of the teacher as:

> A manager of the educational program and learning processes for a group of students.
> Provide counselling and motivational support for students.
> Develop and manage instructional materials in a particular subject area.
> Listen to small group discussions.
> Seek out and organize learning experiences in the community. (p. 229)

Yet in an article entitled "Fifteen reasons not to use the Keller Plan", Ben Green, Jr. (1974) states:

> You have 500 students, no help, and no time off to prepare materials. Clearly a counter-indication. We advise people to start with a class of twenty, recruit two tutors, and allow a month to prepare materials. (p. 118)

How, then, can teachers apply the new educational theory to practise in the traditional school setting? Where can the break be made out of the current problems? Must the help come from above, or can the teacher himself break the ties that bind him to the old instructional methods? Is there a way to use the system to our advantage?

A short time in the library reveals a multiplicity of individualization models: UNIPAC, IPS, PSI, PLAN, COMPAC, IPI, LP, LAP, etc.; the acronyms abound. Such a study also reveals varying degrees of individualization, from systems where every student is diagnosed and treated differently to situations involving almost traditional, instructional patterns with some instructional options present. Lee J. Cronbach (1967) lists these patterns of adaptation to individual differences. Of those on his list, the one which seems most applicable to teachers at this time is that in which "The educational goals are fixed within a course" having "some instructional alternatives provided" as well as some "remedial adjuncts to fixed main tract instruction" (p. 140). The teacher working under the restrictions stated earlier must chose such a "middle of the road" approach to individualization. The multi-media center with hundreds of teaching aids is not a reality in our schools, and as Cardaralli (1972) states:

> If we wait for all this to become a reality, we may never get started. Budgets are getting tighter, demands on teacher time are getting greater and the need for individualization cannot wait any longer. So let us talk about a realistic beginning. (p. 29)

The Learning Activity Package

One procedure for undertaking such a beginning is the LAP. Cardaralli (1972) describes the LAP as:

> Basically, a LAP is a booklet on a given topic containing objectives related to this topic, diverse activities to reach these objectives and evaluations to determine if the objectives have been met. The flexibility of the LAP program is well illustrated by the fact that each school district that adopts the LAP program sets up a format that is somewhat unique, devised to meet specific needs. (p. 23)

This booklet, once developed, is presented to the student to guide his study either alone or in small groups. The general content of each booklet follows the basic design outlined by Arena (1970):

1. Rationale
2. Performance objectives
3. Pretest
4. Pretest analysis
5. Basic references
6. Program for learning
7. Self-evaluation test
8. Self-evaluation test analysis
9. Appendix (p. 784)

Within this framework, which may be altered to suit specific needs, provision is made for remediation at levels

4 and 7. Each LAP is followed by a quiz based on the original performance objectives and rationale. But provision is still made for a reevaluation of students by further remediation exercises after consultation with the teacher. At the end of the remediation the student may then take a make-up quiz. The student's final mark for the LAP is determined by quiz results, written reports on activities and projects, student interaction with media, student-teacher conferences, and the completion by the student of optional upgrading activities.

The other aspects of good instructional design procedures service the development and implementation of the LAP program. Establishment of criteria of mastery, student diagnosis and prescription, application of media, and management of facilities all become a part of the overall program. Feedback from the evaluation system services revision decisions so that a continual process of improvement and refinement of the program is carried out while the program is in place.

What the LAP format or an adaptation of it offers, then, is a systematic means of incorporating the important aspects of good instructional design mentioned earlier. The process of preparing LAPs may take several years on the part of a group of teachers working together or independently but it can be undertaken as a regular part of a teacher's work. After all, tests have to be prepared anyway, so why not make them all of exactly the same format and file them away for future use? Thus, instead of throwing away stencils of material after one use, they are filed away and can be used with minor modifications over and over again. In this way the teacher will save himself time in the future which can be put to better use in designing more LAPs.

A great deal of research has been carried out in the last decade which involves the design, implementation and evaluation of LAPs or some similar form of learning packages. McGovern (1975) describes feedback from teachers using LAPs as very positive:

> LAPs enhance students' self-acceptance, create a non-threatening learning mode, readily demonstrate progress to the student, provide reinforcement and a sense of self-direction, and build students' inquiry skills. (p. 13)

Unlike many other instructional design models, the LAP program places the teacher in the central design role. As Smith (1972) states:

> It is the author's opinion that, up to this point, a standardized LAP (that is, a LAP that can be used by teachers throughout the country or even in two neighbouring school districts) has not been developed. Perhaps it is because of a lack of common agreement on the part of teachers as to what content should be taught or what objectives are really important, or the lack of common learning resources in different districts, or some other reason not mentioned. (p. 28)

He goes on to recommend that LAPs should be written by the teaching staff within a school or district. Most of the people involved in LAP programs agree that, in this way, the LAPs can be individualized not only for the student but for teachers and their facilities as well.

Burnes (1973) states that individualized instruction by the modular or package format is not an all-or-nothing proposition. He believes that anything that can be done in the direction of individualization will be of help to the learner. Indeed, most practising teachers who are using LAPs warn against too ambitious a project. They advise the newcomer to enter the process of individualization slowly and with adequate feedback. They suggest that the amount of individualization in the LAPs should be increased gradually to permit both the teacher and the students to gain experience and learn their roles in the new system.

Smith and Kapfer (1972) describe many of the competencies required by both students and teachers when they undertake learning-package programs. They stress the use of positive reinforcement techniques by the teacher to promote facilitative behavior on the part of the student.

Flynn and Chadwick (1973) carried out extensive evaluation on the effects of individualization on the teacher at the Nova Schools in Florida where LAPs were first introduced. At the time of the study there were traditional, individualized non-LAP, and individualized LAP courses being offered. The analysis of results emphasized the managerial aspects of the teacher's role in the classroom under these three different conditions. In describing their findings they state:

> Compared to teachers in traditional classes, LAP teachers spent:
> (a) less time presenting subject matter information to students;

(b) less time in the management of cognitive activities through the use of non-cognitive directions, requests, etc.;
(c) more time in traffic control (e.g., taking roll, directing students' whereabouts, etc.);
(d) more time using various non-instructional materials to aid in the management of students;
(e) more time getting supplies and materials for students;
(f) more time making evaluative comments about students;
(g) more time giving grades to students and discussing grades;
(h) more time in housekeeping chores such as cleaning equipment;
(i) more time giving directions to students regarding aspects of the educational environment;
(j) more time directing students to do logistical tasks (e.g., having students get supplies);
(k) more time in events coded as "no observable, relevant activity";
(l) less time asking questions and selecting students to answer questions; and
(m) less time interacting with the whole class.

(pp. 330-331)

Among the conclusions that the writers drew from these and other comparisons made in their study were:

1. Students initiated most of the student-teacher interactions in the LAP class. Thus, it appears that the LAP program tends to put the student in charge of his own learning more than do the other two instructional programs.

2. In comparisons made between the LAP and non-LAP individualized programs, it was found that LAPs assist in the control of students and in the instructional duties of the teacher.

3. It was also found, however, that teachers tended to spend more of their time in logistical and environmental

control problems under the LAP program. They became involved in rather mundane matters rather than spending their time more usefully in diagnostic and prescriptive activities for their students. Thus, the writers suggest that models of teacher performance under LAP conditions should be developed and that extensive training of teachers in these roles should be undertaken.

Gerald Ubben (1973) reports on the LAP as a "beautiful design for an individualized management system". He states that such a design can be sequenced to provide continuous progress learning and remediation while leaving the teacher free to help students by diagnostic and remedial activities. All writers warn that teachers should not get bogged down in trivia because the LAP gives them some free time. Such time should be used to interact with students.

Kemp (1971) describes the need for careful selection of media in meeting the instructional objectives in each LAP. He suggests that one method of making such decisions rationally is to make use of a "criterion-questions/flow diagram" which leads the designer through a series of questions to the best selection of media. He also reviews several other designs for selecting media but warns that even the most modern of these are still in the development stage and much more research in this area still needs to be done.

Duane (1973) points to the need for careful evaluation of the LAP in the development stage and provides an evaluation guide to assist the LAP designer. McGovern (1975) also provides a more comprehensive evaluation guide for this purpose (see Appendix D).

The LAP program, then, if carefully designed, initiated, and evaluated, can meet most of the requirements of soundly based instructional design leading to a relatively sophisticated form of individualized instruction. Further, it can provide a base upon which future improvements in the instructional system can be built. The design of the full LAP program, however, involves not only the production of activity packages but several other aspects of instructional design as well.

Instructional Design and the LAP

The LAP program places the teacher at the center of the process of overall instructional design. This, in itself, is no radical departure from what has traditionally been happening in our schools in the past. Whether this trend will continue, or be an interim measure, is a moot point. The professional designer working for educational institutions or industry is gradually drawing together the strings of educational psychology, technology and research to produce whole new designs for course construction and what Glaser (1971) calls "the development of engineering enterprises that back up the teaching profession" (p. 18). However, at this point in time, the teacher can no longer wait for such all-pervasive backup. Instead, the teacher must become the instructional designer, drawing upon what is now known about producing, if not ideal then at least practical, solutions to the problems of individualization and mastery learning strategy. What is new, then, is the application by the teacher of a scientific approach to instructional design based on the models and paradigms of the researchers in this field.

Reduced to the essentials most instructional design systems contain the following pertinent aspects:

1. Analysis of needs, context, learner, and tasks.
2. Statement of behavioral or performance objectives.
3. Prescription of teaching and learning strategies.
4. Organization, appraisal and design of materials.
5. Initial testing and evaluation of program.
6. Feedback to service revision decisions.

The interrelationships between these elements have been described to some extent previously in this paper (see p. 40) and are organized by various designers in slightly different ways, depending on the particular instructional task to be undertaken. The production of LAPs is complicated in that they serve to integrate various learning tasks for the student. The organization outlined by Davies (1973) appears to serve this function well.

Step One, "Analyse overall system", is often referred to in the literature as needs and context analysis. Popham (1972) defines an educational need by the following paradigm (p. 22).

Desired educational outcome − Current status = Educational need

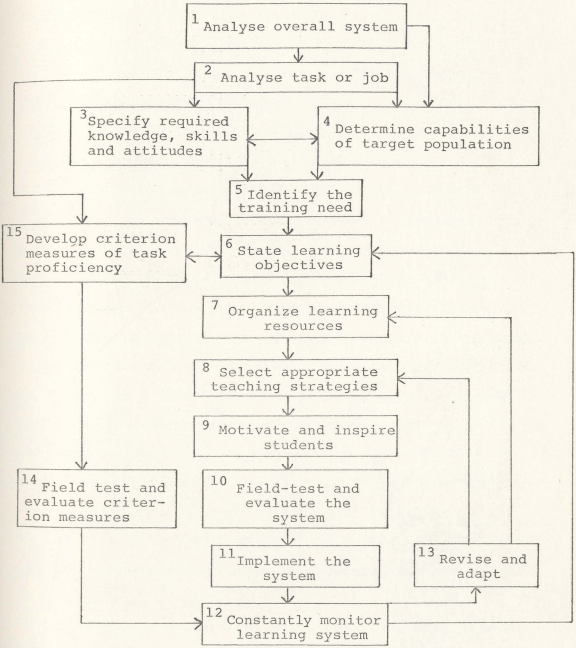

Figure 2.1. The steps involved in developing a learning system.

(Copied from I.K. Davies, Competency Based Learning: Technology, Management and Design, McGraw-Hill Book Co., New York, 1973)

In this context, then, an educational need refers to the required changes that a particular instructional design is meant to bring about.

In looking at the current status, the following points can be readily perceived:

1. Teachers rarely follow a basic overall design for their instruction, which is carried over from one year to the next. For example, tests developed one year are often used, scrapped, and the process repeated in the following year.

2. Since there is rarely a rational plan to instruction, the evaluation of the instructional system used by teachers is a difficult undertaking. Such evaluation by the teacher of his methods only occurs when a particular lecture or experiment is a dismal failure, in which case it is usually scrapped and a different attempt is made.

3. Although we pay lip service to individualization, little has been done to even get started on a systematic plan that will lead to greater individualization.

4. Educational technology is being used as a mere adjunct to instruction rather than forming an integral part of the process.

5. Although mastery learning techniques have been discussed in the literature for well over a decade, quizzes are still treated as a weeding-out process rather than a diagnostic tool. Remediation is still left a great deal to student home study. In all too many cases, instruction is still geared

to the average student. Those attaining below-average marks are sent to "watered down" courses or leave school altogether, and those attaining at above-average levels are left to become bored with instruction because of a lack of challenge.

The desired outcomes are the antithesis of these conditions. The need is for a well designed instructional system which provides for individualization, the integration of the technology available, the development of criterion rather than norm-referenced evaluation, feedback and improvement of the system, and remedial and advanced loops for students.

The context within which these changes must occur have been described to some extent previously (see pp. 41-42). However, some positive action is being taken in our schools. Many school boards are introducing the development of centralized media centers in their districts where expensive equipment not normally available to individual schools is being provided along with expert media specialists to explain its operation and the role that media can play. As more and more teachers begin to use these facilities they begin to demand improved facilities within their own schools. When such facilities become readily available to the teacher, it is only a short step to their integration into the instructional system.

A second important improvement taking place is the gradual replacement of old courses by new programs which call for the integration of media. Physics: A Human Endeavour, CHEM study, the new social studies course, and the new French course, are examples where it is becoming increasingly difficult for the teacher to stick to old, instructional patterns.

Thus, teachers are increasingly aware of the context within which these programs are being introduced. Closer attention is being paid to the support facilities, media equipment, costs, delivery systems, scheduling, and evaluation systems than at any time in the past.

Learner analysis involves the establishment of factors which determine a student's readiness to learn. In most instances the rationale of the high school teacher has been "we take 'em as we get 'em." A student's marks in Grade nine generally determined which course a student would take in high school. Rarely did students with marks averaging below sixty percent in junior high school get a chance to take physics or chemistry. Despite any improvements he made he was locked into a general or non-matriculation program by his Grade nine marks. The problem with this was that it is often in high school that students pick a direction for their lives. However, a student who entered high school with low marks and while there decided that he wanted to become an engineer, or enter some other technical field, could rarely enter physics or chemistry despite improved marks or attitudes.

Further, it was not necessary for teachers to analyse their students because they were all treated the same anyway. However, with greater latitude now being offered students to pick their own courses, and the increasing use of individualization, student analysis is becoming more important.

The step from analysis to prescription of learning methods is still a problem. As Carroll (1971) states,

> I predict the study of instructional methods and individual differences is going to be extremely difficult and frustrating, even if it is "most interesting" psychologically. Cronbach has already pointed to the inconsistency and inconclusiveness of the available literature. It is then possible that research will never be able to come up with a sufficiently solid set of conclusions to justify being adopted into educational practise.

Despite this difficulty, however, some basic analysis and prescription can become part of the instructional design. Such prescription may be on a "hit or miss" basis for a time but teachers may be the ones to discover just what the relationship between learner and task type, and the type of instruction to use in each case, is. At any rate, this type of research is going to require a very large quantity of data for its solution. Perhaps this is one area in which the teacher can help the researcher.

Task analysis consists of isolating component behaviors comprising an overall goal, isolating the conditions for the behaviors to occur, and determining acceptable levels of performance. Such analysis, as proposed by Davies (1973), Gagné (1965) and a number of others, assists in breaking the objectives into discrete but interrelated steps for which the conditions of learning, behavioral objectives and performance levels can be specified. Such analysis should check the components of the task for relevance, completeness, triviality, necessity and redundancy.

Instructional objectives arise from the task analysis. The importance of such objectives, stated in behavioral terms, is stressed by many writers. Mager (1962) states, "When clearly defined goals are lacking, it is impossible to evaluate a course or program efficiently, and there is no sound basis for selecting appropriate materials, content or instructional methods" (p. 3). Such an objective, Mager continues, has three important attributes; it specifies the terminal behavior required, it defines the conditions under which the behavior is to be carried out and it defines the criterion of acceptable performance.

Tyler (1964) and Gagné (1965) explain that such objectives are important as a guide to the instructional designer, to establish teacher roles in instruction, to establish student roles in learning and in defining reinforcement situations for the learner. Some, however, point to an overestimation of the importance of such objectives as a necessary first step in curriculum development. Eisner (1969) states that there is a danger of excluding from the curriculum everything that cannot be stated in behavioral terms. He points to the need for the inclusion of more general or "expressive" objectives if we wish to educate rather than simply train our students.

The next step in the instructional design process is a three-phase, interrelated process involving the establishment of teaching-learning strategies, the selection of learning materials and the designing of component materials not available from other sources. Davies (1973) defines teaching strategies as "broad methods of instruction", for example, lecturing, tutorials, case studies, etc., and distinguishes these from teaching tactics which should be related to the type of learning occurring. Thus, signal learning might best be carried out by questions and answers where many examples and quick reinforcement can be given. Chaining might best be learned through the use of a sequential medium such as slides or overhead transparencies with overlays.

The "conditions of learning", as described by Gagné (1965), and the selection of media and tactics as a result of these conditions, present the designer with many alternatives. These alternatives may show up in the structuring and selection of activities assigned in the learning package. This may vary from teacher to teacher, depending on his preference for certain tactics or possibly simply because certain tactics are not open to him due to lack of delivery systems. Indeed, in some instances, as Ubben (1973) suggests, the choice of media or tactic may be left to the student who may be able to select the learning tactic that he has found most suitable for his learning.

Steps 10 through 14 of Davies' organization chart might be succinctly summed up as evaluation. Taba (1962) describes evaluation as including any way of securing valid evidence on the attainment of objectives, including: testing, records, and observation. Stufflebeam (1968) states that the purpose of evaluation is to provide information for making decisions. More specifically, evaluation is defined as the process of acquiring and using information for making decisions associated with planning, programming, implementing, and recycling program activities. He describes four types of evaluation to be undertaken: context, input, process and product evaluation, each associated with a particular type of decision. Context and input evaluation have already been described. Process evaluation provides feedback from the implementation of the program and services control and refinement plans and procedures. This is what Scriven (1967) would call formative evaluation.

Product evaluation relates the information on the outcome of the program to objectives and to context, input and process data. It is this final information which services the decisions to continue, terminate or modify the program.

The net effect of such an evaluation system, when built into the instructional development system, is to provide relevant data for continuing revision and improvement for as long as the program is in use. The danger here, however, is to become so bogged down in obtaining data that little improvement takes place. Evaluation is probably the most researched topic in all of education, with models and systems of various types abounding in the literature. The developer-teacher must be careful to retain control of the evaluation system and not let it become the main function of the program. Too much data can overwhelm, rather than assist, in program development if it is allowed to.

Mastery Learning, Individualized Instruction and the LAP

"We begin with the hypothesis that any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (p. 33). Bruner (1960) summarizes much of modern educational theory with these words. Effectiveness or efficiency of instruction is the basis upon which mastery learning is based. "Intellectually honest" applies to Gagné's conditions of learning, and stage of development may be taken to be based on Piaget's ideas about student stages of intellectual readiness.

Assuming, then, that an effective way can be found to teach different students at different stages of their development, there should be few, if any, failures within our school system. As Bloom (1971) states:

> Most students (perhaps over 90 percent) can master what we have to teach them, and it is the task of instruction to find the means which will enable our students to master the subject under consideration. Our basic task is to determine what we mean by mastery of a subject and to search for the methods and materials which will enable the largest proportion of our students to attain mastery. (p. 1)

Dunn and Dunn (1975) state:

> It is only recently that we have begun to apply our knowledge that each youngster learns in a manner that is uniquely his own, through perceptual strengths that either fortify or discourage his acquisition of knowledge and skills, and with a learning style that tends to dominate his every effort to achieve. (p. 19)

Individualized instruction is based on the hypothesis that the school environment can be arranged so as to teach and structure learning to take advantage of the "perceptual strengths" and "learning style" of each student at whatever stage of development we find him. Of course, it is impossible for a single teacher to do this for over two hundred students each year without help. As is pointed out by most writers of books on the media, this is media's role. The teacher's role, then, becomes one of structuring instruction around media and directing student interactions with various media forms. Thus, Bruner's original hypothesis implies mastery learning strategies, individualized instruction and use of educational technology to provide the most efficient learning structure for each student.

The mastery learning strategy outlined by Bloom has other implications for the individualization of instruction as well. Carroll (1963) defines aptitude as the time required by the learner to attain mastery of a learning task. Thus, not only should instructional procedures be modified to fit each student, but the time limitations set for such mastery should also be flexible. Bloom believes that, discounting the top five percent who may have special, inherent aptitude for a particular subject and the bottom five percent who may have inherent difficulties, there remains 90 percent of students where aptitudes are predictive of rate of learning rather than rate of success. Despite the effects of the use of optimal learning conditions for each student, time allowances need to be varied also. Thus, it cannot and should not be expected that all students in a class will be at the same point in their instruction at all times.

Another point here, however, is that the time required by some students to attain mastery of a particular unit may not be worth the effort. At that point the student should be guided into areas where his aptitudes and learning abilities are more suited to the task.

The third implication of mastery learning strategy involves the evaluation system. The present norm-referenced system produces what Bloom calls a "self-fulfilling prophecy". Since, in the norm-referenced system, it is expected that a certain percentage of students will fail, the evaluation system is set up to achieve this end. Tests and examinations are geared to test what students do not know rather than what they were expected to know. Certain questions are often placed on such tests to "separate the men from the boys" in a particular subject area, and the result is to produce exactly that distribution of marks that was expected in the first place.

Criterion-referenced testing is based on the assumption that the objectives and criteria of acceptable performance are laid out in the beginning of the course or unit of work and that the students are aware of them. If a student fails to show mastery on the first attempt, then the learning system works to provide the student with remediation until mastery is attained. In this way the expectation is that at least 90 percent of students will attain mastery and the self-fulfilling prophecy becomes one of success rather than failure. If, on the other hand, mastery is not reached by a majority of students, something is wrong with the instructional system itself, and decisions must be made regarding the recycling of criteria, objectives, tactics or evaluation procedures.

Bloom suggests that the criterion of acceptable performance may be established by looking at the A-level standard of the preceding year. Establishing this as the base line, an attempt is made to get all students to this level. In order to accomplish this, the course is split into short sub-units; the elements of each sub-unit, such as terms, concepts, principles, applications and analysis of principles, are determined and brief diagnostic tests are constructed. Such formative evaluation paces student learning, increases motivation and insures that each learning task is mastered before subsequent tasks are undertaken. These diagnostic tests are used to prescribe remedial materials for the student.

It should be readily apparent at this stage that the LAP is structured to fulfill many of the steps outlined by Bloom in his mastery learning strategy. The following table draws a parallel between these two instructional strategies (see Figure 3.2, page 56).

MASTERY STRATEGIES	LAP FORMAT
Improved specificity in regard to goal selection, description, and task and evaluation procedures	Provision of rationale and behavioral objectives based on task analysis
Improved pretesting procedures	Use of pretests, knowledge and aptitude inventories
Improved diagnostic procedures	Self-tests and interviews
Awareness of student background and problems	Make-up tests and remediation exercises
Alternate instructional procedures	Activities include use of media, remedial activities and quest activities
Allow time for mastery	Some scheduling required but some time permitted for remediation by those who have not attained mastery, while those who have either help or undertake quest activities
Non-graded school	Impossible under current conditions

Figure 2.2. LAP format and mastery strategies

The mastery learning model makes it apparent that if the instructional system is working properly, even under present restrictions, then it should be possible for at least 80 percent of our students to attain a B-grade or better. There is, however, one important reservation to be made about the adoption of a mastery learning philosophy. There will be a tendency among teachers and administrators to protect the present system by adjusting the input so that the output meets with acceptable levels. That is to say that teachers may inadvertently set lower mastery criteria so that, in fact, 80 percent of students meet the criteria set. Such an occurrence would have a disastrous effect on education, leading to the downgrading of the system to such an extent that it would become useless. What should always be remembered is that failure to meet the criteria established for the system means that the system needs improvement, not downgrading. In essence, then, mastery learning is a striving for excellence, not only on the part of the student, but also on the part of teachers and instructional designers, and like all such striving, we cannot hope for immediate success.

Technology and the LAP

One of the most important influences on instructional design in the past two decades has been the influx of educational technology of all kinds into the learning situation. While such technology is associated most often with the electronic media, Gillett (1973) states:

> Educational technology, in the broad sense, is a systematic way of designing, applying and evaluating the total process of teaching and learning. Ideally it functions through co-ordinated action of personnel and instructional media to promote more effective learning and gain increasing precision in control of environ-mental factors involved in learning. (p. 2)

Technology and media are not synonymous terms. The Association for Educational Communications and Technology of the National Educational Association defines educational media as follows:

> Educational media are defined here as those things which are manipulated, seen, heard, read or talked about, plus the instruments which facilitate such activity. Educational media are both tools for teaching and avenues for learning . . . (Morris, 1963)

Thus, the LAP is one form of educational technology which attempts to integrate educational media into the learning process. The basic function of media in the LAP is to pro-vide alternate means of instruction to meet individual needs. Before this can be done, however, the state of educational media in our schools must be closely examined.

Electronic media provide for audio and video storage and display, reproduction, and computational facilities unheard of in the schools of thirty years ago. Such recent developments as the cheap pocket-calculator and videotape record units are placing at the disposal of the teacher and the student means of learning unheard of even a decade ago. But media also include books, pictures, diagrams, charts and other printed material, as well as slides, movies, filmstrips, filmloops, transparencies, and programmed instruction materials.

While these tools offer many possibilities for teachers and students, there have been a number of problems associated with the introduction of the newer media.

Rapid obsolescence and incompatability. New developments in the more complicated media such as video recording and computer technology have left some schools holding obsolescent hardware that is difficult to get repaired and is incompatible with the newer systems now coming on the market.

Lack of coordination. Media has been purchased in many cases as the spirit moved. Rarely has any attempt been made to assess the media needs of a school and order accordingly. Only when fully trained media specialists become a part of the school's staff does this occur. As a result, in many instances, the school has an expensive videotape recorder and no overhead projector.

Failure of teachers to use media even when available. A study undertaken by John Weins (1968), designed to provide information regarding the extent of diffusion of a number of innovative practices and to reveal the nature of the influences and their structures which might have a bearing on the adoption of those innovations within individual schools, showed:

(a) 50 percent of teachers made no use of television, while only five percent used it frequently;

(b) 50 percent of teachers made no visits to the instructional service centers; 40 percent made absolutely no contact, and only 10 percent were frequent visitors;

(c) Tape recorders, record players, film-strip/slide projectors, movie projectors and overhead projectors had been available in the school for years, yet only 11 percent of teachers indicated they had used them within the last five months.

These results indicate that, even though equipment was available, and accepted at first, it was rejected at a later date. Thus, the problem becomes one of not only implementing but maintaining change.

Unavailability of media software. Tanzman and Dunn (1963) ask, "Can software keep pace with hardware? Already we have boxes that can talk but have nothing to say" (p. 5). Very often teachers realize that a particular concept or principle may be better taught by the means of media but the material is not commercially available.

Difficulty of setting up media situations. The very environment of the older school does not lend itself to the use of media. Generally, in order to show a short film of slide-tape presentation, the whole class must be taken to the projection room. In many cases the effort does not justify the result.

Cost factors. The cost to schools of providing media in the classroom where it is needed is extremely high. The addition of drapes and screens to every classroom in a school runs into thousands of dollars. Color films are generally available only on loan and rarely at the time when they are required. Further, there is little research on the cost effectiveness of such media and the mood still prevails among administrators that such media are really frills in the educational system.

Trow (1963) states:

> It is, no doubt, evident that no explosive educational revolution is imminent, but that the rate of evolutionary change is accelerating. Further, it is evident, at least in the author's opinion, that the millenium of education will not be ushered in by the purchase of a truckload of teaching machines and another of television equipment. The new media provide the occasion for overhauling educational machinery, for throwing out what is ineffective and even detrimental, but for retaining what is good and necessary.
>
> The new media will not be particularly effective so long as they remain mere aids or adjuncts, an intrusion, a fifth wheel to the educational conveyance. The new parts need to be integrated into a man-machine system, and this requires clear-cut readjustments in organization and procedure. The required changes may take a little time but they are well within the range of feasibility. The educational technologist envisions not machine-produced robots, but a smoothly functioning system in which the several processes it employs are all operating to turn out its product--and that product is educated people. It is not realistic to expect that the product will be perfect. But the schools of tomorrow can be far better places to live and to learn than the schools of today. (p. 180)

Thus, despite the factors mentioned above, media and the supporting technology are becoming an increasingly important part of the instructional system. The need for teaching our students to the ultimate of their capabilities is making the gradually increasing use of this technology mandatory in the progressive educational system. It is through the introduction of such systems as the LAP that teachers will be made to realize the necessity for such technology, and that is a prerequisite for its use. Research shows that LAPs can be made to work under present conditions but the deficiency of media will surely be felt by anyone using them.

Such a statement is not mere speculation. A great deal of statistical evidence is mounting to show that instructional media can increase the efficiency of effectiveness of instruction. In a review of such research, Molstad (1974) describes the results of a large number of studies in which media were used to assist in conventional instructional modes or to replace such modes by self-teaching and discovery-learning programs.

He cites a study by Rulon (1933) which showed an increase in short- and long-term retention by students using films plus text over those using just texts alone. Other studies by Nelson (1952) and Wendt and Butts (1960) tend to confirm Rulon's findings. Research by Clayton Chance (1960), Kelley (1964) and Menne and Menne (1972) showed increased learning on a number of variances when overhead transparencies, filmstrips, and videotapes were used to assist in convention-type instruction.

The replacement of conventional instruction has also been the subject of much study in recent years. The use of programmed instruction, multi-media, audiotutorial and computer-assisted instruction has proven, in many instances, to improve instructional efficiency and effectiveness.

Research by Sparkes and Unbehaun (1971) showed that audiotutorial teaching produced significantly better scores on a biology exam after one semester than did conventional teaching. Paul J. Cowan (1967) conducted a study in which the use of autoinstructional materials produced a reliably higher achievement level than did conventional instruction. The amount of such empirical evidence is growing steadily.

Another important factor is worthy of note, that is, the important role that teachers and students can play in the production of media software. Bullough (1974) details some of the problems involved with commercially produced materials.

1. An item is often created to serve as large a segment of the potential market as possible and therefore contains material which is redundant or extraneous to the concept being taught.

2. Some are too overburdened with material to be effective, while others are too simple.

3. Materials often cannot be obtained when needed.

4. Software in quantity is often very expensive.

Kinder (1973) states:

> Teachers gain valuable insights from producing some of their learning materials. As they produce materials, they inevitably evaluate them, a process which, as we have seen, increases teaching efficiency. The preparation of materials also enables the teacher to visualize content, to put it into that form which best suits his teaching conditions. It is natural for anyone who has created something to take pride in that creation. Although teachers may complain about time spent in producing materials, they usually enjoy the

> work and resent any attempt to force them to forego this effort. (p. 232)

He goes on to show several other advantages of local production, including:

1. The provision of up-to-date materials not otherwise available.

2. The treatment of local problems, applications and situations.

3. Saving money by using voluntary labor.

4. The saving of teacher time in the long run because such material can be used over and over.

Modern reproduction and photographic techniques make the production of materials by a knowledgable teacher and his students relatively simple. The types of materials that can be produced range in complexity from simple posters to a full-scale, videotape production.

Research by the Secony-Mobil Oil Company, the Minnesota Mining Company and P.J. Phillips, quoted in Wilkenson (1971) and Kinder (1973), show that people remember approximately:

10 percent of what they read,
20 percent of what they hear,
30 percent of what they see,
50 percent of what they hear and see,
70 percent of what they say,
and 90 percent of what they say as they do a thing.

It seems that the key to this progression is involvement. Thus, the production of media software by students who read, hear, see, say, do, and write something in the process has much to recommend itself not only as an aid to retention but in motivation, higher-order cognitive and affective learning. Thus, students should use the media in an active as well as a passive way. In this way "The medium becomes the message", as McLuhan (1964) points out, and the prophecy made by Trump (1967) can come true today:

> In the school of tomorrow, students will undertake special projects which they have selected themselves, or which teachers have suggested. The projects will clarify, add to, or enrich subject matter presented in large classes and further explored by discussion in small classes. Teachers will learn to present materials in an open-ended manner. That means in such a way that students will be encouraged to question the information, rearrange the data, seek further answers, and try to surpass previous accomplishments. (p. 27)

CHAPTER III

THE PROBLEM

Statement of the Problem

The problem dealt with in this project was the development of an instructional system as a follow-up to earlier curriculum development. The instructional system was to accomplish the following objectives:

1. Provide a base for constant revision, improvement, and updating of learning materials and procedures.

2. Provide a vehicle for the integration of all available media into the instructional system.

3. Promote student involvement, interest and mastery of content.

4. Provide procedures for independent study, individualization, student research and discovery learning.

5. Provide adequate direction for classroom management during independent study.

6. Provide adequate evaluation of student mastery of content and research skills.

7. Suggest areas for purchase and production of new media.

To summarize, the problem was to provide an instructional system which would meet the philosophical and pedagogical needs of the new physics course while providing teachers with a workable method of classroom and materials management.

The Purpose of the Project

More specifically, the purpose of this project was the development of a set of six learning activity packages (LAPs) to accompany the first module of the course Physics: A Human Endeavour (Paul, Peirce, Stief, 1974). This course was introduced as a pilot program by Mr. R. Anthony and the writer in 1974 and was accepted by the Newfoundland Department of Education to replace the old course, Modern Physics (Dull, Metcalf, Williams, 1964) by 1979 after a three-year "phase-in" period.

The development of the LAPs also included the production of student and program evaluation materials and the development and production of certain media software to accompany the LAPs. Also included was the production of lists of laboratory and media software available commercially to be used with the course (see Appendices).

Thus, a program of activity packages constituted an instructional management system that made it possible to preplan a large number of learning sequences in order to achieve a multi-media, multi-level, multi-procedural system of instruction. It also provided for the preplanned use of educational technology in the learning situation, an essential element if we are to make adequate use of such technology.

In the field of testing and evaluating these materials, an attempt was made to answer the following questions:

1. How did the use of these materials affect student mastery of subject content?

2. How did the use of these materials affect student attitudes towards physics?

3. Did the procedures, as outlined by the materials, form a manageable, instructional system for teachers?

The Significance of the Study

This project is viewed by the writer as a consequence of his previous involvement in the curriculum development associated with piloting the new physics course Physics: A Human Endeavour. The instructional development phase of the work involved in establishing a new course is to involve the production and field testing of LAPs for the first module of the new course.

If the results of this project justify it, the use of LAPs should be extended to the other modules of the course. During this time the materials will be disseminated to other interested teachers who will be asked to aid in the development and revision of the materials. Such an effort could include the testing of new audiovisual materials, experiments and reading materials, the production of revised LAPs and the production and testing of a comprehensive evaluation system.

The maintenance by teachers of old instructional patterns is often caused by the lack of supportive materials and the knowledge of how and where to use them. Few teachers have the time or inclination to test such materials and instructional procedures unless adequate information is provided as an integral part of the new course program. This situation is further compounded by the fact that physics enrollment is so low in most Newfoundland high schools that teachers have only one or two physics classes to teach. Thus, physics is rarely the major interest of such teachers. Few teachers, however, would refuse to make use of such materials if adequate information was provided and if they were convinced that such procedures would help to improve instruction.

Blake and McPherson (1969) point out the following advantages of a well developed, individualized instructional plan for teachers:

> (1) It frees the teacher from teaching many of the routine basic skills of the subject.
> (2) It enables him to meet more accurately the individual need of each child.
> (3) It furnishes him with diagnostic devices.
> (4) It allows him to spend more time with students who need the most help.
> (5) It enables him to bring a structured, carefully thought-out program to his pupils.
> (6) It helps the teacher to serve not only as a lecturer but also as a guide to the pupils in his efforts to increase his (sic) knowledge of a given subject. (p. 65)

Also, as Haney and Ullmer (1970) state:

> A teacher is asking too much of himself to try personally to provide all the stimuli required for learning. Let the media do it. The teacher's job is to organize the circumstances that provide the best opportunity for learning and to ensure that learning takes place. He can ease his own burden if he uses media to its (sic) best advantage and builds replicable, instructional episodes around media forms that can be repeated for successive classes. In plain talk, once he has the "system working", he can spend less time talking and more time on planning and evaluation. He can cease being a drill sergeant and become, instead, an educational executive. (p. 7)

If, then, information can be provided to the teacher with the new course, listing available and useful materials and instructional techniques, and filling in the gaps with locally produced materials, most of the follow-up to curriculum development can be accomplished. When this is coupled with a practical, instructional management system, the teacher has the basis upon which he can build effective instructional development.

Thus, the significance of this project lies in the development of just such an instructional management system designed to promote teacher experimentation with individualized instruction techniques, the integration of new types of media hardware and software, and the local production of media software.

The project's significance is further accentuated by its introduction in conjunction with a new course. Teachers are aware that the new course is to supplant the old one over the next few years, and they have displayed an interest in obtaining relevant information.

Definition of Terms

For the purpose of this study, the following definitions were adopted:

Learning Activity Package (LAP). An organized sequence of learning instructions to guide the student, as an individual or in small groups, through a series of learning activities and evaluation procedures which will lead to the mastery of a set of prestated learning outcomes on one short topic of significance is termed an LAP.

Instructional management system. A framework within which various learning activities may be carried out is termed an instructional management system. The system involves procedures and strategies on the organization and management of learning materials, instructional techniques and evaluation.

Curriculum. A structured series of learning outcomes which are the output of the curriculum development system, and the input of the instructional development system, is defined as the curriculum.

Instruction. The interactional processes that occur among students, teachers and the school time environment are considered to be instruction.

Individualized instruction. For purposes of this study, the individualization of instruction will include the provision of instructional alternatives and adjuncts to fixed main-tract instruction.

Physics. The scientific study of the interaction between matter and energy. For purposes of this study it also involves the historical development of the science, as well as its interaction with contemporary society.

Limitations of the Study

This study, being developmental in nature, was restricted in the following ways:

1. No attempt was made to test the applicability of the procedures used to other than grade ten students.

2. The study was limited to the development of materials on one topic of the physics course, namely, motion.

3. The materials developed make direct reference to passages in the text Physics: A Human Endeavour and are not readily applicable to other texts.

4. The project was limited to field testing in two large urban high schools. The applicability of the materials to smaller schools with different facilities cannot be readily judged.

5. The study was not intended to evaluate LAPs in general nor individualized instructional procedures in general. The conclusions drawn here are restricted to those materials specifically developed in this study. However, it was possible to draw some tentative conclusions to spur future research and development in this area.

6. As a developmental study, the treatment given to the test group was not fixed but was left flexible and was adjusted in the light of formative evaluation as the project was implemented. The study, therefore, was not a strictly experimental study but a field test.

7. Random sampling of treatment groups was not possible. Instead, intact class groups with readily discernible differences were taken as subject groups in both schools.

In reference to number four above, it follows at the outset that any attempt to develop a comprehensive system of

LAPs to meet the needs of all schools with their differing facilities and equipment will be doomed to failure. Only if all schools had the same equipment and facilities could such an undertaking be conceivable. Indeed, such an undertaking was not envisaged; rather, this study has as its main objective the testing of the procedures involved so that other teachers can develop LAPs of their own or adapt those already produced to make them consistent with the facilities and equipment which they have available to them in their own schools.

CHAPTER IV

DEVELOPMENT OF MATERIALS

The development of materials for this project began in the fall of 1975 out of an effort to preplan instruction for the PHE course. Up until that time the writer had conducted instruction using many of the methods described earlier in this report, i.e., the use of media as an adjunct to instruction, the scrapping of test forms and results after one use, the use of tests as a method of rating students rather than as a method of diagnosing their problems, etc.

After teaching the Modern Physics course for a period of ten years, the writer knew the book "backwards" and for the most part was content to continue with the old methods of instruction with a few minor modifications from time to time. However, despite good public examination results, dissatisfaction with the course and instructional procedures grew until finally the writer and a close associate, Mr. Roy Anthony, undertook to pilot the PHE course. This course offered the opportunity for a new beginning. The traditional lecture-lab approach did not fit in well with the new course for reasons outlined earlier and changes had to be made.

Originally the reorganization was to take the form of preplanning a series of lectures with integrated use of media and appropriate demonstrations suggested by the new course. It soon became apparent, however, that this would still retain the student in his mainly passive role, while the aim was to get him involved actively with the course and its materials. Meanwhile during research for a course in instructional design, the writer came across the idea of LAPs. These seemed made-to-order since such a program provided a means for preplanning instruction while, at the same time, provision could also be made for student involvement and a constant process of program revision and improvement. Also, it seemed that the LAP program could be made to operate within the framework and with the facilities then available within the school.

Work was begun on the LAPs for the first module of the PHE course following the Davies learning system development chart (see p. 44), with some minor modifications brought about by the peculiar nature of the LAP. The result was the production of the five LAPs to accompany the first module of the PHE course entitled Motion (see Appendix C). These are considered to be a first approximation and will be revised, edited, and extended as a result of the data gained from the field test described in this study. The following sections of this chapter outline the procedures used in developing the LAP program for the first module.

Context Analysis

Before undertaking such a program it was necessary to look at the environment in which it was going to be used. Luckily, much of this context analysis had already been carried out for the introduction of the new course. This analysis included:

1. Stocktaking of all laboratory facilities and equipment.

2. Stocktaking of all media hardware and software associated with physics within the school.

3. Establishment of costs entailed in the introduction of the new course.

4. Establishment of the facilities and equipment required for the new course, including a complete list of laboratory equipment (see Appendix H) and a list of media available commercially (see Appendix I).

The results of the analysis of materials and facilities available and required led to a program of gradual upgrading of the physics laboratory facilities. In this the writer was helped immensely by the cooperation of the school principal, Mr. Tilley, who saw to it that the laboratory was provided with drapes, a fold-away projection screen, a standard filing cabinet, a thirty-drawer filing locker, and an assignment cabinet.

A second, important factor was the provision by the Department of Education of additional funds amounting over a period of four years to approximately 2000 dollars for laboratory equipment. This, together with the regular lab grant of approximately 300 dollars per year, has permitted the stocking of the laboratory with most of the equipment required to carry out all the activities and experiments described in the text.

A third, important factor has been that the writer was probably the first in the school to make full use of the media hardware available. A collection of a movie projector, super-eight filmloop projector, filmstrip projector, slide projector, tape recorder and television has been appropriated for the physics laboratory without the slightest problem.

The fourth factor which has enabled the improvement of facilities and materials was the establishment in our school of the school board's regional Instructional Media Center. This center is fully equipped for the production of various types of software and contains hardware nor normally available to schools in the system. Mr. Staple, the Director, has been extremely cooperative in assisting in the production of materials and in helping students in the production of projects involving the use of media. One such project in which he assisted two physics students to produce a slide-tape presentation entitled Man In Space was ultimately shown at a meeting of the Royal Astronomical Society of Canada at Halifax in 1976. It received recognition from the Dean of Astrophysics of McGill University and is currently the subject of a CBC production on student projects (see Appendix G).

In terms of facilities, the program is fortunate. Constant improvement is occurring, guided by a plan which includes the setting up of individual viewing screens at the back of the laboratory, ordering of new software, and the local production of materials by teacher and students.

Scheduling restraints have been lifted somewhat by the inclusion of five 40-minute periods in Grade ten physics, up from four last year. However, scheduling is still fairly inflexible and most probably will remain that way for some time. Evaluation procedures are also relatively fixed, with major examinations accounting for from 60 to 70 percent of a student's final mark. Thus, all the activities and projects which the students undertake are worth only 30 to 40 percent. This is established by Board policy and will take some time to change.

The context analysis reveals that what is required more than anything else at this point, however, is more varied software. The delivery systems are, for the most part, in place but, in order to meet the need for remedial work of all sorts various types of programs need to be developed.

Task Analysis

The second step in Davies' organizational chart is the analysis of the task or job. Since the purpose of the LAP program is to organize the learning of the complete sequence of content in the first module of the physics course, this might better be termed content analysis. The content of the module was divided into six major topics which ran basically parallel to the chapter arrangement of the module.

An exception had to be made in the case of Chapter two which contained a lot of new mathematical concepts. It was felt that an LAP to cover the whole chapter would be too long, so it was decided to split the chapter into two parts. The LAP arrangement was:

LAP 1-1-1	PHYSICS BEGINS
LAP 1-2-1	ANALYSING SIMPLE MOTION (Graphs)
LAP 1-2-2	ANALYSING SIMPLE MOTION (Equations)
LAP 1-3-1	GALILEO DESCRIBES MOTION
LAP 1-4-1	KINEMATICS
LAP 1-5-1	THE BIRTH OF DYNAMICS

The next step in the content analysis was to divide the major topic into subtopics showing relationships between them.

Figure 4.1 gives an example of how the topic of a LAP may be broken down into subtopics. At this point, the place of the topic in the overall course scheme and philosophy is established. From this statement comes the rationale for the LAP. The function of the rationale, as outlined by Cardaralli (1972), is "...the rationale is aimed at providing the student with a reason for studying this topic." The basic idea which is illustrated by LAP 1-1-1, for example, is that ancient science was based a great deal on simple qualitative observation and a common-sense description of the phenomenon under question. This is a statement that the student should be able to derive from a study of this chapter without prior prompting.

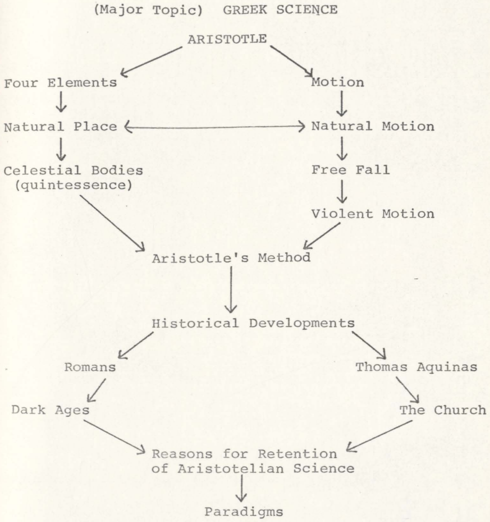

Figure 4.1. Topic trend in LAP 1-1-1
Science by qualitative observation and "common sense"

A more detailed analysis of the concepts and principles in each subtopic was left at this point for future work on the development of software for the LAP. Where such a need was obvious and necessary, such work was undertaken and resulted in the production of a large number of overhead transparencies (see Appendix F), and one tape-text entitled Graphical Analysis: Program One. However, the subtopics gave sufficient direction for the specification of objectives and activities for the LAPs.

Statement of Objectives

Cardaralli (1972) states,

> In the LAP, the function of the objective is to communicate goals to the student, and thus should be written in his language. In the beginning, this may be simply a performance objective. However, most secondary school students will profit by the direction provided through precise behavioral objectives, especially if the students are encouraged to establish their own minimal level of acceptable performance. (p. 25)

Attempts to state behavioral objectives at different cognitive and affective levels immediately ran into problems:

1. The level of the objective often depends on the depth to which instruction is taken, for what may be simply recall in one instance may be some other level in another case.

2. The level of the objective is also often established by the type of question or exercise used to evaluate it.

3. Questions or exercises involving the affective domain are, in many instances, open-ended and cannot be marked right

or wrong definitively. How, then, can criteria of acceptable performance be established?

Thus, establishment of objectives is inseparably intermixed with the statement of questions, selection of student activities and the setting of evaluative criteria. In order to minimize the effects of these problems, the establishment of these three parts of the LAP was taken as a joint venture. The objectives were sometimes stated first and the evaluation system components derived from them, and in other instances the objectives arose from questions contained in past examinations, standard PP quizzes and the results of activities.

By using the "forward" and "backward" approach the writer found that a fairly comprehensive list of objectives could be obtained for each LAP. At this point, however, a fourth problem arose; in some instances the number of objectives for each LAP became inordinately large and in other instances the statements became too long and cumbersome for easy student comprehension. This was especially true where such objectives involved rather complex, mathematical manipulations.

Since the basic function of the objectives at this stage was to inform students, it was thought best in most such cases to sacrifice some specificity for brevity. For most LAPs, after some deliberation, it was found possible to limit the number of objectives to about six per LAP and the length of objectives to about two lines, while maintaining the essential elements for student direction and understanding.

Mager (1962) describes three properties that a well written objective must have:

> First, identify the terminal behavior by name; you can specify the kind of behavior that will be accepted as evidence that the learner has achieved the objective.
>
> Second, try to define the desired behavior further by describing the important conditions under which the behavior will be expected to occur.
>
> Third, specify the criteria of acceptable performance by describing how well the learner must perform to be considered acceptable. (p. 12)

As Mager goes on to suggest, however, it is not always necessary to specify all three conditions to have an acceptable behavioral objective.

Diagnosing Entering Behaviors

Although this appears as number four in Davies' organizational chart, preceding the establishment of objectives, it was placed in the LAP after the objectives. The main purpose of this positioning was to permit students to decide for themselves whether or not they would require upgrading exercises before undertaking the activities. Diagnosis for the various LAPs took the form of a pencil-and-paper pretest, a discussion, or student-teacher dialogue.

The entry behaviors of students entering the LAP program were ascertained in three ways:

1. A knowledge inventory consisting of a 20-item

multiple-choice quiz on the content covered by the LAPs.

2. An attitude inventory consisting of a 50-item questionnaire.

3. A class discussion covering the types of experiences students underwent in previous science courses and what they expected of the physics course in senior high school.

The first two instruments also formed the pretest for overall program evaluation. The results obtained with these instruments will be described in detail in the next chapter.

Entry behaviors for the individual LAPs are usually tested by a pretest which follows the reading of the objectives by the students. In most instances, however, the pretest was omitted in this program because of its sequential arrangement. The quiz at the end of one LAP formed the pretest for the next LAP in the sequence in all but one case. The only exception occurred in LAP 1-2-2 where information was required on the students' ability to use and manipulate algebraic equations and symbols. Remediation for this pretest consisted of references to various elementary mathematics books and the use of the PP programmed instruction booklet Equations 3.

One other important consideration in the decision to leave out pretests was that all students entered Grade ten from feeder schools whose mathematics and science programs were known to the writer. Thus, a reliable source of information on students' previous experiences in these areas was available. Further, the course was so designed that very little in the way of specialized prerequisite knowledge is required. It is generally accepted that students will have a basic knowledge of the following:

1. Units and prefixes of the metric system of measurement, including units of mass, length and volume;

2. Algebraic manipulation of simple equations; and

3. The plotting of graphs

In each case, however, there is sufficient treatment in the text for students without these skills to make up their deficiencies.

The pretest required for LAP 1-2-2 was keyed to an answer sheet and was to be self-corrected by students. The answer sheet contained suggestions for further study with each answer so the student could correct his own errors. Upon completion of the pretest the student should be ready to undertake the learning of the material in the section covered by the LAP.

The general structure used for the LAPs in this program varies from the outline suggested by Arena (see p. 36) from this point on. The general outline used for the LAPs in this program is as follows:

1. Rationale
2. Objectives
3. Pretest
4. Pretest correction and remediation
5. Activities
6. Self-test

7. Self-test correction and remediation

8. Quiz

9. Quiz correction and remediation

10. Make-up quiz

11. Quest activities

The major changes involve a greater opportunity for remediation of student behaviors than that offered by Arena's model. The quest activities provide a place for students to pursue their own interests, and basic references and appendix materials are included in the body of the LAP.

Specification of Activities

In Davies' chart this might fall under blocks 7 and 8, organization and selection of learning resources and teaching strategies. Basically, the activities suggested by the LAP refer the student to various media. The activities are of two types: study and interaction. Those activities requiring the submission of a report of some kind for evaluation purposes are denoted by an asterisk (*). Generally, the activities for each LAP include the following:

1. Direction to study particular pages of the text or some other printed material;

*2. Direction to perform an experiment associated with the content of the LAP;

*3. Direction to solve problems or answer questions in the text or other book; and

*4. Direction to read an article in some book other than the text, or to interact with media and write a brief report or summary of from 8 to 20 lines.

Each of the four basic types of activity is intended to call into play a variety of teaching-learning strategies.

Type one activities. These are intended to be followed by a discussion period in which small study groups discuss the material and compile a set of questions on the content. Each group is then to present their questions orally to the class for suggestions by the other students or the teacher. The group may be referred to other materials to research the question, or the questions themselves may give rise to a teacher lecture on the topic.

Type two activities. Experiments are to be carried out during double periods by groups of from two to four students. The experiments may, however, run for longer periods if required. Each student is expected to hand in a written report on the experiment, which is to form a part of his overall evaluation.

Type three activities. Problems and questions can be done in groups or individually. They may be done in school during regular physics periods, during study periods, or at home. Generally, these exercises are expected to give rise to student-student and student-teacher interaction. If a particular problem gives many students problems the solution may be presented to the class by a student or by the teacher. One good exercise may be to have particular students called to present such solutions.

Type four activities. These are intended to be an individual project to be done during class time or at home. It is expected that many of the suggestions made in the LAP for this type of activity may be substituted for upon student request. Students may wish to report on TV programs, newspaper or magazine articles of interest on the topic under discussion. Such activities present a way of obtaining current and local information into the classroom.

In most instances, however, the types of activities that could be prescribed were limited by the availability of media software. The supply of filmstrips, filmloops, slides, tapes, transparencies, programmed instruction materials, and other software that could be used for specific content was found to be non-existent in most cases, despite a program of upgrading such facilities over the past year or two. It is at this point in the planning that such limitations really show. As more of these materials become available the LAP activities will be updated to include them. For this reason the LAP activities did not meet all the criteria required of them by McGovern (1975), Cardaralli (1972) or Arena (1970).

As Smith (1972) states:

> These activities should provide each student with a choice of alternatives concerning not only how, what, when, and where to learn but also opportunities for the efficient use of a wide range of learning resources. Stated another way, these activities should provide the learner with alternatives in terms of the following:
>
> 1. Multi-media--the use of various kinds of audiovisual equipment and the performance of sensory-oriented tasks;

> 2. Multi-mode--variations in process goals that determine the size of the learning group and the methodology (i.e., large-group instruction, small-group instruction, individual work);
> 3. Multi-content--differing levels of sophistication or difficulty of all resource materials, whether printed or audiovisual; and
> 4. Multi-activities--variations in terms of paper-and-pencil activities such as listening, viewing, speaking, participating in academic games and simulations, manipulating, etc. (p. 25-26)

In providing variety in the forms above, the PHE course will hopefully provide for the types of students that Holton describes and make allowances for their different 'chemical characteristics' described on page 17. Thus, such a program will not only meet the criteria of individualization, but will assist in promoting the philosophy of physics instruction enunciated by the original developers of the Project Physics course.

Evaluation and Remediation Materials

One of the most important aspects of the LAP program is the provisions for diagnosis and remediation of student learning. This is in keeping with Bloom's philosophy of ensuring mastery of one segment of learning before the next segment in the sequence is undertaken. The most rational attitude that a teacher should take is not that some students will fail the course, but that all students should pass with as high a mark as their abilities and time restrictions permit. The evaluation and diagnosis phase of the LAP program is designed with this in mind and permeates the final segments of each learning package.

The first sections of the LAP attempt to ensure that high quality instruction takes place. The latter segments attempt to ensure that, if it does not, then students will have every possible opportunity to redress errors and rectify problems. In the LAPs developed for this program this is a four-phase process. The LAP sections that attempt to ensure full diagnosis and remediation insofar as possible are as follows:

1. Every LAP contains a self-test based on the original objectives stated for the LAP. The function of these tests is two-fold: firstly, the self-test serves to inform the student of the type of questions which arise from the objectives; and secondly, it permits students to check their mastery of the material before undergoing summative evaluation of their learning. In this way the self-test asserts the student's responsibility for his own progress.

Each self-test is provided with an answer key which provides the answers to the questions, thus providing the student with a sample of what is expected from his own answers. The answer key is also provided with directions which suggest various procedures by which the student can correct any errors he might have made.

2. The quiz is again based on the objectives but is corrected by the instructor using an answer key which sets the criteria of acceptable performance for the behavior elicited by the question. The quiz serves to monitor student mastery of the material contained in the LAP and is one of

several instruments used to determine final grades.

3. The make-up quizzes were composed in three different forms, two of which are given on a random basis to students as the quiz above. If, however, a student shows lack of mastery on the quiz, he is directed to do remedial study and is allowed to write the make-up quiz after he has completed the remedial work. The student's final mark is then determined by taking his highest mark in the two quizzes. An attempt was made, in producing the three different forms of the quiz for each LAP, to keep them as equivalent as possible.

4. Students who attain mastery but are still not satisfied with their marks on the evaluation materials for an LAP, can undertake extra activities called quest activities to upgrade their marks. Quest activities are also used to permit students who finish the work ahead of the others in the class to undertake activities which enrich and extend the content covered by the LAP.

The remediation activities suggested in steps 1, 2, and 3 above consist of interaction with various types of media and the recycling of students through the regular activities. The remediation activities may take the form of small groups working with the teacher or advanced student either during class times or after school, or individual study at home or in school. It is most important that students learn early that such remedial activity is designed, not as a punishment for a poor showing on a quiz, but as a genuine attempt to assist them in gaining mastery of the material. Thus, in the LAP program the evaluation system is designed to be used as a means of fostering cooperation between the student and the teacher in the learning enterprise. The function of the teacher in this enterprise then becomes to assist the student in attaining the highest marks he is capable of, while maintaining the highest standards which students are capable of achieving. Hopefully, also, as this philosophy gradually gains acceptance, the evaluation system should also attempt to promote student cooperation rather than competition.

Overall student evaluation is comprised of results from the following student activities:

TYPE OF ACTIVITY	PERCENT VALUE
Quizzes	10
Experiments	10
Problem Sets	10
Articles and Books	5
Projects	10
Quest Activities	5
Major Examinations	50

It was the policy of the school board in which field tests were conducted to place a high value on major examinations; hence the 50 percent value given here.

The second major function of the evaluation system is to provide data for the improvement and modification of the LAP program itself. Information gained on student performance and progress through the program will, in turn, service such decisions as the validity and reliability of quizzes and the efficacy of various types of learning materials and procedures. In the light of such information, quizzes will be modified and instructional strategies altered.

Optional and Quest Activities

The final section of the LAP contains the specification of optional or quest activities. Generally, the suggested quests include the performance of extra experiments found either in the student handbook or some other source, various activities suggested in the handbook or by students themselves, interaction with media which is generally too advanced for the course proper, gold-star problems involving the researching of some topic and the answering of specified questions on the research, and the reading of books.

The basic purpose of such activities is to provide the more able student with opportunities to go beyond the main topics treated in the course and to provide the less able student with opportunities to undertake less rigorous research that is within his grasp. Hopefully, such activities will give even the less able student a chance to experience some of the excitement of self-directed activities in science.

Students are also required to undertake a major assignment project. This project is set early in the year and students may begin and finish at any time during the term.

The student is required to pick his own topic and set his own objectives for the project. He is to conduct his own research of either a library or experimental nature and submit a report on the results. Examples of the types of projects a student may undertake are:

1. Biographies of famous physicists;

2. A report on some area of physics;

3. A report on some area of technology associated with physics;

4. The manufacture of some working model of a scientific or technological nature;

5. A research project including the setting up of experiments of his own design.

The results of such projects become the property of the school and will gradually add to the total stock of materials available for other students.

General Program Materials

Besides the LAPs themselves, a number of other materials associated with the overall running and evaluation of the LAP program were also developed. These included:

1. A student introduction sheet which explained something about the physics course and the LAP program and its use by students (see Appendix A).

2. A student's contract form which explained the basis upon which student evaluation was to occur, and which provided the student with a means of keeping track of his marks

as he worked through the LAPs (see Appendix B).

3. A student progress sheet for posting in the physics laboratory so that students could keep track of their progress (see Appendix E).

4. A student questionnaire on the effectiveness of the LAP program (see Appendix M).

5. Several other evaluation instruments designed to produce information regarding the effectiveness of the LAP materials. Of these, more will be said later.

Following the guidelines outlined in this chapter, the LAPs were completed in May, 1976. During the summer they were submitted to Mr. H. Weir for his comments. Mr. Weir spotted several typographical errors but gave a generally favourable reaction to the contents and proposed method of implementation. The typographical errors were subsequently corrected on all seventy copies of the LAPs. At this point the materials were felt ready for use on a trial basis and the program was subsequently started at Booth Memorial High School by Mr. John Bartlett, and at Bishops College by the writer in September, 1976.

CHAPTER V

THE FIELD TEST AND EVALUATION

Description of Conditions

The LAP program was placed in two adjacent urban high schools of similar size and with similar facilities. The close proximity of the schools permitted constant intercommunication between the two physics teachers involved. Short meetings were held after school at least once a month to discuss such items as availability of materials and classroom management of the program. In this way it was possible to keep close track of developments at both schools and to share equipment and other materials for the program.

Booth Memorial High School has an enrollment of 400 students and a staff of 20 teachers. It is equipped with a physics laboratory used solely for the teaching of physics, and is stocked adequately with equipment and materials for purposes of this study.

Bishops College has an enrollment of 530 students and a staff of 28 teachers. Its facilities, program and staff are very similar to those of Booth Memorial. Both schools operate under the Avalon Consolidated School Board in St. John's, both draw on students with similar socio-economic backgrounds and both share the facilities of the Board's regional Instructional Media Center.

Mr. John Bartlett, the physics teacher at Booth Memorial, holds a B.Sc. and B.Ed., with academic major in physics from Memorial University of Newfoundland, and has been teaching for two years. Mr. J. Walsh, the writer, is the physics teacher at Bishops College. He holds a B.Sc. and B.Ed., also from Memorial University of Newfoundland, with academic major in mathematics. He has four semester courses in physics and has been teaching the subject for eleven years.

The allocation of students to physics classes at both schools is carried out on the basis of student selection of program. This effectively precluded random distribution of students to treatment groups. Generally, students taking the honours mathematics and chemistry courses are allocated to one physics group, while those taking general mathematics and early science or biology are allocated to the second and third groups. Some overlap does occur, however, but it has generally been found that the first of these groups are academically superior to students in the other groups. This finding was borne out by the results of the knowledge inventory and attitude pretests given the groups at the beginning of the treatment period.

It was decided at the outset to select the lowest of the groups as the test group in each school for purposes of this study, while classes of higher academic ability formed the control group in each school.

Implementation Procedures

The teaching procedures and scheduling of the material contained in the module Motion was left as flexible as possible for both experimental and control groups in order to meet the differing situations in both schools. For example, the number of forty-minute physics periods differed from five per week at Bishops College to four per week at Booth Memorial.

The basic difference in treatment between experimental and control groups was that the control groups used the LAPs and were given time to conduct individual and small-group learning activities suggested by the LAPs, while the control group continued with the conventional lecture-lab instruction with small-group activities occurring only during laboratory periods. Particular teaching tactics and strategies within this basic framework were left to the individual teacher to work out with his classes.

It was agreed that both teachers would complete the module on motion before the mid-year examinations at the end of January, 1977. This is accepted practise in the course since the third module, Energy and the Conservation Laws, requires the whole of the second term for its completion. Thus, the time period for field testing the materials ran from September, 1976 to January, 1977, during which time both control and experimental groups completed the module on motion.

The following classroom procedures were agreed upon at the beginning of the program but several had to be altered as teachers became familiar with the peculiar problems associated with teaching with the LAP:

1. The LAPs were handed out to the test groups. This was followed in the same period by a discussion of the objectives of the section and the activities to be completed by the students.

2. Students were given the text reading assignment as a home- or study-period task to be completed for next class.

3. Students were given several periods in which to complete the activities suggested by the LAP. These activities included use of media, experiments, and written assignments. Students were also assigned one major research project for the term.

4. Students, when satisfied that they had completed the required activities, were to ask for the self-test and complete it at home or in class, depending on their time of completion of the activities. Answer sheets for the self-test were posted during periods when the test groups were in class.

5. It was originally intended to permit students to select the time for writing the summative test at the end of the LAP. However, it was found that most students procrastinated well past the projected time of LAP completion and it was finally agreed by students that the teacher should set the time for quizzes, giving the students one week's notice.

6. Students completing the activities ahead of the

majority of students were to do additional, optional activities or continue with the next LAP or provide assistance to others who were working at a slower rate.

LAP 1-1-1

At both schools, the first three physics periods were taken for orientation and pretesting. Students in all classes were given both the Attitude Inventory (Appendix K) and the Knowledge Inventory Pretest (Appendix J). Students in the LAP group were given the Student Introduction Sheet (Appendix A), the Student's Contract Form (Appendix B) and LAP 1-1-1 (Appendix C). Students at Booth Memorial used a slightly different evaluation scheme than those at Bishops College.

Two periods were taken to inform students about the LAP program and their responsibilities. The classes at both schools were divided into small work groups, while the control classes were treated intact except while doing experiments. Students in the LAP groups were shown where the materials were located and a check-out system for materials was established.

Real work on LAP 1-1-1 began in both schools during the week of September 13 to 17. Student activities ran for a period of two weeks. During this period it was found that both students and teachers were having some difficulty adjusting to the new procedures. Several observations could be readily made:

1. Students tended to keep postponing the date for the

final quiz on the LAP.

2. Despite the fact that there were three different forms of the final quiz, it was impossible to allow students to take the quiz individually whenever they felt ready because they tended to retain answers and give them to friends.

3. Most students were not ready to undertake the activities according to their own schedule. They were not used to pacing their own work and not ready for the responsibility of doing so.

4. The first chapter of the text was readily adaptable as a preliminary LAP since it was short and a lot of time could be spent on organization and familiarization activities by both teachers and students.

5. Students were not the only ones having difficulty adjusting to the new system. Both teachers reported that they found themselves spending the time freed by LAP use on mundane matters rather than in helping individual students and small groups. A conscious effort had to be made to refrain from "lecturing" even to small work groups.

In light of these and other findings resulting from the use of the first LAP, some changes were made in operating procedures:

1. Specific periods were set aside for the various activities.

2. A schedule of work with some built-in flexibility was decided upon at the beginning of each LAP.

3. A set date for quizzes was agreed upon for each of

the future LAPs.

4. Greater flexibility was agreed upon for the reading assignments given in the LAPs. The viewing and reviewing of films on loan from the Department of Education was also permitted as a substitute for reader articles.

5. Some typographical and other errors were found in the material and were corrected for future classes. The quiz was found to be too long for one forty-minute period, so the instructions were changed to allow students to complete three of the four long-answer questions. This change was made permanent in the revised LAPs accompanying this report (see Appendix C).

Use of Remaining LAPs

Similar errors and omissions were found in the other LAPs as they came under the perusal of students. Slight changes in the wording of quiz questions to remove ambiguities, the inclusion of a pretest in LAP 1-2-1, substitution of activities at the request of students, and minor adaptations to scheduling and classroom procedures were required as the program progressed. Some of the more important findings and changes were:

1. It was found that most girls in the group adjusted more readily to this type of learning style than did the boys.

2. Approximately 20 percent of the boys showed little or no inclination to cooperate in this system and had to be

closely controlled by the teachers. This finding was similar in test groups in both schools.

3. Text reading assignments were more apt to be carried out if students were required to submit a set of questions about points they wished discussed in class. If these questions were common to the whole class they served as the topic for a lecture or class media presentation.

4. The LAP was extremely useful for students who missed time due to illness or other causes.

5. Students who did not reach a satisfactory level on quizzes were permitted to write make-up quizzes after one week or remedial work suggested by the teacher.

Evaluation Procedures

Since this thesis project was mostly developmental in nature and, as such, stressed formative evaluation of materials and student interaction with them, summative evaluation involving rigorous statistical analysis was considered to be of secondary importance. However, in order to determine the effectiveness of the LAP concept's role in instruction, some form of overall evaluation was required.

As in most cases where research is carried out in the school, random sampling and allocation to groups was not possible. Intact classes were used in both schools as experimental and control groups. This necessitated what Campbell and Stanley (1963) refer to as a "quasi-experimental design" in which efforts are made to correct for pretreatment group differences. Campbell and Stanley describe design 10 as

> One of the most widespread experimental designs in educational research (it) involves an experimental group and a control group both given a pretest and a post-test, but in which the control group and experimental group do not have pre-experimental sampling equivalence. (p. 47)

In this study two null hypotheses were to be checked:

H_{01}: Experimental and control groups will show no significant difference in mastery of content at the .05 level of significance as measured by the Knowledge Inventory.

H_{02}: Experimental and control groups will show no significant difference in attitudes toward physics at the .05 level of significance as measured by the Attitude Inventory.

In order to test these hypotheses according to design ten, two instruments were developed by the writer. These included:

A Knowledge Inventory Quiz (KI). The KI (see Appendix J) consisted of twenty multiple-choice questions involving material from the whole of the first module. In developing this instrument an attempt was made to evenly distribute the test items in terms of difficulty, types of cognitive learning, material covered. The test was submitted to Mr. Harvey Weir of the Physics Department of Memorial University in order to check its validity, and suggested alterations were made before use. The test was administered as a pretest in September and a slightly different but equivalent form was administered as a post-test in January.

An Attitude Inventory (AI). The AI was developed by the writer, using as a model the Inventory of Scientific

Attitudes developed by Moore and Sutman (1970). The ISA was developed to have the following properties, as described by the authors:

> 1. Preparation based upon specification of the particular attitude to be assessed.
> 2. Use of several items to assess each attitude.
> 3. Provision for the respondent to indicate the extent of his acceptance or rejection of an attitude statement.
> 4. Concern with intellectual and emotional scientific attitudes. (p. 85)

The attitudes to be assessed by the Attitude Inventory developed for this project were slightly different from those tested by the ISA. The writer wished to assess the following attitudes:

1. Attitudes regarding the difficulty of physics.
2. Attitudes regarding the relevance of physics.
3. Attitudes regarding the purpose of science and physics in particular.
4. Attitudes regarding the process of science and physics in particular.

Following the development model for ISA, each attitude was assessed by writing five positive and five negative statements associated with each. For example, in the assessment of attitudes regarding the process of science, five statements asserted that science should be carried out through observation, experimentation and activity, while the five negative statements asserted that science is best conducted by reading and basis on authority.

For each statement, students were required to indicate whether they:

1. Agreed strongly
2. Agreed mildly
3. Disagreed mildly
4. Disagreed strongly

The 50 statements were assigned a random place on the quiz, and the statements were scored by assigning values from one to four responses indicating varying degrees of positive attitudes. The test was administered at both schools to all groups as both a pretest and a post-test.

Other instruments used. In order to obtain information regarding the use of LAPs by students and teachers, two questionnaires were developed. These were the Student Questionnaire (see Appendix M) and the Teacher Questionnaire (Appendix L). The student questionnaires were completed by students in the experimental groups after completion of the treatment. The teacher questionnaire was developed more to organize information than to gather it, since there were only two teachers involved in the program.

CHAPTER VI

ANALYSIS AND RESULTS

Analysis of Data arising from the Knowledge Inventory

The purpose of the Knowledge Inventory (KI) was to test whether or not the use of LAPs correlated positively with student achievement. In order to test this hypothesis, students in both control and experimental groups in both schools were given the KI as a pretest and a slightly revised version as a post-test. Analysis of covariance with the pretest as the covariate was then used to determine if students using LAPs did significantly better on this instrument. The data obtained is to be found in the table below.

TABLE 1

Knowledge Inventory Data Analysis

School	Group	n	Pretest Mean	Post-test Mean	F on Covariates	F on Treatment
Booth	Con.	19	8.421	13.526	1.230	0.930
	Exp.	10	8.800	12.500		
Bishops	Con.	35	9.143	15.888	4.883*	0.682*
	Exp.	19	8.895	14.421		

*Significant at the .05 level of significance

The results obtained from this analysis are inconclusive. At Booth Memorial the control group, while rated academically superior to those in the experimental group, scored lower on the pretest. This indicates that their knowledge of the material to be covered was slightly inferior to that of the students in the experimental group. After the treatment, however, the control group's mean score showed that they had surpassed the experimental group. This gain was not sufficient to produce a significant F ratio on main effects and may, in any case, be attributable to the greater ability of the control group to learn, no matter what the form of instruction.

At Bishops College the data showed a significant difference between groups before the treatment and a significant difference on treatment. Again, however, the improvement was in favor of the control group and may simply show their greater ability to profit from instruction rather than any deficiency in the experimental treatment.

In both schools the trend was opposite that anticipated. In the case of Booth Memorial the difference in post-treatment groups was insignificant, while at Bishops College a significant difference in favor of the control group was established. Statistical procedures and design were not capable of determining whether this difference correlated with treatment, academic superiority or some other factor(s) which may have interacted with treatment to produce this result.

Analysis of Data srising from the Attitude Inventory

The purpose of the AI was to test whether the use of LAPs had any appreciable effect on the attitudes of students toward the study of physics. In order to test this hypothesis, students in both schools in both experimental and control groups were given the AI as both a pretest and a post-test. Analysis of covariance with the pretest as the covariate was then used to test the significance of using LAPs on student attitudes. The data obtained is to be found in the table below.

TABLE 2

Attitude Inventory Data Analysis

School	Group	n	Pretest Mean	Post-test Mean	F on Covariates	F on Treatment
Booth	Con.	16	95.563	98.813	22.657*	.097
	Exp.	9	84.111	88.778		
Bishops	Con.	35	98.914	100.771	61.119*	5.798*
	Exp.	19	89.421	89.895		

*Significant at the .05 level of significance

Again results are inconclusive. While both Booth and Bishops groups showed significant differences on pretests, Booth groups showed no significant difference attributable to treatment. At Bishops the groups showed significant difference on main effects but, again, this may have been due to the ability of the academically superior student to learn from any type of instruction rather than from a deficiency in treatment procedures used with the experimental group.

In short, there were no significant differences attributable to experimental treatment on either knowledge or attitudes as measured by the KI and AI tests. Indeed, in certain instances significant differences did arise in favor of the control group. It was not possible to ascertain whether or not this effect may have been due to the academic superiority of the control group.

In summary, the following hypotheses were tested:

H_{01}: Experimental and control groups will show no significant difference in mastery of content at the .05 level of significance as measured by the Knowledge Inventory.

H_{02}: Experimental and control groups will show no significant difference in attitudes toward physics at the .05 level of significance as measured by the Attitude Inventory.

While both of these hypotheses appear to be upheld by the statistical analysis of data obtained from the KI and AI results, the procedures used involved several limitations which acted against the finding of significant differences.

Firstly, the sample sizes were extremely small, especially in the case of the experimental group at Booth Memorial which consisted of only ten students. This group also suffered some experimental mortality in that three students left the course completely at the beginning of the year, while two others did not write the post-test due to illness and their results could not be used for experimental purposes.

Secondly, the small group size at Booth Memorial might well explain why the experimental group scored slightly higher on both AI and KI pretests despite the fact that their teacher rated them academically inferior to those in the control group. If only one or two of these students were subjected to some exceptional pretreatment history, such as an enriched Junior High School science course in physics, such a discrepancy would be explained.

Thirdly, as has already been mentioned, if the teacher and school grouping procedures based on previous marks are to be believed, then the superior gains made by control groups may have been due solely to their greater ability to learn from any kind of instruction.

Fourthly, this project involved a field test and not a comprehensive experimental treatment of a finalized program. Both teachers and students were in the process of experimenting with the new instructional procedures involved in the learning activity package program. On the other hand, both students and teachers were fully aware of and practised in their roles in conventional, instructional procedures. This was less true of the writer, since, by composing the materials he was more fully aware of their content, philosophy, and the instructional procedures involved. The results summarized in the tables tend to bear out this hypothesis.

Fifthly, the experimental groups in both schools did register appreciable gains in mastery, as can be readily seen from a comparison of experimental groups' pretest and post-test results. Thus, the use of LAPs was effective in producing learning for the experimental groups.

Sixthly, since this was a field test, the procedures used with the experimental groups were mainly developmental and not experimental in nature. Teachers and students were trying out different instructional management procedures, different instructional aids, and revisions were made in an attempt to improve the materials during the course of the study.

Information Obtained from the Teacher Questionnaire

Since there were only two teachers involved in the teaching of the materials using the LAP program, the purpose of the questionnaire form was one of systematizing information rather than for use in drawing broad comparisons on a mass of information. In general, the opinions expressed by the cooperating teacher were very similar to those of the writer. In summary, the following information was agreed upon by both teachers:

1. Students in the LAP group were generally academically inferior to those in the control group. The cooperating teacher reports that, "The non-LAP group had a much greater exhibited interest in general academic matters and in physics in particular. The non-LAP group contained a high proportion of honors math students and students with high academic ability." A similar observation was made by the writer.

2. While the cooperating teacher rated the rationales

as good, he made the observation that many students did not bother to read them.

3. All objectives given in the LAPs, except one, were rated highly. Revisions have subsequently been made in the one mentioned as being unclear, and several other revisions and additions have been made in areas the writer found deficient.

4. An extra pretest for LAP 1-2-2 was added to the revised LAPs accompanying this report. It will be used with the materials for next year.

5. Mr. Bartlett found the activities list too restrictive, especially in the reading assignments. He decided to have students submit resumé cards on these. A similar observation was made by the writer, and in subsequent revisions allowance will be made for teacher-selected activities and reader articles by leaving blank spaces in the activities section which the teacher can have his or her students fill in.

6. Mr. Bartlett rated the self-tests as " . . . a very positive aid to students. They completely eliminated the problem of 'We didn't know what to expect on the quiz'. I used the self-tests in both the LAP and non-LAP groups." While the use of the self-tests in the non-LAP groups tended to defeat the purpose of the study, the fact that Mr. Bartlett would feel compelled to do this for the non-LAP students speaks well for the use of this type of material.

7. Quizzes were rated highly on a number of criteria by Mr. Bartlett although he did complain about several errors

which were also found at Bishops College and subsequently corrected. Mr. Bartlett found that students did not take advantage of the opportunity to write make-up quizzes. The reverse was found at Bishops, with students from all classes taking advantage of the 'make-ups' to improve marks.

8. Both teachers found that students were not mature enough to set their own deadlines on an individual basis. As a result, both teachers were forced to set dates for the writing of final quizzes, thereby forcing all students into a set time schedule.

9. Mr. Bartlett found that his students responded more positively to the lecture mode of instruction than to individual work groups. He ascribed this to the immaturity of his students and to the fact that they had little, if any, experience in self-directed and small-group study. A similar observation was made by the writer but in ascribing causes he is just as inclined to explain the problem by the fact that teachers were just as unfamiliar with the use of these modes of instruction. Indeed, the lecture method makes the class easier to control but efforts will continue to develop procedures whereby students can pursue independent and small-group study.

10. Mr. Bartlett rated positive student interactions with the teacher and media as occurring the same or fewer times in the LAP group than in the non-LAP group. The opposite effect was found at Bishops, although no specific effort was made to monitor such interactions.

11. Mr. Bartlett found the rationales, objectives, self-tests and make-up tests most effective in the LAPs. He rated activities as least effective because of their lack of flexibility. This point was made earlier in the paper. Each teacher should develop his own types of activities to suit his style of instructional tactics.

12. In general usefulness, Mr. Bartlett believed that the program would be "more adaptable to Grade eleven students in a good group." He believes that the program demands a mature type of student and a great deal of guidance from the teacher. He states that he will be using the same program with modifications next year. It appears from his comments that the modifications will be to use the materials and adapt them to his own teaching methods. The writer will be using the revised materials again in toto next year and extending the program for the remaining half of Grade ten and into Grade eleven.

Analysis of Results of Student Questionnaires

The purpose of this instrument was to elicit student responses on a number of aspects of the use of LAPs in this study. The questionnaires were given to the students in the experimental groups only. The results generally confirmed the observations of teachers given in the previous section of this report.

1. Less than 40 percent of students read all the rationales, and slightly fewer than 40 percent stated that they

found them useful.

2. 75 percent of students read the objectives given in the LAP and found them useful. Most students reported, however, that they could understand most of the objectives only after the section had been completed. Thus, the objectives served the students as a review tool rather than an initial goal to aim for.

3. 95 percent found that the self-tests were very useful in preparing them to write the end-of-section quiz.

4. Booth students reported that only about one-tenth of their time was spent in small-group activities other than for performing experiments. In rating small-group activities, students rated them alright (70 percent), no good (20 percent) and good (10 percent); fewer than 50 percent reported that they preferred small-group instruction. At Bishops, small-group instruction was reported by students as occupying about one-third of their time, with the remaining two-thirds being split between experiment activities and lectures. Students at Bishops rated such activities 'alright' 80 percent of the time and good 20 percent. The class was evenly split in preference for small-group, individual and large-group instruction.

5. About 90 percent of students in both schools rated self-tests and make-up quizzes as excellent.

In rating LAPs in general the following results were obtained:

20 percent claimed insufficient time to do activities

80 percent reported to have read text chapters as instructed by LAPs.

90 percent rated small-group activities "alright" to "good".

20 percent reported that they spent their time in small groups "fooling around" unless directly supervised.

50 percent reported that teachers interacted with groups more than half the time.

95 percent reported that they felt free to ask the teacher questions most of the time.

60 percent reported that they believed that the LAPs gave them a better chance to pass, with only 5 percent believing that their chance to pass was less using LAPs.

60 percent of students reported that they were sorry that LAPs were not to be used for the remainder of the year.

In the constructed response part of the questionnaire where students were given the opportunity to express their feelings about the use of LAPs, 90 percent of comments reflected favorably on their use. Examples of the types of response included: "The LAPs give me a great understanding on what the chapters are about. Without the LAPs I'd be lost." and "The LAPs are very good and I think they should be used next term and the following years. They have all the information needed to really learn the chapter well."

In general, student comments were positive from 70 to 80 percent of the time, reflecting a much more favorable result than that obtained from the statistical analysis.

Thus, in attempting to answer the questions posed on pages 67 and 68 of this report, the following conclusions can be arrived at:

1. The use of LAPs, specifically, the inclusion of objectives, self-tests and make-up tests were rated by students and teachers as a positive assistance in helping students gain mastery of the subject content.

2. Instructional procedures, especially small-group work, were rated positively by students as assisting them in attaining objectives and in establishing a cooperative attitude between students and teachers. The results of student questionnaires, especially in the constructed response section, showed that the use of LAPs did improve student attitudes regarding their ability to obtain a satisfactory mark in physics.

3. While both teachers indicated some preliminary difficulties in the use of LAPs, both also indicated that the LAPs formed a manageable, instructional system and that they would be using the materials in the coming year.

The LAPs were particularly effective in certain practical areas of instruction:

The LAPs directed student-independent and small-group instruction successfully. In performing this function they provided students with an opportunity to become more actively involved in the learning process.

The LAPs helped develop positive student attitudes regarding their ability to succeed. This was accomplished by the fact that remedial activities were encouraged and students were given the opportunity to improve marks by writing make-up tests and performing optional activities for extra marks. Further student-teacher interaction was enhanced as teachers circulated between small groups to ask and answer questions and direct study activities.

The LAPs provided materials to direct absentees in catching up with the class. The materials can also be sent home to students who are absent for extended periods.

The LAPs provided a mechanism whereby audiovisual materials can be integrated fully into the instructional design. They also promote student use of media hardware and software on an individual and small-group basis.

Multiple-quiz forms tended to prevent student cheating in crowded classroom situations and also tended to prevent students from one class from advising students from other classes on which questions were on the quiz.

The LAPs form a replicable means of instruction which in future years should remove much of the tedious clerical work involved in teaching a course.

The stated instructional objectives and preconstructed quizzes form a guide for teaching as well as a guide to learning.

The LAPs tested provide a sound base upon which to build updated and efficient, instructional strategies. They are particularly useful in pointing out deficiencies in media used for independent and small-group instruction.

For these reasons, then, despite the adverse results from the statistical analysis, it is felt that the LAPs did, in many ways, achieve the original objectives set out for them at the beginning of this report.

CHAPTER VII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This project was concerned with the development and field testing of a series of six LAPs to accompany the module Motion which is the first module of the Physics: A Human Endeavour course. This program is currently being introduced as the approved physics course for Newfoundland high schools. Thus, the project was an attempt to carry out some preliminary, instructional design which incorporated the philosophy of the new course in an instructional management system.

The project, therefore, had two specific aims: The development of a series of study guides, evaluation materials and other information for teachers and the development of an integrated, instructional management system for these materials; and secondly, the field testing and evaluation of the materials developed.

Program materials were used in two adjacent urban high schools in St. John's. The students involved in each school comprised the entire Grade ten enrollment of each school, split up into two classes according to program selected. The experimental group in each school was composed of those students in the lower academic program and were therefore believed to be the less academically inclined.

The LAP program ran for a period of four months in both schools, during which time it was monitored carefully by the two teachers involved.

Evaluation of the program was carried out by use of four instruments. Student mastery was monitored by use of a Knowledge Inventory given as a pretest and post-test to both groups. An analysis of covariance using the pretests as the covariate was used to determine if any significant difference occurred between groups on each of these two factors. Two questionnaires, one for teachers and the other for students in the experimental groups, were used to elicit their feelings regarding the use of the LAPs. All instruments were designed specifically for this study.

Conclusions

Before reading the following conclusions the reader is reminded of the fact that the findings from which these conclusions came were results of a field test involving only four classes, two teachers, and approximately 85 students in two large, relatively well equipped urban high school. Further rigorous, statistical analysis and experimental design were not considered to be central to the project. Random sampling or assignment to groups, and equal group numbers was not possible.

Bearing these factors in mind, the following conclusions were drawn:

1. In future, when this evaluation procedure is used with two groups of classes, treatment should be alternated

between good and poor groups. This will permit the drawing of more comparisons between and within groups.

2. Statistical analysis of data from the KI failed to indicate any significant difference between groups attributable to treatment.

3. Statistical analysis of data from the AI failed to indicate any significant difference between groups after treatment, which indicated that use of LAPs improved student attitude formation about physics.

4. Analysis of data from both tests indicated, in some instances, that students in the control group did significantly better on the tests after treatment. This may have been due to the greater academic ability of the students in the control groups. At any rate, the use of LAPs was not sufficient to overcome this extra learning ability, if indeed it did exist.

5. Analysis of the teacher questionnaire indicates that both teachers feel that entry into a self-directed or small-group study situation should be more gradual than that permitted in this study. Also, students in the lower academic stream may be the poorest subjects for such teaching methods due to their lack of readiness and interest.

6. Both teachers and students found certain aspects of the LAP program very effective in the teaching-learning situation. These included rationales, objectives, self-tests and make-up tests.

7. Teachers and students indicated that the use of such materials should be continued.

8. Both teachers indicated that they found the specified activities too rigid.

9. Both teachers indicated a need for more remedial and other materials suitable for student independent study and review.

Recommendations

The recommendations presented here fall into two main categories. The first set of recommendations concerns alterations and extensions of the LAPs developed for this study, while the second set concerns extension of the LAP program and the requirements of further study in this area.

1. Quizzes and other materials should be revised to remove typographical and other errors.

2. The LAPs should be rewritten to allow greater flexibility in the activities sections.

3. Experience with the LAPs suggested the following schedule:

TABLE 3

LAP Schedule for Module 1 Motion

LAP No.	4 periods per week	5 periods per week
1-1-1	1 week	1 week
1-2-1	3 weeks	3 weeks
1-2-2	4 weeks	3 weeks
1-3-1	3 weeks	3 weeks
1-4-1	3 weeks	3 weeks
1-5-1	2 weeks	3 weeks

4. A special effort should be made to seek out, procure and preview the extra materials required for remedial and self-instructional sequences required by the LAP program.

5. Other teachers should be made aware of the existence of these materials, especially those teachers just starting the PHE program.

In regard to extension and expansion of the work started with this project, the following recommendations may be made:

1. The introduction of a new course should not bring developments and innovations to a stop. A great deal of research is required on the type of instructional procedures which will enhance the new course.

2. The LAP method provides one such vehicle and the program should be extended to cover the remaining modules of the PHE course.

3. Research should be carried out to determine if the use of LAPs with the students in the upper academic streams does lead to the improvement forecasted by the teachers who used this program.

4. More research into the type of instructional procedures required to promote LAP activities is required, as is a continuing process of evaluation to determine the effects of teacher and student familiarity with the procedures on the efficiency of the LAPs in promoting mastery and positive attitudes toward physics.

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APPENDIX A

Student Introduction Sheet

Hi! Welcome to the physics course.

This is probably the first time that you have taken a true, basic science course and a short explanation is in order. Firstly you have made the right choice. Physics is THE basic science. It is the basis of most of our modern technology from medical equipment to engineering, and from the kitchen toaster to the man on the moon. If you are planning a career which involves the use of technology such as nursing, mechanic, engineer, electronics, medicine, plumbing or carpentry you will use some physics and most of the training courses in these areas require that you have at least one course in this science. But even if you are planning a career in business, accounting, or as a salesman the physics course is still the best science course to take because it finds applications in all areas of modern society.

Up until now you have been learning <u>about</u> science-hopefully in this course you will be doing some. We will not only learn about the facts and figures of scientific theories but we will take time to see just how scientific theories are developed, how scientific work is carried on and how science affects our everyday life.

Unless you were extremely fortunate, this will probably be the first time that you are given lab equipment and told to go to it. (Hopefully, you are now mature enough to use it properly and to return it so that other students can have the same freedom) The best way for you to learn how something is done is for you to do it yourself, therefore, this is an activity oriented course. You will be doing the learning and activities by yourself or in asmall group with the help and guidance of your teacher. Formal lectures will occur infrequently and mostly at the request of the class to cover a section that most students are having trouble with.

In order to help you in accomplishing the work you will be provided with a number of Learning Activity Packages as the year progresses. You have already been given the first of these. Take a look at LAP 1-1-1 "Physics Begins". Notice that it is divided into six parts:

PART A. RATIONALE: This short paragraph will explain why this particular section of the course is important in the study of physics and will give a short outline of what is to be covered. Read it carefully because it explains the major emphasis of the section of work to be covered.

PART B: OBJECTIVES: This section tells you precisely what it is that you are expected to learn in the unit of work. It might not make much sense at first because it will contain some terms that are unfamiliar to you but upon completion of the activities it should become more clear. Use this section as a check to make sure you have covered all the work in the section.

PART C. PRETEST: In some sections you will be expected to know some things before you begin. The pretest's function is to check on how well you know them. The answer key to the pretest will offer some suggestions on how to remedy any deficiencies you may have so that when you start a section you will know all that is required. If you still are having problems consult your teacher.

PART D. ACTIVITIES: This section tells you just what work you have to do to accomplish the objectives listed earlier. The activities marked with an asterisk (*) are to be written up and handed in for correction.

PART E. SELF-TEST: Once you have completed the activities and are reasonably sure that you know the work you can test your knowledge with the self-test. Complete it and check your own answers with the SELF-TEST KEY. This key also suggests some methods of remedying the mistakes you have made. If you are satisfied with the results of the SELF-TEST you are now ready for the quiz.

PART F. QUIZ: One period per week will be set aside as a quiz period during which any student who feels ready for the quiz can write it. Students who are not ready can continue on with their study of the section or with uncompleted activities. In order to be eligible for the quiz the student must have completed all the required activities in the LAP. When you have finished the quiz you can, with teacher approval, either move on to the next LAP or complete some of the OPTIONAL ACTIVITIES FOR GRADE IMPROVEMENT listed at the end of the LAP. If you fail to make the grade you want on the quiz you will be permitted to write a make-up quiz one week later. You will be permitted three such make-ups during the term.

PART G. OPTIONAL ACTIVITIES: These are extra activities that you may undertake on your own or in groups to improve your grades still further. The completion of these activities also means added understanding of the section just covered. If you have a suggestion for an activity which is not listed which you would like to try, consult your teacher.

The main point here is that YOU will be doing the learning and YOU are responsible for your own progress through the course. In a few years time you will probably be entering a trades school or university and the skills you learn now will stand you in good stead in you future studies.

In order for you to keep track of where you are, you have also been given a "Students' Contract". This is just what the name implies. You are contracting to do a certain amount of work during the term for which you will be awarded points. If you keep your contract record up to date you can see at a glance how you are progressing and what is still to be done.

There are two items on the contract that need further explanation:

1. The Project. Each student is expected to do one major piece of independent research per term and submit a report on what they have done. Examples of projects completed by past students are all around the lab. It may be a model, a report, a slide-tape presentation, video-tape, movie or something else on some topic in physics. It is best to get to work early on this because if you keep putting it off your work will begin to pile up.

2. Self-Evaluation: Each term you will be given a self-evaluation form at the half way point and at the end. On these forms you will rate your own work during the previous two months. The mark you and your instructor arrive at will also be used in determining your final mark.

Along with the freedom that you will be given during the year comes several responsibilities that you should be aware of.

The freedom to use lab equipment entails the responsibility to use it well and preserve it for future students.

The freedom to progress through the course at your own rate entails the responsibility of keeping up with the work you are required to do. Do not be a drag on the class, and don't let the work pile up.

The freedom to work with others entails the responsibility to carry your own weight, and to help others whenever possible,

The freedom to do your own thing entails the responsibility of making sure your own thing is not to disrupt the class or any of your fellow students. You will note that the first part of the word laboratory is labor. If you get involved with this course it could be a labor of love and not one of drudgery. Above all remember anything worth doing is worth doing well. If you don't want to work to accomplish something besides just getting grades I suggest you switch to some other course.

If however you want to take a course that means something, that will stand you in good stead in the future, and from which you can expect to get something you need, then you are in the right place and we're glad to have you.

......Welcome to the physics course. It should be fun.

APPENDIX B

Student's Contract Form

STUDENT'S CONTRACT FORM UNIT ONE: MOTION

NAME ......................................CLASS......GROUP......

CONTRACTED MARK...... DATE..................

A. REQUIRED WORK

L.A.P. NUMBER	1-1-1	1-2-1	1-2-2	1-3-1	1-4-1	1-5-1	T.P.
1. EXPERIMENTS							60
2. PROBLEM SETS							60
3. ARTICLES & BOOKS							30
4. QUIZZES							60
5. PROJECT							20
TOTAL							230
SELF-EVALUATION							230
MARK AWARDED							

B. OPTIONS FOR GRADE IMPROVEMENT

1. EXPERIMENTS			20
2. GOLD STAR PROBLEM			10
3. FILM LOOPS			10
4. ACTIVITIES			10
TOTAL			50
FINAL MARK AWARDED			

C. GRADES

POINTS	GRADES
140 - 159	C
160 - 199	B
200+	A

MID-YEAR MARK COMPUTATION

$$0.5 \times \frac{\text{Score}}{250} + 0.5 \times \text{Exam Mark}$$

=

= ....

SIGNED................................... DATE ....

APPENDIX C

Learning Activity Packages

LEARNING ACTIVITY PACKAGE

1-1-1

TO ACCOMPANY:

CHAPTER ONE

PHYSICS: A HUMAN ENDEAVOUR

A. RATIONALE

Physics is not just a body of facts which you are required to learn, but a procedure, a process of investigating natural phenomena. In order to learn how this process is carried on we have to trace the development of our ideas about the universe. This course attempts to show that some ideas which were held to be physical laws were just the best description that could be given at a particular time. One of the most important lessons you should learn is that the content of science changes as our knowledge grows and that this process of change and refinement is still going on. To set the stage for learning about the development of physics your text begins with the theories of Aristotle - a view of the universe which lasted for nearly two thousand years.

B. OBJECTIVES

To be more specific, you should, after studying this chapter, be able to:

1. Name and describe the properties of Aristotle's four elements.
2. Describe how Aristotle viewed the structure of the universe.
3. Apply Aristotle's theories to explain some simple phenomena.
4. Explain why Aristotle believed that the same laws do not hold in the heavens.
5. Describe Aristotle's ideas about freely falling bodies.
6. Describe two major differences between Aristotle's and modern scientific methods.
7. State four reasons for the long retention of Aristotle's physics.
8. Describe the contribution of one other early philosopher.
9. Explain or give an example of a paradigm, theoretical physicist and an experimental physicist.

C. PRETEST (none required for this chapter)

D. ACTIVITIES

In order to attain the objectives listed you will be required to carry out the following activities:

1. View the film "Aristotle and the Scientific Method" or Read "About Science" in Conceptual Physics (pp. 1-5)

2. Read the preface, prologue and chapter one of your text. As you read the first chapter answer the six questions contained therein in your notebook, also note any sections you have questions about.

*3. Perform and submit a report on Experiment 1.1.

*4. Read and submit a resume card on article two of reader one, Concepts of Motion or consult with your teacher about some other article as a substitute.

E. SELF-TEST

When you believe that you have studied the chapter sufficiently to meet the objectives listed earlier draw Self-Test 1-1-1 from the file. Complete the test and check your answers against the Self-Test Key. If you are satisfied with the results you are ready to write the quiz on this chapter. Your class will decide on a date for the quiz.
If you are ahead of the rest of the class, you may either work on the next LAP or try one of the optional activities below.

F. QUIZ

Your class, in consultation with your teacher, will decide on the date on which the quiz will be written.

G. OPTIONAL QUEST ACTIVITIES

*1. Perform and submit a report on Experiment 1.2

*2 View the film Cosmic Zoom and write a report of two pages in length on what you observed.

SELF-TEST 1-1-1 PHYSICS BEGINS

NAME. . . . . CLASS....GROUP....DATE....MARK....

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the above headings with the appropriate information on a sheet of paper.

Place the word or phrase which best fills the blank next to the number of the question on your answer sheet.

1. Mental boundaries which often condition our minds into set ways of thinking are called (_?_).

2. A (_?_) physicist is one who uses mathematical equations in an attempt to describe physical phenomena.

3. Aristotle's four earthly elements were (_?_),(_?_), (_?_) and (_?_).

4. The heavenly bodies were thought by Aristotle to be composed of a fifth element called the (_?_).

5. The flight of a bullet would be considered by Aristotle to be an example of (_?_) motion.

6. (_?_) is considered to be the father of modern science.

7. Aristotle believed that the speed of a falling body depended on its (_?_).

8. The basic difference in the way Aristotle "did" physics and the methods of modern physicists is the use of (_?_) and (_?_) by the modern physicist.

LONG ANSWER:

1. Explain in a sentence or two how Aristotle's elements differed from the corresponding materials found naturally.

2. Describe three reasons why Aristotelian science was retained for so long.

3. Describe how Aristotle might explain the rising of a hot air balloon.

4. Describe briefly (two or three lines) on the contribution of two of the following to early science:
   Eratosthenes, Archemedes, Ptolemy, the atomists

ANSWER KEY TO SELF-TEST 1-1-1

PHYSICS BEGINS

PART 1. OBJECTIVES: WHAT TO DO IF YOUR ANSWER IS WRONG:

1. Paradigm (a) Read the first page of the preface.
(b) Look up this word in a dictionary and write two other definitions for it.

2. Theoretical Reread the prologue. Describe the difference between a theoretical and an experimental physicist. Which one of these would Aristotle be classified as?

3. earth, water, air and fire Reread P.2

4. Quintessence Reread p.2 Earlier Greeks would have used the term aether which will play a big part in later discussions.

5. Heavy Reread p.3 and see Q.3 on page 4.

6. Measurement and mathematics See section 1.4 on p.5. Can you think of another reason why Aristotle may not have stressed careful measurement?

PART 2. LONG ANSWER:

1. The Aristotelian elements were thought to be pure forms which do not exist on earth because it was believed that each element contained traces of the other three. Thus water as found on earth would contain traces of air, fire, and earth. It was the combination of these elements in different proportions which were thought to make up all the different substances of which the earth was composed. How do you think Aristotle might have classified ice?

2. Aristotelian science was retained for such a long time because: (a) It was based on common observations and so-called common sense thus it could be easily understood.
(b) Aristotelian explanations of phenomena presupposed some preordained goal. This fit in well with the teachings of the church.
(c) Acceptance by the early Christian church gradually changed Aristotelian science into a set of dogmatic assumptions which were to be accepted by the common man without question.

3. Aristotle might explain the rising of a hot air balloon by saying that the element fire whose natural place is above the air was trapped by the balloon and naturally rises to its natural place carrying the balloon with it. How might he explain its descent?

4. See text Pp. 6 and 7.

QUIZ 1-1-1A PHYSICS BEGINS GRADE 10

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME_________________________CLASS____ GROUP____ DATE__________

Place the letter of the correct answer next to the number of the question on your sheet.

1. A physicist who takes observations of natural phenomena, either in the field or the laboratory is called a(n) _?_ physicist.
(a) natural (b) experimental (c) theoretical (d) observational

2. Aristotle believed that the _?_ was the center of the universe/
(a) sun (b) earth (c) prime mover (d) aether

3. Which of the Aristotelian elements had the highest place?
(a) water (b) air (c) fire (d) earth

4. Aristotle referred to motion as either _?_ .
(a) forced or inherent (b) natural or violent (c) horizontal or vertical (d) circular or linear

5. The horizontal flight of an arrow would be considered to be an example of _?_ motion.
(a) forced (b) violent (c) linear (d) natural (e) inherent

6. According to Aristotle if an object was dropped it would hit the ground with a speed which _?_.
(a) depended on the resistance of the air
(b) depended on the weight of the body
(c) would remain constant throughout its fall
(d) all of the above
(e) a and b above

Write a paragraph of between 5 to 8 lines on three of the following.

1. Aristotle's ideas about the nature of matter.

2. Why the early church accepted Aristotle's ideas.

3. How Aristotle might have used his theories to explain the evaporation of water and its falling as rain.

4. Ptolemy or Archemedes or the atomists (Do one of these)

RETURN THIS SHEET WITH YOUR ANSWER PAPER TO THE TEACHER

ANSWER KEY: QUIZ 1-1-1A PHYSICS BEGINS

OBJECTIVES:

1. (b)	2. (b)	3. (c)	4. (b)
5. (b)	6. (d)	(5 marks each)	

LONG ANSWER:

1. Aristotle believed that there were four earthly elements, earth, water, air and fire each having a natural place. 5 marks
   Earth was the element with the lowest place while fire had the highest position. 5 marks
   These elements were unlike those found naturally on earth in that they were pure forms while those on earth were composed of mixtures of the elements. 5 marks
   The heavens were composed of a different element than those on earth. This element was called the quintessence and had properties unlike any on earth. 5 marks

2. Aristotle's belief that terrestrial laws would not hold in the celestial regions and that the earth was the center of the universe fit in well with the views of the church. His ideas were reconciled with church dogma by Aquinas and he became the chief authority on scientific and philosophical matters for the church. 20 marks

3. Aristotle might have said that the element fire entered the water causing it to rise as steam since fire's natural place is above the air. Once in the air however the fire, now at its natural place might escape from the water and the water would drop to its natural place below the air as rain. 20 marks

4. See pp. 6 and 7. (10 marks each)

QUIZ 1-1-1 B PHYSICS BEGINS GRADE 10

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME______________________CLASS__________DATE__________

Place the letter of the best answer next to the number of the question on your sheet.

1. According to Aristotle the heavenly bodies were composed of a special element called _?_.
(a) quintessence (b) celestia (c) aether (d) vacuua

2. Aristotle believed that the speed of a falling body _?_.
(a) increased over time (b) depended on the body's weight
(c) was independent of the medium through which it fell
(d) was infinite in a vacuum

3. The rising of steam would be considered by Aristotle to be _?_.
(a) natural motion (b) violent motion (c) forced motion
(d) inherent motion

4. _?_ established Aristotle as the major authority of the church on scientific and philosophical matters.
(a) Justinian (b) The Bishop of Alexandria (c) Aquinas
(d) Pope Gregory

5. Aristotle put most emphasis on _?_ in his scientific investigations.
(a) measurement (b) mathematical analysis (c) direct observation (d) experimentation

6. _?_ is considered to be the "Father of Modern Science".
(a) Aristotle (b) Archimedes (c) Thales (d) Galileo

Write a paragraph of between 5 to 8 lines on three of the following:

1. Describe Aristotle's ideas concerning natural and violent motion and give an example of each.

2. Describe how Aristotle might explain the evaporation of water.

3. Describe three factors which lead to the retention of Aristotelian physics for such a long period of time.

4. Describe the contribution of one of the following to early scientific thought: Ptolemy, the atomists or Aristarchus.

OBJECTIVES:

1. (a) 3. (a) 5. (c)

2. (b) 4. (c) 6. (d)

LONG ANSWER:

1. Aristotle believed that there were four earthly elements each having a natural place. The motion of one of these elements towards its natural place was considered to be natural motion. One example of such motion would be the falling of water through the air. Violent motion occurred when one object was in contact with another exerting a force on it to keep it in motion. An example would be the flight of an arrow through the air which according to Aristotle was kept in motion by air rushing in behind it.

2. Aristotle might explain the rising of smoke from a fire by saying that the element fire enters the material that is burning causing it to rise through the air as smoke. The rising of smoke would be a natural motion since it is caused by fire attempting to get to its natural place above the air.

3. Aristotelian science was retained for so long because:

    1. Aristotle gained great respect in other areas such as politics and philosophy and this respect tended to make people uphold his views of science also.
    2. His ideas were naturally well recieved by the church which was most responsible for the education of the time.
    3. His theories, based on direct observation, seemed sensible to the people of the time.

4. See Pp. 6 and 7.

QUIZ 1-1-1C PHYSICS BEGINS

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME_______________________________ CLASS_______ DATE___________

Place the letter of the best answer next to the number of the question on your sheet.

1. A familiar pattern or model upon which we often attempt to base the solution of a problem is called a(n) (_?_). (a) parachute (b) parody (c) parable (d) paradigm

2. According to Aristotle the planets move (_?_). (a) in perfect circles around the sun (b) in ellipses around the sun (c) in ellipses around the earth (d) in circles around the earth.

3. According to Aristotle a stone when dropped fell to earth because (_?_). (a) of gravity (b) of its weight (c) the air pushed it down (d) of a natural tendency to do so.

4. Aristotle believed that the speed of a falling body (_?_). (a) decreased with its distance from the earth (b) increased over time (c) was infinite in a vacuum (d) was constant

5. Aristotle believed that the celestial bodies were composed of a fifth element called the (_?_). (a) quintessence (b) celestium (c) prime mover (d) ether

6. Aristotle believed that a stone when thrown is kept in horizontal motion by (_?_). (a) its inertia (b) gravity (c) air rushing in behind it (d) a natural tendency to remain in motion

LONG ANSWER: (Write a paragraph of from 5 to 8 lines on THREE of the following:

1. Explain what Aristotle meant by "natural" and "violent" motion and give one example of each type of motion.

2. Describe the properties of Aristotle's four earthly elements.

3. Describe how Aristotle might have predicted the results of an experiment in which two objects of identical size and shape but of different weight are dropped from the same height.

4. Describe the contribution of <u>one</u> of the following to early science: Aristarchus, Eratosthenes, Ptolemy.

ANSWER KEY TO QUIZ 1-1-1C

OBJECTIVES:

1. (d) 2. (d) 3. (d) 4. (d) 5. (a)

6. (c)

LONG ANSWER:

1. See Answer Key to Quiz 1-1-1B

2. Aristotle belived that earthly matter was composed of four elements; earth, water, air and fire , each of which occupied a natural position, earth lowest and fire highest. These elements were pure forms not found naturally on earth since all materials on earth were composed of mixtures of the elements. Thus naturally occuring water also contained traces of all the other elements as well.

3. Aristotle would have predicted that the heaviest object would fall at the fastest rate and would therefore reach the earth first.

4. See Pp. 6 and 7 of the text.

LEARNING ACTIVITY PACKAGE

1-2-1

ANALYSING SIMPLE MOTION

TO ACCOMPANY:
CHAPTER TWO

PHYSICS: A HUMAN ENDEAVOUR

A. RATIONALE

Now that we have examined some of the early concepts of motion developed by the Greeks, it is time to look at modern methods of analysing motion. While Aristotle developed his ideas of motion through direct observation, modern procedures make use of careful measurement and the use of mathematical descriptions derived from these measurements in order to explain phenomena. While developed here specifically to analyse motion, graphical techniques are very powerful tools. Graphical descriptions of phenomena are used in many walks of life from auto mechanic to nuclear physicist. Thus an understanding of how to draw and interpret graphs is important not only in physics but in other areas as well.

B. OBJECTIVES

To be more specific, after studying this package you should be able to:

1. Describe the role of an "ideal situation" in scientific descriptions of phenomena.

2. Describe examples of simple uniform and accelerated motion by plotting and analysing graphs.

3. Determine the important characteristics of a graph such as slope, intercept, and area and relate them to the physical properties of motion.

4. Define such terms as distance, speed, instantaneous and average velocity, and acceleration. Be able to calculate the values of these quantities from a graph.

C. PRETEST

Draw Pretest 1-2-1 from the file and complete it. Check your answers against the pretest key.

2. Answer Questions 1 to 15 which are asked within the text of the chapter in your notebooks.

*3. Perform and write up experiment 2.1A

4. Read appendices B and C (pp. 143-4) in your text.

*5. Complete PROBLEM SET 1-2-1 and hand it in for correction. PROBLEM SET 1-2-1 consists of the following questions on pages 28 & 29: 2.1, 2.3, 2.5, 2.6, 2.7, 2.9, 2.10, 2.11, 2.13, and 2.16.

6. If you feel you require further information, see the programmed instruction booklet Graphing Motion

E. SELF-TEST AND QUIZ (NOTE: BRING GRAPH PAPER)

When you have completed these activities, obtain a copy of SELF-TEST 1-2-1 from the file. Check your answers and if you have made errors check the material recommended with the answers to each question on the answer sheet. When you are satisfied that you have mastered the material well enough ask for QUIZ 1-2-1, complete it and turn it in for correction.

F. OPTIONAL ACTIVITIES

1. In order to fully understand the use of graphs, you may like to listen to the tape text PROGRAM 1 - GRAPHICAL ANALYSIS which describes the use of graphs from a more general viewpoint.

*2. Carry out experiment 2.1C using the alternate procedure in the experiment handout sheet E.2.1C. Compare the precision of this method with that of experiment 2.1A.

*3. Complete on of the activities on chapter 2 in the handbook in the back of the text.

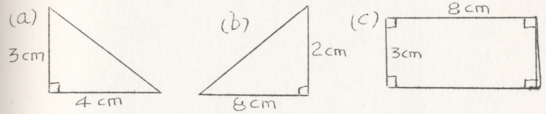
*4. Examine the overhead transparencies 1-2-1 through 1-2-6 and answer the questions on the accompanying worksheets.

PRETEST 1-2-1 ANALYSING SIMPLE MOTION

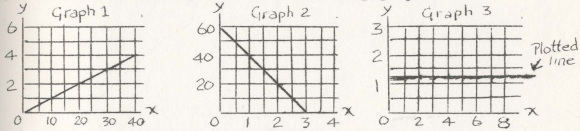
The function of this pretest is to check to see whether you are sufficiently prepared to start chapter two. Please <u>do not write on this sheet</u>. Complete the test on a sheet of your own paper and return this sheet to the file when you are finished. Note: This test will not form part of your evaluation for the course.

1. Convert 1.2 meters into centimeters.

2. Determine the areas of the following figures:



3. Determine the slopes of the following graphs:



4. In Graph 1 above, what is the value of y when x is 10?

5. In Graph 2 above, what is the value of x when y is 20 ?

6. How long will an object travelling at 20 Km per hour take to travel 50 Km?

7. How far will an object travelling at 20 meters per second go in 5 seconds?

ANSWER KEY TO PRETEST 1-2-1 · ANALYSING SIMPLE MOTION

1. 1.2 meters = 120 centimeters
   Note: If you are not familiar with the meaning of metric prefixes consult the text Modern Physics Chapter One.

2. The area of a triangle = $\frac{1}{2}$ base times height
   For triangle (a)
   $\frac{1}{2} \times 4 \times 3 = 6\ cm^2$

   For triangle (b)
   $\frac{1}{2} \times 8 \times 2 = 8\ cm^2$

   The area of a rectangle = base x height
   For rectangle (c)
   $8 \times 3 = 24\ cm^2$

3. Slope = $\frac{rise}{run}$ For Graph 1 slope = 4/40 = 0.1

   For Graph 2 slope = -60/3 = -20

   For Graph 3 slope = 0/x = 0 where x is any number

4. When x is 10, y is 1

5. When y is 20, x is 2

6. At 20 Km/hr an object will take 50/20 = 2.5 hr to travel 50 Km.

7. At 20 m/s an object will travel 20 x 5 = 100 m in 5 seconds.

NOTE: If you have trouble understanding any of these questions please consult with your teacher.

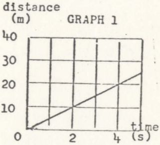
SELF-TEST 1-2-1 ANALYSING SIMPLE MOTION

NAME. . . . . CLASS. . . . . DATE. . . . .

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above with the required information on a sheet of paper. Replace this sheet when finished.

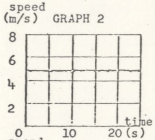
Place the word or phrase which best fits the statement next to its number on your sheet.

1. A car travelling at 16 m/s will travel _?_ m in 8 s.



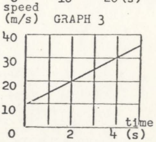
In the graph on the right:

2. The object went _?_ m in the first 4 s.
3. The object went _?_ m between t=2 and t=4 s.
4. The speed of the object was _?_ m/s.



In graph 2 on the right:

5. The object's acceleration was _?_ m/s^2.
6. The object went _?_ m in the first 10 s.
7. The slope of the graph is _?_ m/s^2



In graph 3 on the right:

8. The initial speed of the object was _?_ m/s.
9. The slope of the graph is _?_ m/s^2.
10. The object travelled _?_ m in the first 4 s.
11. The speed of the object at t=4 s is _?_ m/s.
12. The average speed of the object for the first 4 s was _?_ m/s
13. The acceleration of the object was _?_ m/s^2.

LONG ANSWER:

For the object in graph 3: (1) Draw a distance-time graph.
(2) Draw an acceleration-time graph.
(3) Describe its motion in words.

4. Describe the significance of the following properties of a speed-time graph: (a) intercept (b) slope (c) area under the curve

5. Using a car as an example, describe the difference between average and instantaneous velocity.

6. Define acceleration.

7. Why does science deal mainly with "ideal" situations?

8. Using the data table below and a sheet of graph paper, plot a speed-time graph. Determine the acceleration of the object and the distance travelled in the first 20 s.

time(seconds)	5	10	15	20	25	30	35	40
speed(m/s)	1.0	2.1	3.2	4.2	5.3	6.3	7.4	8.4

ANSWER KEY TO SELF-TEST 1-2-1

			Text Ref
1.	128 m	(16 x 8)	11
2.	20 m	read the graph	11
3.	10 m	(20 - 10)	12
4.	5 m/s	slope = 20/4	13
5.	0 m/s^2	slope = 0	15
6.	70 m	area under curve = 10 x 7	14
7.	0		15
8.	10	intercept	13
9.	5 m/s^2	slope = rise/run = 20/4	18
10.	80 m	area under curve	14
11.	30 m/s	read graph	19
12.	20 m/s		22
13.	5 m/s^2	see # 9	18

LONG ANSWER:

1.

time(s)	0	1	2	3	4	5
distance (m)	0	12.5	30.0	52.5	80.0	112.5

See graph sheet for graph.

2. See graph sheet

3. Object 3 starts with an initial velocity of 10 m/s and accelerates at 5 m/s^2 for 5 seconds attaining a velocity of 35 m/s and covering a distance of 112.5 m.

4. In a speed-time graph:

   the intercept = initial velocity
   the slope = acceleration
   the area under the curve = distance travelled.

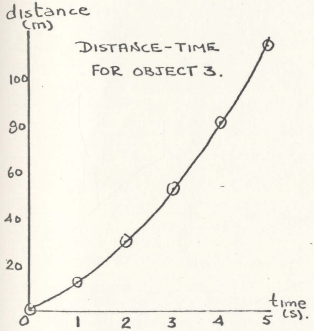
5. A car's instantaneous speed would be shown on the speedometer and would change constantly. Its average speed, however, would be determined by dividing the distance travelled by the time required.

6. Acceleration is the rate of change of velocity with time.

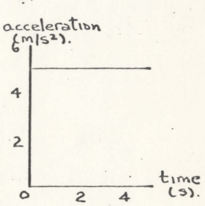
7. Science deals mainly with ideal situations because in the real world phenomena are complicated by extra factors which are not always present and have little if any bearing on the relationship under study. In science, we try to isolate the factors for study and thus create "ideal" situations.

8. See Graph Sheet

#1.

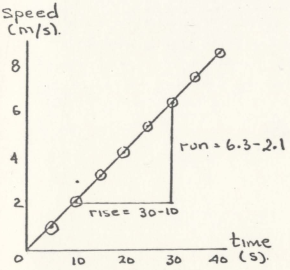


#2.



ACCELERATION-TIME FOR OBJECT 3.

8.



acceleration = slope

$= \text{rise}/\text{run} = \frac{4.2}{20}$

$= 0.21\ m/s^2$.

distance = area. at 20s

$= \frac{1}{2} \times 20 \times 4.2$

$= 42$ m.

QUIZ 1-2-1A ANALYSING SIMPLE MOTION FORM A

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.
NAME. . . . . CLASS. . .GROUP. . .DATE. . . . .
Place the letter of the best answer next to the number of the question.

1. A car travelling at 20 m/s will go (?) m in 5 s.
(a) 4 (b) 0.25 (c) 100 (d) 500

IN GRAPH 1

2. The object covered ? m in 15 s.
(a) 200 (b) 150 (c) 100 (d) 10
3. The distance travelled between t=15 and t=30 is ? m.
(a) 15 (b) 100 (c) 150 (d) 2250
4. The acceleration of the object was ? m/s^2.
(a) 10 (b) 5 (c) 2 (d) 0

IN GRAPH 2

5. The distance covered between t=2 and t=8s was ? m.
(a) 80 (b) 13.33 (c) 480 (d) 320

IN GRAPH #3

6. The initial speed of the object was ? m/s.
(a) 0 (b) 5 (c) 10 (d) 200
7. The average speed of the object for the 40 s shown was ? m/s.
(a) 15 (b) 200 (c) 5 (d) 300
8. The object went ? m in the first 20 s.
(a) 5000 (b) 4000 (c) 12000 (d) 10

IN GRAPH 4

9. The object's acceleration during the first second was ? m/s^2. (a) 40 (b) 20 (c) 10 (d) 0
10. The distance travelled by the object during the first 2 s was ? m. (a) 60 (b) 40 (c) 30 (d) 10

LONG ANSWER: Do THREE of the following four questions.

1. Describe the motion of the object in graph 4 in a few sentences. (Give numerical values where possible)

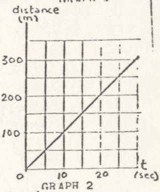
2. Draw a distance-time graph for the object in graph 3.

3. Draw a velocity-time graph for an object accelerating at 10 m/s^2 from an initial velocity of 20 m/s. Plot the data at 5 s intervals from 0 to 20 s.

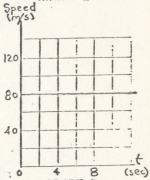
4. "Science is often a study of an ideal situation which is seldom if ever achieved in the real world." Comment on this statement in the light of the content of this chapter that we have studied so far.

Return this sheet with your answer paper.

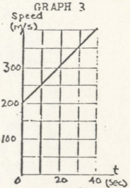
GRAPH 1



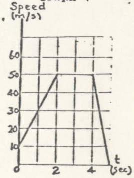
GRAPH 2



GRAPH 3



graph 4



ANSWER KEY: QUIZ 1-2-1 A

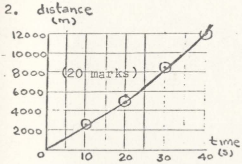
OBJECTIVES

1. (c)	6. (d)
2. (b)	7. (d)
3. (c)	8. (a)
4. (d)	9. (b)
5. (c)	10. (a) 4 marks each

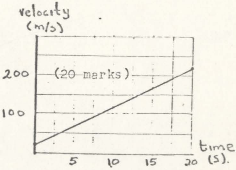
LONG ANSWER

1. Graph 4 shows an object starting from a velocity of 10 m/s and accelerating at 20 m/s^2 for 2 s. (4)
It maintains a velocity of 50 m/s for the next 2 s, (4)
then slows down, coming to a stop after 5 seconds. (4)
The total distance covered by the object was 185 m. (4)
(4)
20

2.



3

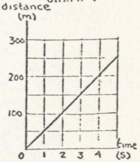


4. Science is often a study of an ideal situation which is seldom if ever achieved in the real world. In this chapter we studied examples of uniform and uniformly accelerated motion in one direction on a line. Such motion is rarely observed in nature. In the real world motions occur in various directions in three dimensions and in most cases objects undergo varying accelerations. A good example of such a common motion is the falling leaf cited in the text. However, the mathematical description of such motions is extremely difficult. Thus in science we seek to understand the simpler ideal situations in the hope that it will lead to a more profound knowledge of the more complex things that occur in nature. (20 marks)

QUIZ 1-2-1B ANALYSING SIMPLE MOTION. FORM B

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.
NAME. . . . . .CLASS. . .GROUP. . .DATE. . . .
Place the letter of the best answer next to the number of the question.

GRAPH 1



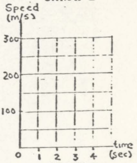
1. A car which goes 320 m in 8 s is moving at an average speed of _?_ m/s. (a) 2560 (b) 0.025 (c) 40 (d) 20

IN GRAPH 1:

2. The object covered _?_ m in 2.5 s.
(a) 125 (b) 100 (c) 150 (d) 80 (e) 50

3. The distance covered between t=2 and t=4 s was _?_ m.
(a) 300 (b) 50 (c) 100 (d) 200

GRAPH 2

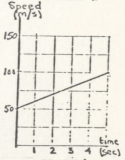


IN GRAPH 2

4. The speed at t=2 s was _?_ m/s
(a) 0 (b) 200 (c) 100 (d) 400

5. The distance covered between t=2 and t=5 s was _?_ m.
(a) 0 (b) 200 (c) 40 (d) 600

GRAPH 3



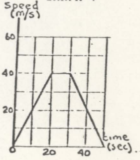
IN GRAPH 3:

6. The slope is _?_ m/s^2. (a) 0 (b) 8 (c) 10 (d) 20

7. The average speed of the object over the time indicated was _?_ m/s. (a) 10 (b) 20 (c) 125 (d) 75

8. The distance travelled during the 5 s. was _?_ m.
(a) 375 (b) 150 (c) 75 (d) 200

GRAPH 4



IN GRAPH 4:

9. The total distance covered was _?_ m.
(a) 400 (b) 800 (c) 1200 (d) 2000

10. The acceleration during the first 20 s was _?_ m/s^2
(a) 40 (b) 20 (c) 10 (d) 2

LONG ANSWER: Do three of the following:

1. Describe the motion depicted by graph 4.

2. Draw a distance-time graph for the object in graph 3

3. Draw a velocity-time graph for an object accelerating at 5 m/s^2 from an initial velocity of 10 m/s.

4. (a) Plot the following data on a d-t graph.
(b) Is this an example of simple uniform or uniformly decelerated motion? Discuss.

Distance (cm.)	10.1	20.0	29.8	38.0	45.1
Time (sec.)	1.5	3.0	4.5	6.0	7.5

ANSWER KEY: QUIZ 1-2-1 B

OBJECTIVES:

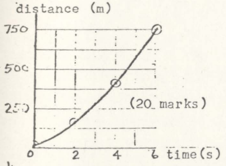
1. (c)
2. (a)
3. (c)
4. (b)
5. (d)
6. (c)
7. (d)
8. (a)
9. (c)
10. (d) (4 marks each)

LONG ANSWER:

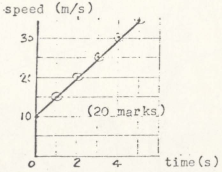
1. Object four accelerated from rest — 4 marks
at 2 m/s^2 for 20 seconds, — 4 marks
attaining a velocity of 40 m/s which it maintained for another 10 seconds. — 4 marks
It then slowed down, coming to rest after another 20 seconds. — 4 marks
The total displacement was 1200 meters. — 4 marks

20 marks

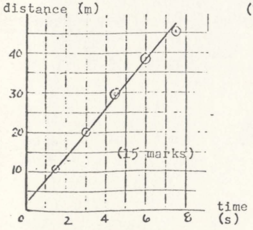
2.



3.



4.



(b) The line of best fit shows that the graph does show some tendency to curve downwards but the amount is not enough to conclude that the object is slowing down. The data would have to be extended for several more seconds before such a trend could be ascertained for sure.

(5 marks)

QUIZ 1-2-1C | ANALYSING SIMPLE MOTION | FORM C

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.
NAME. . . . . CLASS. . . . GROUP. . . DATE. . . . . . .
Place the letter of the best answer next to the number of the question.

1. An object accelerating from rest at 10 m/s^2 for 5 s will attain a speed of _?_ m/s. (a) 2 (b) 0.5 (c) 125 (d) 50

IN GRAPH 1:

2. The object went a distance of _?_ m between t=3 and t=5 s. (a) 10 (b) 20 (c) 30 (d) 40
3. The speed of the object was _?_ m/s. (a) 40 (b) 20 (c) 10 (d) 5

IN GRAPH 2:

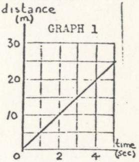
4. The slope is _?_ m/s^2. (a) 500 (b) 50 (c) 0 (d) 20
5. The object went a distance of _?_ m between t=2 and t=6 s. (a) 500 (b) 200 (c) 50 (d) 0

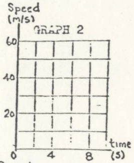
IN GRAPH 3:

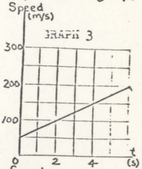
6. The initial speed was _?_ m/s. (a) 25 (b) 1200 (c) 300 (d) 50 (e) 33.3
7. The acceleration was _?_ m/s^2. (a) 25 (b) 1200 (c) 300. (d) 50 (e) 33.3
8. The object covered a distance of _?_ m in the first 6 s. (a) 1000 (b) 750 (c) 600 (d) 300

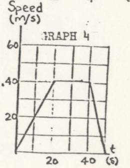
IN GRAPH 4:

9. The acceleration during the first 20 s. was _?_ m/s^2. (a) 20 (b) 40 (c) 2 (d) 400
10. The total distance covered was _?_ m. (a) 2000 (b) 1200 (c) 1400 (d) 2400









LONG ANSWER: Do <u>three</u> of the following:

1. Describe the motion of the object in graph 3.
2. Draw a distance-time graph of object 3.
3. An object beginning with a velocity of 20 m/s accelerates uniformly to a velocity of 80 m/s after 20 s. Draw a graph of this motion and show how you would determine the acceleration from this graph.
4. Give two examples each of uniform motion and uniformly accelerated motion.

Return this sheet with your answer sheet.

ANSWER KEY: QUIZ 1-2-1 C ANALYSING SIMPLE MOTION

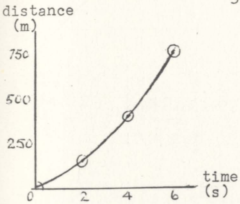
OBJECTIVES:

1. (d)
2. (a)
3. (d)
4. (c)
5. (b)
6. (d)
7. (a)
8. (b)
9. (c)
10. (c) (4 marks each)

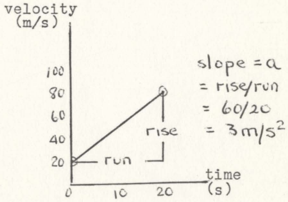
LONG ANSWER:

1. Object four started from rest — 4 marks
and accelerated at 2 m/s^2 for 20 s. — 4 marks
It maintained a speed of 40 m/s from t=20
to t=40, — 4 marks
then slowed to a stop after 50 s. — 4 marks
It covered a total distance of 1400 m. — 4 marks
— 20 marks

2.



3.



4. Answers will vary:

Uniform motion: sound, light, or any wave in a uniform medium. Student might mention that objects rarely undergo uniform motion which is an ideal situation

Uniformly accelerated motion:
Again an idealized situation - students may mention a drag racer, an object in free fall or an object on a ramp.

LEARNING ACTIVITY PACKAGE

1-2-2

ANALYSING SIMPLE MOTION-2

TO ACCOMPANY:

CHAPTER TWO

PART TWO

PHYSICS: A HUMAN ENDEAVOUR

A. RATIONALE

The graphical techniques which you have just studied are an excellent way of representing motion. Graphs give an almost pictorial display of relationships and important quantities can be obtained from them almost at a glance. However, producing graphs is often time consuming and scientists, like other mortals, seek easier ways of describing things. Just as secretaries use shorthand to write things more quickly, scientists use mathematical symbols in the form of equations to express relationships in a quick economical fashion. Equations have an extra added bonus, however, for if they are manipulated following set mathematical rules new equations can be formed which often lead to better insights into the phenomena. In this package you will learn how such equations are related to the graphs we developed earlier and how they may be used to describe motion.

B. OBJECTIVES

More specifically, at the end of this package you should be able to:

1. Derive motion equations from the graphs of motion studied earlier.
2. Analyse a motion problem so that the correct equation can be stated.
3. Solve an equation for an unknown variable.
4. Substitute values into an equation to determine the unknown quantity.

C. PRETEST:

You should be familiar with the solving of equations for unknowns and how to determine the slope-intercept equation for a linear graph. To test your skill at these items, draw PRETEST 1-2-2 from the file, complete it and check your answers. The answer key to PRETEST 1-2-2 will tell you how to correct any problems you may have.

Thanks to Johnny Hart

D. ACTIVITIES

1. Read the text Pp. 23-27 and answer Q 16 p. 26.

*2. Perform and report on Experiment 2.2A Pp. 108-110

*3. Do Problem Set 1-2-2 consisting of the following questions: Pages 28-31 numbers 2.8, 2.12, 2.15, 2.17, 2.18, 2.20, and 2.21

*4. Read Article 8 in Reader One or substitute some other topical article on motion and submit a resume card.

5. Examine Transparency T 1-2-2A and complete the problems given on the Student Directions sheet which accompanies it.

E. SELF TEST AND QUIZ

When you have completed the work above to your satisfaction draw Self-Test 1-2-1 from the file and complete it. Check your answers against the answer key to the test.

Quiz 1-2-1 B will be given at a mutually agreed upon time. Watch the bullitin board for this time.

F. OPTIONAL ACTIVITIES

*1. Carry out Experiment 2.3 and submit a report.

*2. Do activity 2.6 or some other activity of your choice given in the Student Workbook for this chapter.

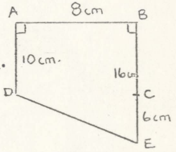
*3. View the film VELOCITY AND ACCELERATION and write a one page report of what you saw.

PRETEST 1-2-2 ANALYSING SIMPLE MOTION 2 EQUATIONS

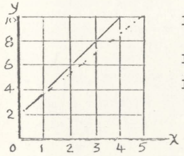
INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the required information below on a sheet of paper.

NAME ....CLASS _....GROUP .....DATE..............

Place the word or phrase which best answers the question next to the number of the question on your answer sheet.



1. The area of the rectangle ABCD is _?_.
2. The area of the triangle BDC is _?_.
3. The area of the quadrilateral ADEB is _?_.
4. Solve the equation $x = 3y$ for y _?_.
5. Solve the equation $x = 4y + 3$ for y
6. Solve the equation $\frac{v_i + v_f}{2} = v_{av}$ for v_f
7. In the equation $x = 4y^2 + 2z$, $y=3$ and $z = -4$ find x
8. Speed is defined to be _?_.
9. Acceleration is defined to be _?_.
10. State question 8's answer as an equation.
11. State question 9's answer as an equation.
12. The symbol $\triangle$ means _?_.



13. What is the y intercept of this graph?
14. What is the slope of this graph?
15. State the slope-intercept equation of this graph.

ANSWER KEY TO PRETEST 1-2-2

1. Area = length x width = 8 x 10 = 80 cm^2

2. Area = $\frac{1}{2}$ base x height = $\frac{1}{2}$ x 8 x 10 = 40 cm^2

3. Area of ADEB = area of ABCD + area of DCE = 80 + 24 = 104 cm^2

4. dividing both sides by 3 yields x/3 = y
   transposing yields y = x/3

5. subtracting 3 from both sides yields x - 3 = 4y
   dividing by 4 yields (x - 3)/4 = y
   transposing yields . . . . $y = \frac{x-3}{4}$

6. multiplying both sides by 2 yields $v_i + v_f = 2\ v_{av}$

   subtracting v_i from both sides yields $v_f = 2\ v_{av} - v_i$

7. $x = 4 \times 3^2 + 2 \times (-4) = 36 + (-8) = 28$

8. Speed is defined to be rate of change of position with time.

9. Acceleration is defined as time rate of change of velocity.

10. $S = \Delta d/\Delta t$

11. $a = \Delta v/\Delta t$

12. Δ means <u>the change in</u>

13. The y-intercept is 2

14. The slope = rise/run = 8/4 = 2

15. The slope-intercept equation for the graph is

    y = mx + b where m = slope and b = y-intercept

    thus y = 2x + 2

(Note: See page 143 in your text for a full explanation of questions 13, 14, and 15.)

SELF-TEST 1-2-2 ANALYSING SIMPLE MOTION-2 EQUATIONS

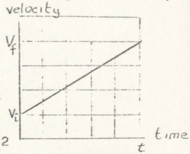
NAME .CLASS. . . . .DATE. . . . .

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading and information above on a sheet of your own paper.

Place the letter of the best answer next to the number of the question on your sheet.

A. In the graph on the right:

1. An expression which best represents the change in velocity of the object shown is (_?_)
(a) v_it (b) v_ft (c) v_i-v_f (d) v_f-v_i



2. An expression which represents the distance the object would have travelled if it had continued with the constant velocity v_i is (_?_)
(a) v_it (b) at (c) v_ft (d) $(V_i-V_f)t$

3. An expression which represents the acceleration of the object is (_?_)
(a) v_it (b) v_ft (c) $(V_f-V_i)/t$ (d) $\frac{1}{2}v_it^2$

B. A car is travelling down a straight level road at 10 m/s.

4. Its acceleration is (_?_) m/s^2. (a) 0 (b) 5 (c) 10 (d) -5

5. It will cover a distance of (_?_) m in t seconds.
(a) t/10 (b) 10t (c) $10t^2$ (d) $5t^2$

C. A car accelerates from rest at 20 m/s^2.

6. Its velocity at time t seconds will be (_?_) m/s.
(a) 20/t (b) 20t (c) $20t^2$ (d) $10t^2$

7. The average velocity of the object during the first 10 s will be (_?_) m/s. (a) 20 (b) 50 (c) 100 (d) 200

8. It will travel a distance of (_?_) m during the first 10 s.
(a) 100 (b) 200 (c) 1000 (d) 2000

D. A car accelerates at 5 m/s^2 from an initial velocity of 20 m/s.

9. Its velocity at t=10s will be (_?_) m/s.
(a) 50 (b) 70 (c) 250 (d) 700

10. It will cover a distance of (_?_) m in the first 10 s.
(a) 700 (b) 450 (c) 200 (d) 1000

LONG ANSWER:

1. A car starts with an initial velocity of 10 m/s. and accelerates uniformly for 5 sec. covering a distance of 150 m. Using equations find:

   (a) The car's average velocity.

   (b) The car's acceleration.

   (c) The car's final velocity.

2. Using the graph given on the objective sheet show how the equation $d = v_i t + \frac{1}{2}at^2$ is related to the graph.

ANSWER KEY TO SELF-TEST 1-2-2

			text ref.
1.	(d)	change of v = rise of graph	p.24
2.	(a)	distance = velocity x time	Pp. 24-25
3.	(c)	a = change in v over time	p. 24
4.	(a)	there is no change in v here	p. 16
5.	(b)	distance = velocity x time	p.23
6.	(b)	$v_f = v_i + at = 0 + 20t = 20t$	p.26
7.	(c)	$v_{av}=(v_i + v_f)/2 = 0 + 200/2 = 100$	p.24
8.	(c)	$d = v_i t + \frac{1}{2}at^2 = 0 + \frac{1}{2}\cdot 20\cdot 10^2 = 1000$	p. 25
9.	(b)	$v_f = v_i + at = 20 + 5 \times 10 = 70$	p. 24
10.	(b)	$d = v_i t + \frac{1}{2}at^2 = 20\cdot 10 + \frac{1}{2}\cdot 5\cdot 100 = 450$	p. 25

LONG ANSWER

1. (a) Average velocity $= \frac{\text{distance}}{\text{time}}$ or $v_{av} = d/t$

$$= 150/5 = 30 \text{ m/s}$$

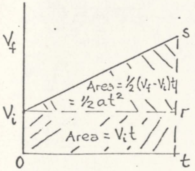
(b) $V_i = 10$ m/s and $V_{av} = 30$ m/s therefore $V_f = 50$ m/s (See part (c))

$$a = \frac{V_f - V_i}{t} = \frac{50 - 10}{5} = 40/5 = 8 \text{ m/s}^2$$

(c) $V_{av} = \frac{V_i + V_f}{2}$ therefore $V_f = 2\,V_{av} - V_i$

$$= 2 \times 30 - 10 = 50 \text{ m/s}$$

2. The area under a v - t graph is equal to the distance travelled by the object.



The area here is equal to that of the rectangle V_i r t 0 plus that of the triangle s r V_i

The area of the rectangle is $V_i t$

and the area of the triangle is one-half the base times the height. But its height is $V_f - V_i$

and the base of the triangle is t, and its area is $\frac{1}{2}(V_f - V_i)\,t$
Thus the total area under the graph is,

$$V_i t + \tfrac{1}{2}(V_f - V_i)\,t$$

But recall that by the definition of acceleration

$$a = (V_f - V_i)/t$$

thus $V_f - V_i = at$

this expression at can be substituted in our equation for the area under the graph.

thus area $= V_i t + \frac{1}{2}at\ \ t$

and therefore

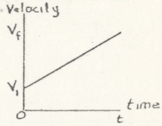
$$d = V_i t + \tfrac{1}{2}\,at^2$$

QUIZ 1-2-2A ANALYSING SIMPLE MOTION-2 EQUATIONS

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME____________________ CLASS_____ DATE______

Place the letter of the best answer next to the number of the question on your sheet.



A. In the graph on the right.

1. The acceleration of the object can be obtained by finding the (_?_) the graph. (a) slope of (b) area under (c) maximum height of (d) total length of

2. The equation for the acceleration of the object will therefore be (_?_). (a) $(V_f - V_i)/t$ (b) $(V_f+V_i)/2t$ (c) $(V_f + V_i)t$ (d) $V_it - V_ft$

B. A car is travelling on a straight level road at 15 m/s.

3. The time required for the car to go 450 m is (_?_) s. (a) 6750 (b) 75 (c) 30 (d) 0.33

4. The car will cover a distance of (_?_) m in 10 s. (a) 1.5 (b) 6.6 (c) 150 (d) 750

C. An object accelerates from rest at 6 m/s^2.

5. Its velocity at t=10 s will be (_?_) m/s. (a) 0.6 (b) 1.67 (c) 60 (d) 300

6. The time taken for it to attain a velocity of 150 m/s will be (_?_) s. (a) 0.04 (b) 25 (c) 20 (d) 50

7. It will cover a distance of (_?_) meters in the first 10 s. (a) 300 (b) 120 (c) 60 (d) 30

D. An object accelerates at 2 m/s^2 from an initial velocity of 10 m/s.

8. Its velocity at t=20s will be (_?_) m/s. (a) 100 (b) 50 (c) 25 (d) 500

9. It will take (_?_) seconds to attain a velocity of 40 m/s. (a) 35 (b) 25 (c) 20 (d) 15

10. It will cover a distance of (_?_) m in the first 6 seconds. (a) 96 (b) 60 (c) 36 (d) 132

LONG ANSWER:

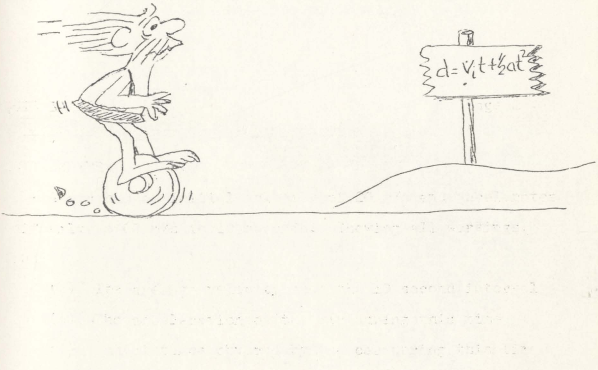
A car has an initial velocity of 20 m/s and accelerates uniformly to 60 m/s in 10 seconds. Showing all workings, find:

(a) Its average velocity over the 10 second interval

(b) The acceleration of the car during this time

(c) The distance covered by the car during this time

(d) The time at which its instantaneous velocity is 40 m/s.



ANSWER KEY TO QUIZ 1-2-2A

OBJECTIVES:

1. (a)	2. (a)	3. (c)	4. (c)	5. (c)
6. (b)	7. (d)	8. (b)	9. (d)	10. (a)

(4% each)

LONG ANSWER: (15% each)

1. (a) $V_{av} = \frac{V_i + V_f}{2} = \frac{20 + 60}{2} = \frac{80}{2} = 40$ m/s

(b) $a = \frac{V}{t} = \frac{V_f - V_i}{t} = \frac{60 - 20}{10} = \frac{40}{10} = 4$ m/s^2

(c) $d = V_{av}t = 40 \times 10 = 400$ m

or alternately $d = V_i t + \frac{1}{2} at^2$

$= 20 \times 10 + \frac{1}{2} 4 \times 100$

$= 200 + 200 = 400$ m

(d) $V_f = V_i + at$

whence $t = \frac{V_f - V_i}{a} = \frac{40 - 20}{4} = \frac{20}{4} = 5$ s

or alternately
the average velocity occurs half way through the time interval over which it is measured for uniformly accelerated motion. Since the time interval is 10 s, then the object will be going at its average velocity of 40 m/s at 5 seconds.

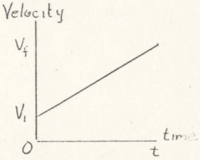
QUIZ 1-2-2B ANALYSING SIMPLE MOTION-2 EQUATIONS

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME________________________________CLASS_________DATE________

Place the letter of the best answer next to the number of the question on your sheet.

A. In the graph on the right:



1. The change in velocity of the object can be obtained by determining the (?) the graph.
(a) rise of (b) run of (c) slope of
(d) length of

2. The expression describing the change in velocity will therefore be (?)
(a) t (b) $V_f + V_i$ (c) $V_f - V_i$
(d) $V_i t$

B. A car travelling along a straight level road goes 400 m in 10 s.

3. Its average velocity was (?) m/s. (a) 4000 (b) 400 (c) 40
(d) 4

4. Its instantaneous velocity at 5 s was (?) m/s.
(a) 20 (b) 200 (c) 40 (d) not determinable from this data

C. A car accelerates from rest at a uniform rate of 10 m/s^2.

5. Its velocity at t=5 s will be (?) m/s.
(a) 2 (b) 50 (c) 25 (d) 125

6. The time required for the object to attain a velocity of 80 m/s will be (?) s. (a) 8 (b) 800 (c) 4 (d) 16

7. The object will cover a distance of (?) m in the first 10 s.
(a) 50 (b) 500 (c) 1000 (d) 10

D. An object with an initial velocity of 40 cm/s accelerates uniformly at a rate of 4 cm/s^2.

8. Its velocity at t=5 s will be (?) cm/s.
(a) 2 (b) 50 (c) 60 (d) 32

9. It will take (?) s to attain a velocity of 120 cm/s.
(a) 3 (b) 20 (c) 30 (d) 10

10. It will cover a distance of (?) cm in 5 s.
(a) 60 (b) 32 (c) 220 (d) 250

LONG ANSWER:

An object with an initial velocity of 20 m/s accelerates uniformly to cover 300 meters in 10 seconds. Showing all calculations, find:

(a) The average velocity of the object during the 10 seconds

(b) The final velocity of the object after 10 seconds.

(c) The acceleration of the object during the 10 seconds.

(d) The time at which the instantaneous velocity of the object was 30 m/s.

ANSWER KEY TO QUIZ 1-2-2B

OBJECTIVES: (4 marks each)

1. (a)	2. (c)	3. (c)	4. (d)	5. (b)
6. (a)	7. (b)	8. (c)	9. (b)	10. (d)

LONG ANSWER: (15 marks each)

(a) $V_{av} = d/t = 300/10 = 30$ m/s

(b) $V_{av} = (V_i + V_f)/2$

Thus $V_f = 2\ V_{av} - V_i$

$= 2 \times 30 - 20 = 40$ m/s

(c) $a = (V_f - V_i)/t$

$= \frac{40 - 20}{10} = 20/10 = 2$ m/s^2

(d) Since here $V_{inst} = V_{av}$, this must have occured half way through the time interval or at 5 seconds.

or alternately;

from the equation used in (c)

$t = (V_f - V_i)/a = (30 - 20)/2 = 10/2 = 5$ s

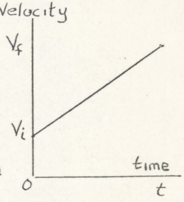
QUIZ 1-2-2C ANALYSING SIMPLE MOTION-2 EQUATIONS

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the above heading and the information requested below on a sheet of paper.

NAME_____________________________CLASS___________DATE___________

Place the letter of the best answer next to the number of the question on your answer sheet.

A. In the graph on the right:



1. $V_f - V_i$ would represent the (_?_) of the object. (a) acceleration (b) distance (c) average velocity (d) change in velocity
2. The area under the graph would represent the (_?_) the object. (a) distance travelled by (b) velocity of (c) acceleration of (d) average speed of

B. A toy tractor travels at a constant speed across a lab bench.

3. If it covers 200 cm in 25 s, its average speed was (_?_) cm/s. (a) 50 (b) 40 (c) 8 (d) 16

4. If it continues at the velocity above it will cover (_?_) cm in 40 s. (a) 250 (b) 500 (c) 400 (d) 320

C. A car accelerates from rest at 20 m/s^2.

5. Its velocity at t=5 seconds will be (_?_) m/s (a) 100 (b) 250 (c) 312.5 (d) 500

6. The time taken for it to attain a velocity of 50 m/s will be (_?_) s. (a) 0.5 (b) 2.5 (c) 5 (d) 10

7. It will travel a distance of (_?_) m in the first 8 seconds. (a) 1280 (b) 160 (c) 640 (d) 320

D. An object with an initial velocity of 20 m/s accelerates uniformly at a rate of 4 m/s^2.

8. It will attain a velocity of (_?_) m/s at t=10 s. (a) 80 (b) 60 (c) 50 (d) 240

9. It will take (_?_) seconds to attain a velocity of 40 m/s. (a) 5 (b) 8 (c) 10 (d) 200

10. It will cover a distance of (_?_) m in the first 8 seconds. (a) 400 (b) 144 (c) 200 (d) 288

LONG ANSWER:

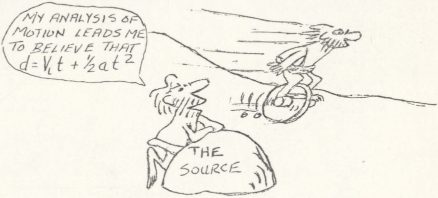
An object with an initial velocity of 30 m/s accelerates uniformly to a velocity of 150 m/s in 6 seconds. Showing all calculations find:

(a) Its average velocity during the 6 seconds.

(b) Its acceleration during the six seconds.

(c) The distance the object covered during the six seconds.

(d) The time taken for the object to attain an instantaneous velocity of 90 m/s.



ANSWER KEY: QUIZ 1-2-2C

OBJECTIVES: (4 marks each)

1. (d) 2. (a) 3. (c) 4. (d) 5. (a)

6. (b) 7. (c) 8. (b) 9. (a) 10. (d)

LONG ANSWER: (15 marks each)

(a) $V_{av} = (V_i + V_f)/2 = (30 + 150)/ 2 = 90$ m/s.

(b) $a = (V_f - V_i)/t = (150 - 30)/6 = 120/6 = 20$ m/s^2.

(c) $d = V_i t + \frac{1}{2}at^2 = 30 \times 6 + \frac{1}{2}\, 20 \times 36 = 180 + 360$
$= 540$ meters

(d) Since $V_{inst} = V_{av}$ in this case the time taken to attain this velocity would be one-half the total time or 3 seconds.

or alternately;

From the equation in part (b)

$t = (V_f - V_i)/a = (90 - 30)/20 = 60/20 = 3$ seconds

LEARNING ACTIVITY PACKAGE

1-3-1

GALILEO DESCRIBES MOTION

TO ACCOMPANY:

CHAPTER THREE

PHYSICS: A HUMAN ENDEAVOUR

A. RATIONALE

Now that you have learned how to describe simple motion graphically and algebraically, we can turn to a description of falling bodies. The first mathematical analysis of such motion was carried out by Galileo in the early sixteen hundreds. An understanding of his work is important, not only for its application to the study of motion, but for its wide-ranging effects on the whole process of doing science. His radically different methods lead the way in the modern scientific approach and the gradual overthrow of the Aristotelian cosmology.

B. OBJECTIVES: Upon completion of this package you should be able to:

1. Summarize Galileo's argument against Aristotle's claim that heavy objects fall faster than light ones.

2. Describe the differences between Galileo's way of doing science and that of Aristotle.

3. Describe the hypothesis, prediction and test involved in Galileo's work on free fall.

4. Discuss the points affecting the validity of Galileo's experiments on an inclined plane.

5. Describe the effects of Galileo's work on the philosophy of the time.

6. Analyse free fall motion both graphically and algebraically.

C. PRETEST: The quiz for LAP 1-2-2 forms the pretest for this package.

D. ACTIVITIES:

1. Read Chapter 3 of the text and answer all Q questions.

*2. Conduct Experiment 3.1 P. 119 and submit a report.

*3. Do Problem Set 1-3-1 consisting of the following questions on Pp. 50 and 51 of the text.

3.1, 3.3, 3.4, 3.7, 3.8, 3.10, 3.13, and 3.16

*4. Examine the film Galileo and submit a one page report. or discuss questions 3.12 and 3.15 with your study group and submit a report.

E. SELF-TEST AND QUIZ.

Use Self-Test 1-3-1 to check your mastery of the material. Quiz 1-3-1 will be given on a mutually agreed upon day.

F. OPTIONAL ACTIVITIES:

*1 View Filmloop 3.1 "Acceleration due to Gravity" and answer the questions on page 128 of the text.

*2 Carry out Experiment 3.2 p. 121

*3 Try one of the activities on this chapter in the Student Handbook.

Instructions: DO NOT WRITE ON THIS SHEET. Use a sheet of your own paper as your answer sheet and return this test to the files once you are finished.

Fill the Blanks:

1. Galileo lived in a time of a great creative revival in the arts and sciences known as (_?_)

2. Galileo, unlike Aristotle, based his work on (_?_) observations.

3. Because the velocity of an accelerating body is difficult to measure Galileo chose to measure the ratio of (_?_)

4. In Galileo's theory of falling bodies the cause is considered to be (_?_)

5. The process of extending data beyond that actually measured is called (_?_)

6. A well informed guess about the possible explanation of a phenomenum is called a(n) (_?_)

7. The average speed of a body accelerating uniformly from rest is 30 m/s over a period of 6 sec. The instantaneous velocity of the body at 6 sec is(_?_) m/s.

8. For the object in #7 the instantaneous velocity of 30 m/s would occur at the (_?_) sec point.

9. A body accelerates uniformly from rest and covers a distance of 180m in 3 sec. The acceleration of the body is (_?_) m/s^2.

10. An object falling through the air has its acceleration slowed by air resistance. When the acceleration is 0 the body is said to have reached its (_?_)

LONG ANSWER

1. Describe Galileo's argument against Aristotle's hypothesis that heavy objects fall faster than light ones.

2. State three major consequences of Galileo's work on free fall.

3. An object is dropped from a height of 80m calculate:

   (a) the time required for it to hit the ground.
   (b) its average velocity on the way down
   (c) its instantaneous velocity just before it strikes the ground ($g = 10m/s^2$)
   (d) the time when its instantaneous speed would be 25 m/sec.

Fill the blanks:

1.	The Renaissance	See p. 34
2.	quantitative	See p. 34
3.	d to t^2	See p. 40 and p. 41
4.	premature	See p. 39
5.	extrapolation	See margin p. 44
6.	hypothesis	See p. 38
7.	60 m/s	See p. 48
8.	3	See p. 48
9.	$\sqrt{40} = 6.3$	See p. 48 & 49 $d = \frac{1}{2}at^2$ therefore $a = 2d/t^2 = 360/9$
10.	terminal speed	See p. 51 problem 3.13

LONG ANSWER:

1. Consider a light object falling more slowly than a heavy one. Joining the two objects leads to a dilemma.
   Firstly one could argue that the light object would tend to slow the fall of the heavy one so that there speed would lie somewhere in between the falling speeds of the two objects.
   Secondly, one could argue that the two objects joined would form an even heavier object which would fall at a speed greater than either of the two objects falling alone.
   It is clearly impossible for such a system to fall at two different speeds at the same time, therefore the original hypothesis must be wrong. (See p. 36)

2. Three of the major consequences of Galileo's work on free fall are:
   (i) Galileo presented a new method of carrying out scientific research.
   (ii) He showed that acceleration as he defined it was constant for an object rolling down a ramp.
   (iii) He showed that spheres of different weights have the same acceleration on such an incline.
   (iv) He developed a mathematical theory of motion

3\. (a) $d = \frac{1}{2} g t^2$ therefore $t = \sqrt{2d/g}$

$$= \sqrt{\frac{2 \times 80}{10}}$$

$$= \sqrt{16} = \underline{4 \text{ sec}}.$$

(b) $v_{av} = d/t = 80/4 = \underline{20 \text{ m/sec}}$.

(c) $v_f = g\ t = 10 \times 4 = \underline{40 \text{ m/sec}}$.

(d) $v_f = g\ t$ therefore $t = v_f/g = 25/10 = \underline{2.5 \text{ sec}}$.

Note: If you are having trouble with the manipulation of equations, you might like to look at the Project Physics programmed instruction booklets entitled Equations 1, 2 and 3

QUIZ 1-3-1 A GALILEO DESCRIBES MOTION

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above with the information requested below on a sheet of paper.

NAME________________________________CLASS__________DATE_______

Place the letter of the best answer next to the number of the question on your answer sheet.

1. Galileo believed that heavy objects fell faster than light ones mainly due to the influence of (_?_).
   (a) gravity (b) air friction (c) density (d) a natural tendency to do so

2. "A motion is said to be uniformly accelerated, when starting from rest, it acquires during equal time-intervals, equal increments of speed." This was the (_?_) in Galileo's analysis of motion.
   (a) assumption (b) hypothesis (c) definition (d) test

3. The basic difference in Galileo's and Aristotle's way of doing science was Galileo's emphasis on (_?_)
   (a) observation (b) logic (c) proposing and testing an hypothesis (d) authority

4. Galileo stated that an object in free fall undergoes uniformly accelerated motion. This was his (_?_) in his analysis of the motion of falling bodies.
   (a) hypothesis (b) definition (c) prediction (d) test

5. When an object undergoes uniform velocity motion the ratio of (_?_) is constant. (a) d/t^2 (b) t/d^2 (c) d/t (d) d^2/t

6. Galileo's major contribution to science was (_?_).
   (a) calculation of "g" (b) a new mode of scientific reasoning
   (c) a definition of acceleration (d) finding that acceleration on an incline was constant

7. An acceleration of 9.8 m/s^2 for a body in free fall means (_?_)
   (a) it falls 9.8 m/s faster every meter
   (b) it falls 9.8 meters every second
   (c) it doubles its speed every 9.8 meters
   (d) it falls 9.8 m/s faster each second.

8. A body falling from rest takes 3 seconds to hit the ground. Its velocity just before it hits the ground will be (_?_) m/s.
   (a) 3.33 (b) 30 (c) 45 (d) 9.8

9. A body free falling from a height of 180 m will take (_?_) s to hit the ground if it starts from rest.
   (a) 18 (b) 9 (c) 6 (d) 4

QUIZ 1-3-1 A page 2

10. A body accelerating at 1 m/s^2 from rest will travel (_?_) meters in the first second.
(a) 0.5 (b) 1 (c) 2 (d) 0.25

LONG ANSWER:

1. Describe the argument which Galileo presented against Aristotle's idea that heavy objects fall faster than light ones. (10 to 15 lines)

2. Briefly describe a modern method of measuring acceleration for a freely falling object. (10 to 15 lines)

3. An object is dropped from a height of 80 meters. Find:

   (a) Time taken to fall to the ground.

   (b) Its velocity just before it strikes the ground.

ANSWER KEY: QUIZ 1-3-1A

OBJECTIVES:

1. (b)	2. (c)	3. (c)	4. (b)	5. (c)
6. (b)	7. (d)	8. (b)	9. (c)	10. (a)

LONG ANSWER:

1. According to Aristotle heavy objects fall faster than light ones by an amount proportional to their weight. Galileo stated that following Aristotle's line of reasoning, if a heavy and a light object were joined and allowed to fall, then (a) The light object should slow the heavy one and the heavy one should speed up the light one so that the combination of the two should fall at an intermediate speed.
(b) The two combined should make a heavier object which should fall faster than either of the two objects alone.
Since these results lead to a contradiction the original statement must be wrong and all objects should fall at the same speed.

2. Answers will vary. Electronic timers to measure an object falling, strobe photography, use of "g" apparatus, and ticker tapes are all acceptable answers.

3.
(a) $t = \sqrt{2d/a} = \sqrt{2 \times 80/10} = \sqrt{16} = 4$ seconds

(b) $v_f = at = 10 \times 4 = 40$ m/s

QUIZ 1-3-1 B GALILEO DESCRIBES MOTION

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME________________________________CLASS________DATE__________

Place the letter of the best answer next to the number of the question on your sheet.

1. The equation $d = \frac{1}{2}at^2$ can be used only when (_?_)
   (a) The object starts from rest
   (b) the object accelerates uniformly.
   (c) neither a nor b above
   (d) both a and b above

2. When an object is undergoing uniform acceleration, the ratio (_?_) is constant. (a) t/d (b) t/d^2 (c) v/t^2 (d) d/t^2

3. In performing his experiment Galileo showed that for objects rolling down an incline (_?_)
   (a) acceleration is constant (b) acceleration increases with the slope of the incline (c) distance travelled is proportional to time squared (d) all of the above

4. In Galileo's theory of falling bodies the cause of the motion was thought to be due to (_?_).
   (a) the inherent properties of matter (b) the force of gravity (c) air friction (d) some unknown and irrelevent factor

5. An acceleration of 9.8 m/s^2 for a body in free fall means (_?_).
   (a) it falls 9.8 meters further each second
   (b) it falls 9.8 meters each second
   (c) It falls 9.8 meters/second faster each second
   (d) It will fall 9.8 meters in the first second

6. Galileo spent much time in measuring the time of descent for an object travelling over different lengths of an incline. This was the (_?_) in his analysis of motion.
   (a) hypothesis (b) definition (c) assumption (d) test

7. The most significant thing that distinguishes modern from ancient and medieval science is (_?_).
   (a) the use of logic (b) the use of careful observation (c) methods of proposing and testing hypotheses (d) the idea of basing arguments on authority

8. An object dropped from the top of a cliff requires 4 s to reach its base. The velocity of the object just before it strikes the ground at the base of the cliff is (_?_) m/s.
   (a) 40 (b) 160 (c) 80 (d) 20

9. The height of the cliff in number 8 above is (_?_) m.
   (a) 20 (b) 40 (c) 80 (d) 160

QUIZ 1-3-1 B page 2

10. The average velocity of the object in number 8 during its fall is (?) m/s.
(a) 20 (b) 40 (c) 80 (d) 160

LONG ANSWER:

1. List three reasons why we might doubt the validity of Galileo's incline plane experiments.

2. Explain why Galileo did not perform a direct test to analyse motion in free fall.

3. An object dropped from the top of the Confederation Building hits the ground with a velocity of 60 m/s. Using this data determine the height of the building.

What factors may cause your answer to be in error.

ANSWER KEY: QUIZ 1-3-1 B

OBJECTIVES:

1. (d) 2. (d) 3. (d) 4. (d) 5. (c)

6. (d) 7. (c) 8. (a) 9. (c) 10. (a)

LONG ANSWER:

1. Three reasons why we might doubt the validity of Galileo's inclined plane experiment are:

   (a) The use of the water clock which may not have been accurate enough to give acceptable readings of time of descent.

   (b) The large extrapolation made by Galileo in extending his results from objects rolling on an incline to objects falling freely.

   (c) In extending his results by increasing the angle Galileo made no effort to check what would happen when objects begin to slide instead of roll on the incline.

2. Galileo did not perform a direct test for objects falling because he had no accurate time measuring instruments. He was restricted to the use of a water clock which could not give accurate times for objects falling over short distances.

3. (a) Since the object attained a velocity of 60 m/s and it was accelerating at 10 m/s^2, it must have fallen for 6 seconds.

$$t = V/a = 60/10 = 6 \text{ seconds}$$

During this time its average velocity was 30 m/s

$$V_{av} = (V_i + V_f)/2 = (0 + 60)/2 = 30 \text{ m/s}$$

Therefore the distance it fell was 180 m

$$d = V_{av}t = 30 \times 6 = 180 \text{ m.}$$

   (b) During its descent the object would have been slowed by air friction causing its final velocity to be less than that of a freely falling body. The result of this would be to give a smaller than actual value for the answer.

QUIZ 1-3-1C GALILEO DESCRIBES MOTION

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME_____________________________ ____CLASS______ ____DATE________

Place the letter of the best answer next to the number of the question on your answer sheet.

1.. Objects falling through the air from the same height if starting at the same time will (?)
   (a) hit the ground at exactly the same time
   (b) will require a time that is inversely proportional to their weight.
   (c) will fall at slightly different rates which depend on the amount of air friction
   (d) will fall with constant speed.

2. An acceleration of 9.8 m/s^2 for a body in free fall means (?).
   (a) The body falls 9.8 meters each second
   (b) The body falls 9.8 meters further each second
   (c) the body falls 9.8 m/s faster each second
   (d) for every meter the body falls it goes 9.8 m/s faster

3. Which of the following would fall fastest from the same height in an evacuated chamber?
   (a) a brick (b) a feather (c) a coin (d) they would all fall at the same rate (e) they would not fall because gravity does not act in a vacuum

4. Galileo's description of free fall took no notice of the (?).
   (a) time of the motion (b) causes of the motion
   (c) acceleration of the body (d) weight of the body

5. Galileo defined acceleration as being an increase of speed with (?). (a) time (b) velocity (c) acceleration (d) distance

6. Galileo's major contribution to science was (?).
   (a) the measurement of "g" the acceleration of gravity
   (b) a comprehensive mathematical analysis of motion
   (c) the overthrow of Aristotelian science
   (d) A new process of proposing and testing hypotheses

7. For an object accelerating uniformly the ratio of (?) is constant. (a) d/t (b) a/t (c) d/t^2 (d) v/t^2

8. An object undergoing free fall for 10 seconds before striking the ground would be half-way down in about (?) seconds
   (a) 2 (b) 5 (c) 7 (d) 9

QUIZ 1-3-1 C   page 2

9. A body on the moon free falls at about $1.6\ m/s^2$. If allowed to drop from rest such an object would fall (?) meters in the first second. (a) 1.6 (b) 0.8 (c) 3.2 (d) 16

10. How long would it take the object in number 9 to attain a velocity of 80 m/s?
(a) 5 s (b) 25 s (c) 50 s (d) 80 s

LONG ANSWER:

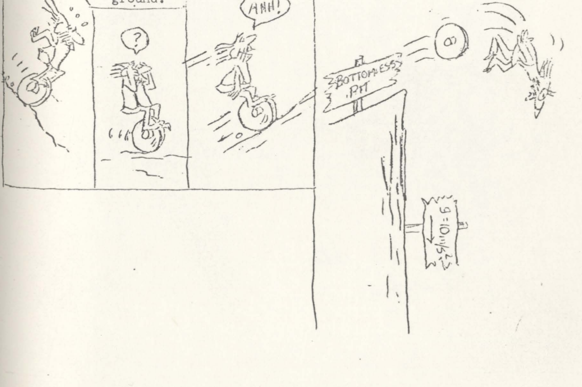
1. An object free falling from a great altitude to the earth finally stops accelerating and continues to fall with a terminal velocity. Write a short description of three factors that might affect this terminal velocity.

2. Summarize Galileo's argument against Aristotle's claim th heavy objects fall faster than light ones by an amount proportional to their weight.

3. An object is dropped from a height of 180 meters. Showing all calculations find:

   (a) the time taken for the object to reach the ground.

   (b) The velocity of the object just before it strikes the ground.



ANSWER KEY: QUIZ 1-3-1C

OBJECTIVES:

1. (c) 2. (c) 3. (d) 4. (b) 5. (a)

6. (d) 7. (c) 8. (c) 9. (b) 10. (c)

LONG ANSWER:

1. The terminal velocity which an object attains while falling through the air is determined primerily by the amount of air friction acting upon it. Thus the following factors would have an effect:
   (a) The shape of the object. Streamlined objects permit air to flow around them freely thus reducing air friction and incresing terminal velocity.
   (b) Weight. The heavier the object is the higher its velocity must be to build up air friction to the point where it will balance the downward force acting on the body.
   (c) Density of the air. The denser the air the quicker air friction will build up. Thus an object will have a slightly lower terminal velocity in dense air than it will in thin air.

   Other factors might be: the value of "g", density of the object, and height above sea level.

2. See answer sheet to Quiz 1-3-1 A number 1

3. (a) $t = \sqrt{2d/a} = \sqrt{2 \times 180/10} = \sqrt{36} = 6$ seconds

   (b) $V_f = V_i + at = 0 + 10 \times 6 = 60$ m/s

LEARNING ACTIVITY PACKAGE

1-4-1

KINEMATICS

TO ACCOMPANY:

CHAPTER FOUR

PHYSICS. A HUMAN ENDEAVOUR

A. RATIONALE

So far in our study of motion we have been restricted to motion in one direction along a line. In this chapter we will extend these ideas to motion in both directions along a line and finally, motion in any direction on a surface. This chapter will attempt to show how such motions are represented graphically and algebraically. In order to deal with motion on a surface a new type of quantity called a vector will be described and rules for adding and subtracting these quantities will be defined. While motion on a surface is about as far as this course goes in treating this topic, remember that motion in the real world takes place in three dimensions. We will not quite reach the degree of sophistication required to deal with the motion of the falling leaf mentioned in Chapter Two.

B. OBJECTIVES

In more detail then, the things you are required to learn in this chapter are:

1. To be able to describe situations involving relative motion from two or more frames of reference.

2. To be able to define and give three examples of vector and scalar quantities.

3. To be able to analyse and solve problems involving motion in two directions along a line and on a surface.

4. To be able to carry out the addition and subtraction of vectors using scaled diagrams.

5. To analyse and sketch graphs of motion in two directions on a line.

C. PRETEST None required

D. ACTIVITIES

1. Read the text Pp. 53-64.

2. Watch the film "Frames of Reference" and answer the questions on the film report sheet.

*3. Conduct Experiment 3.3.

*4. Do Problem Set 1-4-1 consisting of:
Pp. 65-67 numbers 4.3, 4.4, 4.5, 4.7, 4.9, 4.10, 4.12, 4.13, 4.14, and 4.15.

*5. Read article 10 in Reader One and complete the exercise contained there or substitute some other article or exercise agreed upon with your teacher.

6. Answer the twelve questions contained within the chapter text.

E. SELF-TEST AND QUIZ

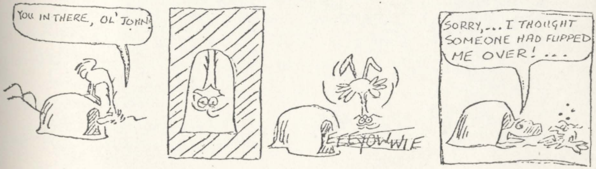
Complete the self-test and check your answers with the answer sheet. If you require more study consult your teacher. Remember to bring a geometry set for the quiz.

F. OPTIONAL ACTIVITIES

*1. View filmstrips 4.1 and 4.2 and answer the questions on page 130 of your text.

*2. Examine the transparencies T 1-4-1, T 1-4-2 and T 1-4-3 and answer the questions on the student direction sheet which accompanies them.

*3. Read the article "Frames of Reference" and complete the GOLD STAR PROBLEM number 10 at the end of the article.



SELF-TEST 1-4-1 KINEMATICS

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

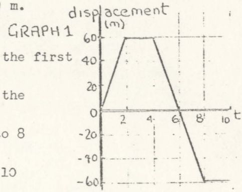
NAME . . . . CLASS.... GROUP.... DATE..........

Place the correct answer next to the number of the question on your sheet.

1. The area of physics that seeks to answer the question "When does an object move" is called (?).

2. An object moves 8 m North and 6 m East. The magnitude of its total displacement is (?) m.

IN THE GRAPH ON THE RIGHT:



3. The velocity of the object for the first two seconds is (?).

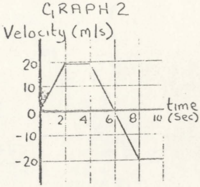
4. The velocity of the object for the period 2 to 4 seconds is (?).

5. The velocity for the period 4 to 8 seconds is (?).

6. The total displacement for the 10 seconds shown is (?).

7. The average velocity of the object over the 10 second interval shown is (?).

IN GRAPH 2 ON THE RIGHT:



8. The velocity of the object at t = 6 seconds is (?)

9. The acceleration of the object at t = 6 seconds is (?).

10. The total displacement of the object for the 10 seconds shown is (?).

LONG ANSWER:

1. Sketch an acceleration - time graph for graph 2 above.

2. Describe the motion of the object in graph 2 in a few sentences.

(CONTINUED OVERLEAF)

SELF-TEST 1-4-1 (CONT'D)

3. An object is thrown vertically upward with an initial velocity of 100 m/s. Assuming the acceleration due to gravity (g) is 10 m/s^2, Find:

   (a) The time the object will be in the air.

   (b) The height it will reach.

   and (c) Its velocity after 6 seconds.

4. A boat can travel at a rate of 20 Km/hr in still water. It is to travel directly across a stream to a dock on the other side. If the river flows at a speed of 5 Km/hr, Find:

   (a) The direction in which the boat must head.

   and (b) The velocity it can maintain across the river.

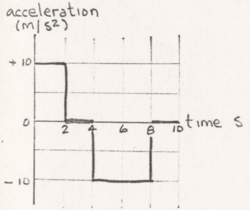
ANSWER KEY FOR SELF-TEST 1-4-1

OBJECTIVES:

1. relativity
2. 10
3. 30 m/s
4. 0 m/s
5. -30 m/s
6. -60 meters
7. 6 m/s
8. 0 m/s
9. $-10\ m/s^2$
10. 20 meters right

LONG ANSWER:

1.



2. The object in graph 2 accelerates from rest towards the right for 2 s then continues toward the right for another 2 seconds with a constant velocity. Thereafter it slows to a stop at 6 s and accelerates toward the left for the next 2 s. It then continues toward the left at a constant velocity ending up 20 meters to the right of where it started from.

3. (a) $t_{up} = \Delta V/a = 100/10 = 10$ seconds

$t_{tot} = 20$ seconds

(b) $d = V_i t + \frac{1}{2}at^2 = 100 \times 10 + \frac{1}{2}(-10)\,10^2$

$= 1000 - 500 = 500$ meters

(c) $V_f = V_i + at = 100 + (-10)\,6$

$= 100 - 60 = 40$ m/s

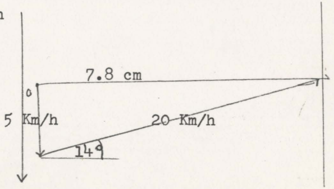
4.

Scale: 1 cm = 2.5 Km/h

7.8 cm = 7.8 x 2.5

= 19.5 Km/h

The boat must head 14° upstream



QUIZ 1-4-1A KINEMATICS

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME____________________________ CLASS____________ DATE________

Place the letter of the best answer next to the number of the question on your sheet. THIS IS AN OPEN BOOK QUIZ.

A. A boat can travel in still water at 40 Km/h. It heads directly upstream in a river flowing at 10 Km/h.

1. The velocity of the boat with respect to a log floating down stream is (_?_) Km/h. (a) 50 (b) 40 (c) 30 (d) 10

2. The velocity of the boat with respect to an observer on the bank of the river is (_?_) Km/h.
(a) 50 (b) 40 (c) 30 (d) 10

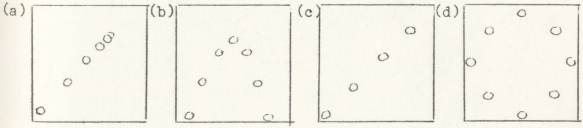
B. A race car completes on lap of a 2 Km race track in 60 s.

3. The total displacement of the car is (_?_) Km.
(a) 0 (b) 30 (c) 60 (d) 2

4. The average velocity of the car is (_?_) Km/h.
(a) 0 (b) 30 (c) 120 (d) 2

5. The average speed of the car is (_?_) Km/h.
(a) 0 (b) 30 (c) 120 (d) 2

C. The figures below are stroboscopic pictures of a ball describing various types of motion. The strobe rate is constant.



6. Which picture depicts uniform motion? (_?_) (a) (b) (c) (d)

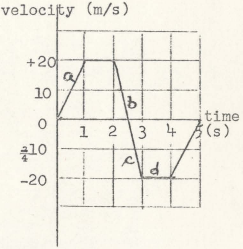
7. Which picture(s) could have been taken with the ball motionless and the camera moving? (a) a (b) a and c (c) b and d (d) all of them

8. In which picture could the ball's acceleration be acting opposite in direction to its velocity?(_?_) (a) (b) (c) (d)

D. In the velocity vs. time graph on the right:

9. The object's acceleration between second 2 and 3 is (?)m/s^2.
(a) 40 (b) 20 (c) -20 (d) -40

10. The object's acceleration is acting opposite its velocity at (?)
(a) (b) (c) (d)



LONG ANSWER: (DO TWO OF THE FOLLOWING)

1 An object is given an upward velocity of 80 m/s. The acceleration due to gravity g is 10 m/s^2. Find:

(a) The time the object will be in the air.

(b) Its maximum height.

(c) Its height after 10 sec.

2. A ship leaves St. Johns harbour and travels on a heading of 90° for a distance of 100 Km. It then changes course to a new heading of 220° and travels for a distance of 200 Km. Determine the total displacement of the ship. Use a vector diagram.

3. Sketch an acceleration - time graph for the motion described in the velocity - time graph of part D of the objective section.

ANSWER KEY TO QUIZ 1-4-1 A

OBJECTIVES:

1. (b)	2. (c)	3. (a)	4. (a)	5. (c)
6. (c)	7. (d)	8. (a)	9. (d)	10. (b)

LONG ANSWER:

1. Since the object reaches 0 velocity at its maximum height

(a) $V = 80$ m/s and $t = \Delta V/a$

$= 80/10 = 8$ seconds

Thus the object rises for 8 s and falls for the same time. The time in the air is 16 s.

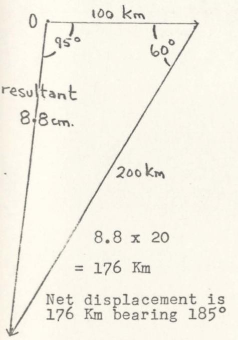
(b) $d = V_i t + \frac{1}{2}at^2$

$= 80 \times 8 + \frac{1}{2}(-10)\,64 = 320$ m

(c) $d = V_i t + \frac{1}{2}at^2$

$= 80 \times 10 + \frac{1}{2}(-10)\,100 = 300$ m

2. Scale: 1 cm = 20 Km

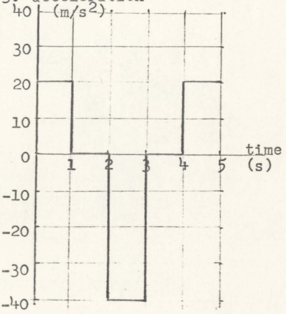


8.8 x 20

= 176 Km

Net displacement is 176 Km bearing 185°

3. acceleration



QUIZ 1-4-1B KINEMATICS FORM B

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME.....................CLASS.... GROUP.... DATE............

Place the letter of the best answer next to the number of the question on your sheet. THIS IS AN OPEN BOOK QUIZ.

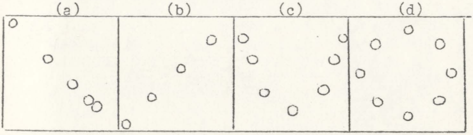
A. A hijacker in the front of an airplane flying at 400 Km/hr fires a gun at a guard in the back of the plane. The gun fires the bullet with a muzzle velocity of 400 Km/hr.

1. To an observer capable of watching this scene from the ground (?)
   (a) the bullet is motionless and the guard flies into it at 400 Km/hr.
   (b) the bullet flies toward the guard at 400 Km/hr.
   (c) the guard flying at 400 Km/hr has the bullet overtake him at 800 Km/hr.
   (d) The guard and the bullet fly toward each other each travelling at 400 Km/hr.

2. Which of the above would appear to happen to an observer seated on the plane? (a), (b), (c), or (d)

3. Which of the above would the ground observer see if the guard was at the front of the plane and the hijacker was at the back? (a), (b), (c), or (d)

B. The figures below are stroboscopic pictures of a ball describing various types of motion.

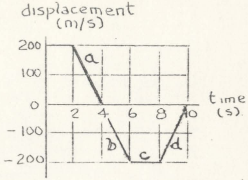


4. The acceleration is zero in picture (?)
   (a) a (b) b (c) c (d) d

5. Which could have been taken with the ball stationary and the camera moving?
   (a) a (b) a and b (c) c and d (d) all of them

6. The ball's velocity is opposite in direction to its acceleration in picture (?) (a) a (b) b (c) c (d) d

C. In the displacement-time graph on the right.....



7. The ball's velocity is positive at (?).
(a), (b), (c), or (d)

8. The ball was stopped (?).
(a) between 0 and 2 sec.
(b) between 2 and 4 sec.
(c) at 4 sec.
(d) between 4 and 6 sec.

9. The total displacement of the ball was (?)m.
(a) 0 (b) 200 (c) -200 (d) 1400

10. The average velocity of the ball was (?) m/s.
(a) 0 (b) 20 (c) -20 (d) 140

LONG ANSWER: (DO TWO OF THE FOLLOWING)

1. Some students are conducting an experiment in which a cart is given an initial velocity of 40 cm/sec up an incline. The cart travels 80 cm up the incline and then descends again. Determine from this data:
(a) the cart's average velocity while ascending the incline.
(b) The time the cart would take to reach the bottom of the incline again.
(c) The acceleration of the cart.

2. A light plane can fly in still air at 240 Km/hr. It leaves Gander and flies on a heading of 290°. The wind at the time is blowing from the North at 80 Km/hr. Determine the ground speed and direction of the plane.

3. Sketch a velocity-time graph of the motion of the cart described in question 1 above.

ANSWER KEY TO QUIZ 1-4-1B

OBJECTIVES:

1. (a)	2. (b)	3. (c)	4. (b)	5. (d)
6. (a)	7. (d)	8. (a)	9. (c)	10. (c)

LONG ANSWER:

1. The cart's velocity at its maximum height up the incline would be 0 m/s

(a) Thus $V_{av} = (V_i + V_f)/2 = (40 - 0)/2 = 20 cm/s$

(b) Time up the incline $t = d/V_{av} = 80/20 = 4$ s

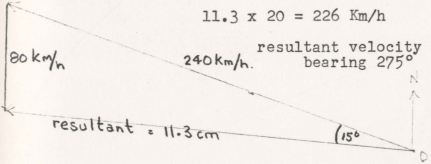
Total time on the incline = 8 seconds

(c) $a = \Delta V/t = 40/4 = 10 cm/s^2$

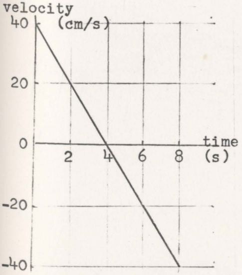
2. Scale: 1 cm = 20 Km/h

11.3 x 20 = 226 Km/h

resultant velocity = 226 Km/h
bearing 275°



3.



QUIZ 1-4-1C KINEMATICS FORM C

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET. Copy the heading above and the information requested below on a sheet of paper.

NAME ______________________________ CLASS__________ DATE______

Place the letter of the best answer next to the number of the question on your answer sheet.

A. Captain Nemo's submarine the Nautilus can travel in still water at 30 Km/h. The submarine heads north into a current flowing south at 10 Km/h.

1. To a jellyfish floating with the current, the velocity of the Nautilus is (_?_) Km/h north.
(a) 40 (b) 30 (c) 20 (d) 10

2. To a lobster sitting on the bottom of the sea, the velocity of the Nautilus is (_?_) Km/h north.
(a) 40 (b) 30 (c) 20 (d) 10

3. To a squid swimming through the water at 10 Km/h with the current, the velocity of the Nautilus would appear to be (_?_) Km/h north. (a) 40 (b) 30 (c) 20 (d) 10

B. A toy train completes two laps of an oval 10 meter track in 100 seconds.

4. The average speed of the train over 100 s is (_?_) m/s.
(a) 0 (b) 0.1 (c) 0.2 (d) 5

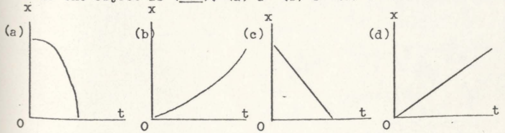
5. The average velocity of the train over two laps is (_?_) m/s.
(a) 0 (b) 0.1 (c) 0.2 (d) 5

C. An object is dropped from a height of 30 meters. ($g = 10\ m/s^2$)

6. In the first second the object will drop (_?_) meters
(a) 30 (b) 10 (c) 5 (d) 0.3

7. The average velocity of the object during the first two seconds is (_?_) m/s downward. (a) 30 (b) 10 (c) 5 (d) 0.3

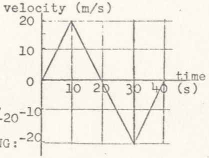
8. The displacement-time graph which best represents the motion of the object is (_?_). (a) a (b) b (c) c (d) d



D. In the graph on the right:

9. The net displacement of the object is (?) meters.
(a) 200 (b) 100 (c) 20 (d) 0

10. The total displacement of the object after 30 s was (?) m.
(a) 200 (b) 100 (c) -100 (d) -20



LONG ANSWER: DO TWO OF THE FOLLOWING:

1. A collision cart is given a push up an incline and rises up it a distance of 120 cm in 8 seconds, after which it descends.

FIND: (a) Its average velocity while ascending the incline.

(b) The initial velocity it had when it started up the incline.

(c) Its acceleration while on the incline.

2. A man wishes to row his canoe directly across the Gander River to a dock on the other side. He can row the canoe at 8 Km/h in still water. The current in the river averages 3 Km/h at this point. Using a scaled diagram, determine the direction in which he should head the canoe in order to counteract the current and his speed across the river.

3. Sketch an acceleration-time graph of the motion depicted in the graph in part D of the objective section.

ANSWER KEY FOR QUIZ 1-4-1C

OBJECTIVES:

1. (a)   2. (b)   3. (a)   4. (c)   5. (a)

6. (c)   7. (b)   8. (b)   9. (d)   10. (b)

LONG ANSWER:

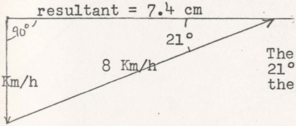
1. (a) $V_{av} = d/t = 120/8 = 15$ cm/s

   (b) Since $V_{av} = (V_i + V_f)/2$

   Then $V_i = 2V_{av} - V_f = 30 - 0 = 30$ cm/s

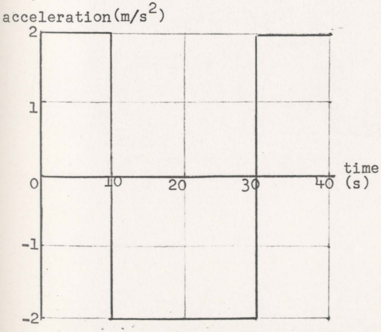
   (c) $a = V/t = -30/8 = 3.75$ cm/s^2

2. SCALE: 1 cm = 1 Km/h



The man must head his canoe 21° upstream and will cross the river at 7.4 Km/h

3.



FILE NO. 1-5-1 THE BIRTH OF DYNAMICS

LEARNING ACTIVITY PACKAGE

1-5-1

TO ACCOMPANY

CHAPTER FIVE

PHYSICS: A HUMAN ENDEAVOUR

A. RATIONALE

In the year that Galileo died, Isaac Newton was born. Twenty three years later Newton had developed his famous laws of motion. These laws, the final attainment of a long scientific revolution, were to complete the overthrow of the Aristotelian ideas that had dominated the thinking of the best minds for over two thousand years. (Hewitt, 1974, P.22)

Galileo had dealt with the question "how objects move", Newton was to deal with "why objects move". His three laws can be used to explain the motion of objects as varied as molecules and moons and they were to have important ramifications in philosophy, politics and culture to this present day. It was not until the advent of Einstein's theory of relativity that Newton's findings were seriously questioned. In this package we will learn about Newton's three laws and some of their applications.

B. OBJECTIVES:

To be more specific after studying this section you should be able to:

1. Distinguish between kinematic and dynamic concepts.
2. Define the terms force, mass, inertia and weight.
3. Describe what is meant by the term "explanation" in science.
4. Analyse the action of two or more forces acting simultaneously from a point on an object by means of scaled vector diagrams.
5. State Newton's laws of motion and apply them in the analysis of dynamic interactions.
6. Determine the apparent weight of an object in an accelerated frame of reference.

C. PRETEST: QUIZ 1-4-1 forms the pretest for this package.

D. ACTIVITIES:

1. Read Chapter 5 and the Epilogue in your text. For a non-mathematical treatment you may like to read CONCEPTUAL PHYSICS by Paul Hewitt, Chapter 3.

2. Complete the Q questions in the chapter. These should form part of your notes on the chapter.

*3. Conduct and report experiment 5.2.

*4. Do problem set 1-5-1 consisting of the following problems on pages 92 and 93:
5.2, 5.3, 5.7, 5.8, 5.13, 5.16, 5.22, 5.25, 5.26, 5.27

*5 Read articles 18 and 19 in READER ONE.

E. SELF-TEST: When you have completed the activities above draw SELF-TEST 1-5-1 from the file, complete it, and check your answers with the KEY.

NOTE: Bring a geometry set to all quizzes.

F. QUIZ 1-5-1: When you are satisfied with your mastery of the section ask your instructor for the quiz.

G. OPTIONAL ACTIVITIES:

*1. Examine transparencies 1-5-4 and T 1-5-5 and write a one page report on the dynamics of the situations depicted.

*2. Conduct any one of experiments 5.1, 5.3, or 5.4

*3. Conduct any one of activities 5.1, 5.4 or 5.8.

*4. Discuss any two of questions 5.4, 5.9, 5.15 or 5.14 and be ready to submit a report to the class.

SELF-TEST 1-5-1 THE BIRTH OF DYNAMICS

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET: Copy the heading above and the information requested below on a sheet of paper.

NAME.......................CLASS....GROUP....DATE..............

Place the answer next to the number of the question on your sheet. (Use 10 m/s^2 for the acceleration due to gravity)

1. The tendency of a body to retain its state of rest or uniform motion is a property of matter called (_?_).

2. An object with a mass of 12 Kg weighs (_?_) N on earth.

3. If the acceleration due to gravity on Planet X is 15 m/s^2, an object weighing 800 N on earth will weigh (_?_) N on Planet X.

4. A 20 Kg mass has a net force of 60 N acting on it. The acceleration the object will undergo is (_?_) m/s^2.

5. The net force required to accelerate an object weighing 200 N at 5 m/s^2 is (_?_) N.

6. An object weighing 400N is placed in an elevator which is accelerating downward at 3 m/s^2. The apparent weight of the object in the elevator is (_?_) N.

7. A student lifts his text book. The reaction force to the gravitational attraction of the earth on the book is (_?_).
   (a) the force of the boy's hand on the book.
   (b) the force of the book on the student's hand.
   (c) the gravitational attraction of the book on the earth.
   (d) only acting if the boy lets the book fall.

8. Under which condition(s) below is an object said to be in equilibrium? (_?_)
   (a) All forces acting on the object add vectorially to zero.
   (b) The object is at rest.
   (c) The object is moving in a circle at constant speed.
   (d) The object is moving at a constant velocity.

9. Two dogs are fighting over a bone. One pulls to the right with a force of 40 N and the other to the left with a force of 50 N. The net force acting on the system is (_?_) N.

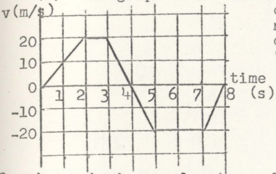
10. A force is applied to a mass causing it to accelerate at 10 m/s^2. If the same force is applied to an object with half the mass of the first the acceleration of the second object will be (_?_) m/s^2.

(Long Answer part continued overleaf)

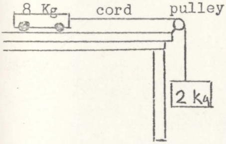
LONG ANSWER:

1. (a) State Newton's three laws of motion.

(b) The graph below shows a velocity - time graph for an object. Sketch a graph of the net force acting on the object over the same time period. The mass of the object is 1 Kg.



2. A man is in an elevator. He drops a ball and measures its acceleration at 8 m/s^2. Can the man tell from this experiment if the elevator is moving up or down? Discuss.

3. 

An 8 Kg cart lies on a table and is connected by means of a cord passing over a pulley to a 2 Kg weight as shown in the diagram. Assuming no friction acts:
(a) What is the acceleration of the 8 Kg cart?
(b) What is the tension (force) on the cord?

4. A force of 40 N acts southward on an object. A second force of 60 N bearing 60° acts simultaneously on the object. Determine the resultant force by drawing a scaled vector diagram.

ANSWER KEY TO SELF-TEST 1-5-1

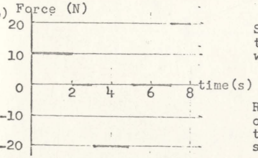
OBJECTIVES:

1. inertia	See Pp. 77 - 79 in your text	
2. 120	$Wt = ma_g = 12 \times 10 = 120$ N.	P. 87
3. 1200	$Wt = ma_g = 80 \times 15 = 1200$ N	P. 87
4. 3	$a = F/m = 60/20 = 3$	P. 83
5. 100 N	mass = 20 Kg $F = ma = 20 \times 5 = 100$	P. 87 and 83
6. 280	$F = ma = 40 \times 3 = 120$ $400 - 120 = 280$	Pp. 90 - 91
7. (c)		P. 86
8. (a), (b) and (d)		P. 79
9. 10 N left		P. 73
10. 20		P. 83

LONG ANSWER:

1. (a) See pages 77, 83, and 85.

(b)



Since $F = ma$ and $m = 1$ Kg the force-time graph will be similar to the acceleration-time graph for the motion.

Recall that acceleration is obtained from a velocity-time graph by calculating the slope.

2. If the man assumes that the elevator is on earth, he can be sure that the elevator is accelerating downward at about 2 m/s^2. However, the elevator may be moving upward and decreasing its speed or it may be moving downward and increasing its speed. Thus the man cannot tell in which direction the elevator is moving.

3. The net force on the system is caused by gravity acting on the 2 Kg mass;

$$F_g = ma_g = 2 \times 10 = 20 \text{ N}$$

ANSWER KEY TO SELF-TEST 1-5-1 (cont'd)

3. This 20 N force acts to accelerate the whole system whose total mass is 10 Kg, neglecting the weight of the cord and the inertia of the pulley.

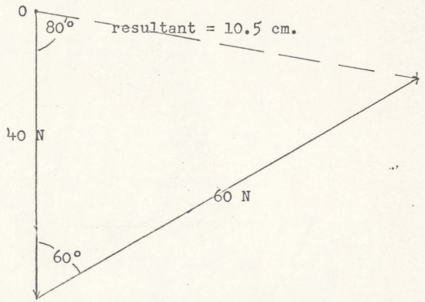
$$a = F/m = 20/10 = 2 \text{ m/s}^2$$

(a) Thus the acceleration of the 8 Kg cart is 2 m/s^2

(b) The force on the cord is the action force which accelerates the 8 Kg cart at 2 m/s^2.

Thus $F = ma = 8 \times 2 = 16$ N

4. Scale; 1 cm = 5 N



Resultant force = 10.5 x 5 = 52.5 N bearing 110°

QUIZ 1-5-1 THE BIRTH OF DYNAMICS FORM A

INSTRUCTIONS: Do not write on this sheet. Copy the heading above and the information requested below on a sheet of paper.

NAME......................CLASS....GROUP....DATE.............

Place the letter of the best answer next to the number of the question on your sheet. (Use $g = 10\ m/s^2$)

1. (?) is a concept in the study of dynamics.
   (a) speed (b) acceleration (c) time (d) mass

2. That which causes or tends to cause a change in a body's velocity is called (?).
   (a) a displacement (b) inertia (c) a force (d) a vector

3. A phenomenum is said to be explained in science when (?).
   (a) It can be made to happen at will
   (b) It is consistent with a generally accepted law
   (c) It can be defined
   (d) It can be measured

4. An astronaut weighs 800 N. He is placed in a rocket sled which accelerates him horizontally at 60 m/s^2. The force pushing him back against the seat is (?) N.
   (a) 133 (b) 13.3 (c) 48000 (d) 4800

QUESTIONS 5, 6 and 7 CONCERN THE STATEMENT BELOW:
The acceleration of gravity on the moon is 1.6 m/s^2.

5. An object with a mass of 10 Kg would weigh (?) N on the moon.
   (a) .16 (b) 160 (c) 12.5 (d) 11.6

6. An object weighing 30 N on earth would weigh (?) N on the moon. (a) 4.8 (b) 48 (c) 4.1 (d) 0.53

7. An object with a mass of 40 Kg on earth would have a mass of (?) Kg on the moon.
   (a) 40 (b) 6.4 (c) 640 (d) 10

8. The weight of your textbook "Motion" is closest to (?) N.
   (a) 0.1 (b) 1 (c) 10 (d) 100

9. A 2 Kg mass is accelerated at 3 m/s^2 by a certain force. If the same force is applied to a second object the acceleration is 4 m/s^2. The mass of the second object is (?) Kg. (a) 1.5 (b) 4 (c) 8 (d) 3

10. (?) is a measure of the inertia of a body.
    (a) weight (b) mass (c) force (d) acceleration

LONG ANSWER CONTINUED OVERLEAF

QUIZ 1-5-1 A

LONG ANSWER: THE STUDENT IS REQUIRED TO DO TWO OF THE FOLLOWING FOUR QUESTIONS.

1. A girl weighing 400 N sits on a swing. Her boyfriend pulls the swing back with a horizontal force of 200 N. Determine by the use of a scaled vector diagram, the tension on each of the two ropes and the angle A through which the ropes are displaced.

2. A boy is pulling a loaded wagon across a horizontal floor with a horizontal force of 100 N. The mass of the wagon is 40 Kg and its acceleration is 2 m/s^2.

   (a) What is the net force acting on the wagon?
   (b) What is the frictional force acting on the wagon?
   (c) How hard should the boy pull on the wagon to double its acceleration?

3. A man weighing 700 N stands in an elevator. Determine the force the elevator floor exerts against the man's feet when:

   (a) the elevator accelerates upward at 2 m/s^2.

   (b) the elevator is moving upward but is slowing down at a rate of 2 m/s^2.

4. An astronaut is in orbit around the earth, and experiences the condition of weightlessness.

   (a) Are things actually weightless? Discuss using a paragraph or two.
   (b) If the astronaut has two objects, describe how he could determine which of the two has the greatest mass under these conditions.

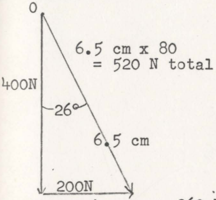
ANSWER KEY TO QUIZ 1-5-1A

OBJECTIVES:

1. (d)	2. (c)	3. (b)	4. (d)	5. (a)
6. (a)	7. (a)	8. (c)	9. (a)	10. (b)

LONG ANSWER:

1. SCALE: 1 cm = 80 N



Force on each rope = 260 N

2. (a) $F = ma = 40 \times 2 = 80$ N

(b) $F_f = F_t - F_n = 100 - 80$

$= 20$ N

(c) The net force causing the acceleration was 80 N, therefor the net force required to give double this acceleration would be 160 N. But there is also 20 N of frictional force acting, so the total force required would be 160 + 20 or 180 N

3. $W_a = mg - ma$ (Let acceleration upward be -)

$= 700 - 70(-2)$ (note that Mg = weight = 700)

$= 700 + 140 = 840$ N

(b) If the elevator is moving upward but is slowing down at 2 m/s^2 the acceleration is now directed downward and is thus positive.

$W_a = mg - ma = 700 - 70 \times 2 = 700 - 140 = 560$ N

4. (a) To the astronaut using the space capsule as his frame of reference there would appear to be no tendency for an object to accelerate in any particular direction. The space capsule would appear to have no "floor" towards which an object tends to "fall". If a spring balance were to be used in an effort to measure the weight of an object it would not work and the object would be considered by the astronaut to be weightless.

However to an observer outside the space capsule (ie., examining it through a telescope on earth) all objects in the capsule would appear to have weight. It is this weight, the force due to gravity, which keeps the capsule and any object in it in orbit and prevents it from travelling off into space. Thus objects aboard the capsule are affected by gravity and do have weight.

ANSWER KEY TO QUIZ 1-5-1A page 2

4. (b) The astronaut could determine which of the two objects was the most massive by exerting an equal force on both and noticing which of the two objects accelerated least. The one which accelerated least would be the most massive of the two.

QUIZ 1-5-1 B THE BIRTH OF DYNAMICS FORM B

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET: Copy the heading above and the information requested below on a sheet of paper.

NAME.............. ........CLASS....GROUP....DATE..............

Place the letter of the best response next to the number of the question on your sheet. (Use $g = 10\ m/s^2$)

1. (_?_) is a concept in the study of dynamics.
   (a) velocity (b) time (c) weight (d) acceleration

2. When no net force acts on a body its (_?_) is always zero.
   (a) acceleration (b) inertia (c) velocity (d) displacement

3. A phenomenum is said to be explained in science when (_?_)
   (a) It can be made to happen at will
   (b) It can be described by mathematical equations
   (c) It follows as a logical consequence of a general law.
   (d) It can be defined

4. The net force required to accelerate an object weighing 200 N at $5\ m/s^2$ is (_?_) N.
   (a) 1000 (b) 100 (c) 200 (d) 4

Questions 5, 6 and 7 refer to the statement below:
The acceleration due to gravity on Planet X is $6\ m/s^2$.

5. An object with a mass of 20 Kg would weigh (_?_) N on planet X. (a) 0.3 (b) 3 (c) 1200 (d) 120

6. An object weighing 30 N on earth would weigh (_?_) N on planet X. (a) 30 (b) 18 (c) 5 (d) 0.2

7. An object with a mass of 20 Kg would have a mass of (_?_) on planet X. (a) 20 (b) 120 (c) 3.3 (d) 33

8. Your weight is closest to (_?_) N.
   (a) 0.5 (b) 5 (c) 50 (d) 500

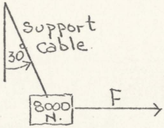
9. A force is applied to a 2 Kg mass causing it to accelerate at $30\ m/s^2$. If the same force is applied to a mass of 3 Kg the acceleration will be (_?_) m/s^2.
   (a) 45 (b) 20 (c) 60 (d) 10

10. An 80 Kg fireman slides down a pole in a fire station. His grip on the pole causes a frictional force of 240 N opposing his fall. The approximate value of his acceleration toward the floor below is (_?_) m/s^2.
    (a) 13 (b) 10 (c) 8 (d) 7

Long Answer part of the paper continued overleaf

LONG ANSWER: You are required to do two of the four questions

1. A weight of 8000 N is suspended from a steel cable. A second cable pulls horizontally on the suspended weight causing it to be pulled in the direction of the horizontal force. The vertical cable is displaced through an angle of 30°. Determine the magnitude of the horizontal force F and the tension on the supporting cable.



2. Distinguish between the natural dynamic properties attributed to matter by Aristotle and Newton.

3. A man is pushing a 60 Kg crate across a horizontal floor. A frictional force of 100 N opposes the motion of the crate. The acceleration of the crate is 2 m/s^2. Find:

   (a) The total force the man must apply.

   (b) The net force acting on the crate.

   (c) The force the man must apply to double the crate's acceleration.

4. A boy weighing 500 N stands on a set of bathroom scales and jumps upward. During the moment that he jumps the pointer on the scales registers 600 N.

   (a) What was his vertical acceleration?

   (b) What would the pointer read as he lands back on the scales?

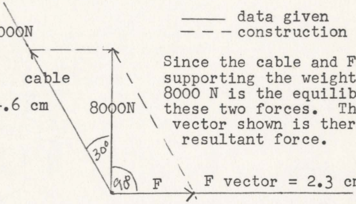
ANSWER KEY TO QUIZ 1-5-1B

OBJECTIVES:

1. (c)	2. (a)	3. (c)	4. (b)	5. (d)
6. (b)	7. (a)	8. (d)	9. (a)	10. (d)

LONG ANSWER:

1. Scale: 1 cm = 2000N



cable vector = 4.6 cm = 9200 N

Since the cable and F are supporting the weight then 8000 N is the equilibrant of these two forces. The 8000N vector shown is therefore the resultant force.

F vector = 2.3 cm = 4600N

2. Aristotle believed that objects maintained a constant speed when moving towards a natural position in the universe. He also thought that objects moving horizontally had to be maintained in their motion by an outside force. Newton believed that it was the natural tendency of any object to move at a constant velocity in any direction <u>unless</u> it was acted upon by an outside force. He abandonned the distinction between natural and violent motion. He also believed that his laws of motion applied equally well in the heavens.

3. Force required to cause acceleration
   $F = ma = 60 \times 2 = 120$ N
   Total force $= F_n + F_f = 120 + 100 = 220$ N

   (b) The net force acting on the crate would be 120 N

   (c) In order to double the acceleration the net force must be doubled while the frictional force remains the same. Thus the force would be $2 \times 120 + 100 = 340$ N

4. (a) Net force acting on boy = 600N - 500 N = 100 N
   $a = f/m = 100/50 = 2$ m/s^2

   (b) When the boy lands back on the scale the pointer should read approximately 600 N again assuming it takes the boy as long to decellerate to a stop as it did for him to accelerate upward from the scale.

QUIZ 1-5-1 C THE BIRTH OF DYNAMICS FORM C

INSTRUCTIONS: DO NOT WRITE ON THIS SHEET: Copy the heading above and the information requested below on a sheet of paper.

NAME.......................CLASS....GROUP....DATE............

Place the letter of the best answer next to the number of the question on your sheet. (Use $g = 10\ m/s^2$)

1. (?) is classified as a kinematic concept.
   (a) mass (b) force (c) weight (d) acceleration

2. A satellite in orbit around the earth (?).
   (a) has no acceleration (b) has no net force acting on it (c) is in equilibrium (d) attracts the earth with a force equal to the force keeping it in orbit

3. (?) is not a vector quantity.
   (a) displacement (b) force (c) speed (d) acceleration

4. If a net force of 100 N is required to accelerate an object at $5\ m/s^2$, the weight of the object is (?) N.
   (a) 200 (b) 500 (c) 50 (d) 20

Questions 5, 6 and 7 refer to the statement below:
An object with a mass of 20 Kg is found to weigh 80 N on planet X.

5. The acceleration of gravity on planet X is (?) m/s^2.
   (a) 40 (b) 4 (c) 2.5 (d) 10

6. The object would weigh (?) N on earth.
   (a) 80 (b) 200 (c) 800 (d) 8

7. The mass of the object on earth would be (?) Kg.
   (a) 20 (b) 80 (c) 200 (d) 500

8.. Your mass is closest to (?) Kg.
   (a) 5 (b) 50 (c) 500 (d) 5000

9. An 80 Kg fireman slides down a pole in a fire station. His downward acceleration is $6\ m/s^2$. The frictional force of his hands on the pole is (?) N.
   (a) 480 (b) 133 (c) 320 (d) 75

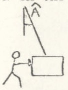
10. An apple falls from a tree. If the action force is considered to be the force of gravity, the following can be said about the reaction force, (?).
   (a) there is none (b) it is the force of air friction encountered by the apple (c) it is only felt when the apple makes contact with the ground.
   (d) it is the upward gravitational force of the apple on the earth.

LONG ANSWER SECTION OVERLEAF

QUIZ 1-5-1 C page 2

LONG ANSWER: DO THREE OF THE FOLLOWING FOUR QUESTIONS

1. A 40 Kg crate is suspended by means of a cable. A deckhand pushes on the crate with a horizontal force of 100 N on the crate. Determine the tension (force) on the supporting cable and the angle A through which it is displaced. Use a scaled vector diagram.



2. A man pushes a box with a mass of 50 Kg across a horizontal floor with a force of 200 N. A frictional force of 100 N opposes the motion.
   (a) What is the net force on the box?
   (b) What acceleration will result?
   (c) How hard should the man push to double the acceleration?

3. Use Newton's laws to explain why objects of different mass free fall at the same acceleration.

4. A man weighing 500 N is in an elevator. Determine the force exerted by the elevator floor against the man's feet of:

   (a) The elevator rises at a constant velocity
   (b) The elevator is still rising but is slowing down at a rate of 2 m/s^2.
   (c) The elevator is moving downward but is slowing down at a rate of 2 m/s^2.

ANSWER KEY TO QUIZ 1-5-1C

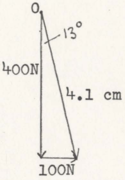
OBJECTIVES:

1. (d)	2. (d)	3. (c)	4. (a)	5. (b)
6. (b)	7. (a)	8. (b)	9. (c)	10. (d)

LONG ANSWER:

1.

Scale 1 cm = 100 N



4.1 cm = 410 N

angle of displacement 13°

2. (a) 100N $F_n = F_t - F_f$

   (b) $a = F/m = 100/50 = 2\ m/s^2$

   (c) In order to double the acceleration the man should double the net force (200) while maintaining the frictional force (100).

   Total force = 300 N

3. The weight of an object varies with the mass of the object. ie., double the weight implies double the mass etc. However if the mass of an object is doubled it <u>requires</u> double the force to give it the same acceleration as before. Since, therefore both the mass and weight vary in the same way the acceleration of the object due to gravity will remain the same. In mathematical form,
   since

   $g = W/m$ doubling the mass gives double the weight

   then $g = 2W/2m$ thus g remains constant.

4. (a) Constant velocity means 0 acceleration therefore the force will remain at 500 N

   (b) $W_{app} = mg - ma = 500 - 50x2 = 400N$

   (c) $W_{app} = mg - ma = 500 - 50(-2) = 500 + 100 = 600\ N$

APPENDIX D

LAP Evaluation Checklist

SANTA MARIA JOINT UNION HIGH SCHOOL DISTRICT

Check List
For the preparation of
Learning Activity Packages

Rationale

.... Where has the previous LAP (or instruction) left the student?

.... Why should he consider these topics (in his terms, not the teachers)?

.... What assumptions has the teacher made about previous acquisition of knowledge and / or skills?

.... What might he expect to do in this LAP?

.... Where will this LAP lead him; what is the next step?

Primary Idea

.... What is the central topic of this LAP? (is it skill oriented or concept centered?)

.... What will he know, understand, or be able to do when his is done?

Secondary Ideas

.... How is the main idea divided?

.... Are these parts of the main idea sequentially arranged?

.... What aspects of these topics must the learner know to understand the main idea?

Instructional Objectives (A set for each secondary idea) Written in behavioral terms.

.... How will the learner be able to perform when the secondary idea is understood?
-at what minimum level of competence?
-within what limitations or with what knowledge, equipment, material, or skills?

.... Have the knowledge and skills involving both the subject matter content and the learning process been considered?

.... If attitudinal objectives have been included, have they been stated in performance terms? How will they be evaluated?

Core Experiences (A set for each secondary idea)

.... Does the learner have a variety of required activities from which to choose?

.... Do the activities include a variety in instructional media, size and composition of groups and specific content?

.... Are the references organized (authors, title, publisher, date) and their location noted?

10

.... Do the activites provide the experiences through which the instructional objectives may be achieved?

.... Have regular student-teacher contact points been included?

.... Are the core activities arranged in a hierarchial fashion – both in level of difficulty and concept or skill formation?

.... Is the possibility of recycling students into different kinds of similar activities available?

Depth Opportunities

.... Have opportunities been provided for the:

- creative student
- "loner"
- group oriented student
- dramatist
- practical student
- gifted student
- non-reader
- etc.
- . . .and the student who wants to suggest his own Depth Activity

.... Are depth opportunities directly related to the Core of Activities?

.... Are cross-discipline depth options provided?

Evaluation

.... Is there both a pre-test and post-test?

Student Self-Assessment

.... Do the assessment items allow the student to indeed check his performance as stated in the instructional objectives?

.... Do the questions parallel the type of questions on the teacher's exam?

.... Have questions at levels above the mere recall of facts been included?

.... Are a variety of kinds of test items included (T-F, multiple choice, essay, short answer, fill-in, etc.)?

.... Has the use of non paper and pencil tests been considered?

Teacher Assessment

.... Has the learner been asked to practice the kinds of skills and knowledge included in this test?

.... Is the teacher assessment parallel in form and content to the student self-assessment?

.... Do the evaluation implements measure achievement of the objectives?

Exemption (From all or part of the learning activities.)

.... Have the procedures for exemption been clarified to the students?

... . Does the exemption procedure include an assessment of student knowledge and skills?

... . Is the student referred to the teacher for exemption procedures?

Student Directions

.. .. Has the learner been informed in these areas:
the method of grade assignment?
the composition of grades?
the procedure for using the LAP?

.... Has the attempt been made to explain the several parts of the LAP to the learner?

... . In what ways will the procedures be clarified to the slow reader?

.... Have motivational techniques been included?

Other Inclusions

.... Bibliography of Materials.

.... Flowchart of check list of Procedures for Students.

.... Table of contents.

Figure 4. Checklist for evaluating Learning Activity Packages.

APPENDIX E

Progress Sheet

GRADE_____ STUDENTS' PROGRESS SHEET CLASS____

NAMES	LAP 1-1-1					LAP 1-2-1					LAP 1-2-2					LAP 1-3-1					LAP 1-4-1					LAP 1-5-1				
	Expts	Problems	Readings	Quiz	Quest	Expts	Problems	Readings	Quiz	Quest	Expts	Problems	Readings	Quiz	Quest	Expts	Problems	Readings	Quiz	Quest	Expts	Problems	Readings	Quiz	Quest	Expts	Problems	Readings	Quiz	Quest

APPENDIX F

Overhead Transparencies

OVERHEAD TRANSPARENCY MASTERS TO ACCOMPANY MODULE ONE OF THE PHYSICS: A HUMAN ENDEAVOUR TEXT

These transparencies were designed to be used either by the teacher in lecturing large groups or by the students in an individualized or small group setting. Each set of masters is accompanied by a teacher notes sheet which explains production procedures and gives hints on their use for lectures. Also accompanying each transparency is a set of student notes to guide individual or small group study.

The materials required for the production of the transparencies are:

1. A thermofax copier
2. A box of colored transparency sheets.
3. 23 transparency frames
4. A roll of masking tape
5. A razor blade
6. 15 sheets of black transparency sheets

T 1-2-1 A Uniform Motion 1

Teacher Notes

Production:

Sheet 1, color black, acts as transparency base

Sheet 2, color red, overlay 1

Sheet 3, color blue, overlay 2

Sheet 4, color purple, overlay 3

Lecture Notes:

Before showing the transparency ask the students how far an object travelling at 20 m/s will travel in 2, 4, 6, 8, and 10 seconds.

Show transparency with overlays removed. Ask for a guess as to what the graph of this data would look like. Tell students to plot such a graph.

Show overlay 1 and explain how scales are decided upon and the qualities of a good graph.

Show overlay 2. Explain that this is a thought experiment and that in normal experiments data points rarely lie in such a straight line. Mention the idea of line of best fit.

Show overlay 3. Ask students to guess the velocity of this object. (10 m/s)

T 1-2-1 A UNIFORM MOTION 1

Student notes and directions:

1. Remove all overlays.

   (a) Can you see how the data table arises from the statement?

   (b) What distance would the object have travelled in 3 s.?

2. Turn up overlay 1.

All graphs should take from $\frac{1}{2}$ to a full page. The quantity and units on each axis are stated and the title of the graph given. Time is generally plotted on the horizontal axis. Data points should be circled.

   (c) Plot the answer you gave for question (b)

3. Turn up overlay 2.

The points are connected by what is called a "line of best fit". In this case the line is straight and all points are exactly on it. In an actual experiment the points may be scattered because of unavoidable experimental errors.

   (d) Does the point you plotted for (c) lie on the line? (If it doesn't, consult your teacher)

4. Turn up overlay 3.

   (e) What is the velocity of this object?

   (f) Check you answer to (e) on the bottom of the sheet.

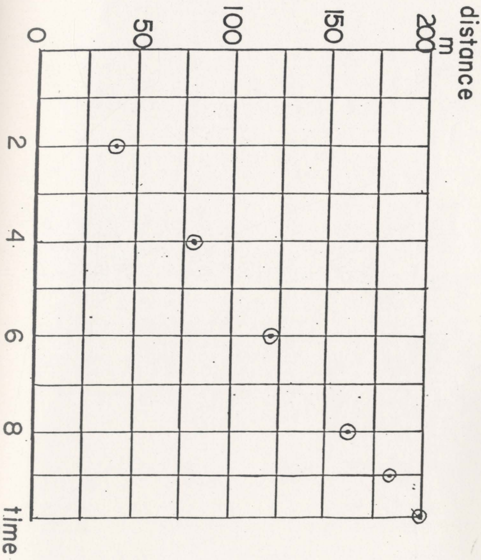
   (g) Use a velocity of 30 m/s, draw up a table of d-t data and plot the graph. (Check your answer with your teacher)

ANSWERS: (e) 10 m/s

UNIFORM MOTION

A cart is travelling to the right at 20 m/s

time (s)	distance (m)
0	0
2	40
4	80
6	120
8	160
9	180
10	200


distance
m
0
50
100
150
200
0
2
4
6
8
time
s

T 1-2-1 B UNIFORM MOTION 2

Teacher Notes

Production:

Sheet 1 Color red, use as transparency base

Sheet 2 Color black, overlay 1, hinge on right

Sheet 3 Color black, overlay 2, hinge on left

Lecture Notes:

Show the tansparency base. Have students guess the velocity of the object. Also have them determine the distance travelled in 5 and 10 seconds.

Turn up overlay 1. This overlay shows the calculation of the graph's slope. Ask how the slope compares with the velocity of the object. Ask also if the selection of the particular triangle makes any difference. Elaborate. Make sure students realize that the slope of a distance-time graph equals velocity.

Remove overlay 1 and show overlay 2. Ask students to calculate the slope of this graph. (3 m/s) Point out that rise= distance travelled and run = time elapsed. Thus slope is equivalent to $\frac{\text{distance}}{\text{time}}$ or velocity.

T 1-2-1 B

UNIFORM MOTION 2

Student notes and directions:

1. Remove all overlays.

   The transparency shows a distance-time graph for an object undergoing uniform motion.

   (a) Guess at the velocity of the object.

   (b) How far did the object go in 12.5 s.?

2. Turn up overlay 1.

   The slope of a line is defined as slope $= \frac{\text{rise}}{\text{run}}$ and is found by drawing a right angled triangle using a part of the graph as the hypoteneuse as shown. Check through the calculations given on the overlay.

   (c) How does your answer to (a) compare to the slope? They should be the same, if not, consult your teacher.)

   (d) Does the particular triangle used effect the result? Try a different triangle to make sure.

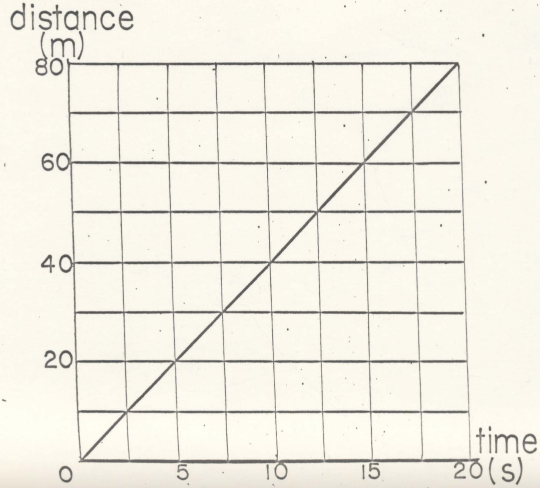
3. Remove overlay 1 and turn up overlay 2.

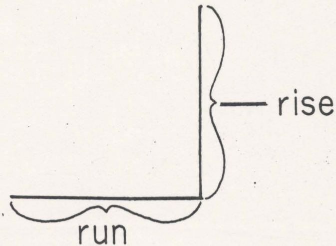
   (e) Using the method just described calculate the slope of this graph.

   (f) What is the speed of this object?

ANSWERS: (b) 50 m (e) and (f) 3 m/s

UNIFORM MOTION

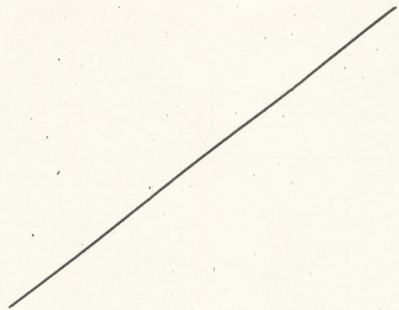




$$\text{rise} = 60 - 20$$
$$= 40\ \text{m}$$

$$\text{run} = 15 - 5$$
$$= 10\ \text{s}$$

$$\text{slope} = \frac{\text{rise}}{\text{run}}$$
$$= 40/10$$
$$= 4\ \text{m/s}$$



slope of a distance-time graph = speed

$$s = \frac{\Delta d}{\Delta t}$$

T 1-2-1 C UNIFORM MOTION 3

Teacher Notes

Production:

Sheet 1	Color Red,	transparency base
Sheet 2	Color Black,	overlay 1a, Hinge on left
Sheet 3	Color Green,	overlay 1b, Hinge on left
Sheet 4	Color Black,	overlay 2, Hinge on right

Lecture Notes

1. Show base sheet, explain that this is a set of speed-time axes. Ask students to guess what the graph of an object travelling at a constant velocity of 3 m/s would look like.

2. Show overlay 1a and explain why the line is horizontal. Ask the distance an object travelling at this speed would cover in 20 seconds.

3. Show overlay 1b. Follow the calculation and show that

   distance = area under curve = vt

4. Remove overlays 1a and 1b and show overlay 2. Ask students the speed of this object and the distance it would go in 5, 10 and 20 seconds.

   Show the area calculations for these times and stress that:

   AREA UNDER A SPEED-TIME GRAPH EQUALS DISTANCE

T 1-2-1 C UNIFORM MOTION 3

Student Notes and Directions:

1. Examine the set of coordinate axes shown. Note that this set of axes plots speed against time.

   (a) What would the graph of an object travelling at a constant speed of 3 m/s look like on this set of axes?

2. Turn up overlay 1a.

   (b) How does your answer to (a) compare to the graph shown?

   (c) This object is travelling at 3 m/s. How far would it go in 20 seconds?

3. Turn up overlay 1b.

   (d) How does your answer to (c) compare to the answer for the area under the curve at 20 seconds?

   (e) What general relationship does this example illustrate between distance travelled and area under a speed-time graph?

4. Remove the overlays and turn up overlay 2.

   (f) What is the speed of this object?

   (g) How far would this object go in 20 seconds?

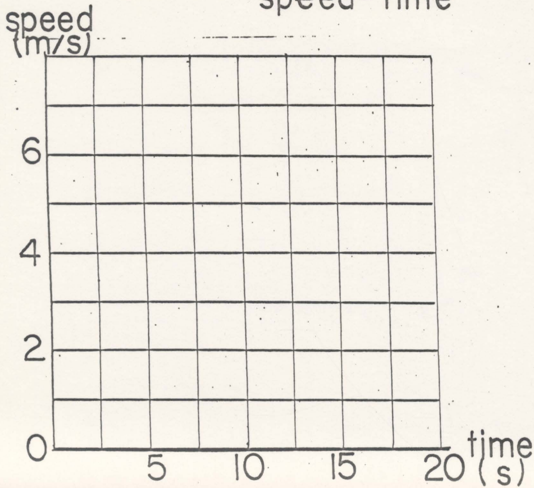
   (h) How does your answer to (g) compare to the area under this line at 20 seconds?

(See answers to questions below)

ANSWERS: (e) The distance travelled by an object in a given time equals the area under the speed time graph at that time.
(f) 5 m/s (g) 100 m (h) the same

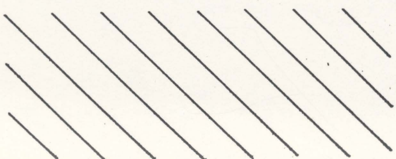
UNIFORM MOTION

speed - time



$$\text{area} = \text{distance}$$

$$\begin{aligned} \text{area} &= h \cdot l \\ &= v \cdot t \\ &= 20 \cdot 3 \\ &= 60\,\text{m} \end{aligned}$$



T 1-2-1 D

UNIFORM MOTION 4

Teacher Notes

Production:

Sheet 1. Color Red, base transparency

Sheet 2. Color Black, overlay 1

Sheets 3 & 4. Color Black, overlay 2 & 3

Lecture Notes

Using the concept area under a speed-time graph = distance, this transparency shows how distance-time data can be derived from a speed-time graph of uniform motion.

1. Show base transparency and ask what the graph of an object travelling at 5 m/s would look like. Ask also how far such an object would travel in 5 seconds.

2. Show overlay 1 and show calculation of area. Have students construct a data table similar to the one shown. Have students fill in the data for 10 seconds.

3. Show overlay 2 and have students complete the table.

4. Show overlay 3. Have students plot the distance-time data on a graph.

5. Have students determine the slope of the d-t graph and compare their results with the speed of the object.

T 1-2-1 D

UNIFORM MOTION 4

Student Notes and Directions:

1. Remove all overlays.

   (a) What would the graph of an object travelling at a constant speed of 5 m/s look like on this set of axes?

   (b) How far would such an object travel in 5 seconds?

2. Turn up overlay 1.

   (c) How did your answers to (a) and (b) above compare to those shown here?

   (d) Copy the table shown here on your notebook.

   (c) Calculate the area under the curve at 10 seconds and put your answer in the table on the next line.

3. Turn up overlay 2.

   (f) How does your table compare to that shown? If you do not understand how the values were obtained consult your teacher.

   (g) Complete the table for 15 and 20 seconds.

4. Turn up overlay 3.

   (h) Check your table against the one shown.

   (i) Plot a distance-time graph of the data in the table.

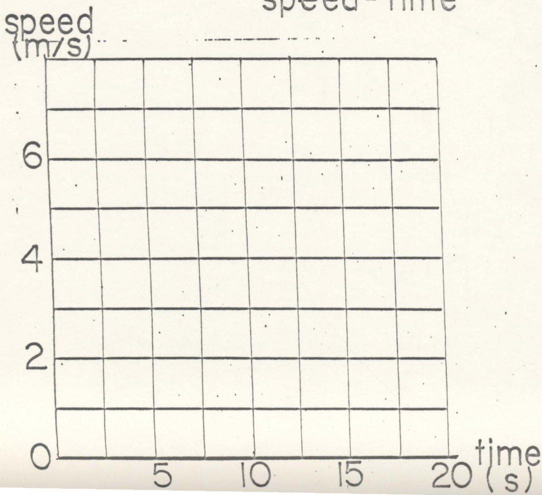
   (j) Determine the slope of your distance-time graph. What is the slope equal to?

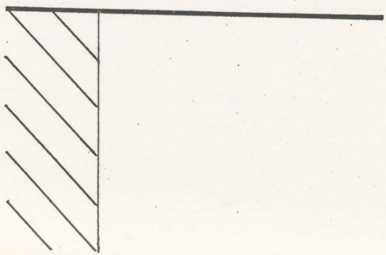
   (See answers below)

ANSWERS: (j) 5 m/s, this is equal to the speed of the obje

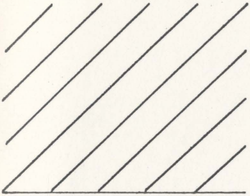
UNIFORM MOTION

speed - time

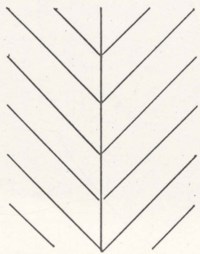




t (s)	d (m)
0	0
5	25



10 50



15 75

20 100

T 1-2-1 E

UNIFORM ACCELERATION 1

Teacher Notes

Production:

Sheet 1. Color Black, Base transparency

Sheet 2. Color Red, overlay 1

Sheet 3. Color Green, overlay 2

Lecture Notes

Before showing transparency ask students to draw up a velocity-time data table for an object accelerating from rest at a rate of 20 m/s^2. The table should consist of readings for time in 2 second intervals from 0 to 8 s.

1. Show base transparency and have students check their table against the one shown. Also ask students what the graph of such data would look like.

2. Show overlay 1. Ask students to calculate the slope of the graph. Point out that slope of a velocity-time graph equals acceleration

3. Show overlay 2 and work through the calculation.

T 1-2-1 E UNIFORM ACCELERATION 1

Student Notes and Directions:

1. Remove all overlays

   Examine the statement and the data table. Do you see how the data in the table arises from the statement?

   (a) What would the velocity of the object be at 3 seconds?

   (b) Describe the shape of the speed-time graph plotted from this data.

2. Turn up overlay 1.

   (c) Does this graph agree with your answer to (b)?

   (d) From the graph determine the speed of the object at 5 seconds?

   (e) From the graph determine the time it took the object to attain a speed of 140 m/s.

   (f) Determine the slope of the graph. How does its value compare to the acceleration of the object?

3. Turn up overlay 3.

   (g) Did your value for slope agree with the value given on this overlay?

   (h) What general relationship can you surmise from this example between slope and acceleration?

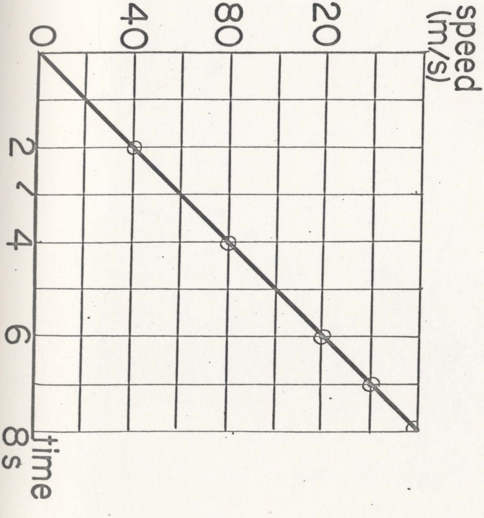
   (i) What was the slope of a distance-time graph equal to?

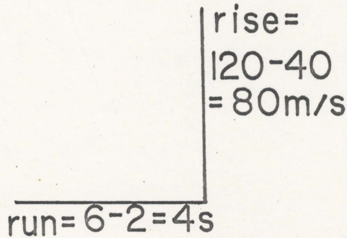
ANSWERS: (a) 20 m/s (d) 100 m/s (e) 7 s
(h) Slope of a v-t graph = acceleration
(i) Slope of a d-t graph = velocity

UNIFORM ACCELERATION

a cart is accelerating at 20 meters/s/s

time (s)	speed (m/s)
0	0
2	40
4	80
6	120
7	140
8	160


speed (m/s)
120
80
40
0
2
4
6
8 s
time



slope = 80/4

= 20 m/s^2

slope = acceleration

T 1-2-1 F

UNIFORM ACCELERATION 2

Teacher Notes

Production:

Sheet 1. Color Black, base transparency

Sheet 2. Color Red, overlay 1

Sheet 3. Color Black, overlay 2

Lecture Notes

See Student Notes and Directions

T 1-2-1 F

UNIFORM ACCELERATION 2

Student Notes and Directions:

1. Remove all overlays.

   Remember that in the speed-time graph for uniform motion we obtained a horizontal line and found that the area under the line at any given time gave the distance travelled by the object at that time. If you do not remember this, go back to T 1-2-1 C. In this transparency we will find that this relationship between area and distance is also true for the speed-time graphs of uniformly accelerated motion.

2. Turn up overlay 1.

   (a) What type of motion does this graph show?

   (b) How fast is the object going at 5 seconds?

   (c) What is the acceleration of the object? (Check your answer below and if wrong see T 1-2-1 E)

   (d) What is the distance travelled by this object in 6 seconds? (Remember distance = area under the graph)

3. Turn up overlay 2

   This overlay shows an example calculation for question (d). Does your answer agree? Do you understand how such calculations are made? If not consult your teacher.

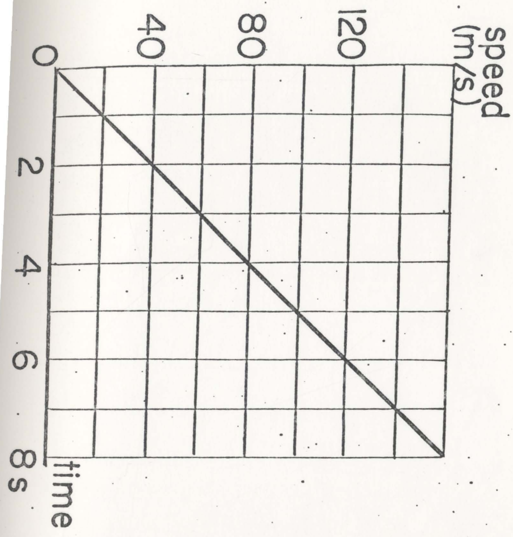
   (e) Calculate the distance travelled by this object in 8 seconds.

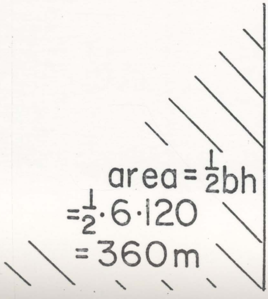
ANSWERS: (a) See title (b) 100 m/s (c) 20 m/s^2

(e) 640 m

UNIFORM ACCELERATION

RECALL: area under an S-T graph = distance


speed
(m/s)
120
80
40
0
2
4
6
8 s
time



this object
travelled
360m in
6 seconds

UNIFORM ACCELERATION 3

Teacher Notes

Production:

Sheet 1; Color Green, transparency base

Sheet 2; Color Black, overlay 1

Sheets 3 & 4; Color Black, overlay 2 & 3

Lecture Notes:

Have students recall that we were able to obtain d-t data by calculating areas under a speed-time graph for uniform motion. This transparency repeats the process for uniformly accelerated motion.

Show the transparency base and have students calculate the area under the graph for the time period from 0 to 2 seconds.

Overlay 1.

Check the area calculation above using an erasable felt-tipped pen. Ask students to calculate the area for the time interval from 0 to 4 seconds.

Overlay 2.

Ask students to complete a table similar to the one shown for 6 and 8 seconds.

Overlay 3.

Ask the students to plot the data on a distance-time graph. There will probably be some confusion since the graph the students meet with at this point is a parabola and this may be the first time the students have met with a graph that turns out to be curved. Sketching the line of best fit as a smooth curve may also cause some trouble but take the time to let everyone do it correctly.

T 1-2-1 G UNIFORM ACCELERATION 3

Student Notes and Directions

1. Remove all overlays.

The graph shown is a speed-time graph of uniformly accellerated motion. Do you see how the graph arises from the statement on the top of the transparency? Previously we obtained distance-time data from a speed-time graph of uniform motion by calculating areas under the horizontal line. In this transparency we are going to carry out a similar process for uniformly accelerated motion. In this case, however the areas are areas of triangles.

Recall that;

Area of a triangle = $\frac{1}{2}$ x base x height

(a) Calculate the area under the graph from 0 to 2 seconds.

(b) What does this quantity represent. (See bottom of sheet)

2. Turn up overlay 1.

(c) Check your answer against the table. If you are wrong review T 1-2-1 F again.

(d) Calculate the area under the curve for 4 seconds.

3. Turn up overlay 2.

(e) Check your answer to (d) against the table.

(f) Compute the distances travelled in 6 and 8 seconds and complete the table in your notebook.

4. Turn up overlay 3.

(g) Check your answers to (f) against the table.

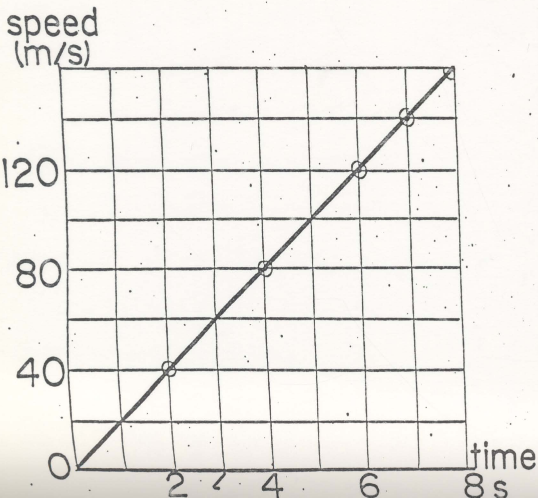
(h) Now, plot the distance-time data on a graph. Do the points lie in a straight line?

(i) Connect the points with a SMOOTH curve. This curve is called a PARABOLA. (Check your graph against that on T 1-2-1 H)

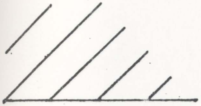
ANSWERS: (b) Distance travelled by the object in 2 seconds

UNIFORM ACCELERATION

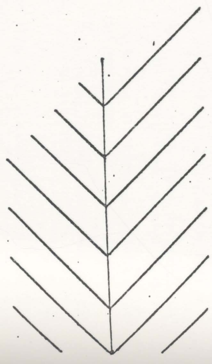
a cart is accelerating at 20 meters/s/s



time (s)	distance (m)
0	0
2	40



4 160



6 360

8 640

T 1-2-1 H UNIFORM ACCELERATION 4

Teacher Notes

Production:

Sheet 1; Color Blue, transparency base

Sheet 2; Color Black, overlay 1

Lecture Notes:

The base transparency shows the data table arrived at from the previous transparency T 1-2-1 G.

Overlay 1.
Show how the points are plotted and what is meant by a smooth curve or line of best fit.

Mention again that the shape of a d-t graph for uniformly accelerated motion is a parabola.

Have students determine the distance travelled in five seconds (answer approximately 250 m).

Have students notice that the slope of the graph is increasing and have them recall that the slope of a d-t graph equals velocity. A plastic ruler can be used to illustrate the increasing slope.

T 1-2-1H UNIFORM ACCELERATION 4

Student Notes and Directions

1. Remove all overlays.

   Notice that this data table is the one arrived at in T 1-2-1 G and that the distances do not increase uniformly.

2. Turn up overlay 1.

   Check that the data points are plotted correctly.

   Note that the points are connected by a smooth curve and NOT by a series of straight lines. The resulting curve is called a PARABOLA.

   (a) From this graph, how far did the object travel in 5 seconds? (Check answers below)

   (b) Would you say that the slope of this graph is constant, increasing or decreasing?

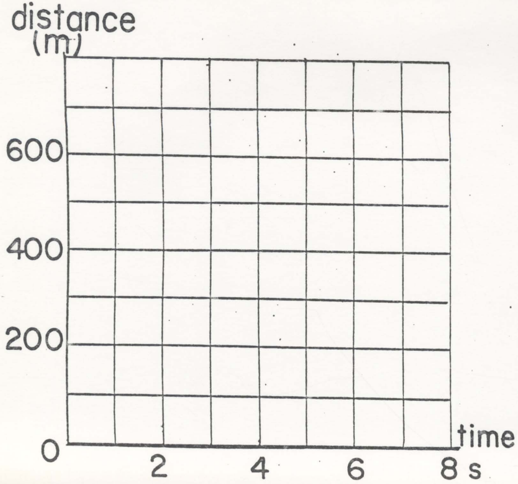
   (c) Recall that the slope of a distance-time graph is equal to the speed of the object. What is happening to the speed of this object according to the slope of the line?

ANSWERS: (a) Approximately 250 meters.

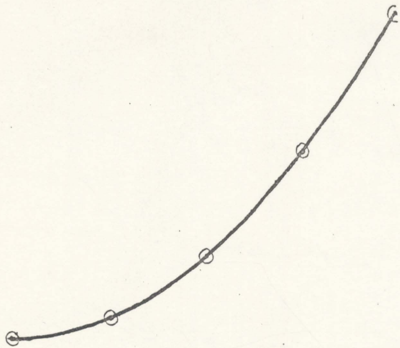
(b) Increasing

(c) Increasing

UNIFORM ACCELERATION



time (s)	distance (m)
0	0
2	40
4	160
6	360
8	640



The shape of the graph is a parabola

T 1-2-1 I UNIFORM ACCELERATION 5

Teacher Notes

Production:

Sheet 1; Color Red, transparency base

Sheets 2 to 5; Color Black, sequential overlays

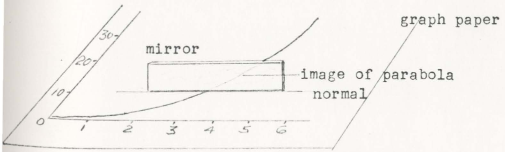
Lecture Notes:

This graph is the same as that produced in T 1-2-1 H. Have students recall that this graph was produced from data derived from a velocity-time graph. This transparency reverses the process. Starting with a d-t graph we wish to derive a v-t graph.

After showing the transparency base illustrate the idea that the slope of this graph is increasing. This may be done with the use of a clear plastic ruler. Mention also that the slope of a d-t graph = velocity.

Explain, however, that it is difficult to determine the slope of this line at any given point. Have students make suggestions as to how this may be accomplished. Explain that the ruler placed correctly on the line may be called a TANGENT to the line and that the slope of the TANGENT at any point is the slope of the line at that point.

One big omission of the text at this point is that it gives no indication of how a tangent may be drawn except by guess. One method which can be used is illustrated below and makes use of a plane mirror.



The mirror is positioned on the parabola so that the image of the parabola in the mirror is in line with the upper part of the parabola. This permits a line to be drawn along the mirror approximately normal to the parabola. A line drawn perpendicular to this at the point of intersection is approximately tangent to the parabola.

Teacher Notes (Cont'd)

The remaining overlays show the use of tangents to calculate instantaneous velocities at various times. The results of such calculations are not exact for obvious reasons of measurement and approximating tangents.

T 1-2-1 I UNIFORM ACCELERATION 5

Student Notes and Directions

1. Remove all overlays.

Note that this graph is the same one derived in the previous transparency. Recall that the slope of a d-t graph equals velocity and that the slope of this line is increasing steadily because the object is accelerating.

In this transparency we wish to obtain values for the slope of the graph at various points.

2. Turn up overlay 1.

Note that the circled data point on this overlay lies directly over the time 2 seconds. We wish to find the slope of the parabola at that point. This slope will equal the velocity of the object at 2 seconds. The straight line AB which also passes through the data point is called a TANGENT and has the property that its slope equals the slope of the parabola at the point indicated. The slope has been calculated to be 40 m/s. Recall that the acceleration of the object is 20 m/s^2.

(a) What do you think the slope of the tangent at 4 seconds will be?

3. Turn up overlay 2.

(b) Was your answer to (a) correct?

If you obtained 80 m/s for your answer, the slight difference in the answer given on the overlay may have been due to problems in drawing the tangent and problems involved in taking measurements from the graph. If you do not understand the answer please consult with your teacher before proceding.

(c) What do you think the slopes of the tangents to the parabola at 6 and 8 seconds will be?

4. Turn up overlay 3.

(d) How did your answers to (c) compare with those given?

(e) Draw a velocity-time graph from the data given and compare it with that on T 1-2-1 G.

(f) If you do not already know how to draw tangents to a parabola consult your teacher.

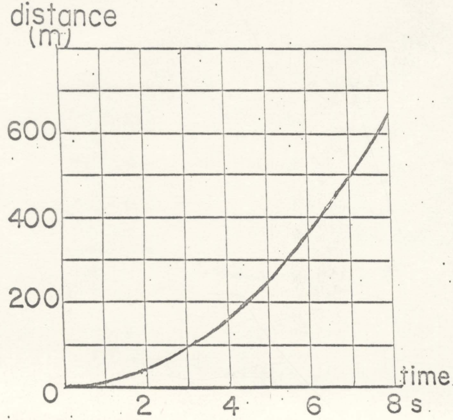
Student Notes and Directions (Cont'd)

(g) Plot the d-t data below on a full sheet of graph paper. Find the slopes of the tangents to the resulting curve at 2 second intervals and from the data so derived plot a velocity-time graph.

(h) What was the acceleration of the object in (g)?

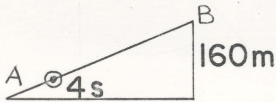
DISTANCE (m)	0	5	20	45	80	125	180	245	320	405
TIME (s)	0	1	2	3	4	5	6	7	8	9

UNIFORM ACCELERATION

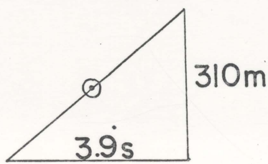


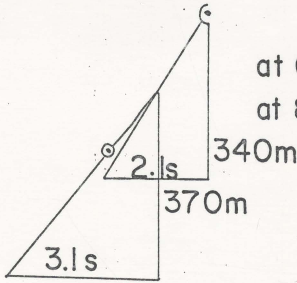
RECALL: slope of a d-t graph = speed

slope of tangent
at 2s = 40m/s



at 4 s = 79.5 m/s





at 6s = 119.4 m/s

at 8s = 161.9 m/s

T 1-2-1 J UNIFORM ACCELERATION 6

Teacher Notes

Production:

Sheet 1; Color Green, transparency base

Sheets 2 to 4; Color Black, overlays 1-3

Lecture Notes:

See student sheet

T 1-2-1 J UNIFORM ACCELERATION 6

Student Notes and Directions

1. Remove all overlays.

   (a) What values are plotted on the axes?

   (b) What would the graph of an object accelerating uniformly at 20 m/s^2 look like on this graph?

   (c) Assuming such an object started from rest, how fast would it be going after 2 seconds?

2. Turn up overlay 1.

   (d) How does this graph compare to your answer to (b)?

   (e) How does the area under the curve for 2 seconds compare to your answer to (c)?

   (f) What general relationship exists between area under an acceleration-time graph and velocity of an object if it starts from rest?

   (g) Calculate the area for 4 seconds.

3. Turn up overlay 2.

   (h) Is your answer to (g) correct?

   (i) What does the value of this area represent?

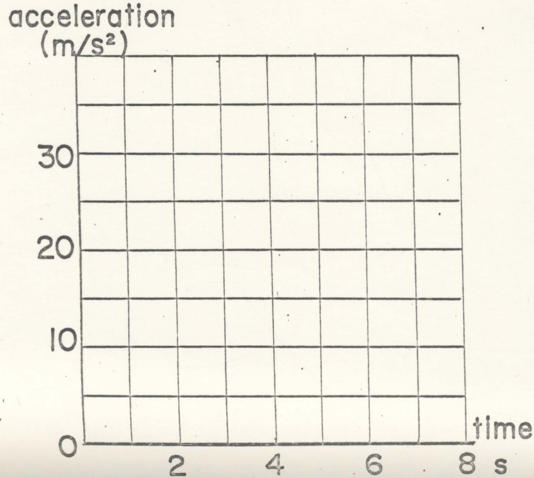
   (j) Draw up a data table of v against t for T = 0, 2, 4, 6, and 8 seconds by calculating the areas involved.

4. Turn up overlay 3.

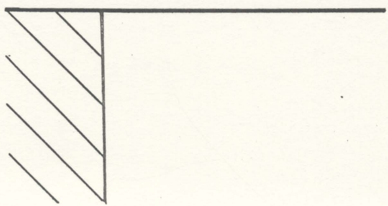
   (k) How does your data compare to the values given?

   (l) Sketch a v-t graph for the data. (Compare it to that on T 1-2-1 E)

UNIFORM ACCELERATION

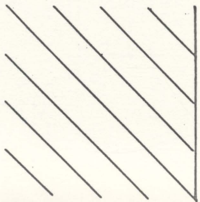


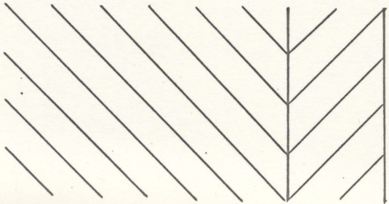
area = l × h
= 2 · 20
= 40 m/s



Area under an a − t graph = speed

area at 4 s
= 80 m/s





at 6s = 120 m/s
and
at 8s = 160 m/s

T 1-2-1 K UNIFORM ACCELERATION 7

Teacher Notes

Production:

Sheet 1; Color Red, transparency base

Lecture Notes:

This transparency summarizes many of the concepts developed previously. It is used as follows:

On the right; given a d-t graph . . take slope . . to find speed(or slope of tangent to find instantaneous speed)
given a v-t graph . . take slope . . to find acceleration.

On the left; Given an a-t graph . . take area . . to find instantaneous velocity
Given a v-t graph . . take area . . to find distance travelled at any time.

T 1-2-1 K UNIFORM ACCELERATION

Student Notes and Directions

This transparency attempts to summarize many of the procedures outlined in previous transparencies.

Look at the left side of the transparency.

(a) Suppose you had a distance-time graph how would you find the velocity of the object?

The transparency shows that Given the graph of distance against time TAKE SLOPE TO FIND velocity.

Remember that if the distance-time graph is a parabola we find instantaneous velocity by taking the slope of the tangent to the curve at a given time.

(b) Given the graph of speed-time how would you find the acceleration of the object?

The transparency shows that Given the graph of speed-time take slope to find acceleration.

Look at the right side of the transparency.

(c) Given the acceleration-time graph how would you find instantaneous velocity?

The transparency reads up on this side and tells you that you would take the area at a given time to find speed at that time. (provided the object started from rest)

(d) Given a speed-time graph how would you find the distance travelled?

(See answer below but if you cannot answer this question yourself check with your teacher)

ANSWERS: (d) Take the area under the curve at any given tim to find the distance travelled in that time.

SUMMARY of GRAPHICAL ANALYSIS

GIVEN the graph of

DISTANCE

TO FIND

TAKE SLOPE

SPEED

TAKE AREA

TO FIND

ACCELERATION

GIVEN the graph of

T 1-2-2A MOTION EQUATIONS

Teacher Notes

Production:

These three sheets can be mounted on separate frames or,

Sheet 1, clear sheet of acetate to form transparency base

Sheet 2, Color Red, overlay 1, hinge on left

Sheet 3, Color Green, overlay 2, hinge on top

Sheet 4, Color Blue, overlay 3, hinge on right

Trim so that overlays can be used one at a time.

Lecture Notes:

See text pp. 24-25

Note also that on this transparency B = base, H = height, W = width and L = length

T 1-2-2 A

MOTION EQUATIONS

Student Notes and Directions:

In these transparencies we will be using what we have learned about slopes and areas of graphs to derive algebraic equations for distance and average velocity.

In each transparency

V_i means initial or starting velocity

V_f means final velocity

T means time as does t

a means acceleration

and d means distance

1. Turn up overlay 1.

This transparency shows the sketch of the motion of an object accelerating uniformly from an initial velocity V_i.

Recall that for a velocity-time graph distance = area

Thus to derive an expression for distance we must derive an expression for the area under this graph.

The area under the graph may be broken into a triangle and a rectangle.

The area of a triangle = $\frac{1}{2}$ base time height or $\frac{1}{2}$ BH
The area of a rectangle = width times length or WL

Follow through the remainder of the derivation on the overlay.

(a) Can you see why we can substitute T for the base of the triangle and $(V_f - V_i)$ for its height? If not consult your teacher.

(b) Can you see why we can substitute V_i for the width of the rectangle and T for its length?

(c) If you are having trouble with this derivation see your teacher.

(d) An object accelerates to a speed of 125 m/s from an initial velocity of 25 m/s. Using the derived equation calculate the distance travelled by the object if this was done in 10 seconds.

ANSWERS: (d) 750 m

T 1-2-2 A

Student Notes (Cont'd)

2. Remove overlay 1 and turn up overlay 2.

In this transparency we wish to derive a second expression for average velocity, one which we will use many times in solving problems.

Recall that we can define average velocity as distance travelled divided by time elapsed.

An algebraic equation for this definition is

$$V_{av} = {}^{d}/_{t}$$

Solving this expression for d yields,

$$d = V_{av} \cdot t$$

But from the previous overlay we found that,

$$d = \frac{V_f - V_i}{2} \, t$$

Thus $V_{av} = \dfrac{V_f - V_i}{2}$ for an object accelerating uniformly

(a) An object accelerates uniformly from 20 m/s to 80 m/s. What was its average velocity?

ANSWERS: (a) 50 m/s

T 1-2-2 A

Student Notes and Directions (Cont'd)

3. Remove overlay 2 and turn up overlay 3

The derivation here is similar to that on the first overlay except that this time we will introduce a term representing the acceleration of the object.

Recall that acceleration may be defined as the change in velocity over time. In algebraic terms this is,

$$a = \Delta V/t$$

Where the symbol Δ means"the change in".

Solving this equation for V yields,

$$\Delta V = at$$

But $\Delta V = V_f - V_i$ which in turn equals the height of the triangle.

Thus the height of the triangle may be expressed as at

and the area of the triangle as $\frac{1}{2}$ t times at or $\frac{1}{2}at^2$.
The area of the rectangle is still $V_i t$.
Thus the total area under the graph is

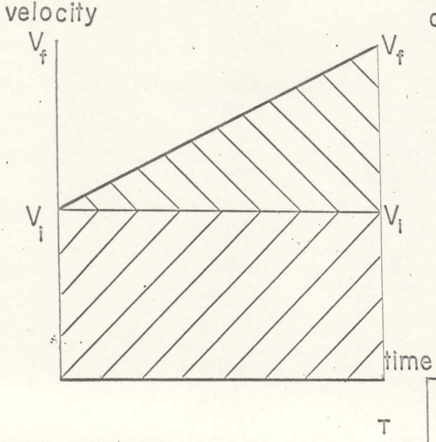
$$V_i t + \tfrac{1}{2}at^2$$

and this equals the distance travelled by the object.

(a) An object accelerates uniformly at a rate of 5 m/s^2 from an initial velocity of 30 m/s. Determine the distance travelled by this object in 8 seconds.

ANSWERS: (a) 400 m

DERIVING MOTION EQUATIONS



d = area under graph

= area of triangle + rectangle

$= 1/2\,BH + WL$

$= 1/2\,T(V_f - V_i) + V_iT$

$= 1/2\,V_fT - 1/2\,V_iT + V_iT$

$= 1/2\,(V_i + V_f)\,T$

$$\boxed{d = \frac{V_i + V_f}{2}\,T}$$

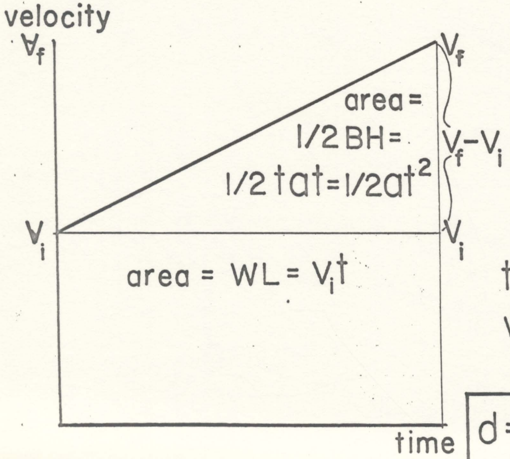
DERIVING MOTION EQUATIONS

RECALL: $d = v_{av} t$

and $d = \dfrac{v_i + v_f}{2} t$

then $v_{av} = \dfrac{v_i + v_f}{2}$

DERIVING MOTION EQUATIONS



$V_f - V_i = \Delta V = at$

distance =
total area =
$v_i t + 1/2\,at^2$

$$d = v_i t + 1/2\,at^2$$

T 1-3-1 A GALILEO'S INCLINE

Teacher Notes:

Production:

Sheet 1; Color Red, transparency base

Sheets 2 & 3; Color Black, overlays 1 and 2

Lecture Notes:

See student notes.

T 1-3-1A GALILEO'S INCLINE

Student Notes and Directions

1. Remove all overlays.

   (a) Explain why Galileo believed that for an object accelerating uniformly the ratio d/T^2 would remain constant.

Galileo set out to check whether or not this was true for objects rolling down an incline.
In conducting the experiment, Galileo rolled a sphere from different points along the incline. He performed several trials for each position.

   (b) Why would he use several trials for each position?

In each case he calculated the ratio of d/T^2 as shown in this transparency. Notice that time is measured in volumes of water.

   (c) Why did Galileo use such a weird unit for time?

2. Turn up overlay 1.

   (d) Would you say that the ratios of d/T^2 agree here? Why or why not?

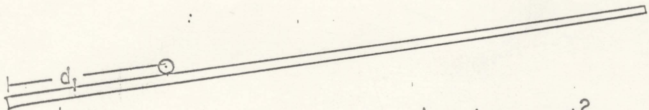
3. Turn up overlay 2

   (e) In the results obtained here is d/T^2 constant?

   (f) What could Galileo conclude from such results?

   (g) If you have difficulty answering these questions consult your text(pp. 40 - 43)

GALILEO'S INCLINE EXPERIMENT



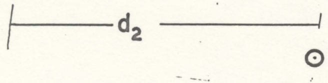
$$d = V_i t + 1/2 a t^2$$

but: $V_i = 0$

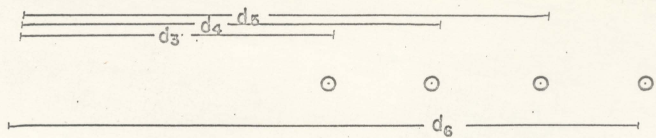
thus: $d = 1/2 a t^2$

and $d/t^2 = 1/2 a$

distance (cubits)	time (vols of water)	d/T^2
3.000	1.200	2.083



5.0 1.55 2.081



6.0	1.70	2.076
8.0	1.96	2.082
10.0	2.19	2.085
12.0	2.40	2.083

$$d_1/T_1^2 = d_2/T_2^2 = \ldots$$

The acceleration of a sphere on an incline of fixed slope is constant.

T 1-3-1 B GALILEO'S INCLINE

Teacher Notes

Production:

Sheet 1; Color Blue, transparency base

Lecture Notes:

See student notes.

T 1-3-1 B Galileo's Incline

Student Notes and Directions;

In order to show that a similar type of acceleration might take place in free fall Galileo tried the same experiment described on T 1-3-1 A several times with the incline at different angles as shown here. The angles here are exaggerated, however, because it is debatable whether Galileo ever exceeded an angle of 6°.

(a) What trend is established by the ratios of d/T^2 in this table.

(b) Do you think that Galileo was justified in extrapolating results such as these to a situation where the object is free falling?

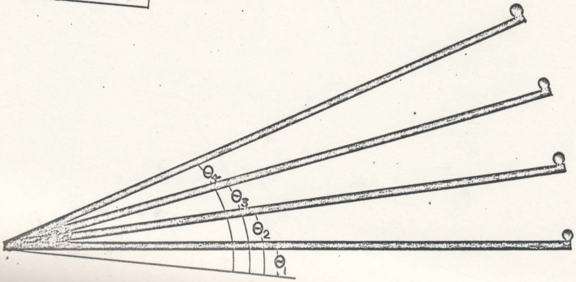
(c) List two other factors which may cast doubt on the validity of Galileo's results.

(d) If (c) is true, Why then was Galileo referred to as the Father of Modern Science?

Check your text for answers.

GALILEO'S INCLINE EXPERIMENT

angle degrees	average d/T^2
5	2,082
13	2.701
20	3.472
26	4.576



T 1-4-1 A MOTION ON A LINE

Teacher Notes

Production:

Sheet 1; Color Black, transparency base

Sheet 2; Color Red, overlay 1, trim to $\frac{1}{2}$ sheet, hinge on left.

Sheet 3; Color Black, overlay 2, trim to $\frac{1}{2}$ sheet, hinge on right

Sheet 4; Color Red, overlay 3, trim to $\frac{1}{2}$ sheet, hinge on top left

Lecture Notes:

The purpose of this transparency is to show the graphing of motion in two directions on a line by use of a sign convention and to show the derivation of a velocity-time graph from an acceleration-time graph.

Note: The acceleration-time graph on sheet 2 may require touching up with an indelible pen to become visible.

See student note sheet.

T 1-4-1 A MOTION ON A LINE

Student Notes and Directions

1. Remove all overlays.

   This transparency deals with objects travelling back and forth along a line. Quantities, therefore, will be given a direction by means of a sign convention. We will assign; + to mean "directed to the right" and - to mean directed to the left.
   Remember also that we are now dealing with vector quantities of displacement, velocity, and acceleration. Distance and speed now have special meanings that you should be aware of before studying this transparency.

2. Turn up overlay 1.

   This overlay shows an acceleration-time graph for an object which STARTED FROM REST.

   (a) What was the acceleration of the object for the first second? (Check answers below)

   (b) What was the acceleration for the time interval from t = 1 to t = 3?

   (c) Does this mean that the object was travelling to the left during the time in (b)?

   (d) Recall that velocity = area "under" an acceleration-time graph and that areas above the T axis are positive and those below are negative. Draw up a velocity-time data table for the motion using 1 s intervals as follows:
   (i) Determine the area under the a-t graph during the first second. This equals instantaneous velocity of the object at t=1. What was the velocity at t=0. Put these two pieces of data in the table.
   (ii) Determine the area between the a-t graph and the T axis from t=1 to t=2s. This represents the <u>change in velocity</u> during that time. Is this area positive or negative? What is the instantaneous velocity of the object at 2 seconds? Enter this in the table.
   (iii) Continue to determine areas and sum velocities in this way to determine the rest of the table.

ANSWERS: (a) +4 m/s^2 (b) -4 m/s^2 (c) No, during the time t=1 to t=2 s the object was travelling to the right but slowing down.
(d) (i) +4 m/s at t=1 and 0 m/s at t=0
(ii) -4 m/s, 0 m/s at t=2s

Student Notes (Cont'd)

3. Turn up overlay 2.

   (e) How does your data table compare to that shown? Check your answers and consult with your teacher if you do not understand any part of the table.

   (f) Plot a v-t graph of the data.

4. Remove overlay 1 and turn up overlay 3.

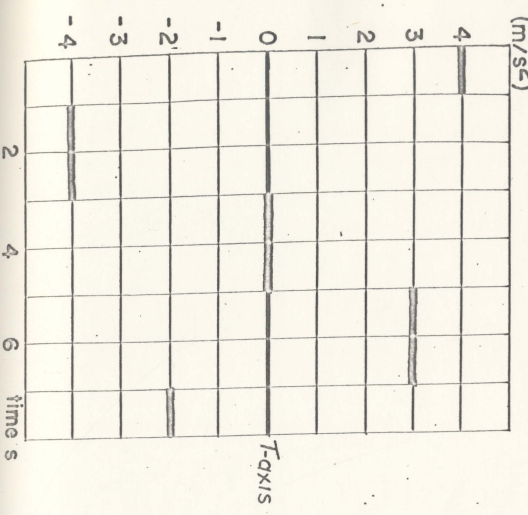
   (g) How does your v-t graph compare to that shown?

   (h) Calculate the slopes of each section of the v-t graph and compare them to the accelerations on the a-t graph in overlay 1.

   (i) If you had started with a v-t graph, how could you obtain an a-t graph?

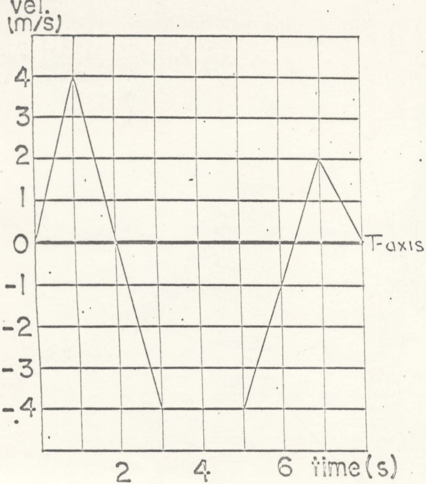
MOTION ON A LINE

+ MEANS RIGHT
- MEANS LEFT


accel.
(m/s2)
4
3
2
1
0
-1
-2
-3
-4
2
4
6
time s
T-axis

THE TABLE FOR THIS GRAPH
IS AS FOLLOWS

time s	velocity m/s
0	0
1	4
2	0
3	-4
4	-4
5	-4
6	-1
7	2
8	0


vel.
(m/s)
4
3
2
1
0
-1
-2
-3
-4
T-axis
2
4
6
time(s)

T 1-4-1 B MOTION ON A LINE

Teacher Notes

Production:

Sheet 1; Same as Sheet 1 for T 1-4-1 A

Sheet 2; Same as Sheet 4 for T 1-4-1 A , Hinge on left. forms overlay 1.

Sheet 3; d-t table, Color Black, $\frac{1}{2}$ page, Hinge on right. forms overlay 2

Sheet 4; d-t graph, Color Red, $\frac{1}{2}$ page, Hinge on top left.

Lecture Notes:

This transparency shows the derivation of a displacement-time graph from a v-t graph.

See student notes.

T 1-4-1 B MOTION ON A LINE 2

Student Notes and Directions:

1. Turn up overlay 1.

This is the same v-t graph obtained in T 1-4-1 A. Recall that area "under" a v-t graph = displacement and that areas above the T axis are positive while those below are negative.

(a) Why are we using the term displacement rather than distance?
(b) What was the displacement d of the object during the first second?
(c) What was d during the time from t=1 to t=2s?
(d) What was the displacement of the object during the first two seconds?
(e) Make up a data table showing total d against t for t=0 to t=2 seconds and leave space for data up to t= 8 s.

2. Turn up overlay 2.

(f) How does your data table compare so far?

(g) The distance in the table means <u>distance from origin</u>. Is this equivalent to displacement?

(h) Why does this displacement get less after 2 seconds?

(i) Why does the displacement become negative only at four seconds in the table? At what time do you think it was zero during this time interval?

(j) Plot a displacement - time graph from the data.

3. Turn back overlay 1 and turn up overlay 3.

(k) How does your graph compare to the one shown?

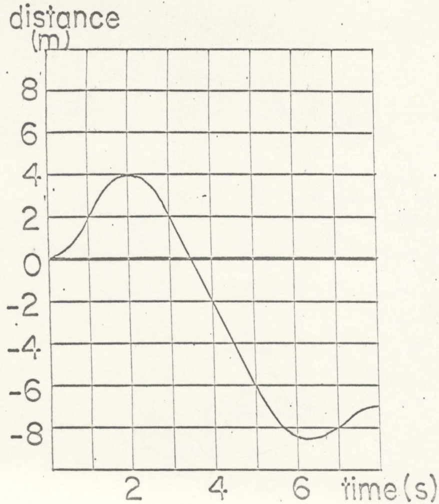
(l) At what times is this graph horizontal?

(g) Compare the times for (l) to the times when the velocity of the object was zero on overlay 1. Why is this?

(h) How would you derive a v-t graph from the d-t graph?

ANSWERS: (a) We are dealing with directed distance. (c) 2 m.
(g) Yes (h) The object is moving back toward the origin
(i) $3\frac{1}{2}$ s (j) velocity = slope of a d-t graph
(h) By obtaining slopes of tangents to the curve.

time (s)	distance (m)
0	0
1	2
2	4
3	2
4	-2
5	-6
6	-8.5
7	-8
8	-7


distance
(m)
8
6
4
2
0
-2
-4
-6
-8
2
4
6
time (s)

T 1-4-1 C DISPLACEMENT VECTORS

Teacher Notes

Production:

Sheet 1; Color Black, transparency base

Sheet 2; Color Green, overlay 1

Sheet 3; Color Blue, overlay 2

Sheet 4; Color Red, overlay 3

Lecture Notes:

The student should be familiar with how vector quantities are drawn and how compass directions and bearings are used.

See student notes.

T 1-4-1 C DISPLACEMENT VECTORS

Student Notes and Directions:

1. Remove all overlays.

   Read the problem.

   (a) What scale is being used here?

   (b) How long should the vector representing 20 m E be? Check it using a ruler directly on the transparency.

   (c) Draw this vector to scale on your notebook.

   (d) Draw the vector representing 16 m N on your notebook so that its tail rests on the head of the 20 m vector.

2. Turn up overlay 1.

   (e) How does your answer to (d) compare with that shown?

   (f) Represent the displacement of 10 m bearing 300° in a similar way. ie., with its tail on the head of the preceding vector.

3. Turn up overlay 2.

   (g) How does your third vector compare to that shown?

   (h) To find the resultant displacement means to find out how far and in what direction the object now is from its starting point. Draw the resultant with its tail at O and its head at the head of the last vector drawn.

   (i) Measure its length and bearing and convert its length back using the scale.

4. Turn up overlay 3.

   (j) How does your answer compare to that given? Remember their may be some difference due to errors in measurement.

   (k) State a rule for summing displacements.

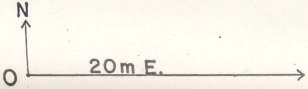
   (l) In what direction and how far would the object have to travel to get back to its starting point? This is called the equilibrant vector.

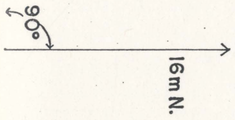
ANSWER: (l) 23.8 m bearing 209°

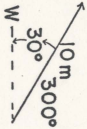
MOTION ON A SURFACE

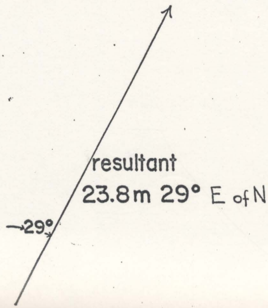
327 DISPLACEMENTS

An object moves 20 m East, then 16 m North, then 10 m bearing 300°. What is its resultant displacement? <u>SCALE: 1 cm = 2 m</u>




90°
16m N.


10 m
300°
30°
W



length r
= 11.9 cm

resultant
= 11.9 · 2
= 23.8 m

T 1-4-1 D VELOCITY VECTORS

Teacher Notes

Production:

Sheet 1; Color Black, transparency base

Sheet 2; Color Green, overlay 1

Sheet 3; Color Red, overlay 2

Lecture Notes:

Students should be familiar with representing velocities by vectors.

See student notes.

T 1-4-1 D VELOCITY VECTORS

Student Notes and Directions:

1. Remove all overlays.

   Read the problem carefully and note the scale used.

   (a) Using a clear plastic ruler measure the length of the vector representing the velocity of 200 Km/h. Does this length agree with the scale?

   (b) Draw the vector in your notebook.

   (c) Draw a vector to represent the wind velocity so that its tail is on the head of the first vector.

2. Turn up overlay 1.

   (d) How does your vector compare to the one shown?

   (e) Represent the resultant velocity by a vector drawn from O to the head of the wind vector.

   (f) Measure the length and direction of the resultant vector.

   (g) What is the resultant velocity of the plane?

3. Turn up overlay 3.

   (h) How does your answer compare to that given?

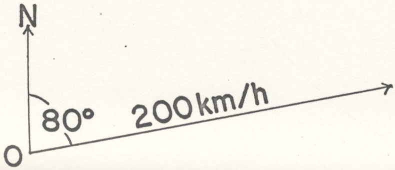
   (i) State the rule of addition for velocity vectors.

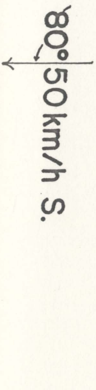
333

VELOCITY VECTORS

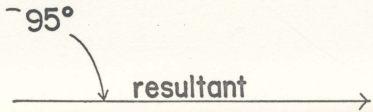
An aeroplane flies in still air at 200 km/h. If it heads on a bearing of 80° into a 50 km/h wind from the north, what is the resultant velocity of the plane?

SCALE: 1 cm = 20 km/h




80°
50 km/h S.

length r =
9.9 cm
resultant =
9.9·20 =
198 km/h 95°



T 1-4-1 E VELOCITY VECTORS 2

Teacher Notes

Production:

Sheet 1; Color Black, transparency base

Sheet 2; Color Blue, overlay 1

Sheet 3; Color Purple, overlay 2

Lecture Notes:

See student notes.

T 1-4-1 E VELOCITY VECTORS 2

Student Notes and Directions:

1. Remove all overlays.

Read through the problem carefully. Note the scale.

(a) What must the boat do if it is to travel directly across the stream? Check answer below.

(b) Copy the diagram carefully in your notebook. The diagram shows: (i) the velocity of the river
(ii) the direction of the RESULTANT velocity.

2. Turn up overlay 1.

This vector represents the direction and speed of the boat relative to the river current. What is its length? Note that it is drawn so that its head just touches the direction in which the boat wishes to travel.

3. Turn up overlay 2.

This overlay shows the two componant velocities originating from O. Notice now that the direction in which the boat must head and its speed across the river can be obtained directly from the diagram.

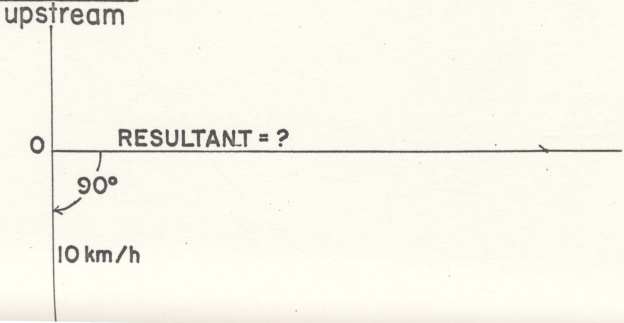
(c) Complete a similar problem with the boat able to travel in still water at 20 Km/h.

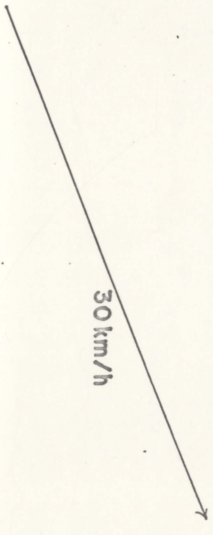
ANSWER: (c) Resultant speed across the river 17.3 Km/h direction 30° upstream.

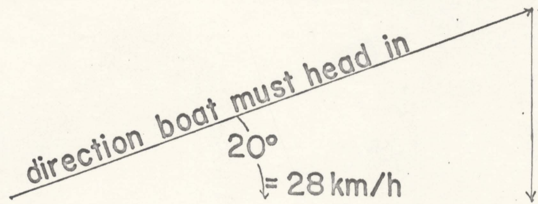
VELOCITY VECTORS

338 A boat travels in still water at 30 km/h. it is to go directly across a river to the other side. If the river flows at 10 km/h, in what direction must the boat head and at what velocity will it cross the river?

SCALE: 1cm = 2 km/h




30 km/h



the boat must head 20° upstream and will cross at 28 km/h.

T 1-5-1 A FORCE VECTORS

Teacher Notes

Production:

Sheet 1; Color Black, transparency base

Sheet 2; Color Red, overlay 1

Sheet 3; Color Green, overlay 2

Lecture Notes:

See student notes

T 1-5-1 A FORCE VECTORS

Student Notes and Directions:

1. Remove all overlays.

   Read the problem and note the scale.

   The diagram shows the vectors representing the weight of the boy on the swing seat and the 200 N force applied by the second boy.

   (a) On your notebook copy this diagram and using the two given vectors as sides complete a parallelogram. Draw the diagonal of the parallelogram from the 90° angle indicated.

   This diagonal represents the resultant force acting on the swing seat.

2. Turn up overlay 1.

   (b) How does your diagram compare to that shown?

   (c) Measure the length of the resultant force and its direction.

   (d) What force does this resultant represent?

3. Turn up overlay 2.

   The two original or COMPONANT forces could be replaced by the single RESULTANT force to give the same result. The swing ropes must apply an equal and opposite force to the resultant. Thus the EQUILIBRANT force is 540 N at an angle of 22° to the vertical.

   (e) How many ropes are on a swing?

   (f) Thus how much force must each swing rope be exerting?

   (g) State the answer to the original problem.

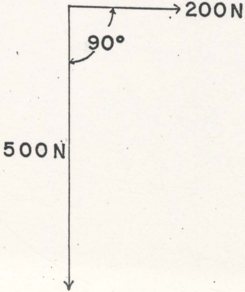
   (h) Complete a similar problem but this time have the boy on the swing weigh 600N

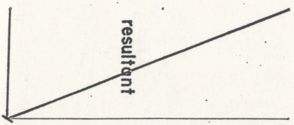
ANSWER: (h) 316 N at 18° to the vertical.

FORCE VECTORS

343 A boy weighing 500 N sits on a swing. Another boy pulls the swing back with a force of 200N. Find the tension on each of the ropes, and the angle they make to the vertical.

SCALE: 1cm = 50 N




resultant

length r = 10.8 cm

resultant force = -22°

10.8 · 50 = 540 N

thus equilibrant =
540 N and force on each
rope = 270 N

T 1-5-1 B FORCE VECTORS 2

Teacher Notes

Production:

Sheet 1; Color Black, transparency base

Sheet 2; Color Green, overlay 1

Sheet 3; Color Red, overlay 2

Lecture Notes:

See student notes.

FORCE VECTORS 2

Student Notes and Directions

1. Remove all overlays.

   Read the problem carefully. Note on the sketch the position of the boom and the tie cable. Note also the scale.

   The sketch is represented below by a vector diagram. This diagram shows:

   (i) The magnitude and direction of the weight force.

   (ii) The direction of the force on the boom.

   (iii) The direction of the force on the tie cable.

   Solving the problem involves completing the parallelogram

   (a) Copy this vector diagram on your notebook.

   (b) Complete a parallelogram with sides along the tie cable and weight vectors and diagonal along the boom.

2. Turn up overlay 1.

   (c) How does your diagram compare to that shown?

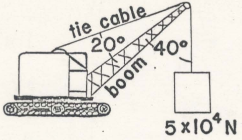
   The lengths of the vectors along the tie cable and boom can now be computed from a measure of their length on the diagram.

   (d) Do so.

3. Turn up overlay 2.

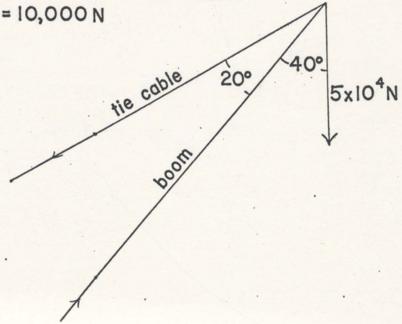
   (e) How do your values compare to those given?

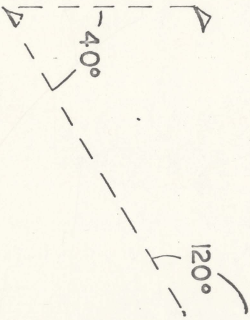
FORCE VECTORS



SCALE: 1 cm = 10,000 N

The crane on the right is supporting a load of 50,000N. Find the force acting along the boom and tie cable.




40°
120°

tie cable = 9.7×10^4 N

boom = 12.8×10^4 N

9.7 cm

12.8 cm

T 1-5-1 C NEWTON'S LAWS

Teacher Notes

Production:

Sheet 1; Color Black, transparency base

Sheet 2; Color Green, overlay 1, Hinge on left

Sheet 3; Color Blue, overlay 2, Hinge on top

Sheet 4; Color Purple, overlay 3, Hinge on right

Trim sheets so that they can be turned up one at a time.

Lecture Notes:

This transparency is best used as a review or summary of Newton's Laws after a full treatment has been given

T 1-5-1 C NEWTON'S LAWS

Student Notes and Directions:

This transparency should be used to REVIEW Newton's Laws of Motion.

1. Turn up overlay 1.

   (a) Would the inertia of a body be different on the moon?

   (b) Give an example of a situation in which an object may be said to be moving or at rest depending on who is observing it.

   (c) What is meant by "frame of reference"?

   (d) How does statement D differ from what Aristotle said?

   (e) What are the conditions of forces acting on a body, the body's velocity and its acceleration when it is in equilibrium?

2. Remove overlay 1, Turn up overlay 2.

   (f) What would happen to a body's acceleration if the net force acting on it were doubled?

   (g) How many newtons of force would be required to accelerate 5 Kg at 3 m/s^2?

   (h) What acceleration would be produced by a net force of 3 N acting on a mass of 6 Kg?

3. Remove overlay 2, turn up overlay 3.

   (i) Name the action and reaction force in each of the situations shown.

ANSWERS: (a) No (b) Objects in a train travelling at a constant velocity (c) This refers to the state of rest or motion of an observer relative to the object being observed. (d) See p.2 of text (e) Forces sum to zero, velocity constant, acceleration zero (f) it would double (g) 15N (h) 0.5 m/s^2 (i)1 action-skate on ice, reaction-ice on skate; 2 action-gravity pulling professor down, reaction-professor pulling earth up; 3 ice on head, head on ice.

NEWTON'S LAWS

I. THE LAW OF INERTIA.

A body will continue in its state of rest or uniform motion unless acted upon by an unbalanced force.

THIS PROPERTY IS CALLED INERTIA AND IS MEASURED BY THE BODY'S MASS

THIS LAW PROVIDES THE FOLLOWING IMPORTANT INSIGHTS:

A. INERTIA IS A BASIC PROPERTY OF ALL MATTER.

B. THERE IS NO DYNAMIC DIFFERENCE BETWEEN REST AND UNIFORM MOTION.

C. WHETHER AN OBJECT IS AT REST OR IN UNIFORM MOTION DEPENDS ON THE FRAME OF REFERENCE OF THE OBSERVER.

D. THIS LAW HOLDS FOR ALL BODIES WHETHER CELESTIAL OR TERRESTRIAL.

E. EQUILIBRIUM IS DEFINED AND THE STAGE IS SET FOR THE SITUATION WHERE UNBALANCED FORCES DO ACT ON A BODY.

355

2. THE SECOND LAW.

The acceleration of a body is directly proportional to the unbalanced force and inversely proportional to the mass of the body.

$$a \propto f \qquad a \propto 1/m$$

IF 1 NEWTON IS DEFINED TO BE THAT FORCE WHICH CAUSES A 1 KILOGRAM MASS TO BE ACCELERATED AT 1 METER PER SECOND PER SECOND, WE MAY WRITE:

$$a = f/m$$

3. THE LAW OF ACTION & REACTION.

For every force that one object exerts on a second, the second object exerts an equal and opposite force on the first.

THIS LAW SHOWS THAT:

A. FORCES ALWAYS OCCUR IN PAIRS

B. EACH FORCE OF THE ACTION - REACTION PAIR ACTS ON A DIFFERENT OBJECT.

C. THE FORCES ARE EQUAL IN MAGNITUDE BUT OPPOSITE IN DIRECTION.

T 1-5-1 D APPARENT WEIGHT

Teacher Notes

Production:

Sheet 1; Clear acetate, transparency base

Sheet 2; Black, overlay 1

Sheet 3; Black, overlay 2

Lecture Notes:

This transparency is best used for discussion purposes. See student notes for questions which might arise.

T 1-5-1 D APPARENT WEIGHT

Student Notes and Directions:

1. Turn up overlay 1.

Frame 1.
(a) Is the professor in equilibrium? Be careful.

Frame 2.
(b) Why has the professor's weight apparently increased?

Frame 3.
(c) If Professor Whizz normally weighed 600 N what would his apparent weight be here?

Frame 4.
(d) It may be said that the professor is pulling 3 gees at this point. What do you think this means?

Frame 5. Something has gone wrong with the motor. At this point it is just working well enough to overcome gravity pulling it downward. Thus the rocket's upward acceleration is zero.
(e) Would the rocket stop at this point?

(f) Assuming the rocket has not risen very high, what is the professor's weight now?

Frame 6.
(g) Is it possible for the rocket to be moving upward in this frame?

(h) What would the professor's weight be here?

2. Turn back overlay 1, turn up overlay 2.

Frame 7. The rocket's motors have stopped altogether.
(i) What is the professor's apparent weight now?

(j) What action and reaction forces are there?

Frame 8. The rocket flips over.

Frame 9. The failing motor reignites.
(k) What is the professor's apparent weight now?

(l) According to the professor, what is he doing?

Frame 10.

(m) According to the professor, which end of the rocket is the floor?

ANSWERS: (a) It depends on which frame of reference you are using. (b) Because the scales must exert extra upward force to accelerate him (c) 1200N (d) He has three times his normal weight (e) No, it would have to decellerate to a stop. (f) 600N (g) Yes, only a is downward (h) 300 N (i) 0 N (j) Gravity pulling the rocket down-Gravity pulling the earth up. (k) -120 N (l) standing on his head (m) the top as we now see it (n) No, we did not know the weight of the scales in the beginning and that is all they are measuring now. (o)-2 Gees (p) Up and down would suddenly reverse and the professor would go plunging at high acceleration into the nose of the rocket.

Student Notes (Cont'd)

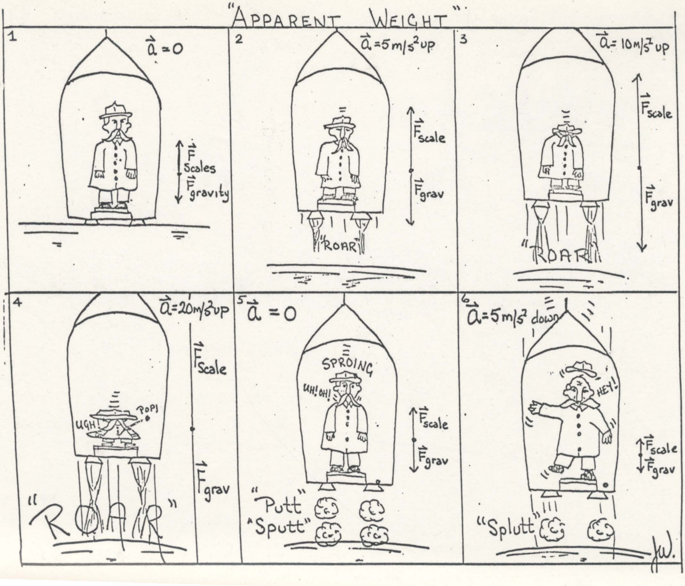
Frame 11.

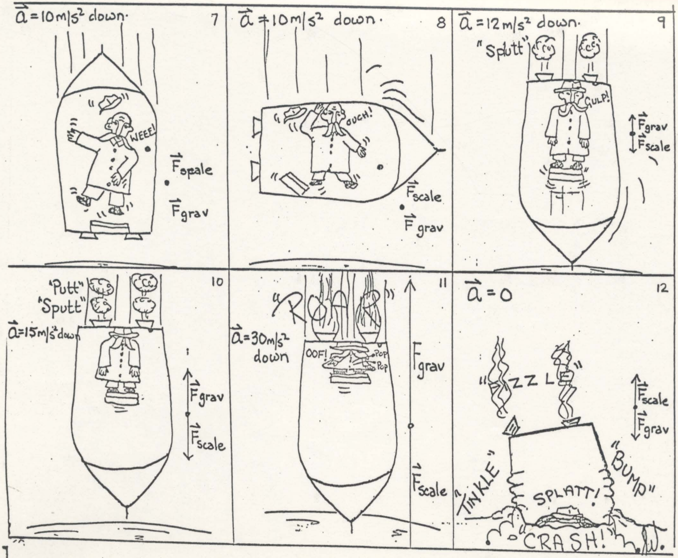
(n) Is it possible to tell what the scales would read at this point? Why or why not?

(o) How many Gees is the professor pulling at this point?

Frame 12.

(p) What would happen to the professor at the instant the rocket made contact?


"APPARENT WEIGHT":
1
$\vec{a} = 0$
$\vec{F}$ Scales
$\vec{F}_{gravity}$
2
$\vec{a} = 5 m/s^2$ up
$\vec{F}_{scale}$
$\vec{F}_{grav}$
"ROAR"
3
$\vec{a} = 10 m/s^2$ up
$\vec{F}_{scale}$
$\vec{F}_{grav}$
"ROAR"
4
$\vec{a} = 20 m/s^2$ up
$\vec{F}_{Scale}$
$\vec{F}_{grav}$
UGH!
POP!
"ROAR"
5
$\vec{a} = 0$
SPROING
UH! OH!
$\vec{F}_{scale}$
$\vec{F}_{grav}$
"Putt"
"Sputt"
6
$\vec{a} = 5 m/s^2$ down
HEY!
$\vec{F}_{scale}$
$\vec{F}_{grav}$
"Splutt"
JW.


a = 10 m/s² down.
7
WEEE!
F spale
F grav
a ≠ 10 m/s² down.
8
OUCH!
F scale
F grav
a = 12 m/s² down.
9
"Splutt"
GULP!
F grav
F scale
10
"Putt"
"Sputt"
a = 15 m/s² down
F grav
F scale
11
a = 30 m/s² down
OOF!
Pop
Pop
F grav
F scale
a = 0
12
"ZZ L"
F scale
F grav
"TINKLE"
"BUMP"
SPLATT!
"CRASH!"

APPENDIX G

Letter of Commendation

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

363

252 COLLEGE STREET TORONTO 2B, ONTARIO

Toronto Centre, R.A.S.C.

Dear David,

On the agenda of our latest General Assembly held in Halifax, the end of June, I happened to notice under the heading of "Exhibitions" a slide and tape presentation prepared by some people from St. John's, on the topic of the advancments made in space travel. Being an avid fan of all space shots, I made a special attempt to view this show.

I was delightfully suprised by the quality of this project! I liked it so much infact, I sat through the whole thing three times! The photography was excellent, and the script (of which I have Xeroxed off, while at the Post Office) was a remarkable piece of research! I asked Randy what caused these two people to devote so much effort to the completion of this project. The answer that he gave me, was that it was completed by two High School students. I disaggreed, for I had only seen work of this high standard, attempted by some students of Astronomy, attending U.B.C.

Randy had told me that your Physics teacher, for whom this project was originally done, had awarded you all possible marks for it. He was more than correct in his evaluation. You and your partner, John Baird, have certianly produced an excellent project, for six-month's work.

Good luck in your future studies, to both of you.

Your's Truely

C.H. Holland R.S.C.

Asst. Sect. Toronto, R.A.S.

Dean of Astrophysics,

McGill University.

APPENDIX H

Laboratory Equipment List

A COMPLETE LIST OF LABORATORY
AND ACTIVITY MATERIALS FOR
PHYSICS: A HUMAN ENDEAVOUR

by Bill Walsh

INTRODUCTION:

The following list was compiled to form several functions:
1. To let teachers know the complete range of materials required for the course.
2. To let teachers know what materials are required and which are frills
3. To serve as an inventory checklist on a permanent basis
4. To list the materials required for each individual experiment and activity
5. To let teachers know the current average cost (1976) of these materials
6. To offer some suggestions about how some of the materials may be produced by the teacher

In ordering electronic componants the teacher will do well to select one reliable supplier and stick with him. Many of these componants produced by different companies are not compatible.

Explanation of headings:

E&A Experiment and/or activity which the equipment is used for.
QUAN Quantity of materials required for 5 (five) lab groups working at a time.
PRI Priority - Tells whether the equipment is required (R). Nice to have in the lab but not absolutely essential (N), or uneccessary (U)
CH An inventory check space to keep a running check on materials in stock or yet to be ordered

HOW TO USE THE LIST:

Note that items recur whenever they are required for an experiment or activity. recurring items have no price given and in the NOTES you are referred to the experiment or activity in which they originally appeared. The list can be used as a checklist for each experiment or activity and as a running inventory list.

Note that no audio visual equipment is listed here. Some of the experiments require certain A-V Materials these are listed in a separate form. See"Audio-Visual and other Instructional materials for PHYSICS: A HUMAN ENDEAVOUR"

MODULE ONE

M O T I O N

E or A	QUAN.	DESCRIPTION	PRI	CH	COST	NOTES
E 1.1	1+4	Cloud Chamber	R		3.25	Purchase with dry ice scource
	1+4	High power light source	R		8.95	
	3	Sheets polarizing film	R		1.33	Edmund
	1+4	1 liter cylinders (Plastic)	R		7:56	
	1+4	Tubes to fit in above	R			obtain locally
	1+4	Tuning forks 512 Hz	R		4.50	
	1	Fan cart	N		25.85	Holt, Rinehart
	1	Collision Balls app	R		5.95 *1	Edmund
	1	St. Louis Motor	R		20.15	
	1+4	6v battery **	R			obtain locally
	1+4+5	SPST switch	R		.84	
	2	1 lb spool commutator wire	R		5.30	obtain locally
	6+14	alligator clips (pk. 12)	R		3.36	obtain locally
E 1.2		5 1-l. cylinders				See E 1.1
	5	1" diam steel balls	R		.65	
	"	¾" d " "	R		.40	
	"	" " glass "	R		.40	
	"	¼ " cork "	R		.50	
	6 liters	glycerine or light oil	R			obtain locally
E 2.1-A	5	Ticker tape timers	R		9.20	60Hz 120 volt
	5	{Power supplies multi-range *2	N			
	or 5+5	{2-D cell & holder	R			obtain locally
	5+10	Dynamics Carts Pr. *3	R		17.10	Get spring bumpers also
	5+5	C clamps	R		3.70	or obtain locally
	5	Meter sticks	R		1.35	
2.1-B	1	Balloon Pucks *4	P		9.50	
	or 1	{Linear air track	A			
	1	{Vacuum cleaner	U			get on loan
	1	{Polaroid 420 camera	U		86.35	with motor strobe
	1	{Tripod	U			
	1	{Xenon Strobe	U		124.50	

FURTHER NOTES: 1. Combination Motor-Generators can also be purchased at about the same price.
2. These are expensive but permanent, at least two should be purchased for other uses. Put aside the cost of one each year and gradually build up to five.
3. Carts with exploding spring are best. Spring bumpers can be attatched to them
4. Generally this is frill equipment. The purchase of an air track could be undertaken as a project for students. If a table is required air hockey games are much cheaper.

EorA	QUAN	DESCRIPTION	PRI CH	COST	NOTES
E2.1C	5	Drapery tracks 6 ft.	R		Obtain locally
	1	Roll masking tape	R		" "
	5	Electric stopclocks	R,0	24.60	Cheaper & better than stopwatches +
	5	steel balls			See E 2.1A
E2.2A	5	sets slotted weights & holder	P.	23.90	
	5	ticker tape timers			See E 2.1A
	5	C clamps			" " "
E2.2B	5	wood ramps 6"x6'			Obtain locally
	5	ticker tape timers & C clamps			See E 2.1A
E2.2C					See E 2.1C
E2.3	5	Hand held strobes	R	3.54	
	5	Ticker tape timers & C clamps	R		See E 2.1A
E3.1	5	large plastic funnels(Buchner)*1	R	3.96	Use tops of Javex bottles.
	12'	Rubber hose	R	.60	
	5	eyedroppers (Dz)	R	1.10	
	5	hose clamps	R	.50	
	10	lab stands	R	2.75	
	5	ring & clamps	R	1.70	
	5	test tube clamps	R	1.84	
		tracks & balls			See E 2.1C
E 3.2A		Tracks balls & stopclocks			See E 2.1C
B		Air track			See E 2.1B
	2	Photocell relays	U	8.00	
	1	5 Decade counter timer*2.	R	160.00	
E3.3A	1	stopwatch 1/10 sec	R	38.35	
	1	steel ball			See E1.2
	1	impact board 2'x2' plywood	D		Obtain locally
E3.3B	5	bureetes	U	6.10	Get from chem lab
	5	tin plates			obtain locally
	5	electric timers			See E2.1C

FURTHER NOTES: 1. Can be replaced by Galileo Lab Materials Kit at $5.15 (not as good but serves the purpose 2. An expensive item but gets more use in radioactivity experiments.

E or A	Quan	DESCRIPTION	PRI	CH COST	NOTES
3.3C	1	Xenon Strobe light *1	U	124.50	Useful also for demonstrations
	1	Golf Ball	U		Obtain locally
	1	Photographic meter stick	U	3.60	
3.3D	5	pendulum bobs	R	2.00	Use a hooked weight
	3	spools fishing line	R		Obtain locally
3.3E	5	Acceleration of gravity app	U		Make as described
3.3F	1	" " " filmloop	R	23.00	
3.3G		See E 2.1C for all equipment			See 2.1C
A3.1	1	Drapery track 4'	R		obtain locally
A3.3	1	Dime and feather tube	R	19.70	Make up locally
	1	Vacuum Pump	R	275.00	
A3.5	1	Ping pong ball	U		Obtain locally
A3.6	3	Large washers	U		" "
	1	tape recorder	U		" "
E4.1	1	Shutter for linear air track	U		make locally
E5.1	5	1 ft. rulers with center channels	R		obtain locally
	5	collision carts			See E2.1A
	5	steel balls			See E 1.2
E5.2	5+10	0-2.5 Nt. Spring balances	R	3.00	
	5	collision carts			See E2.1A
	5	TT timers			" "
E5.3					See E2.1A
E5.4	5	20" diam. circles from perf board	R		Obtain locally
	2 pk	perf bd. hooks			" "
	15	spring balances			See E 5.2
A 5.4	1	spool of cotton	R		Obtain locally
A5.5	1	ballistics cart	U	29.40	
A 5.6	1	Accelerometer (large)	N	16.50	
Missed	1	Batery driven Bulldozer	R		

FURTHER NOTES: 1. Strobe light is useful only where room can be dimmed or completely darkened if not buy a blinky.

MODULE TWO

M O T I O N I N T H E H E A V E N S*

* Not a core module

EorA	QUAN.	DESCRIPTION	PRI	CH	COST	NOTES
6.1A		No equipment required				
B	1	Celestial Globe	R		66.95	
6.2		No equipment required				
6.3A		" " "				
B	5	Transparent globe kit	R		7.50	Use balls about 30 cm. diam.
6.4		No equipment required				
A6.4	5	large styrofoam balls 9"diam	U			Obtain locally (See above)
A6.7	1	Filmstrip "Retrogd mot of mars	R		21.00	Holt, Rinehart
E7.1	1	Sun Photos Filmstrip	R		3.80	" "
A7.3	1	Phonograph turntable	R			Use a broken record player
A7.4	1	Foucault Pendulum	M			Make using turntable
E8.1	2 pk.	Thumbtacks	R			Obtain locally
E8.2	1 set	Mars orbit lab books & overlays	R		18.75	
E9.1	5	Centripetal force app.	N		2.70	See picture & obtain locally

MODULE THREE

E N E R G Y   A N D   T H E   C O N S E R V A T I O N   L A W S

EorA	QUAN	DESCRIPTION	PRI CH	COST	NOTES
10.1	10	Rubber bands 9" long	R		Obtain locally
		Carts, clamps, stands & TT timers			See E 2.1A
10.2		Same as above			
10.3		Plasticine.	R		Obtain locally
		Same as above			
10.4	1	Linear air track & vacuum clr.			See 2.1B
	2	Photocells			See 3.2B
	1	5 Decade counter timer			See 3.2B
10.5 & 6		No equipment required			
A10.1	2	Triple beam balances	R	44.00	
	2	Micro test tubes (doz)	R	1.77	Get from chem lab
	2	Boiling flasks & stoppers	R	4.00	" " " "
	1	100 g lead nitrate	R	3.55	" " " "
	1	100 g KI	R	3.20	" " " "
	1	Pk large flash bulbs	R		Obtain locally
11.1	5	Conversion of Energy app	R	3.87	
	5	3V power supplies	-		See E2.1A
11.2		Dynamics car, spring scale, timer and meter sticks			See E2.1A, E2.1C, E5.2,
11.3A		TT timer & weights			See E2.1A and 2.2A
B		Camera, strobe, meter stick & golf ball			See E2.1B, E2.1A, 3.3C
A11.1	1	Radiometer	R	4.25	
	1	Thermocouple	R	2.50	
	1	Microammeter	R	40.75	Cheaper ones available
	1+9	Battery & bulb light source	R	1.89	
	1	250 ml conc H_2SO_4	R		Get from Chem Lab
	1	Hand generator (Magneto)	R	48.50	
	1	microphone	R		From a broken tape recorder
	1	Amplifier & power supply	R	95.00	Used again later
	2	Speakers	R	8.00	Get from old radio or TV

[illegible] #1. Get loan of analytical balances from Chem.

EorA	QUAN	DESCRIPTION	PRI CH	COST	NOTES
A11.1	1	Auto thermostat			Obtain locally
	1	Geiger tube	R	45.00	Used again later
	1	5 Decade counter timer			See E3.2A
E12.1	5	lever supports	R		use test tube clamps
	15	lever clamps	R	1.70	use fishing line
	5	sets slotted wts & hanger			See E2.2A
12.2	5	single pulleys	R	1.25	
	10	double pulleys	R	1.85	
		weights & nt balances			
A12.1	1	inclined plane with pulley	M	9.00	
13.1	2	Wave demonstrators (spring)	R	6.05	
13.2		As above			
13.3	5	Ripple tanks *1	M	46.50	You can make your own
	5	Hi Power light sources	R	8.95	" " " " "
	5	3V power supplies			See E2.1A
	5	Rheostats	R	4.65	
13.4,5,6		See above			
13.7					See E13.1
13.8					See E13.3
A13.1	1	Rotator motor	N	102.25	Hand rotator 40.95
A13.5	2	Moire patterns on acetate	N		
A13.6	1	Wave machine	N		

FURTHER NOTES: 1. These expensive items can be substituted for by the use of the PSSC filmloops on waves. When shown on a rear view projector these can be used for quantitative experiments. Obtain instead the Ripple tank for the overhead projector price- $44.50 Even this one can be made if a wave generator is purchased.

MODULE FOUR

THE NATURE OF LIGHT AND SOUND

E&A	QUAN	DESCRIPTION	PRI CH	COST	NOTES
14.1	2	plastic funnels (medium size)	R	1.00	
	2	speakers			See A11.1
	1+1	Audio Function Generator	R	50.00	
	1	Amp & power supply			See A 11.1
	1	Sheet 6"x6" each of glass, wood, metal styrofoam, cardboard, cloth	R		Obtain locally
	1	Sound meter	U		Optional
	1	large balloon	R		Obtain locally
	1	source of CO_2	R	22.50	Or get a CO_2 extinguisher
14.2		No Equipment required			
14.3	10	tuning forks	R		See E1.1
	5	1 l. cylinders	R		See E1.2
	5	plastic cylinders to fit above	R		Obtain locally
	5	cardboard cylinders	R		" "
A14.1	1	variable speed motor			See A13.1
	1	Savart's wheel	N		
A14.2	1	Oscilloscope	N	310.00	Cheaper models avbl.
		Amp., Power Sup., Mic., Tuning Fork			See A11.1
A14.3		Sound Meter			See E14.1
A14.5		Variable speed motor			See A14.1
A14.6		Pc sheet metal 15x15 cm.			obtain locally
A14.7	1	Sonometer	N	96.00	
A14.8	1	Kundt's App.	N	27.00	
A14.10	1	Resonance of Tuning forks App	N	47.00	Can be made with two similar forks
	1	Amp-Power Sc., 1 speaker, Oscilloscope			See A11.1, A14.2
	2	Function gens			See E14.1
E15.1	1	Large magnifying glass	R		Obtain locally
	1	Photocell & motor	R		
	1	Discharge tube Power supp.	R	48.50	
	3	" " @ $6.90	R	20.70	
E15.2A	5	Ray boxes	R		
	5	Ray box optics kits	R		
E15.2B	2	Pk ball head pins	R		Obtain locally
	5+5	Plane mirrors 1.5x6" on a stand	R		Make from broken mirror

E&A	QUAN	DESCRIPTION	PRI CH	COST	NOTES
E15.3A	5	Refraction Dishes *1	S.		
	1	liter of glycerine			See E1.2
E15.3B		Refraction dishes & ball head pins			See E15.3A & E15.2B
E15.4	5	Equilateral prisms 75mmx9mm	R	2.60	
	5	Ray boxes			See E15.2A
	5	Sets plastic color filters	R	5.25	
	1	Laser	N	225.00	Best quality many demo. uses
	5	Sheets red paper	R		Obtain locally
	10	Battery & bulb sets			See A11.1
	1	Water paint set			On loan from art room
	1	Youngs slit app	R	4.15	
	1	Micrometer	R	18.75	
A15.1	2	Refraction of particles app	N	5.80	Make your own
A15.2		Polarizing filters			See E1.1
A15.3	3	Iceland spar crystals	R	.85	
A15.4		Laser			See E15.4
	1	set laser lenses 1 convex,1concave	R*2		
	1	Pk 3000 ASA Polaroid film	R		Obtain locally
A15.5	1	wire loop 2" diam			Make your own
	1	Hg lamp	R	21.50	
	1	set interference plates	R	3.95	
	1	Nts. rings app	R	29.50	
A15.6	1	Color wheel	N		
E16.1AB	10	Plane mirrors,ray boxes, pins			See E15.2B
E16.2A		Ray box & optics kit			See E15.2A
E16.2B	10	Light bench supports (pr)	R	1.15	Meter sticks see E2.1A
	5	lens holders (small)	R	1.15	
	5	candle holders	R	1.20	
	5	candles	R		Obtain locally
	5	screen holders	R	1.15	
	5	concave mirrors	R	1.35	
E16.3ABC	5	convex lenses		1.50	See E16.2B

NOTES: 1. Pssc Optics kit contains all these elements at $6.25

MODULE FIVE

E L E C T R I C I T Y

E&A	QUAN	DESCRIPTION	PRI CH	COST	NOTES
E17.1	5	each friction rods of ebonite hard rubber, lucite, glass, vinyl & acetate & wax	R	1.05	Average cost
	5	Friction pads of fur, plastic bags, cello wrap, silk, wool etc	R		Obtain locally
	5	ring stands & clamps	R		See E3.1
	10	Wire stirrups	R		Make your own
E17.2	10	metal rods 3" long	R		Make your own
	or 10	metal spheres on insulated stands	N		Expensive items, make yr. own
	5	Pith ball electroscopes (dz. balls)	R	3.90	Make your own stands
E17.3	1	Pk soda straws, pins, toothpicks	R		Obtain locally
	1	Pk (50) graphite coated strofoam balls	R		
	5	Plastic cups	R		Obtain locally
	1	l. glycerine			See E1.2
E17.4	1	Millikan's app	N	62.00	
	1	Hi Voltage power supply	R	20.00	
A17.1	5	Leaf type electroscopes	R	7.00	
		Friction rods & pads			See E17.1
A17.3	1	Electrostatic pinwheel	N		
	1	Van de Graff	N	52.50	Kit form
E18.1	5	student cells with electrodes (10)	R	7.90	
	5	0-3 vdc voltmeters	R		Triple range vm better @$28.75
	1	100 g Potassium dichromate	R	2.95	Get from chem lab
	1	300 cc conc H_2SO_4	R		See A11.1
E18.2	5	Circuit boards see notes (construction sheets)			
		5 pcs perf bd 18"x12"	R		Obtain locally
	5	3 range ammeters	R	28.75	
	5	3 rg VM, power supplies 3 VDC			See E18.1 & E2.1A
	5	rheostats		4.65	See E13.3
	5 ea	Resistors 6,3,2 ohm	R		or other combination
	5	SPST switches			See E1.1
	1	spool annunciator wire			obtain locally
	20	test leads w alligator clips (clips only)		3.36	per dz

E&A	QUAN	DESCRIPTION	PRI CH	COST	NOTES
E18.2-4	1	Pk nuts & bolts	R		Obtain locally
	35	terminals	R		" "
E19.1	5	2' lengths of thick copper wire	R		" "
	20	small compasses (dz)	R	3.60	
	5	power supplies (or 6V batteries)	R		Obtain batteries locally
	5	rheostats & ring stands			See E13.3 & E3.1
	5	wire helixes	R		"Roll your own"
E19.2	5	current balances	R	31.55	Cheaper model avbl *1
E19.3	5	induction coils(prim & sec) *2	R	22.29	"Roll your own"
	5	bar magnets	R	3.21	
	5	galvanometers(use 3 rg ammeters)	R		See E18.2)
A19.3	1	Electric fields app. (for overhead)	N		

EXTRA NOTES: 1&2 Instead of purchasing both coils get the air core solenoid @ 14.57 and wind your own primary coil. The air cor solenoid is then used with a cheaper current balance @ 3.50. Extra materials required with this balance are a rheostat, 6v-5amp source, ammeter and wires all materials already listed.

MODULE SIX

THE NEW PHYSICS*

* Not a core module

E&A	QUAN	DESCRIPTION	PRI CH	COST	NOTES
E21.1	1	6 vdc 1" spark induction coil	M	37.80	
	1	discharge tube (canal ray)	M	36.20	Dis tube Fisher @ 6.78
	1	Crookes tube	M	43.10	
	1	Fluorescent effects tube	N	43.05	
	1	Maltese Cross tube	M		
	1	X-Ray tube (inoperative)	N		Get from local hospital
	1	large horshoe magnet	R	4.40	
E21.2A	5	Radiation sources	R		1 comes with each cloud chamber
	5	Good quality leaf electroscopes			See A17.1
E21.2B	5	Cloud chambers			See E1.1
E21.2C	1	Geiger tube (for use with decade counter)		45.00	See E3.2B
	1	Pk radiation absorbers	R		Obtain locally
E21.3					See 21.2C
21.4A	1	Random events app.	R	39.90	Cheaper ones avbl
21.4B		Cloud chambers & acc.			See E1.1
21.4C		Geiger counter & acc			See E21.2C
21.5A	5	sets (60) 6 faced dice	R		
21.5B	1	Radioisotope minigenerator	R	40.00	
	1	Geiger counter & acc			See E21.2C
		Hydrochloric acid			Get from chem lab
A21.1	1	Hand held tesla coil	N	23.15	
	1	Crookes tube			See E21.1
		3000 ASA polaroid land film			See A 15.4
A21.2		No equipment required			
A21.3	1	Vacuum cleaner, 1 geiger counter			See E2.1B & E21.2C
A21.4	1	Pk gas lantern mantels	N		Obtain locally
	1	Pk filter paper			Chem lab
	1	Pk Ion exchange resin beads	N		
E22.1	1	Spectroscope (good quality)	R	92.00	
		Spectrum tubes & power supply			See E15.1

E&A	QUAN	DESCRIPTION	PRI CH	COST	NOTES
A22.2	1	Circular tray 18" diam	R		Obtain locally
	20	ring magnets (pk 16)	R	7.25	
	1	lb dyalite beads	R	2.75	
A22.3	1	Potential hill	N		
		marbles	N		Obtain locally
E23.1	1	Decay series set	R		See E21.4A

A CIRCUIT BOARD

1 PS Power supply - 3v DC

1 A triple range ammeter

1 V ~~triple range~~ voltmeter

1 R_v rheostat

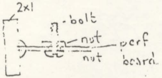
1 S switch

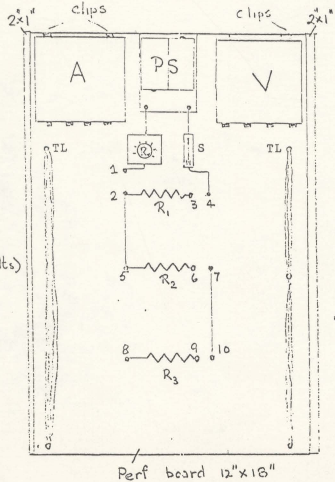
$R_{1,2,3}$ resistors

TL test leads

15 Terminals (nuts & bolts)

20 alligator clips.





$R_1 = 40\Omega$ ½ watt

$R_2 = 60\Omega$ ½ "

$R_3 = 120\Omega$ ½ "

A = 0-20 ma
0-200 ma
0-2 a

V = 0-3 v

R_v = min ½ watt
0-60Ω.

Note PS, A, V, S & R_v should be removable for other applications

Connections can be made between 3&4 6&7 & 9&10 by small spring clips

DESCRIPTION	@
Twin D cell holders	0.79
Resistors 5 ea. as listed	0.29 for 2 (approx values only)
Alligator clips	1.79 for 10

QUAN	DESCRIPTION	@	NOTES
5	Cloud chambers	3.25	Require a CO_2 extinguisher
6	liters of semi- or fully transparent viscous liquid		Locally avbl- antifreeze or glycol
5	electric stopclocks	24.60	These are cheaper than most stopwatches
1	Five decade counter timer*	160.00	Many uses
1	Battery driven toy bulldozer	10.00	Locally available
1	Celestial globe	66.95	
5	Energy conversion apparatus	3.87	
1	Amplifier - Power supply *	95.00	
1	Geiger tube*	45.00	
2	Function Generators*	50.00	One will suffice
1	High VDC Power supply*	20.00	
1	Random events app (dice set)		
1	Radioisotope minigenerator	40.00	

* Make sure when ordering electronic equipment that the componants are compatible. It is best to select one supplier and stick with them for all such componants.

Total cost of these materials is $645.55 - all prices quoted are from Boreal Labs Ltd 75-76 catalogue. The implimentation period for the course is two years so this amounts to $323 per year. Not an exhorbitant figure.

Some schools will require more equipment than this and some will have some of it. The $645 figure is an average amount which should be provided by the gov't.

See "A Complete list of Laboratory and Activity Materials for Physics: A Human Endeavour" by bill walsh for complete list.

APPENDIX I

Media Checklist

INSTRUCTIONAL MATERIALS

for

PHYSICS: A HUMAN ENDEAVOUR

MODULE 1

MOTION

FILMLOOPS

1. From Project Physics

	Check	Rating
Acceleration Due to Gravity 1		2
2		2
Vector Addition; Velocity of a Boat		1
A Matter of Relative Motion		1
Galilean Relativity 1		1
2		1
3		1
Analysis of a Hurdle Race 1		3
2		3

OVERHEAD TRANSPARENCIES

1. From Project Physics

	CHECK	Rating
Using Stroboscopic Photographs		3
Stroboscopic Measurements		2
Graphs of Various Motions		2
Instantaneous Rate of Change		2
Instantaneous Speed		2
Derivation of $d = V_i t + \frac{1}{2} at^2$		1
Tractor Log Problem		3
Projectile Motion		3
Path of a Projectile		3

2. Locally Produced

Uniform Motion 1 Plotting d-t graph
2 Slope of d-t graph
3 Area and distance
4 Area and distance
Uniform Acceleration 1 v-t graph
2 Area & distance
3 Area & distance
4 d-t graph
5 tangents
6 a-t graph
7 Summary
Deriving Motion Equations
Galileo's Incline 1
2
Motion on a Line 1 a-t graph analysis
2 v-t graph analysis
Displacement Vectors
Velocity Vectors 1
2
Force Vectors 1
2
Newton's Laws
Apparent Weight

PROGRAMMED INSTRUCTION MATERIALS

	Check	Rating
1. From <u>Project Physics</u>		
<u>Booklets</u>		
Equations 1 Solving Simple Equations		1
2 Application of Simple Equations		1
3 Combining two Relationships		1
Vectors 1 The Concept of Vectors		
2 Adding Vectors		
3 Componants of Vectors		
2. Merlan		
<u>Tape - Text</u>		
Graphical Analysis Series		
Program 1		
2		
3		
4		1

FILMS

			Check	Rating
1. From <u>Project Physics</u>				
People and Particles				2
Synchrotron				3
The World of Enrico Fermi				3

2. From The Department of Education
Division of Instruction Film Catalogue (1977)

Action and Reaction	15 min.	color		1
Albert Einstein	16 min.	color		1
Aristotle and the Scientific Method	14 min.	color		2
Cosmic Zoom	8 min.	color		1
Deflecting Forces	30 min.	b w		3
Galileo	14 min.	b w		
Galileo's Law of Falling Bodies	5 min.	b w		
Laws of Motion	13 min.	color		
Preface to Physics	15 min.	color		
Velocity and Acceleration	14 min.	b w		

APPENDIX J

Knowledge Inventory

KNOWLEDGE INVENTORY

PHYSICS: A HUMAN ENDEAVOUR

NAME__________________ CLASS__________ DATE__________

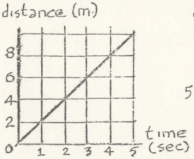
Note to students: The purpose of this quiz is to determine how familiar you already are with the materials which we will be studying during the first term. It is not expected that you will get a high mark on this paper and the results will not count in your evaluation.

SELECT THE LETTER OF THE BEST RESPONSE WHICH COMPLETES THE MEANING OF THE STATEMENT AND PLACE IT IN THE BLANK ON THE RIGHT.

1. A car travelling at 16 meters per second will travel (?) meters in 8 seconds. (____)
   (a) 2 (b) 0.5 (c) 24 (d) 128

2. A car increases its speed at a rate of 6 meters per second every second. If it starts from rest, its speed after 3 seconds will be (?) meters per second (____)
   (a) 2 (b) 0.5 (c) 9 (d) 18

3. (?) is known as "The Father of Modern Science". (____)
   (a) Newton (b) Galileo (c) Aristotle (d) Einstein

4. 

The slope of the graph on the left is (?) m/s. (____)
(a) 2 (b) 50 (c) 10 (d) 5

5. In the graph on the left, the object travelled a distance of (?) meters in four seconds. (____)
   (a) 32 (b) 2 (c) 0.5 (d) 8

6. An object accelerates from rest at 10 meters/second^2 for four seconds. The distance the object will travel in this time is (?) meters. (____)
   (a) 2.5 (b) 40 (c) 80 (d) 0.4

7. A brick and a coin are dropped from the same height at the same time. Then, (?). (____)
   (a) they will hit the ground at exactly the same time
   (b) They each fall at a constant speed which depends on their weight.
   (c) They fall at different rates which depend on air friction
   (d) They fall at the same rate

8. An acceleration of 9.8 m/s^2 for a body in free fall means (?). (___)
(a) the body falls 9.8 meters each second
(b) the body falls 9.8 meters further each second
(c) the body falls 9.8 m/s faster each second
(d) the body's velocity increases by 9.8 m/s for every meter it falls

9. Which of the following would fall faster if dropped from the same height in a vacuum? (?). (___)
(a) a brick (b) a feather (c) they would both fall at the same rate (d) they would not fall because they will have no weight in a vacuum

10. A quantity which requires the statement of both size and direction is called a(n) (?). (___)
(a) vector (b) scaler (c) ray (d) segment

11. The property of a body to retain its state of motion unless acted upon by an external force is (?). (___)
(a) momentum (b) inertia (c) density (d) energy

12. The basic unit of weight in the MKS system of metric measurement is the (?). (___)
(a) newton (b) kilogram (c) pound (d) megaton

13. A phenomenum is said to be explained in science when (?). (___)
(a) it can be made to happen at will
(b) it is consistent with a generally accepted law
(c) it can be defined
(d) it can be measured

14. Your mass is closest to (?) kilograms. (___)
(a) 0.5 (b) 5 (c) 50 (d) 500

15. When no net force acts on a body its (?) is always zero. (___)
(a) speed (b) velocity (c) acceleration (d) weight

16. A force of 100 newtons is required to accelerate an object at 20 m/s^2. The mass of the object is (?) Kg. (___)
(a) 50 (b) 5 (c) 0.2 (d) 2000

17. Joe and Moe are standing on skates in the middle of a frictionless ice rink and are holding on to opposite ends of a rope stretched between them. If Joe pulls on the rope (?). (___)
(a) Joe will move towards Moe
(b) Moe will move towards Joe
(c) Moe and Joe will move towards each other
(d) Neither Joe nor Moe will move

18. An object is fired vertically upward from earth at 50 m/s. If the acceleration of gravity is 10 m/s^2, the object will be in the air for (?) seconds before returning to the earth's surface. (____)
(a) 5 (b) 10 (c) 200 (d) 500

19. A satellite in orbit around the earth (?). (____)
(a) has no acceleration (b) has no weight
(c) has no net force acting upon it
(d) pulls the earth toward it with a force equal to that keeping it in orbit

20. The acceleration of gravity is 10 m/s^2. A man in an elevator is accelerating upward at 2 m/s^2 and drops a ball. The man will measure the ball's downward acceleration toward the floor as (?) m/s^2. (____)
(a) 20 (b) 5 (c) 8 (d) 12

KNOWLEDGE INVENTORY POSTTEST

NAME______________________CLASS______________SCHOOL___________

NOTE TO STUDENTS: The purpose of this test is to determine how well you have come to understand the material covered in the first module of the Physics: A Human Endeavour Course. The results of this test will not be used for grading purposes and will have no effect on your final marks.

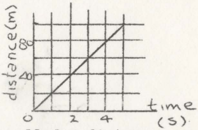
PLACE THE LETTER OF THE BEST RESPONSE IN THE BLANK ON THE RIGHT

1. A car travelling at 14 m/s will travel (_?_) m in 7 sec. (______)
   (a) 2 (b) 0.5 (c) 21 (d) 9.8

2. A car increases its speed at a rate of 8 m/s every second. If it starts from rest, its speed after 4 seconds will be (_?_) m/s. (______)
   (a) 2 (b) 0.5 (c) 12 (d) 32

3. (_?_) is known as the "Father of Modern Science". (______)
   (a) Newton (b) Aristotle (c) Galileo (d) Einstein

4. The slope of the graph below is (_?_) m/s. (______)
   (a) 5000 (b) 20 (c) 5 (d) 100



5. In the graph above the object travelled a distance of (_?_) m in 4 seconds.
   (a) 16 (b) 8 (c) 20 (d) 80

6. An object accelerating from rest at 20 m/s^2 for four seconds will cover a distance of (_?_) meters. (______)
   (a) 160 (b) 80 (c) 5 (d) 320

7. A dime and a tennis ball dropped from the same height at the same time (_?_) (______)
   (a) will hit the ground at exactly the same time
   (b) will fall at a constant speed which depends on their weight
   (c) will fall at different rates depending on air friction
   (d) will both fall at the same constant velocity

8. An acceleration of 9.8 m/s^2 for an object starting from rest means (_?_). (______)
   (a) it moves 9.8 meters each second
   (b) it moves 9.8 m/s faster after each meter travelled
   (c) it moves 9.8 m/s faster each second
   (d) it moves 9.8 meters further each second

9. A brick and a feather are dropped in a vacuum (_?_) (______)
   (a) the brick would fall faster
   (b) the feather would fall faster
   (c) they would fall at the same rate
   (d) they would not fall because gravity does not act in a vacuum.

10. A (_?_) requires the statement of both magnitude and direction. (______)
   (a) vector (b) scaler (c) ray (d) segment

11. (_?_) is a measure of the inertia of a body. (______)
   (a) momentum (b) density (c) mass (d) volume

12. The basic unit of force in the MKS system of measurement is the (_?_) (______)
   (a) kilogram (b) pound (c) newton (d) dyne

13. A phenomenum is said to be explained in science when (_?_), (______)
   (a) it can be defined (b) it can be measured
   (c) it is consistent with a generally accepted law
   (d) it can be made to happen at will

14. Your height is closest to (_?_) meters. (______)
   (a) 0.2 (b) 2 (c) 20 (d) 200

15. When no net force acts on a body its (_?_) is zero. (______)
   (a) speed (b) velocity (c) acceleration (d) weight

16. If an unbalanced force of 200 N is required to accelerate a mass at 20 m/s^2, then the mass is (_?_) kg. (______)
   (a) 10 (b) 0.1 (c) 4000 (d) 1.0

17. Joe and Moe are standing on skates at the center of a frictionless ice rink and are holding on to opposite ends of a rope stretched between them. If Joe pulls on the rope, (_?_) (______)
   (a) Joe will move toward Moe
   (b) Moe will move toward Joe
   (c) Moe and Joe will move toward each other
   (d) Neither Joe nor Moe will move

18. An object fired vertically upward at 80 m/s will if fired from the ground, remain in the air for (_?_) seconds. ($g = 10\ m/s^2$) (______)
   (a) 8 (b) 16 (d) 32 (e) 64

19. A satellite in orbit around the earth (?) (______)
(a) has no acceleration (b) has no weight
(c) has no net force acting on it (d) none of these

20. A man in an elevator accelerating upward at 5 m/s^2 drops a ball. The man will measure the ball's acceleration towards the floor as (?) m/s^2 (______)
(a) 2 (b) 15 (c) 5 (d) 50

APPENDIX K

Attitude Inventory

WHAT IS YOUR ATTITUDE TOWARD PHYSICS?

This questionnaire contains some statements about science and physics in particular. After you have carefully read a statement decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. Then, find the number of that statement on the answer sheet and blacken the space in column:

1 if you agree strongly

2 if you agree mildly

3 if you disagree mildly

and 4 if you disagree strongly

Please respond to every question and blacken only one space for each.

EXAMPLE:

0. I would like to have a lot of money

0. ■ — — —

This means the respondant agrees strongly with the statement.

1. Working in physics would be an interesting way to make a living.

2. Scientific ideas may be said to undergo a process of evolution in their development.

3. Ideas are one of the more important products of physics.

4. Physicists have to study too much and I would not want to be one for this reason.

5. The products of scientific work are mainly useful to scientists, they are not useful to the average person.

6. I expect physics to be one of the most difficult courses I take this year.

7. If one scientist says a theory is true then all other scientists will agree with him.

8. An important purpose of science is to help man to live longer.

9. I expect to enjoy the remainder of the physics course this year.

10. There are some things which are known by science to be absolutely true.

11. I would enjoy working with other physicists in an effort to solve scientific problems.

12. Physicists do not have enough time for their families and fun.

13. Science is devoted to describing how things happen.

14. I do not want to be a physicist because it takes too much education.

15. I expect physics to be one of the easier courses which I am taking this year.

16. Every citizen should understand science because we are living in a scientific age.

17. The value of physics lies in its theoretical products.

18. Scientists believe that nothing is known to be true with absolute certainty.

19. The main purpose of physics is to describe nature.

20. Science is best learned through careful observation of nature.

21. Scientific laws cannot be changed.

22. It is not necessary for most people to understand about science.

23. Today's electrical appliances are an example of the really valuable products of physics.

24. I enjoy studying physics and would enjoy using it in some field of science or technology.

25. Looking at natural phenomena is a most important source of scientific information.

26. I expect my marks in physics to be lower than those in most of the other courses I am taking this year.

27. Most students would be able to understand the physics course.

28. Most people are able to understand the work of physics.

29. I believe that physics is no more difficult than most of my other courses.

30. I expect my knowledge of physics to be useful to me in my later life.

31. Physics is interesting.

32. Physics should only be taken by those students interested in a career in science or technology.

33. I expect that I will not use what I learn in physics very much after I leave school.

34. Physics should only be attempted by above average students.

35. I would like to work in a scientific field.

36. People need to understand the nature of science because it such a great effect on their lives.

37. Scientists are always interested in improving their explanations of natural events.

38. Science is learned best by reading books.

39. I expect that I will have difficulty in understanding physics.

40. I expect that physics will be one of my highest marks.

41. The day to day search for scientific knowledge would become boring to me.

42. Physics may be described as being mainly an idea generating activity.

43. A major purpose of science is to help man live more comfortably.

44. The value of physics lies in its usefulness in solving practical problems.

45. Scientists should not criticize other's work.

46. A major purpose of physics is to produce new energy sources.

47. Physics is dry and dull.

48. I would like to work in a scientific field.

49. All one has to do to learn to work in a scientific manner is to study the writings of great scientists.

50. Most people are not able to understand the work of physics.

ANSWER SHEET

COLUMN	1	2	3	4	COLUMN	1	2	3	4
1.					18.				
2.					19.				
3.					20.				
4.					21.				
5.					22.				
6.					23.				
7.					24.				
8.					25.				
9.					26.				
10.					27.				
11.					28.				
12.					29.				
13.					30.				
14.					31.				
15.					32.				
16.					33.				
17.					34.				

(continued next page)

NAME______________________________

35. ___ ___ ___ ___

36. ___ ___ ___ ___

37. ___ ___ ___ ___

38. ___ ___ ___ ___

39. ___ ___ ___ ___

40. ___ ___ ___ ___

41. ___ ___ ___ ___

42. ___ ___ ___ ___

43. ___ ___ ___ ___

44. ___ ___ ___ ___

45. ___ ___ ___ ___

46. ___ ___ ___ ___

47. ___ ___ ___ ___

48. ___ ___ ___ ___

49. ___ ___ ___ ___

50. ___ ___ ___ ___

APPENDIX L

Teacher Questionnaire

TEACHER QUESTIONNAIRE FOR

THE LAP PROGRAM

Name of Teacher ______________________________________

School ______________________ Location ________________

Date __________ Grade Level ________________

A. Teacher Qualifications

Teaching grade ______ Degrees held ________________

Number of physics courses ________

mathematics courses ______

Years experience ________

B. Context Analysis

Type of school ____________________________________

Number of students attending this school ____________

Number of classrooms ________ Grade levels __________

Would you consider your laboratory facilities: (check one)

(a) above average ____ (b) average____ (c) below average______

Would you consider your laboratory equipment: (check one)

(a) above average ____(b) average____(c) below average______

Would you consider the media resources: (check one)

(a) adequate ____ (b) less than adequate _____

Describe any special features regarding facilities and materials below.

C. Learner Analysis

Compare the students in the LAP group and non-LAP groups in terms of the following:

(a) I.Q. Range

(b) Acedemic Interest

(c) Acedemic Capabilities

(d) Reading Level

(e) Mathematics Level

(f) Age Level

State the number of students in each group: LAP ______

non-LAP ______

D. LAP Materials

(a) Rationale

Did you find the rationales; good ____ fair____ poor_____?

Did you supplement any of the rationales with other motivational materials? Yes ____ No _____

If so, specify.

To what extent do you feel students read the rationales?

(b) Objectives

Rate the objectives given for each LAP from 1 (good) to 5 (poor) on the following criteria:

	1-1-1	1-2-1	1-2-2	1-3-1	1-4-1	1-5-1
completeness	___	___	___	___	___	___
range of levels	___	___	___	___	___	___
clarity of meaning	___	___	___	___	___	___
necessity	___	___	___	___	___	___
relevence	___	___	___	___	___	___

Specify any changes you made in the objectives:

Specify any changes you would make to improve objectives:

(c) Pretest

Are extra pretests required? _____

Specify where and for what reason:

(d) Activities

Rate activities as to how well they met the following objectives:

	Good	Fair	Poor
(i) Provide for a variety of learning experiences	___	___	___
(ii) Provide for a variety of student types	___	___	___
(iii) Provide sufficient experiences to meet stated objectives . . .	___	___	___
(iv) Provide for remediation . . .	___	___	___
(v) Provide for the advanced student	___	___	___

(vi) Provide adequate student directions . . . . ___ ___ ___

Describe and explain any changes you made in the suggested activities. (Use back of sheet if necessary)

Describe any changes requested by students in suggested activities.

Where materials readily available for suggested activities?
Comments:

(e) Self-tests

Did items on the self-tests relate to stated objectives?
Comments:

Were remediation instructions on self-test answer sheets adequate?
Comments:

(f) Quizzes

Did items on quizzes relate to stated objectives and the student self-tests?
Comments:

Were opportunities provided for students to do remedial work and makeup tests if they failed to gain mastery as shown by the quizzes?
Comments:

(g) Optional activities (See activities)

E. Methods

How many scheduled physics periods did you have per week? ___

Specify the length of time spent on each LAP in the space below:

LAP number	1-1-1	1-2-1	1-2-2	1-3-1	1-4-1	1-5-1
weeks	____	____	____	____	____	____

Were all students kept on this schedule?
Comments:

At what points were student-teacher interactions present?

Estimate percent of time spent by students in;

Activity	LAP	non-LAP
(i) Small group discussion	___	___
(ii) Small group work	___	___
(iii) Experiments	___	___
(iv) Lectures	___	___
(v) Independant study.	___	___

Comments:

F. General Comparisons

Indicate whether the following items occurred more (1), the same (2), or fewer (3) times in the LAP group

(a) Student initiated student-teacher interactions ____

(b) Teacher initiated student-teacher interactions ____

(c) Student undertaking of optional activities ____

(d) Use of media (electronic) ____

(e) Use of printed materials ____

(f) Unexpected occurences ____

Did you find any unintended learning outcomes as a result of the use of these materials? ____ Specify.

Were there any affective consequences noticable? _____ Specify.

What sections of the materials did you find most effective?

What sections did you find least effective?

Will you use these or other similar materials next year?

State any general comments you have regarding the materials and their use.

Comment on the practicality and usefulness of these materials in classroom management.

APPENDIX M

Student Questionnaire

STUDENT QUESTIONNAIRE

ON THE USE OF LAPs

School ______________________________

Date ____________ Grade ______________

Place the letter of the response which best represents your feelings about the use of LAPs in the physics course.

1. How many of the rationales did you read?
   (a) 1 (b) 2 (c) 3 (d) 4 (e) all five (_____)

2. Did you find them ___
   (a) useful (b) not very useful (c) useless (_____)

3. Did your teacher use other methods to explain why a particular chapter was important?
   (a) yes (b) no (_____)

4. Did you find the objectives in the LAP ___
   (a) useful (b) not very useful (c) useless (_____)

5. Did your teacher state objectives other than those in the LAP? (a) yes (b) no (_____)

6. Did you understand the objectives ____
   (a) before you studied the section
   (b) after you studied the section
   (c) never understood most of them
   (d) never understood some of them
   (e) never read them (_____)

7. Were you given sufficient time to do the activities?
   (a) yes (b) no (c) sometimes (_____)

8. Did you read through the chapters on your own ___
   (a) at home (b) in school (c) only read them sometimes (d) never read them (_____)

9. About what fraction of your time was spent in small group activities?
   (a) 1/10 (b) 1/3 (c) $\frac{1}{2}$ (d) more than $\frac{1}{2}$ (_____)

10. Did your teacher circulate among groups asking questions and explaining things ___
    (a) seldom (b) half the time (c) most of the time (_____)

11. Did you feel free to ask your teacher for help ___
    (a) whenever you needed it
    (b) sometimes
    (c) never because you didn't need it
    (d) never because you didn't want to disturb him (_____)

12. Did you find the small group work __
    (a) good (b) alright (c) no good (_____)

13. In the small groups, did you spend most of your time (a) fooling around (b) having things explained to you (c) explaining things to others (_____)

14. Which way do you like to learn best? (a) lectures (b) small groups (c) studying by yourself (_____)

15. Did you find that the self-tests ____. (a) helped a lot (b) helped somewhat (c) didn't help (_____)

16. Where the questions on the self-test ____.
(a) similar to those on the quizzes
(b) not similar to those on the quizzes (_____)

17. Did you check your answers on the self-test against those on the answer key? (a) yes (b) No (_____)

18. Did you find the suggestions in the answer key to the self-test ___
(a) useful (b) not useful (_____)

19. Were the questions on the quizzes ____
(a) about what you were lead to expect
(b) almost exactly what you were lead to expect
(c) not like you expected at all (_____)

20. Do you think that makeup quizzes ____
(a) are a good idea
(b) are a poor idea
(c) made you take it easy while studying for the quizzes because you could always fall back on them(_____)

21. Do you think the LAPs ____?
(a) give you a better chance to do well
(b) give you about the same chance as other methods
(c) give you less of a chance (_____)

22. Do you think that the LAPs ___?
(a) made you work harder
(b) made you work about the same as you would have without them
(c) made you work less than other teaching methods (_____)

23. Do you think that LAPs ___?
(a) are a good idea
(b) are about the same as other methods
(c) are not as good as other methods (_____)

24. Did you enjoy the course so far?
(a) yes (b) no

25. You will be going back to regular methods of instruction for the rest of the course. Are you (a) glad about that (b) sorry about that (_____)

26. Use this sheet to make any comments on your answers that you wish to make. Also try to suggest any ways to improve the LAPs.