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ABSTRACT

As a supplement to the principal reports, the underlying management system of the U. S. Naval Academy Self-Paced Physics Course is presented in this documentation report. The management system is discussed on three "levels" which are intrinsic in the programmed-instruction format, focused on remedial activities, and related to the handling of student performance data. Detailed information is given in connection with the recommended course implementation procedures, nature and form of tests, methods of scoring and recording scores, kinds of feedback provided by students, methods of presenting feedback, record-keeping procedures and forms, and computer-managed operations. Also described are the methods of utilizing data generated during the course to evaluate and improve the course material and presentation strategies. Besides a flow chart reflecting the responsibilities of students, clerks, instructors, and managers, a total of 25 exhibits and illustrations are provided. (Related documents are SE 016 065 - SE 016 088 and ED 062 123 - ED 062 125.) (CC)

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DOCUMENTATION REPORT

UNITED STATES NAVAL ACADEMY

Self-Paced

PHYSICS

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5.4(a) MANAGEMENT SYSTEM REPORT

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DOCUMENTATION REPORT 5.4(a)

MANAGEMENT SYSTEM REPORT

NEW YORK INSTITUTE OF TECHNOLOGY

SPRING 1971

MANAGEMENT SYSTEM REPORT

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MANAGEMENT SYSTEM REPORT

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Study Guide

Progress Check

Student Diagnostic Answer Sheet

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Diagnostic Report Forms

1. INTRODUCTION

MANAGEMENT SYSTEM REPORT

1. INTRODUCTION

Background

This Report is the product of an extensive educational research and development effort that was conducted in conjunction with the U.S. Naval Academy and the N.Y.I.T. Learning, Management & Resources Center. Documented in this manual are procedures which are based on the educational philosophy and management techniques developed during an O.E. sponsored, three-year experiment. We do not purport to have created the "perfect" management system, but rather a system which contains the foundation for practical implementation and the ability to evolve when dynamic educational needs become apparent.

The Management System operates on three "levels." The course, in essence, is made up of sophisticated, multimedia, multi-resources, independent study materials presented in a branching programmed-instruction format, with a maximum of response demand frequency. The student's progress through a variety of learning experiences, ranging from tests and conventional lectures to single concept audiovisual materials and tutorial sessions, is guided by his own responses and is student self-managed to a high degree.

The first level of management is, therefore, instrinsic in the programmed-instruction format.

The second level of management derives from instructional activity focused upon tutorial remediation as indicated necessary by immediate analysis of student performance on the study guide response

sheets and progress (criterion-referenced) checks. This remediation may be individual, or grouped by student section, and may be based, in part, upon analysis of individual student performance alone, or as related to parallel performance of the rest of the sections or to the class as a whole. The tools for this management are the students' responses and the item analysis performed by the clerical data management support groups.

The third level is provided by the output of the computer or Data Management Group which utilizes the performance data from the progress checks and quarterly diagnostic exams to provide a more in-depth prescription for independent and group remediation.

The input of all student responses into the computer also provides the basis for the revision guidelines for use in optimizing the course materials.

One of the many factors determined during the experiment was that, using the system's approach, the data handling capability of the computer in conjunction with the exercise of the instructor's managerial judgment represented the best of two distinct management methods.

The procedures set forth in this manual reflect the most current concepts in course management deriving from the experiences of this contract.

Purpose

The procedures for implementation of the management system are described in two sub-manuals:

1) The Course & Data Management Manual, and

2) The Performance Data Analysis for Course Revision & Optimization.

The Course & Data Management Manual describes to the course manager: a) requirements for planning and preparation needed prior to course implementation; and b) procedures, decisions and record keeping required while the course is in progress.

The Performance Data Analysis for Course Revision & Optimization contains descriptions for utilizing the data generated during the course in order to evaluate and improve the course material, material presentation and strategies, and the management system itself.

Instruments

In order to accomplish the several levels of management, a large number of recording methodologies, reporting devices, test forms and instructions to the students, data manager, instructors and course managers have been created. Examples of these instructions have been incorporated herein, directly or as exhibits.

Associated Documents

The following documents are a necessary part of understanding and implementing the full computer managed portion of the system:

Course & Data Management Manual

User's Manual: A350

Operator's Guide: A380

Program Logic Manual: A370

Systems Manual: A360

Performance Data Analysis for Course Revision & Optimization

Systems Descroption

User's Description

Supplement

Programs

Additionally, many pertinent technical reports have been submitted during the course of, and as final reports to, the multimedia physics development program. These reports contain the rationales and experimental data analyses upon which the management system has been built. In these technical reports will be found the justification for all the elements of the management system.

2. COURSE AND DATA MANAGEMENT MANUAL

2. COURSE AND DATA MANAGEMENT MANUAL

2.1 Learning Resources [illegible] Managed

Several purpose[illegible] the program's development and operation. The Academy is provided with a cost-effective physics course designed with the most modern educational technology. The experience garnered in the construction of the program is incorporated into a course development model to serve as a prototype for construction of similar programs in other hard science courses. Extensive record keeping capabilities of the program allow it to serve as a vehicle for educational research.

The course is individualized, self-paced, and self-healing. By offering media options and optional routes through the learning materials, each student's learning experience is individualized. Likewise, within broad time constraints, the student can progress through these materials at his own pace.

The self-healing aspect of the program pertains to learning materials and processes. These are improved by an iterative process of successive tryouts and revisions. In this way, the program undergoes an empirical optimization procedure.

Most standard topics in introductory classical physics are included in the two-semester course: mechanics, wave phenomena, electricity, magnetism, and optics. One unusual feature is the omission of heat and thermodynamics in favor of more intensive developments in mechanics and optics to suit the Academy's particular needs. The subject matter is loosely defined as university physics with calculus at the level of Halliday and Resnick.

Optimization of the program must be attained empirically, since no satisfactory predictive theory of educational psychology is known. This situation is well suited to a systems approach when the output of the system can be fed back to modify the system input.

This approach requires that the course objectives are clearly defined and measurable so that the output of the system is quantitative. Consequently, over a thousand measurable behavioral objectives (MBOs) were developed to completely specify the performance which the program should elicit. MBOs fall into two categories: terminal objectives (TOs) which describe the desired final student behavior, and the subordinate enabling objectives (EOs) which are steps toward the terminal behavior.

The TOs constitute a complete description of course content and are represented in the course by central core problems. When a student can answer a core problem correctly, he is said to have achieved that TO. In this way a student knows exactly what is expected of him as to content and level of proficiency.

When a student cannot answer a core problem after a single exposure, he can execute subordinate enabling problems which correspond to the EOs. At the end of an enabling sequence, the student is presented with another version of the core problem to check his achievement of the TO. All these problems are contained in the Problem and Solution Book volumes.

Videotape presentations are available for forty-nine topics. These tapes average about fifteen minutes apiece. Illustrated texts and talking books (taped voice-over illustrations in book form) are available with essentially the same information content as the videotapes.

(Computer-assisted instruction (CAI) was initially included as a parallel path for topics in mechanics, primarily to be compared with the other options for cost effectiveness, and was deleted as a learning option in the final revision.) Conventional physics texts are also included among the available learning materials.

Each student is provided with a Study Guide which directs him through the problem books and various media assignments. When the student completes a specified assignment (roughly approximated by a chapter in Halliday and Resnick), he schedules a Progress Check (test) on the material. This criterion check does not influence his grade but is used for management and remediation purposes. Grades are determined by quarterly tests and final examinations for each semester.

Minor remediation is accomplished by distributing a remedial sheet associated with each problem missed on the Progress Check. These sheets have a statement of the appropriate core problem together with references to pertinent auxiliary material. More serious remediation is provided by individual tutorial sessions with a professor.

The laboratories have as their objectives the measurement of fundamental physical quantities, including the processing and recording of this data with an error analysis. An innovative aspect of the data analysis is that a dialogue may be established between the student and the computer which would culminate in the student's achievement of the objective. This computer-dialogue lab format is not an essential element of the multimedia learning materials, and in the current implementation the Navy physics staff is using a conventional laboratory experience for the self-paced course.

2.1.1 Problem and Solution Book (P & S)

This is bound study material which contains the work of forty-five (45) segments for a semester. Each Problem and Solution Book contains:

a) A problem section in which the questions are presented in a sequential order;

b) A solution section in which the correct method of answering is presented;

c) Information Panels strategically placed throughout the problem section.

A description of the topics covered by the segments is as follows:

Measurement and Vectors
Vector Multiplication and Velocity
Motion in One and Two Dimensions
Newton's Laws of Motion
Linear Motion: Friction
Uniform Circular Motion
Work and Energy
Conservation of Energy
Motion of the Center of Mass
Linear Momentum
Impulse and Collisions in One Dimension
Collisions in Two Dimensions
Gravitation
Gravitational Potential Energy
Electric Charge and Coulomb's Law
The Electric Field
Electric Field Problems
Electric Dipoles and Electric Flux
Gauss's Law
Electric Potential
Electric Potential Energy
Capacitance
Energy Stored in Capacitors
Current and Resistance
Electrical Energy & Electromotive Force
Circuits & Kirchhoff's Rules
Ammeters & Voltmeters
Charge in a Magnetic Field
Current in a Magnetic Field
Magnetic Flux & the Earth's Magnetic Field
Ampere's Law
The Biot-Savart Law
Faraday's Law of Induction
Self Inductance
The RC Circuit
The LR Circuit

Twenty additional segments were prepared by the Naval Academy staff.

2.1.2 Remedial Sheets

The student receives a remedial sheet for each question he misses on the Progress Check (PC). The remedial sheet contains:

a) A restatement of the appropriate core problem;

b) Reading assignments, and

c) Related problems when appropriate.

The remedial sheet serves as a multi-purpose remediation element depending upon the student's achievement level in specifically identified problems on the Progress Check. For example:

Student Achievement on Progress Check is:	Student Use of Remedial
1) 80 — 100% correct	Retains for review purposes
2) 50 — 70% correct	Reviews remedial and schedules Progress Check retake only on appropriate core problems
3) 40% or less correct	Reviews remedial, schedules tutorial session and Progress Check retake.

It is necessary, therefore, that a sufficient number of copies be prepared in advance for each Progress Check item to be used. Several examples of remedials follow.

SEGMENT 1

MEASUREMENT AND VECTORS

Problem 6: Addition of Vectors

6. A plane travels 40 miles due north, then changes its course to a direction of 37°east of north and travels for 50 miles. Finally it travels for 30 miles due east. Its total displacement is:

A. 100 miles
B. 120 miles
C. 100 miles at 37° east of north
D. 120 miles at 37° east of north

Reading Assignment

Halliday and Resnick: Ch. 2, Sect. 1-3

Semat and Blumenthal: Vol. II, Ch. 2, Fr 11-18, 36-40

Related Problems

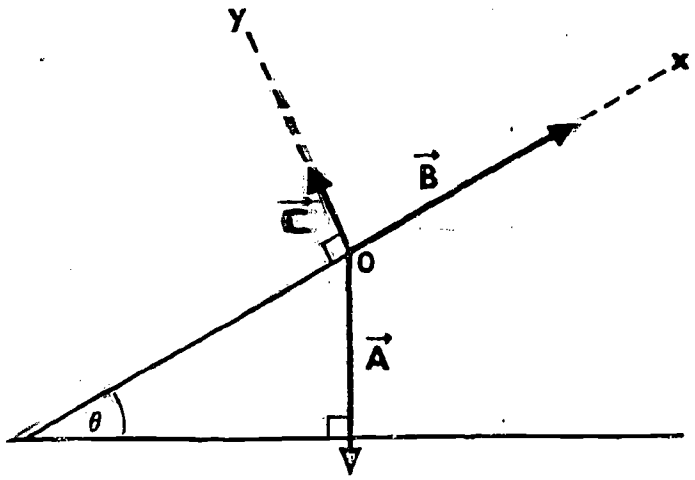
Schaum: Ch. 1, Nos. 1, 2, 14

SEGMENT 1

MEASUREMENT AND VECTORS

Problem 10: Resolution of Vectors

10.



Find the components R_x and R_y of the vector $\vec{R}$, where vector $\vec{R}$ is the resultant (sum) of the vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$. Use the coordinate system indicated.

A. $R_x = A \sin\theta$ $R_y = A \cos\theta$

B. $R_x = B \cos\theta$ $R_y = A \sin\theta$

C. $R_x = B - A \sin\theta$ $R_y = C - A \cos\theta$

D. $R_x = C - B \cos\theta$ $R_y = A - B \sin\theta$

Reading Assignment:

Halliday and Resnick: Ch. 2, Sect. 3

Sears and Blumenthal: Vol. I, Ch. 2, Pr 34-36

Related Problems:

Schaum: Ch. 1, Nos. 10, 11, 14

2.1.3 Audiovisuals

The Audiovisuals, representing the various media support materials prepared for this course, consist of one complete set of videotapes, talking books and illustrated books. All three of the media have basically the same information content and cover the topics shown on the list below.

The criteria used to determine when an Audiovisual would be prepared for a particular topic was as follows:

a) If the topic concerned the concept of motion, or

b) If the subject matter was rated difficult and the text was not sufficiently elaborate, or

c) If material for enrichment did not appear in the text at all.

All of the Audiovisuals were prepared in order to provide multimedia paths for the student to optimize and individualize his learning process.

The videotapes contain prerecorded illustrated lectures to be displayed on individual monitors. The average playing time is about fifteen minutes.

The talking book consists of a tape recorded lecture (on either open reel or cassette) and an accompanying booklet containing the illustrations for that lecture.

The illustrated book contains the same lecture material as the talking book but is presented without the audio medium.

A videotape, talking book and illustrated book were prepared for each of the following topics:

Sequence No.	Title
1	Projectile Motion
2	Newton's First Law
3	Newton's Second Law
4	Newton's Third Law
5	Atwood's Machine
6	Circular Motion
7	Work When Force Varies in Magnitude and Direction
8	Kinetic Energy
9	Potential Energy
10	Conservation of Energy
11	Movement of Center of Mass
12	Conservation of Momentum
13	Impulse and Momentum
14	Collisions
15	Gravitation
16	Angular Quantities Treated as Vectors
17	Moment of Inertia
18	Rolling Without Slipping
19	Angular Momentum
20	The Gyroscope
21	Simple Harmonic Motion
22	Energy in SHM
23	Pendulums
24	The Reference Circle
25	Traveling Waves
26	Wave Velocity
27	Combination of Waves
28	Standing Waves
29	Beats and the Doppler Effect
30	Reflection and Refraction
31	Huygens' Principle
32	Total Internal Reflection
33	Images by Reflection
34	Images by Thin Lenses
35	Calculation of E for an Infinite Uniformly Charged Wire
36	Deflection of Electrons in an Electric Field
37	Flux
38	Calculation of E Using Gauss's Law
39	Capacitors
40	The Capacitor in Action
41	Kirchhoff's Rules
42	Definition of a "B" Field
43	Force Between Parallel Current-Carrying Conductors
44	Ampere's Law Applied to a Long Straight Conductor
45	The Law of Biot-Savart
46	Faraday's Law of Induction

Sequence No.	Title
47	Motion of an Electron in Combined E and B Fields
48	LR Transients
49	RC Transients

2.1.4 Texts

The principal text which is issued to each student is Halliday & Resnick; Physics for Students of Engineering and Science. Supplementary reading assignments are to be found in other texts which are made available during the classroom period. These texts are:

Sears and Zemansky, University Physics

Albert Baez, The New College Physics--A Spiral Approach

Shortley and Williams, Elements of Physics

2.1.5 Instructor

One of the major differences between this course and a conventionally taught course is the role of the instructor. The instructor is available during class sessions but does not give a lecture. His primary function is to assist students with their problems on a one-to-one basis or to schedule additional assistance in a tutorial or extra-instruction session. This "individualized" instruction applied to identified weaknesses or needs constitutes one of the basic foundations upon which the course has been structured.

An average instructor/student ratio of 1:20 was scheduled but varied somewhat in practice because of student drop-outs.

Further description of the instructor's role is to be found in this report under Section 2.3.2.1, entitled "Notes to the Instructor of Self-Paced Physics."

Certain "demonstration" type lectures were prepared because of the appropriateness of the subject matter. For the first semester these demonstrations covered the following topics:

Linear Momentum

Angular Momentum

Wave Motion

Sound

Geometrical Optics

The second semester covered these topics:

Electrostatics

Electromagnetism

Physical Optics

Polarization

2.1.6 Laboratory Sessions

Two alternative self-paced laboratory approaches were developed in conjunction with the physics course.

The conventional approach involved twenty (20) experimental set-ups in the laboratory at any one time. Duration of the experiments was planned to range between 1-3 hours; however, the experiment need not be completed in one session. Ideally, no more than two students at a time are recommended to participate in an experiment. A complete description of the laboratory procedure and policy is in Section 2.3.2.4 of this report, including an identification of the twelve (12) experiments scheduled for the first semester. This conventional lab procedure was developed by the Naval Academy physics staff.

The laboratory program, in conjunction with the multimedia physics course developed by New York Institute of Technology, consists of fifteen (15) independent study, computer-supported experiments, covering the following topics:

1. Probability and Experimental Errors in Science
2. Permutation and Combination
3. The Direct Measurement of Length
4. Electric Fields
5. Current Balance
6. RC Transients
7. Projectile Motion
8. Graphical Analysis of Data and the Method of Least Squares
9. Collisions
10. Conversion of Linear Momentum
11. Potential
12. The Magnetic Circuit and Hysteresis
13. Measurement of Frequency Response
14. The Inclined Plane
15. Error Analysis

Plus Overview and Summary Report, Instructor's Guidelines and Answer Lists.

This program is described in detail in the separate submission entitled "The Multimedia Labs."

2.2 Management Devices and Controls

The management tools that were designed to operate with the course material while the course is in progress consist of the Study Guide, the Progress Check and the Quarterly Diagnostic. This section more fully describes these items and includes sample reports.

2.2.1 Study Guides, Progress Checks (including remedial progress checks) and Quarterly Diagnostics

Study Guide

This guide is used in conjunction with the Problem and Solution Book. Its purpose is to:

a) guide the student through the course segments;

b) provide the student with a mechanism for testing his understanding of the subject matter with immediate feedback;

c) indicate reading and audiovisual assignments, and,

d) provide paths for reinforcement and/or remediation.

An intrinsic element of the self-paced concept, embodied in the Study Guide, is the mechanism for the student to proceed through the course as fast as he is able to grasp a thorough understanding of the subject matter.

It is recommended that if a student schedules a tutorial, he bring with him his completed Study Guides as an additional aid for the instructor to determine the student's problem areas.

An example of a Study Guide page is included in this section but a full description of its use is to be found in the Student Manual, Section 2.3.2 of this report, Instructor/Student Orientation.

Progress Checks (including Remedial Progress Checks)

The Progress Check is a management device designed to aid the student as well as the instructor and course manager.

It indicates to the student to what degree he has achieved a mastery of the Terminal Objectives; it represents the first formal feedback to the instructor in order to evaluate individual student success with the course at an early stage so that he can take corrective action; and it forms the basis for the course manager to judge overall student progress in the course and ascertain problem areas.

When a student completes a certain number of segments he schedules a Progress Check with his instructor on the material covered. (A full description of the Progress Check procedure is covered in Section 2.4.2.1.2 of this report.)

For the initial half of the fall semester of 1970, Progress Checks were administered on groupings of segments as follows:

a) Segments 1, 2, 3, 4, 5

b) Segments 6, 7, 8, 9, 10

c) Segments 11, 12, 13, 14

The Progress Check is an "individualized" test in that it consists of ten questions randomly selected from a large bank of test items but is not used for the student's grade. (Refer to Preparation of Progress Checks below.)

The satisfactory completion of the Progress Check permits the student to continue with the next series of segments.

A student answering correctly 70% or less is given a remedial Progress Check on the particular core questions missed on his

first Progress Check; i.e., the remedial Progress Check contains variations of each item incorrectly answered. The remedial Progress Check is usually scheduled by the student after he has completed appropriate remediation.

If the student answers correctly on 40% or less on the Progress Checks, he schedules a tutorial session with his instructor prior to taking the remedial Progress Check.

Progress Check results are summarized by the Data Management Group and submitted to the course manager for review.

The first page of a sample Progress Check is submitted in this section.

Preparation of Progress Checks

The preparation of Progress Checks, while done manually, is designed to be compatible with a CMI system. That is, the questions were coded with unique numerical identification and were, for the most part, multiple-choice to facilitate computer verification of the manual grading.

The content of each question was determined by reference to the core questions in the Problem and Solution Book and to the Terminal Objectives which the core questions support.

Questions used were of the multiple-choice, true-false, or completion type.

Five variations of each question were produced, usually by rearranging numerical parameters within the text of the question rather than restating the question in completely different language. Although the Progress Checks were not used for midshipmen's grades, and one

Progress Check could have been given to all midshipmen, additional copies were required for midshipmen who scored low enough to require retakes.

The original questions were stored on cards, one card per question. The first Progress Check on each group of segments was limited to ten questions. Tests were prepared by putting several cards in a holder, masking off certain administrative information, and producing a ditto master on a commercial copier. The ditto master then was used to produce the number of copies required. Clerical personnel selected, from the appropriate group of questions and versions, the specific cards that made up a test. A pattern was set up to ensure use of all versions of all questions. Questions required for retakes depended on which questions the midshipman missed on this Progress Check. Requests for those questions were passed to the clerical personnel in the form of graded Progress Checks or listings of specific question numbers.

Course policy required 48 hours notice of intent to take Progress Checks, but this lead time appears generous for the production system employed.

Time alloted for midshipmen to complete a Progress Check varied with instructor, but was usually 50 minutes. Many midshipmen frequently took longer. Upon completion of the Progress Check, the instructor, having been provided an answer key, graded the Progress Check and either returned it to the midshipman for review or passed it to clerical personnel for statistical analysis and preparation of retake Progress Checks.

Quarterly Diagnostics

At four scheduled class periods during the semester, a Quarterly Diagnostic is administered. Each student section receives an

individua[illegible]t. These Diagnostics are used both for grading purposes and [illegible]st further the instructor in diagnosing any weak areas of each st[illegible] achievement. The items thoroughly cover the Terminal Objectives [illegible] during the period. Generally, these test items are created to [illegible] student's performance on general and specific concepts of physi[illegible] complex mathematical procedures are not emphasized.

The diagnostic problem types are categorized as follows:

Diagnostic Problem Types

- R Recognition of material that should have been memorized.
- U Conceptual understanding; single concepts isolated from problem applications.
- R Conceptual relationships; recognition and/or selection for use in problems but no actual solution required.

At present, all Diagnostic items are multiple-choice questions or problems--to facilitate grading. At the next class period, each student receives a personalized "Student T.O. Key Sheet" which indicates his score for the test. Also, the test items missed are circled, and he is directed to the particular locations within each segment he should review.

(A full description of the Diagnostic procedure is included in Section 2.4.2.1.3 of this report.)

The results of the Diagnostic form the basis for a complete evaluation of the student and the course effectiveness. Sample summary reports are included in the following section; a complete set of report f[illegible] to be found in Section 2.4.2.1.3.

STEP	
	1.1 Reading: HR 4-4/4-6; 6-3; 11-5 SZ 6-[illegible] AB 9-5; 9-6
	1.2 Information Panel, "The Vocabulary of Circular Motion"
1	T F (ans)
	1.3 Information Panel, "The Characteristics of Uniform Circular Motion"
	A B C D T F
	2.1 If your first choice was correct, advance to 7.1; if not, continue sequence.
3	T F (ans)
4	A B C D
5	A B C D
6	A B C D
7	A B C D T F
	7.1 Audiovisual, CIRCULAR MOTION
8	v_1 = (ans)
	T F v_2 = (ans)

P	STEP
	8.1 Information Panel, "Centripetal Force"
9	T F (ans)
	9.1 If correct, advance to P 14; if not, continue sequence.
10	A B C D
11	A B
12	(ans)
13	T F (ans)
14	T F (ans)
15	A B C D T F
16	T F (ans)
	16.1 Homework: HR Problem 4-20

Name _____ ID _____ Progress Check (1) Seg 1-5

Section _____ Date _____ Rerun No. _____ Made _____

Progress Check Score _____ out of 10 Digitex _____ Charted _____

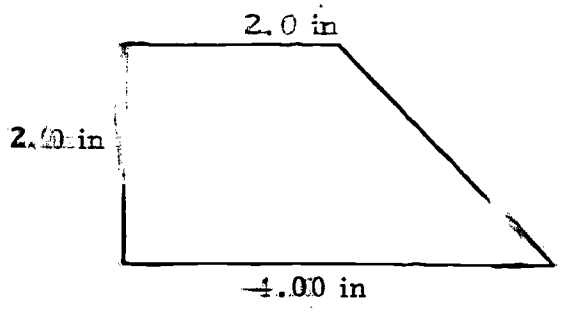
1-1.1 The dimensions of the figure shown were measured with different instruments. The area should be expressed in how many significant figures?

A. 1

B. 2

C. 4

D. 6



1-13.2

A car moving at a constant rate R covers a distance D during a time interval T. Its rate can be expressed in

A. mi-sec

B. sec per ft

C. mi per hr

D. hr/ft

2.2.2 Sample Management Reports

This section contains sample management reports which reflect actual data. A complete set of management report forms are included in Section 2.4.2.

The reports shown here are:

a) Progress Check Summary

b) Diagnostics

(1) All Sections--Score Distribution

(2) TO Summary Comparison--Percents

(3) TO Summary Comparison--Students

(4) Bar Chart Percentile Distributions

SAMPLE REPORT

(Page 1 of 2)

PROGRESS CHECK -- SUMMARY REPORT

NAVY PHYSICS - PS210 DATE 10 Nov 15

SEGMENT 1-2-3-4-5 NUMBER OF STUDENTS: 97

SEGMENT-CORE	CORRECT and INCORRECT Responses on Progress Checks: 0101 ✓ - X	0301 ✓ - X	0501 ✓ - X	0801 ✓ - X	1101 ✓ - X	1201 ✓ - X	ALL STUDENTS ✓ - X
1-1	4-1	5-3	11-	4-	6-	7-	37-5
1-6	10-2	2-2	-	5-5	9-4	10-4	36-17
1-10	2-3	8-1	15-2	6-1	5-	-	36-7
1-13	12-	5-	6-	15-	10-2	6-	54-2
SUB TOTAL	28-6	20-6	32-2	30-	30-6	23-5	163-31
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
2-1	6-2	5-	3-3	9-	9-2	6-2	38-9
2-6	4-5	4-3	3-6	1-3	-	2-1	14-18
2-10	-	2-	5-3	2-	3-1	-	12-4
2-14	4-5	1-1	7-1	6-6	9-3	3-8	30-24
2-17	5-3	8-2	2-1	7-3	5-4	3-3	30-15
SUB TOTAL	19-15	20-6	20-14	25-11	26-10	14-14	124-70
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
3-1	6-2	8-	2-1	4-3	5-7	3-1	21-14
3-6	-1	10-	6-	-	-	-	16-1
3-9	7-1	1-1	3-5	4-7	2-4	5-5	22-23
3-12	5-1	8-3	-	10-2	1-1	3-3	27-10
3-18	8-3	1-1	6-11	4-2	7-9	3-5	29-31
SUB TOTAL	26-8	21-5	17-17	27-10	15-21	14-16	115-79
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
SEG. 1-2-3 TOTAL	73-29	61-17	69-33	77-31	71-37	51-33	402-180

(SEE PAGE 2 for Seg. 4 & 5.)

SP211 Self-Paced Physics, USNA

ALL SECTIONS - SCORE DISTRIBUTION

(SECOND QUARTERLY DIAGNOSTIC TEST)

NOVEMBER 10, 1970
(Includes all Make-Up Tests)

SCORE	SECTION TOTALS						GRAND TOTAL
	Theta 0101	Lambda 0301	Mu 0501	Iota 0801	Kappa 1101	Eta 1201	All Sections
100%	1 = 6%			1 = 6%			2%
90	2 = 11%	1 = 7%	2 = 10%	4 = 22%		1 = 7%	10%
80	6 = 35%	5 = 33%	11 = 55%	7 = 39%	3 = 19%	6 = 40%	36%
70	6 = 35%	5 = 33%	4 = 20%	2 = 11%	5 = 31%	3 = 20%	25%
60	2 = 11%	2 = 13%	3 = 15%	4 = 22%	7 = 44%	5 = 33%	23%
50	1 = 6%	2 = 13%			1 = 6%		4%
40							
30							
20							
10							
>10							
TOTAL STUDENTS	18	15	20	18	16	15	102

SAMPLE REPORT
(Page 2 of 2)

SAMPLE REPORT

DIAGNOSTIC T.O. SUMMARY COMPARISON

Second Quarterly Diagnostic Test

November 6 and 7, 1970

T.O. # (or * CORE #)	TEST QUESTION #	PERCENT WRONG BY INDIVIDUAL SECTION						PERCENT WRONG BY ALL SECTIONS
		0101	0301	0501	0801	1101	1201	
34	34	22	13	5	–	6	13	10
35	35	33	7	–	11	81	13	24
36	36	11	40	20	22	19	33	24
37	37	11	–	5	–	–	13	5
38	38	–	13	10	6	81	13	27
40	40	11	33	5	39	13	20	20
41	41	39	47	–	39	69	–	31
42	42	28	13	15	61	63	–	30
43	43	50	40	5	6	13	13	20
46	46	39	33	25	11	19	20	24
47	47	22	20	45	11	13	47	26
48	48	11	27	30	28	13	53	26
S45-C1	50	6	–	–	–	–	–	1
S45-C8	51	–	–	20	6	–	7	3
S45-C14	52	44	33	50	22	25	60	39
S45-C25	53	17	33	30	28	25	47	29

* Diagnostic Test Items for Segments 45 are identified with the Core Question of Segment 45.

SP211
USNA Self-Paced Physics

SAMPLE REPORT

DIAGNOSTIC T.O. SUMMARY COMPARISON

Second Quarterly Diagnostic Test

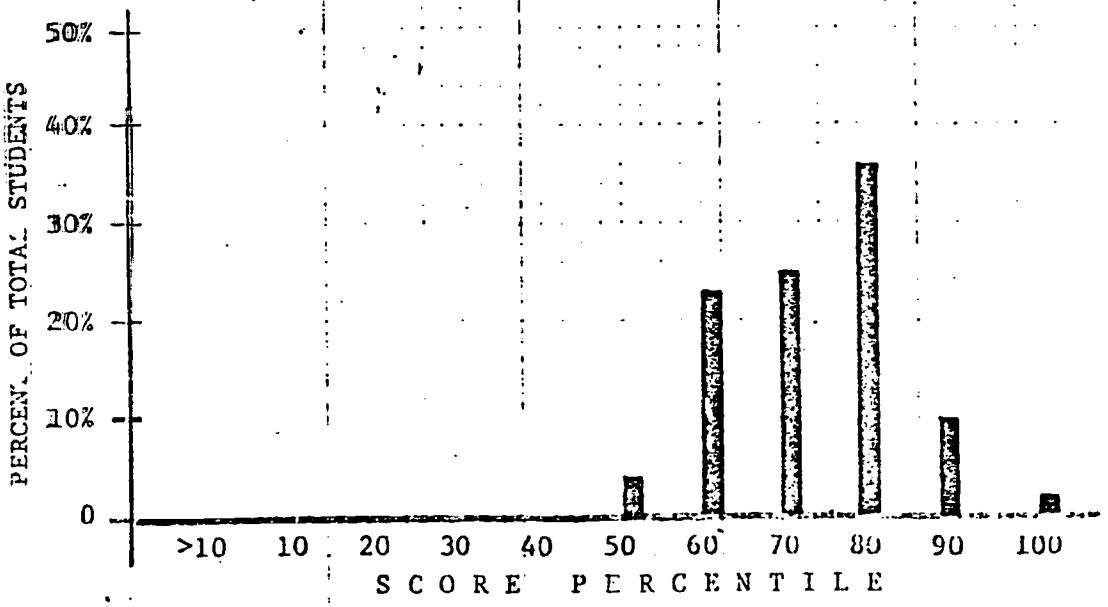
November 6 and 7, 1970

T.O. # (or * CORE #)	TEST QUESTION #	No. STUDENTS WRONG BY INDIVIDUAL SECTION						NUMBER OF STUDENTS WRONG IN ALL SECTIONS
		Theta 0101	Lambda 0301	Mu 0501	Iota 0801	Kappa 1101	Eta 1201	
34	34	4	2	1	—	1	2	10
35	35	6	1	—	2	13	2	24
36	36	2	6	4	4	3	5	24
37	37	2	—	1	—	—	2	5
38	38	—	2	10	1	13	2	28
40	40	2	5	1	7	2	3	20
41	41	7	7	—	7	11	—	32
42	42	5	2	3	11	10	—	31
43	43	9	6	1	1	2	2	21
46	46	7	5	5	2	3	3	25
47	47	4	3	9	2	2	7	27
48	48	2	4	6	5	2	8	27
S45-C1	50	1	—	—	—	—	—	1
S45-C8	51	—	—	1	1	—	1	3
S45-C14	52	8	5	10	4	4	9	40
S45-C25	53	3	5	6	5	4	7	30
TOTAL STUDENTS IN GROUP:		18	15	20	18	16	15	102

* Diagnostic Test Items for Segments 45 are identified with the Core Question of Segment 45.

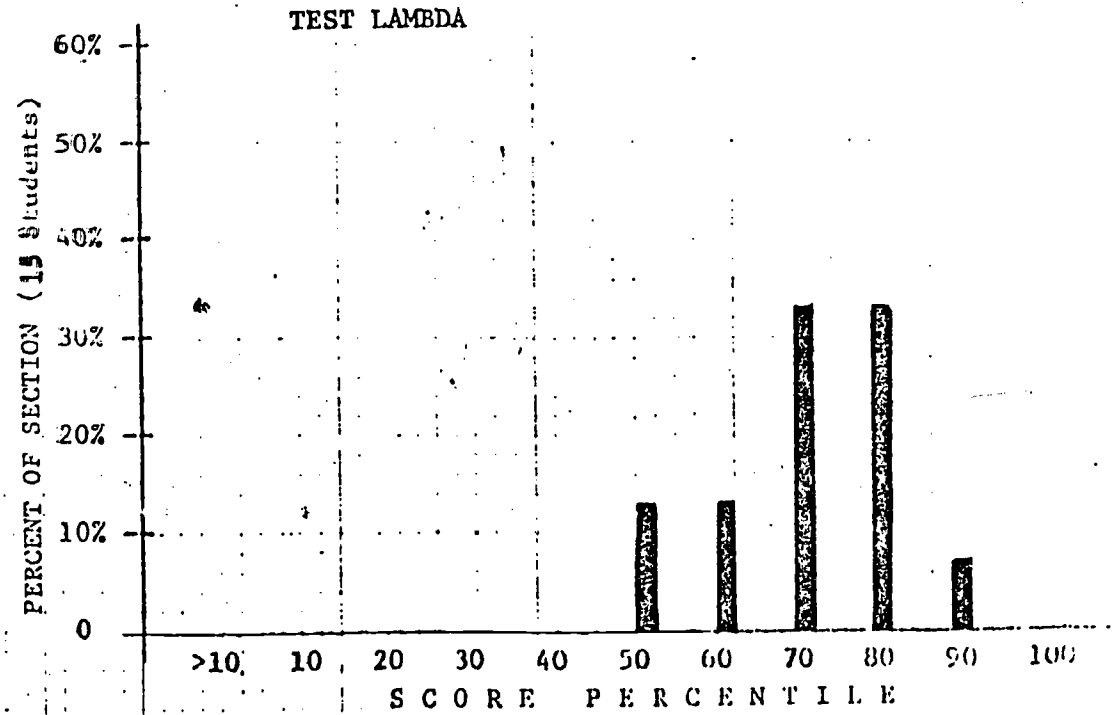
BAR CHART PERCENTILE DISTRIBUTIONS

ALL SECTIONS (102 Students)



SECTION 0301

TEST LAMBDA



2.3 Control Points and Orientation

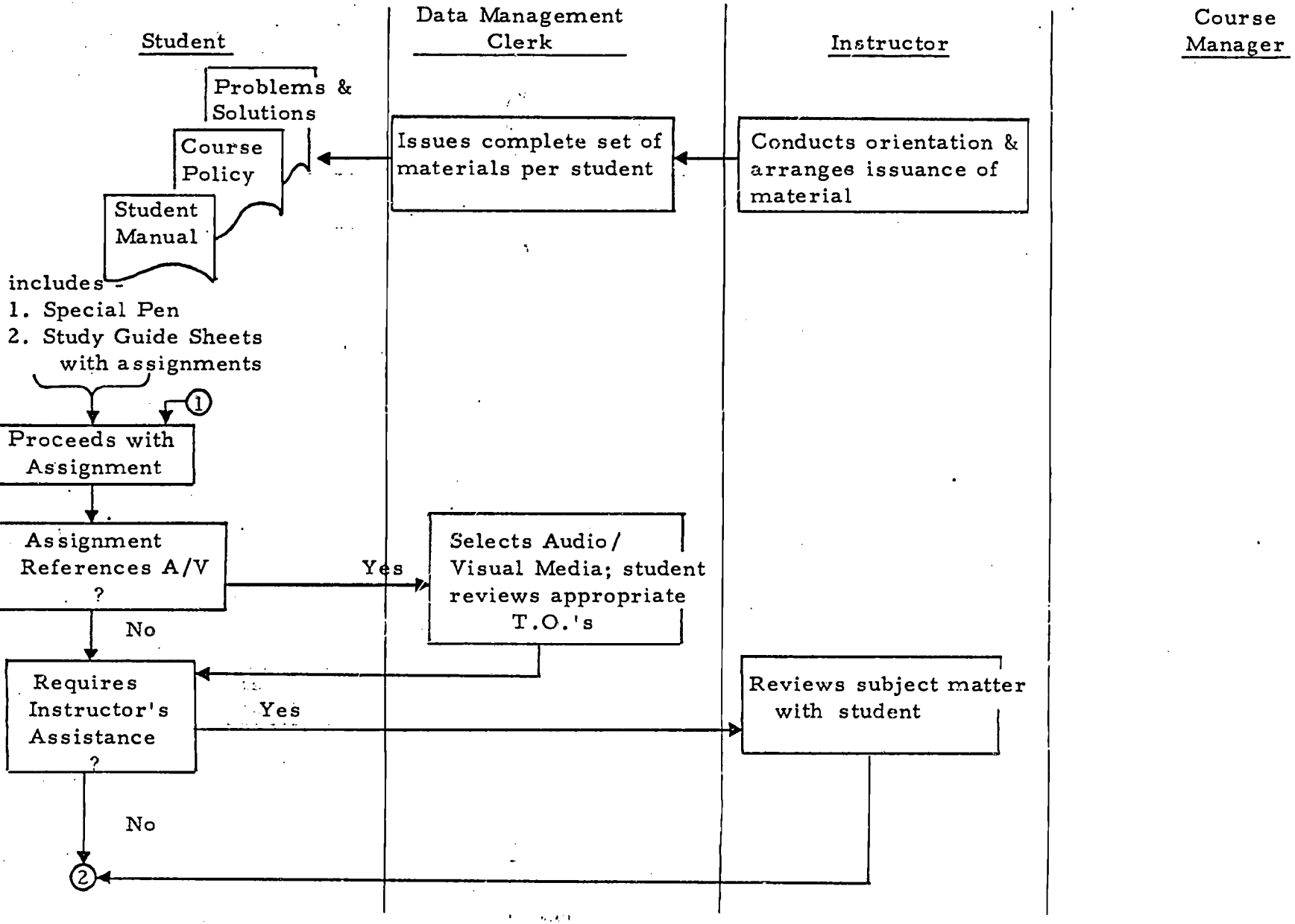
Incorporated in this section is a pictorial description (flow chart) which reflects a general overview of the operational functions of the course. Various control points and lines of communication/responsibility have been identified in the flow chart for the benefit of the instructor and course manager.

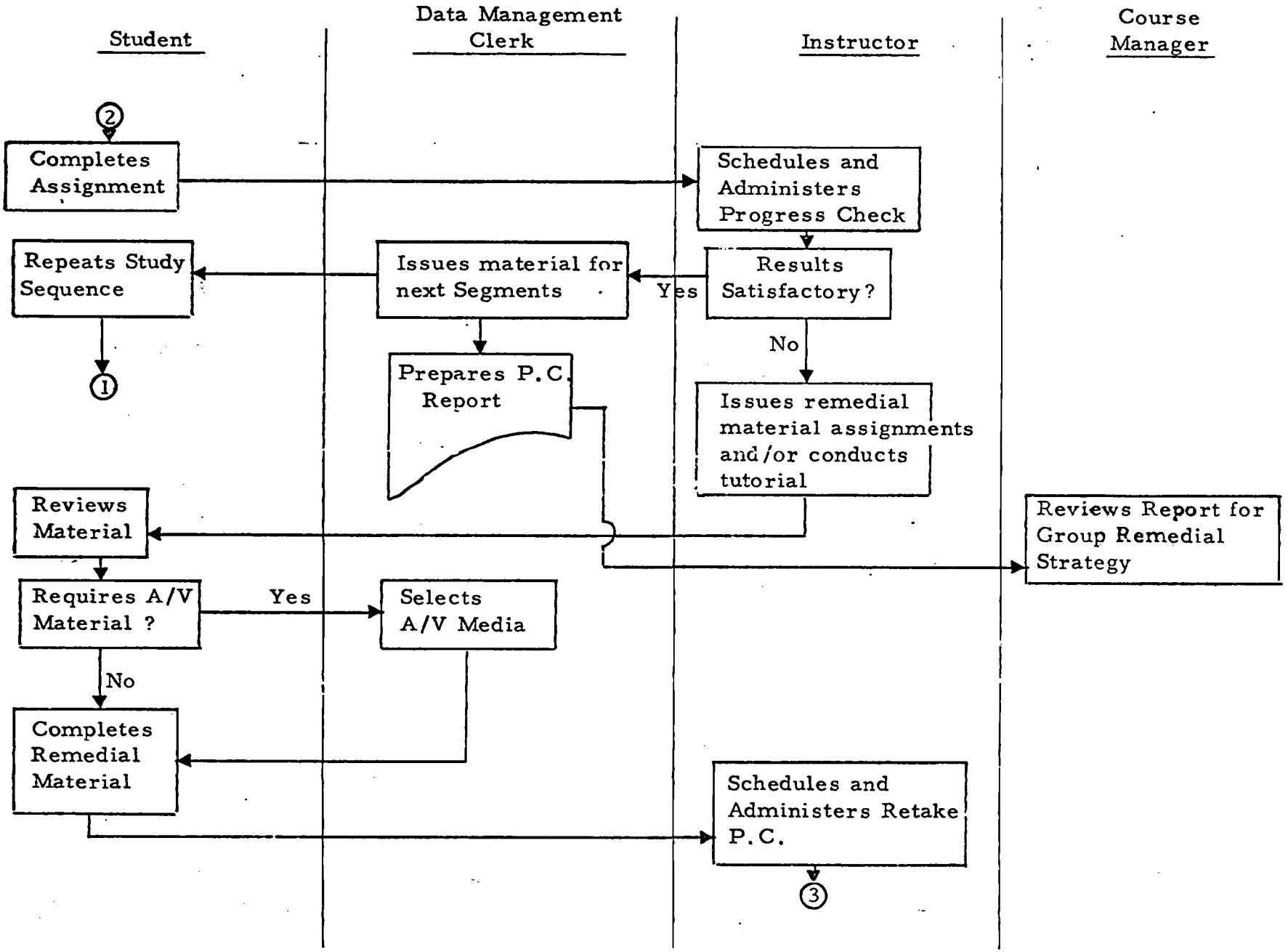
Descriptions which amplify these items are in the Instructor/Student Orientation section and other references found throughout this report.

2.3 Control Points and Orientation

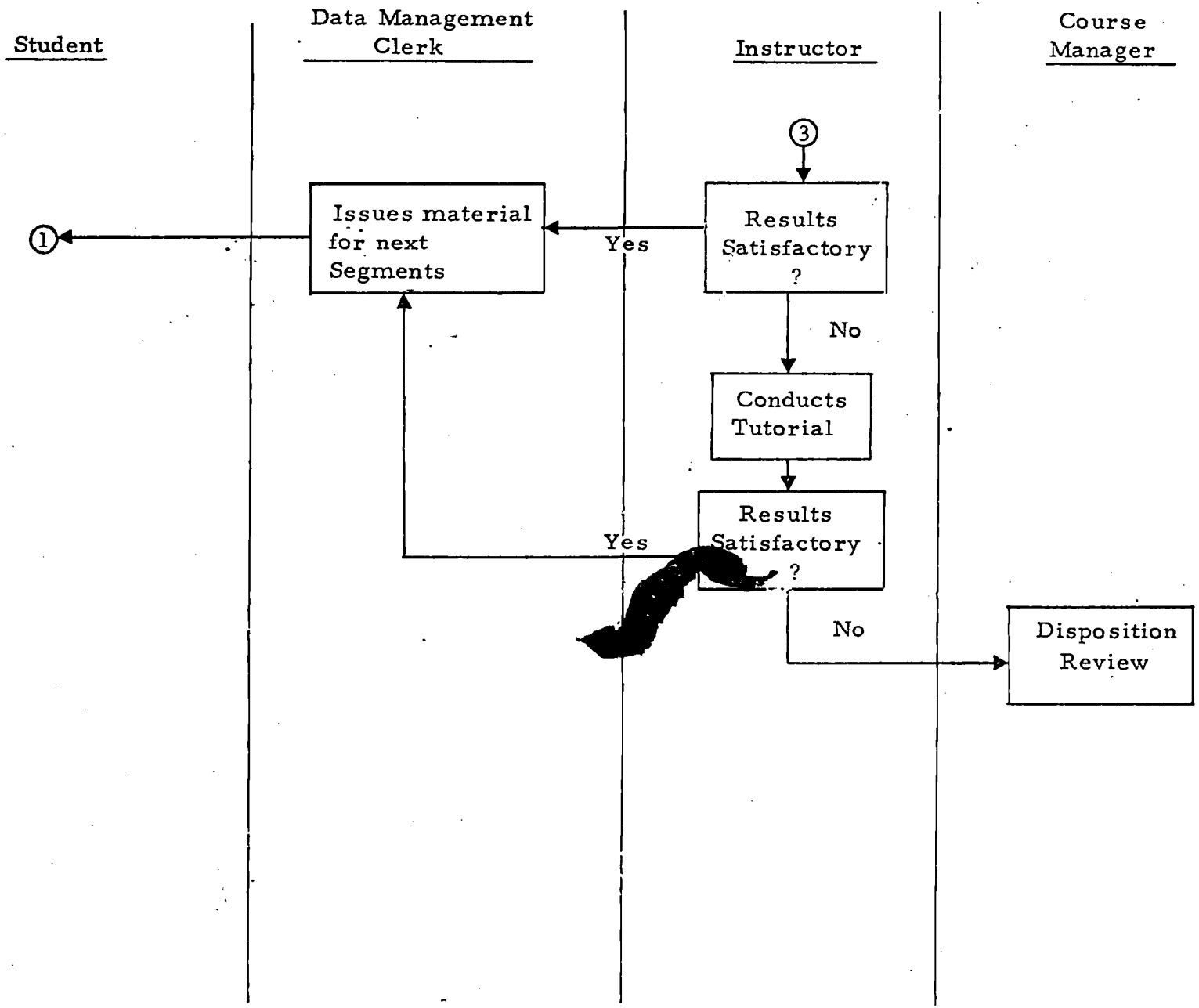
2.3.1 Flow Chart (and Interfaces)

SELF-PACED PHYSICS COURSE (Page 1 of three pages)




Student
Data Management Clerk
Instructor
Course Manager
2
Completes Assignment
Schedules and Administers Progress Check
Repeats Study Sequence
Issues material for next Segments
Results Satisfactory?
Yes
No
1
Prepares P.C. Report
Issues remedial material assignments and/or conducts tutorial
Reviews Material
Reviews Report for Group Remedial Strategy
Requires A/V Material ?
Yes
Selects A/V Media
No
Completes Remedial Material
Schedules and Administers Retake P.C.
3

SELF-PACED PHYSICS COURSE
(Cont'd)



2.3.2 Instructor/Student Orientation

This section contains information which should be reviewed by the instructor to familiarize himself with the course. The descriptions are divided into five parts consisting of:

a) Notes to the Instructor

b) The Management Sequence

(The following three items consist of documentation which is distributed to the students during the orientation session.)

c) Course Policy

d) The Self-Paced Laboratory

e) The Student Manual

2.3.2.1 Notes to the Instructor of Self-Paced Physics

1. Introduction

The methods and operation of the self-paced physics course may seem strange to new instructors as well as to the students. This information is presented to assist the instructor in developing his individual class policies. It is presumed you are familiar with the Student Manual and Course Policy Statement.

2. Objective

The objective of the course is to enable each midshipman to complete the tasks defined by the Terminal Objectives (TOs). If you have not done so previously, you should read the TOs, as they constitute the most accurate definition of course content. Because of the way the Problem and Solution books have been constructed, successful completion of all the core questions should cover all the TOs. Since the core questions were also designed to provide a path for fast students, they

are frequently complex problems that combine elements of several TOs. Due to the limited time available for testing, the body of TOs is sampled randomly during Progress Checks and Diagnostic Tests.

3. Class Atmosphere

There are few constraints on how you use class time to move the students through the material. If your class size permits, you are encouraged to use Room 203 as your regular classroom. Initially, a certain amount of encouragement may be needed to steer the midshipmen to the various media. You should try as many of the media yourself as time permits so you can recommend a particular Audiovisual if a midshipman is having trouble in a specific area. You may wish to add additional demonstrations or conduct small topical lectures occasionally. Comprehensive reviews prior to Diagnostic Tests are frequently given.

4. Student Progress

One of the by-products of the course organization is the early identification of potential failures, before they reach the Diagnostic Tests. This early identification can be done most effectively by careful screening of Study Guide responses and Progress Check responses. The individual prescription for assistance is in your hands, but the early identification of these individuals and the variety of materials available should provide you with considerable flexibility.

5. Areas of Concern

a. Minimum Lecture. You, as well as some of your midshipmen, may feel uncomfortable, initially, because you are not conducting lectures during most of the class time. Experience has shown that most students adapt readily to the self-paced class routine within

four to six weeks. You may choose to lecture frequently; however, you will probably have little time left to grade Progress Checks or counsel slow students, except in EI (Extra-Instruction) Sessions. Another by-product of the course organization is to move a substantial amount of student counseling and remedial work into the classroom.

b. Student Progress. Because of the great amount of material covered by the course, you will soon find students dropping well behind the average (or, from your view, a desirable) class progress. Your success in keeping the class moving will be limited only by your imagination. One reason for the apparently slow class progress may be confusion between a very weak physics student and a good student who chooses to "pace" himself to the speed of slower classmates. Careful screening of Study Guide and Progress Check responses can usually separate the two.

2.3.2.2 The Management Sequence

1. Each student is issued one prime textbook; at least two other supplementary texts are at all times available in the physics room or in the library.

2. Each student is issued a Student Manual intended to supply the student with all the procedural information required.

3. Course work begins with the issuance of Segment 1 of Problem and Solution Book and the Study Guide for the same segment. The Study Guide is a latent image type on which sequencing information is revealed by means of a special pen.

4. The Study Guide features are:

(a) A reading assignment indicating prime reading and supplementary reading, both clearly identified.

(b) Core problems identified by score lines over and under the problem number.

(c) Remedial loop problems ("enabling problems"). The instructions for short-circuiting the loops, or following them, are contained in the Study Guide for each individual set.

(d) Titles and directions for Information Panels contained in the Problem and Solution book.

(e) Titles and directions for Audiovisuals. These are available in three formats:

(1) Videotapes;

(2) Talking books;

(3) Illustrated texts

(f) Homework assignment, generally in the form of additional problems in the prime text.

5. The Problem and Solution book features are:

(a) Problems and diagrams in numerical sequence.

(b) Core problems identified by enclosing each one in a box.

(c) Information Panels preceding core groups.

(d) Scrambled problem solutions: directions for reaching solution is revealed only in the Study Guide when correct answer is chosen.

(e) Each solution for core and core-prime questions is followed by a true-false question whose answer is derivable from the solution to which it pertains. These TF's are answered in special boxed sections of the Study Guide. NOTE: Each core problem which is answered incorrectly requires that the student follow the remedial or enabling loop which always continues with another problem having the same conceptual basis as the core problem initially missed. Such problems are called "core-primes."

(f) The scrambling process used for the solutions is extremely difficult to compromise. The time required to short-circuit the response pattern is expected to be too great to make it worthwhile.

6. The Progress Check. This is a form of test which follows a unit of work. The Progress Check is graded by the teacher. The performance of the student is evaluated and he is then guided into one of the channels indicated below. To be eligible for the Progress Check, the student must submit to his instructor all of the relevant revealed Study Guides for that unit.

(a) Using a predetermined cut-off grade, the student is given the "go" signal if his performance is above this level. He is also given a set of enrichment suggestions in the form of reading, programmed material, films, etc.

(b) If his performance falls below the cut-off, he is given a "stop" signal with remedials, after which he retakes a Progress Check. Questions on these checks will be randomized so that no two students ever take exactly the same examination, nor does the same student take the same check on the second round.

(c) If his performance falls below cut-off on the retake, he will be given individual tutorial assistance and required to take a third test. Disposition of the student after the third failure will be left to the chairman of the physics committee at the Academy.

7. Quarterly Diagnostic Tests. These tests will be carefully generated to test for recognition and recall, understanding of concept, ability to recognize concepts which appear in problems, and ability to solve problems. These tests will all be of the multiple-choice variety, with a response mechanism suitable for computer grading. One of the Quarterly Diagnostics will replace the mid-term examination and the last of them will be administered about one week before the standard final examination.

8. At the end of each quarter the instructor will submit a diagnosis and recommendations based upon Study Guide responses, performance on Progress Checks, and Quarterly Diagnostics. Possible recommendations include continuation of sequence, repetition of specific segments, further use of other program texts, additional tutorials, and dropping out.

2.3.2.3 Sample Course Policy

SP2[illegible] SELF-PACED PHYSICS

Course Policy

1. Background. This course is part of an experimental education program which has been conducted by the U.S. Naval Academy and New York Institute of Technology since summer 1967. The course is characterized by rather unconventional teaching methods and, as you will see, emphasizes:

> Each student's proceeding through the course at his own pace.
>
> Use of instruction via texts, programmed problem and solution books, videotapes, audiotape recordings, and instructor consultation.

2. Instructional Methods. A variety of instructional methods will be available to you during this course. The large number is provided so that you can find the combination of materials that is most efficient for you. To be sure of optimizing your use of classroom time, you are urged to try each type of material at least twice. The materials available are:

> A. Problem and Solution Book. This book, together with the Study Guide, is the principal material. Description and Organization are contained in the Student Manual.
>
> B. Audiovisuals (AV's). These take several forms; you should try all.
>
> > (1) Videotapes. Prerecorded lectures on specific topics are shown on the large monitor in Rm 203. The schedule for this monitor is posted on the wall. If you wish to look at a different videotape, you may check one out and play it on the videotape machines in Rm 203.
> >
> > (2) Talking Book (TB). This method consists of a tape recorded lecture (on either open reel or cassette) and a booklet containing the illustrations for the lecture. The TB materials are checked out in Rm 203. Cassettes may be checked-out overnight.

(3) Illustrated Book. This is a short illustrated booklet comtaining the same lecture as the Talking Book, but without the audio portion. Note that the subject matter of the Videotapes, TB, and Illustrated Book is virtually the same.

C. Alternate Texts. While the principal text for this course is Halliday & Resnick, Physics for Students of Engineering and Science, collateral text for references are provided on the Study Guides. Copies of all other texts mentioned are available for use during the classroom period. Because of the limited supply, however, they must be returned to the supply room at the conclusion of class.

D. Class Instructor. One of the major differences between this course and a conventionally taught course is the role of the instructor. Your regularly assigned instructor will be available during all class sessions to assist you with problems you encounter. He will not be lecturing. You are encouraged to seek help during the regular classroom period or during an EI period, if you are having difficulty with the course content or mechanics of the course material.

3. Course Schedule. Every effort has been made for you to determine your own speed in covering course materials. The Progress Checks, which will be mentioned later in detail, are taken at the completion of a number of Problem and Solution Book segments and not on a fixed date. Obviously, to complete the course in the sixteen (16) weeks allowed, some minimum rate of progress must be maintained. This minimum rate of progress is determined by the Test areas in the following schedule.

TEST/LECTURE SCHEDULE

9/10	Oct	TEST: SEGMENTS 1-10
23/24	Oct	LECTURE: LINEAR MOMENTUM
6/7	Nov	TEST: SEGMENTS 11-45
13/14	Nov	LECTURE: ANGULAR MOMENTUM
4/5	Dec	TEST: SEGMENTS 46-52
11/12	Dec	LECTURE: WAVE MOTION
16/17	Dec	LECTURE: SOUND
8/9	Jan	LECTURE: GEOMETRICAL OPTICS
19/20	Jan	TEST: SEGMENTS 54-62

Progress Checks to be completed after the following segments:

5, 10, 18, 46, 48, 52, 58, 62

Midshipmen who complete all of the course segments (and appropriate Progress Checks) early will be excused from class early except for tests and lectures noted above.

4. Testing. Two types of testing or evaluation are used in this course.

A. Progress Checks are completed as noted in course schedule. Each midshipman will notify his instructor one period in advance when he wishes to take a Progress Check. Each Check consists of ten questions, similar to those in the Problem and Solution Book, covering the material since the last Progress Check. Fifty minutes per Check will be allowed. The primary purpose of the Progress Check is to identify areas where the student is weak. Although they are scored, the scores are not used in determining course grades. Scoring is as follows:

Questions Correct	Action
8 or more	Continue with next segment
5-7	Schedule recheck with instructor
Less than 5	Schedule EI period

In all cases, midshipmen will be provided references to appropriate course materials for the questions they miss. The recheck will cover only items missed on the Progress Check and must be scheduled in advance.

B. Diagnostic Tests covering more material than the Progress Checks will be administered as shown on the class schedule. These tests will be used for determining progress marks submitted to the registrar. Students who have difficulty maintaining the minimum class schedule may find themselves taking a test for grade on material for which they have not had a Progress Check. In these cases, the test will also count as a Progress Check. Midshipmen who maintain an A average in the four tests will have the test grade counted as the final exam grade.

5. Laboratory Work. The operation of the self-paced laboratory is outlined in a separate handout. It is emphasized that completed Experiment Guides represents the work of the midshipman whose name appears on the cover. Material from the laboratory will be covered on the final examination.

6. Homework. Homework problems assigned in the Study Guide are supplementary. They will not be collected.

7. Grades. Progress and semester grades remain the perogative of the individual instructor and will be based on:

Quarterly Diagnostics
Final Examination
Laboratory

Weights assigned to each item will be determined by individual instructors.

2.3.2.4 Sample Procedure Form

UNITED STATES NAVAL ACADEMY
Physics Department

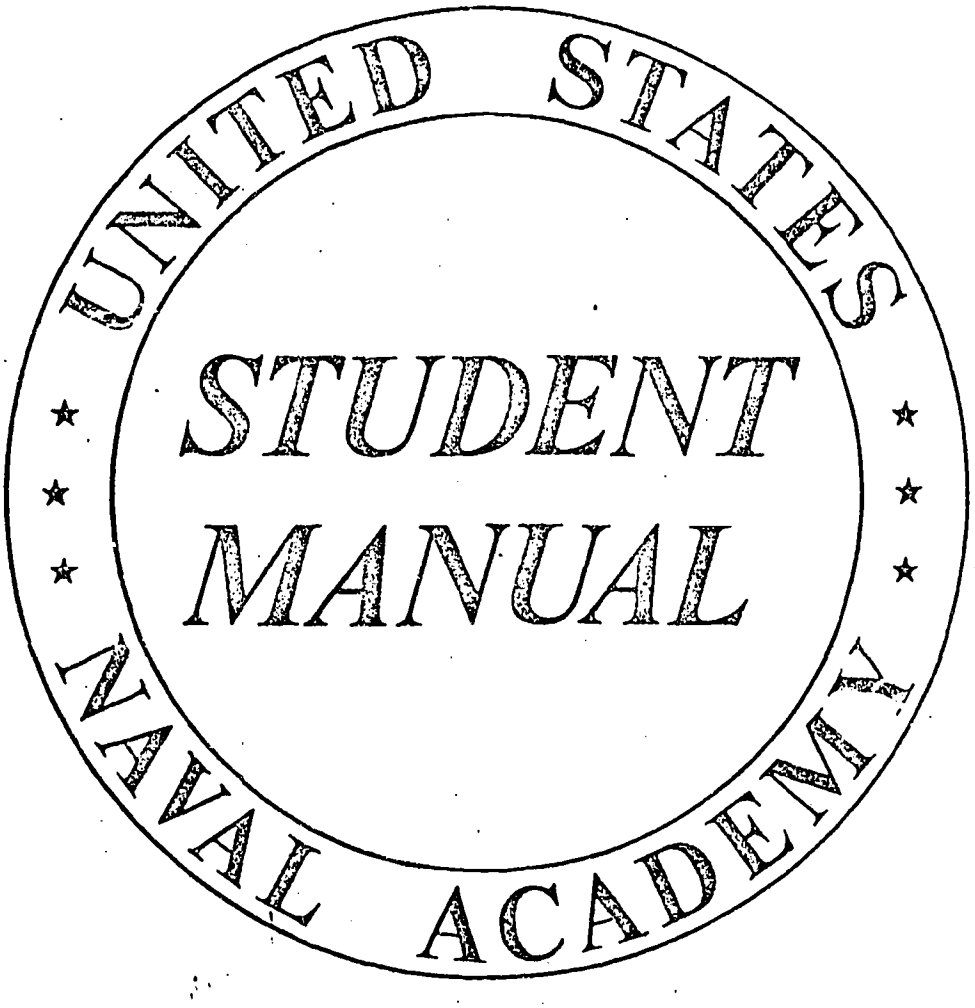
SP211, Engineering Physics I — First Semester, 1970-1971

The Self-Paced Laboratory

For the laboratory portion of SP211, Engineering Physics I, you will be allowed to proceed at your own pace through the experiments listed below. Although you have been scheduled for a particular laboratory period, you may disregard this and report to the laboratory (Room B8, Michelson Hall) at any time during the academic day (0755 to 1145 and 1315 to 1505, Monday through Firday, and 0755 to 1145, Saturday). Upon reporting to the instructor on duty in the laboratory, you will be given an Experiment Guide and directed to a laboratory station for the appropriate experiment. On the Experiment Guide, you will record your name and section, your insturctor's name, the date, and the times of arrival and departure. Upon completing the experiment you may leave, but you must give the completed Guide to the laboratory instructor who will, in turn, give it to your instructor. Your work will be graded and returned to you. If you wish, you may complete more than one experiment in a given week; however you will probably find it advisable not to out-pace your classroom assignments. Should you find it impossible to complete the experiment in the time available, make a note to this effect on the Guide and turn it in to the laboratory instructor before you leave. It will be held in the laboratory so that you may return and finish it later. In any event, you must complete the experiments within the spans of time given in the list below. You must complete all experiments or stand in danger of receiving no credit for the course. All work is to be accomplished individually, but the instructor in the laboratory will answer questions and try to ensure that you have adequate equipment and that it is working properly. Laboratory Manuals will be provided at each station, but you should always bring your slide rule, textbook, and a straight edge to the laboratory.

EXPERIMENTS

Number	Title	Available Beginning	Must be Completed no later than
1	Measurement I	14 Sep	3 Oct
2	Acceleration	21 Sep	10 Oct
3	Measurement II	28 Sep	17 Oct
4	Centripetal Force	5 Oct	24 Oct
5	Inclined Plane	12 Oct	31 Oct
6	Ballistic Pendulum	19 Oct	7 Nov
7	Rotational Inertia	2 Nov	21 Nov
8	Vibrating Spring	16 Nov	5 Dec
9	Speed of Sound in Air	30 Nov	17 Dec
10	Standing Waves	7 Dec	9 Jan
11	Single Lens	4 Jan	15 Jan
12	Lens Combinations	4 Jan	20 Jan



Self-Paced Physics

STUDENT MANUAL

1. DESCRIPTION OF THE COURSE

The self-paced physics course differs from conventional courses in a number of ways. It is largely student-managed programmed instruction. Most of your learning will be derived from reading carefully selected passages in excellent textbooks, simplified written discussions of the highlights of the various subject areas, and the use of audiovisual aids in the form of videotapes, "talking books", and brief, meaty illustrated pamphlets called Illustrated Texts. An instructor will be available for tutorial assistance as well as diagnosis of your progress.

The format of the course permits you to monitor your performance and achievement by means of instant feedback from the visual response mechanism to be described later.

In addition to self-paced theoretical instruction, you will also spend an adequate amount of time in the physics laboratory and attend a demonstration-lecture periodically.

You will always know in advance when a check quiz or an evaluation test is to be given. As a matter of fact, you will determine for yourself when progress checks will be administered to you. In addition to other periodic tests, a final examination will be used to evaluate your achievement.

2. COURSE STRUCTURE

Assigned reading--From standard textbooks, coded as follows:

HR means Halliday and Resnick, PHYSICS FOR STUDENTS OF SCIENCE AND ENGINEERING, fifth edition, combined form;

SZ means Sears and Zemansky, UNIVERSITY PHYSICS, third edition, complete;

AB means Albert Baez, THE NEW COLLEGE PHYSICS - A SPIRAL APPROACH, first printing;

SW means Shortley and Williams, ELEMENTS OF PHYSICS, fourth edition.

The required or prime reading assignment for each segment of the course will be identified by one or more asterisks before the chapter numbers. The remaining reading is to be considered supplementary. A typical reading assignment and its interpretation will be presented as a sample later in this Manual.

For maximum effectiveness, all assigned reading should be completed before you begin work on the programmed instruction. This first reading need not be exhaustive because it is anticipated that you will return to certain sections of it time and time again as you work through the segment.

Information Panels--Aside from your textbook reading, much of your factual and procedural information will come from Information Panels presented in the PROBLEM AND SOLUTION booklet for each segment. These Panels are concise discussions relating to the principles and methods of solution involved in the accompanying problems. If you should find that you do not fully understand the material in the Panel for a given section of your work, you would be expected to return to the textbook assignment for clarification.

Audiovisuals--These are important adjuncts to your reading and problem solving. When you are directed to work with a specified audiovisual, you will usually be given the option of selecting one of three media of presentation.

Videotape: a demonstration accompanied by a discussion that you view on the screen of a small videotape playback;

Talking Book: a set of carefully constructed pictures and diagrams accompanied by an audiotape lecture;

Illustrated Text: a set of pictures similar to those used for the Talking Book accompanied by a formal written discussion matched page by page to the illustrations.

Progress Checks--groups of relevant questions which you must answer after completing a specified number of segments. These checks will be used for diagnosis, progress evaluation, and tutorial assistance should the latter be needed.

Quarterly Diagnostics--special test forms administered periodically to assist your instructor in diagnosing possible weak areas in your learning pattern, and to enable him to prescribe remedial work where required. The Quarterly Diagnostics will also be used to evaluate your achievement.

Final Examination--standard examination which provides information relative to your final grade.

Enrichment Packages--for those students whose progress warrants additional, higher level material; to be a student option.

3. PRINTED LEARNING MATERIALS

PROBLEM AND SOLUTION BOOK. (Hereafter referred to as the P&S.) This is bound study material containing the work for three or more segments in a volume. The entire course consists of 45 segments for the semester. The P&S material in a given volume will contain blue title sheets between segments to help you find the one you want quickly. Each P&S contains:

(a) A problem section in which the questions and numerical problems are presented in strict numerical order, to be worked on in sequence.

(b) A solution section in which the correct methods of answering questions and solving problems are presented in scrambled order. Many of these solutions are terminated by additional "true-false" questions to be answered immediately after you study the individual solutions.

(c) Information Panels strategically interspersed throughout the problem section.

STUDY GUIDE. This is just what its name implies: a written guide that you must follow step-by-step, strictly in the order presented, to work your way through the problems, information panels, audiovisuals, reading, solutions, and other check points. The remainder of this Manual will be devoted to an explanation of the way in which all these aspects of your learning are related.

4. HOW TO USE THE STUDY GUIDE

Please refer to the sample Study Guide which is the last page of this booklet. It is a partial mock-up of a segment that doesn't really exist, and will be used for explanation purposes only. If you are to understand how the system works, if you are to avoid blunders when you start work on your first actual segment, you must walk through the following explanation without missing a step. Take your time; be absolutely certain you understand each maneuver perfectly. If you need help in interpretation, ask for it.

Before you begin work on any segment, ascertain that you have the correct STUDY GUIDE by checking the number near the upper right-hand corner, then complete the heading on each STUDY GUIDE sheet.

Another preliminary step: look at the bottom of the STUDY GUIDE sheet and note the number of pages you should have in your hand. Few STUDY GUIDES contain more than two pages. Be sure you have what you need before you start work.

The letter P above the left column means "Problem Number;" the STEPS are also numbered to indicate the sequence of things you must do other than problem solving.

All right. Let's go through the sample.

Step 0.1 The reading assignment for the segment. The required reading is in Halliday and Resnick, paragraphs 49-3 *through* 49-6 and paragraph 49-9. The slash-bar (/) always means from one paragraph through the other, inclusive. The supplementary reading is in Sears and Zemansky, paragraphs 45-6, 45-7, and 45-11. This reading should be gone through at least once before continuing.

Step 0.2 When you have finished your reading, turn to the first page in the P&S for this segment. Read the Information Panel, be sure you understand if fully, then continue.

1 This is the first problem in the P&S. Note the overscore and underscore lines. These indicate that the problem is a core type, required of all students in the course. You will find this problem boxed for the same reason in the P&S. The problem you find in the P&S as number 1 is:

How many gallons of regular gasoline could you have purchased with 5 Martian zilches in Septimus, Ohio in the year 1960 and still have some change left over?

A. 1
B. 2
C. 3
D. 4

Now obviously, to solve this problem you would have to know the price of gasoline per gallon in U.S. currency and also the equivalent buying power of a Martian zilch. Presumably, your reading and the Information Panel contains this information but let us suppose that you didn't do any of the reading and so didn't know the answer. So--you're about to make a wild guess, let's say, answer A. At this point you rub the "reveal" pen provided all over the inside of box A for the first question. As you do so, you will see an X appear, showing that the selection was incorrect. Do it now; reveal the X in box A with your pen. (Best results are obtained by rubbing the pen lightly over the surface, then waiting a few moments for the revealed information to darken.)

Making another stab at it, you choose answer B and use the pen bringing out another X. Trying C, you find that the pen reveals the characters 29[a]. This tells you to turn to page 29, item [a] in the P&S where you will find the full explanation of the method used to solve the problem. For this core question, you will also find a very short true-false question immediately after the correct solution. This question reads as follows:

> A Martian zilch is the equivalent of three U.S. nickels. True or False?

You must now use the reveal pen on either the T-box or the F-box for question 1.

If you make the correct true-false selection, a ✓ will appear in the box. If you choose incorrectly, *an X will appear in the box.* The true-false questions are usually so simple that you will be permitted few, if any, errors in this part of the work. Getting one of these T-F's wrong is a pretty sure indication that you are not reading the solutions. You must avoid this.

Let's go down to the next step.

Step 1.1 You are now being given an option. If your first choice was correct, you will be permitted to skip over the next four questions and advance to the next Information Panel. If you answered incorrectly, even once, you must go through the remedial loop consisting of questions 2 through 5.

We are assuming that you missed question 1, so let's go through this loop together.

2 Problem 2 in the P&S. It is not scored, hence it is not a core problem. It reads as follows:

> It is predicted that a gallon of regular gasoline will sell for $1.05 by the year 1998. If this is roughly 3-1/2 times the price of gasoline in 1960, how much did one gallon cost in 1960?

This is *not* multiple-choice. It's a completion type of question where you must write in the answer. So, write your answer on the line below the rectangle for question 2. The answer is, of course, 30¢ because $1.05 is 3-1/2

times 30¢. After writing it in, reveal the answer in the rectangle with the pen; the answer 30¢ will appear accompanied by the referral page and item 14[c]. Turning to the referral, you find the solution worked out for you to check your own thinking. Problems that are not core types are not accompanied by true-false check questions, so you're ready to go to question 3.

Let's interrupt the sequence for a moment. Even if you were able to answer the original core question correctly the first time, *you should go through the remedial loop anyway if you have any doubt at all about the method of solution or the answer*. You may have guessed at the right answer, or you may have made two errors that canceled out. In any case, if you feel that your choice of the right answer was a fluke in any way, we urge you to go through the remedial loop.

3 Problem 3 in the P&S; it is not a core problem. Here it is:

> Ten Martian zilches will buy exactly the same number of 2-1/2 inch McIntosh apples in a given market on a given day as two U.S. dollars. Thus, one zilch is the equivalent of
>
> A. 10¢
> B. 20¢
> C. 40¢
> D. 60¢

A glance at the STUDY GUIDE corroborates the fact that this is another multiple-choice question. Apparently 10 zilches is the equivalent of $2.00, so one zilch must be worth 20¢. This is answer B, so if you use the reveal pen in box B you will bring out the instruction 18[b] indicating that page 18, item [b] in the P&S has the solution. Whether you were right or wrong in your selections, it is important that you read and understand the solution. If you had chosen any answer other than B, you would have revealed an X as before. There is no true-false question, hence you can now go on to question 4.

Here is your first modified true-false question:

> True or false? Five martian zilches will purchase *more* milk than 20 U.S. dimes.

Note the italicized word. Read the statement and (a) if you decide it is true, simply ink the T-box on the STUDY GUIDE; (b) if you feel that it is false, write a word that can replace *more* and thereby make the statement true. *After* you have written the correction word on the line under the F rectangle, then, and only then, you are to reveal the answer with the pen. In this particular instance, the correct answer is "false" and you would write in the word "less" in place of *more*. Your reveal pen will bring this out, too. If you had selected "true" as your answer, the pen would have revealed an X inside the T-box. So, after writing "less" you would see revealed: "less (21[d])." At this point in an actual lesson, you would turn to this page and item in the P&S and read it carefully before continuing the sequence.

Continuing with the remedial loop:

5 Another multiple-choice question:

In order to have filled your 18-gallon tank with gasoline in 1960 in Septimus, Ohio, you would have spent at least

A. 15 zilches
B. 21 zilches
C. 23 zilches
D. 27 zilches

The correct answer is, of course, 27 zilches since each zilch is worth 20¢ and each gallon costs 30¢, so you would reveal box D and find inside the instruction "27[b]." After reading the solution, you again encounter a check T-F question which is then answered as before by revealing either the T or F box in question 5. Any answer other than D above would have revealed an X just as described for the previous multiple-choice question.

Step 5.1 Everyone is now expected to devote some time to the Information Panel, "The Currency of Venus" and then

Step 5.2 select the medium he wants for running through the audio-visual, COINAGE AND BILLS OF THE INNER PLANETS.

After that is finished, everyone starts once again on an equal footing with the core question 6.

And so forth.

U.S. NAVAL ACADEMY STUDY GUIDE SELF-PACED PHYSICS

P	STEP	NAME
	0.1	Reading: HR*49-3/49-6;*49-9 SZ 45-6, 45-7; 45-11
	0.2	Information Panel, "The Currency of Mars"
1		A B C D T F
	1.1	If your first choice was correct advance to 5.1; if not, continue sequence.
2		_____ (ans)
3		A B C D
4		T F _____ (ans)
5		A B C D T F
	5.1	Information Panel, "The Currency of Venus"
	5.2	Audiovisual, COINAGE AND BILLS OF THE INNER PLANETS
6		T F _____ (ans)
	6.1	If your answer was correct, advance to 9.1; if not, continue with sequence.
7		_____ (ans)

P	STEP	SECTION SEGMENT 60
		Note: In this sample "walk through", we have not included the Information Panels nor any set-up P & S. The problems that would normally appear in the P & S are given in the Student Manual for explanation purposes. AND SO FORTH

2.4 Information and Data Handling Procedures

A complete definition of the course content is necessary and was accomplished by the identification of over one thousand MBO's. These are to be found in the two volume MBO documentation.

2.4.1 Data Preparation Prior to Course Implementation

2.4.1.1 Establish Course Structure

1. Student Background and Enrollment File - Prepare a student background card for each student to be enrolled in the course. See Exhibit "A" for data and format. Under CMI, there is an allowable maximum of one-hundred and eighty-five students per CMI course.

Purpose - This data registers a student in the course and provides the basis to accomplish the following:

a) Assignment of Course Student Number

b) Creation of Student Roster

c) Computation of Capability Index

d) Storage of Background Data

2. Preparation of Course Header File - Prepare a course header card (Port-A-Punch format) for each test (or Study Guide) to be administered during the course. See Exhibit "B" for data and format. There is an allowable maximum of 48 questions per test.

Purpose - This data establishes the correct answer matrix for each test to be computer graded and provides certain lesson identification data.

3. Preparation of Question (MBO) Description File - Prepare a question description card for each question within a test (or Study Guide). See Exhibit "C" for data and format. Following the basic

structure of the course, each question should be designed to test the student's knowledge of a specific Terminal Objective (and Enabling Objective where applicable).

Purpose - This data will be used in the preparation of the individual student performance report (Refer to Exhibit "D") and the TO analysis reports (as described later).

The prescriptions (remedial assignment for a student) for each question should be carefully constructed and will be printed for the student only when the question is answered incorrectly. See AIMS III Systems Manual for more detailed information on these files.

Non-CMI Procedure - If the CMI is not utilized for generating prescriptions, then a TO Key Sheet should be prepared as in Exhibit "E." These sheets are issued subsequent to each Quarterly Diagnostic. Section 4 contains a detailed description of this procedure and the Progress Check procedure.

2.4.1.2 Data Verification and Updating

Once the data files have been prepared, CMI reports are generated to reflect what data has been entered into the system. These reports should be reviewed to verify accuracy of the data.

1. Student Background and Enrollment

Printed reports consist of the Class Roster (Exhibit "F") and Course Background Roster (Exhibit "G").

The Course Student Number (CSN) is created by the system and is printed on the Class Roster. The CSN is the identifying number to be used subsequently on all student response input data.

To add a student to the file, prepare a student background card as above; to drop a student from the file, prepare a student drop card as in Exhibit "H."

2. Course Header

Certain types of errors input to this file, will automatically be printed by the CMI; however, the temporary (or Permanent) Header File Listing (Exhibit "I") should be reviewed for completeness and accuracy. The AIMS III User's Manual contains detailed instructions on the method of updating this file.

3. Question (MBO) Description

The Course Structure Summary Listing (Exhibit "J") provides a line-by-line printout of the MBO descriptions. Review of the listing is necessary to verify all question description data. Additional information is contained in the AIMS III User's Manual.

2.4.2 Course-in-Progress Procedures

2.4.2.1 Student Data

1. Data Preparation

Under CMI, two forms of collecting test data are possible:

a) Port-a-Punch and

b) Optical scanning form

See Exhibits "K" and "L" for Port-a-Punch formats and descriptions. See Exhibit "M" for Opscan data.

If the non-CMI procedure is utilized, the Opscan form is also utilized but as described in Exhibit "N."

Note that "completion time" data is an optional data requirement.

2. Progress Check Procedure

Responsibility	Procedure
STUDENT	1. Schedules Progress Check (PC) with instructor upon completion of appropriate segments.
	2. Submits Study Guide to instructor.
INSTRUCTOR	1. Reviews student's Study Guide just prior to PC.
	2. Administers PC to student.
	3. Grades PC "on-the-spot."
	4. Takes following action:
	a) if 40% or less correct: schedules tutorial session & issues remedial material. Student will retake PC.
	b) if 50-70%: issues remedial material; may reschedule PC.
	c) if 80-100%: issues remedial material; and new Study Guide.
	NOTE: Instructor Option:
	Examines Study Guide as aid to diagnosis of student weakness; may conduct immediate tutorial if warranted.
	5. Issues a "filled-in" Study Guide to the student for each one he turns in finally.
	6. Forwards PC responses to course manager.
COURSE MANAGER	1. Forwards graded Progress Check to Data Management Group. Do not include "retakes."
DATA MANAGEMENT GROUP	1. Prepares Progress Check worksheet (See following sample.)
	2. When approximately 33% of all students have taken the PC, prepares Progress Check-summary report (See following sample.)
	3. Forwards summary report to course manager.

2. Progress Check Procedure (cont'd)

Responsibility	Procedure
COURSE MANAGER	1. Reviews summary report with instructor.
	2. Determines remedial strategy.

PROGRESS CHECK -- SUMMARY REPORT

NAVY PHYSICS - PS211

DATE _____

SEGMENT _____

% TAKEN _____

CORE PROBLEMS	% ACHIEVEMENT SECTION						AVERAGE % ACHIEVEMENT
	0101	0301	0501	0801	1101	1201	
Total %							

PROGRESS CHECK WORKSHEET SEGMENT _____

Core Problem	Section 0101		0301		0501		0801		1101		1201		TOTAL (all sections)			
	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong	R	W	% Right	Date

SAMPLE PROGRESS CHECK WORKSHEET

3. Quarterly Diagnostic Procedure

Responsibility	Procedure
COURSE MANAGER	1. Prepare a random question Diagnostic for each section, consisting of one question for each TO, drawn from a Multi-Version Question Bank.
	2. Prepare sufficient copies of Student TO Key Sheets.
	3. Prepare sufficient copies of each Diagnostic.
	4. Prepare correct answer key.
INSTRUCTORS	1. Administer the Diagnostic.
	2. Forward the Student Diagnostic Answer Sheet to the Data Management Group.
	3. Prepare make-up Diagnostics, administer and grade them.
DATA MANAGEMENT GROUP	1. Sort Diagnostic Answer Sheets into sections.
	(See following procedures for items 2-5)
	2. Prepare Student TO Key Sheet (one per student) for Diagnostic.
	3. Prepare Diagnostic TO Summary Report for each section.
	4. Prepare Diagnostic Score distribution (Histogram) by section.
	5. Prepare Diagnostic T.O. Summary Comparison Report.
	6. Forward TO Key Sheets and Reports to course manager
COURSE MANAGER	1. Distribute appropriate reports and TO Key Sheets to instructor.
	2. Review Comparison Reports.
INSTRUCTORS	1. Distribute TO Key Sheets to students.
	2. Review reports to determine remedial strategy.

Procedure for Marking
Student TO Key Sheet and TO Section Summary Worksheet

1. Post student's last name and Academy # to TO Key Sheet from his Diagnostic Test.

2. Review each Student Diagnostic Test Sheet to determine incorrect answers.

3. a. For each incorrect answer, use cross-reference list to determine appropriate TO; circle that TO on the TO Key Sheet.

   b. For each incorrect answer, post a check mark to the TO Section Summary Worksheet.

4. Calculate and post % wrong = $\frac{\text{Total wrong}}{\text{Total students this section taking test}}$

5. Also post % wrong to the Diagnostic TO Summary Report for the appropriate section and the Diagnostic TO Summary Comparison.

6. Calculate % wrong - all sections = $\frac{\text{Total wrong answers for TO}}{\text{Total students taking test}}$

   and post to Diagnostic TO Summary Comparison.

Procedure to Prepare Diagnostic Score Distribution

1. Count the number of correct answers on each student test sheet and post the # correct on upper right corner of his test sheet.

2. When all student tests have been marked as in (1) above, complete the Score Conversion Table as follows:

   a. Place a mark in the check box for each student opposite the appropriate "# Right" line;

   b. When all student tests have been checked as above, post the total for each line in "Total" column.

3. Draw Bar Chart for section on Score Distribution Form.

4. Post totals from "Total" column to "All Sections" Score Table.

5. When all sections have been posted as in (4) above, add and post totals to "Grand Total" column.

6. Draw Bar Chart for all sections on each Score Distribution Sheet.

ALL SECTIONS - SCORE DISTRIBUTION

DATE _____

SCORE	SECTION TOTALS						GRAND TOTAL
	0101	0301	0501	0801	1101	1201	All Sections
100%							
90							
80							
70							
60							
50							
40							
30							
20							
10							
>10							

SAMPLE FORM

SAMPLE FORM

SCORE CONVERSION TABLE

DATE _____

SECTION _____

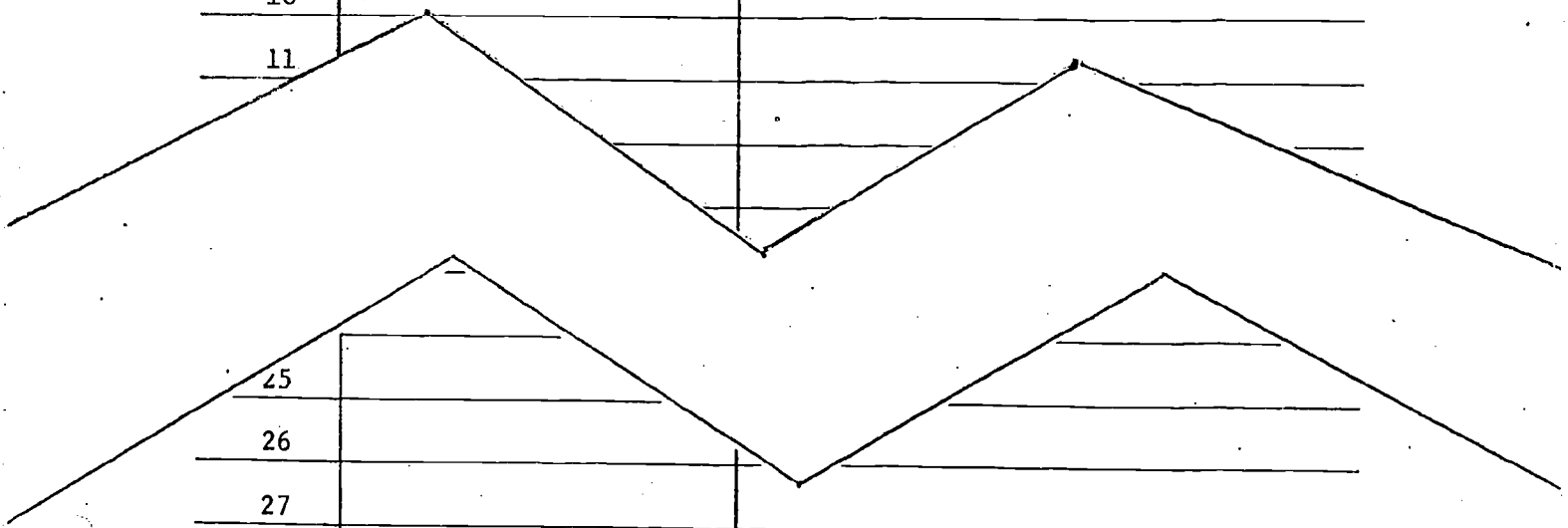
# RIGHT (inclusive)	SCORE	√(CHECK BOX)	TOTAL
31	100%		
28 - 30	90		
25 - 27	80		
22 - 24	70		
19 - 24	60		
16 - 18	50		
13 - 15	40		
10 - 12	30		
7 - 9	20		
4 - 6	10		
0 - 3	> 10		

SAMPLE FORM

DIAGNOSTIC T.O. SUMMARY REPORT

SECTION _____ DATE _____

T.O.#	SECTION % WRONG	ALL SECTIONS % WRONG
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
25		
26		
27		
28		
29		
30		
31		



SAMPLE FORM

DIAGNOSTIC T.O. SUMMARY COMPARISON

DATE _____

% WRONG

T.O.#	0101	0301	0501	0801	1101	1201	All Sections
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
26							
27							
28							
29							
30							
31							

T.O. SECTION SUMMARY WORKSHEET

SAMPLE FORM

DATE _____

SECTION _____

Total Students This Section Taking Test _____

T.O.#	CHECK WRONG	TOTAL WRONG	% * WRONG
1			
2			
3			
4			
5			
6			
7			
8			
23			
24			
25			
26			
27			
28			
29			
30			
31			

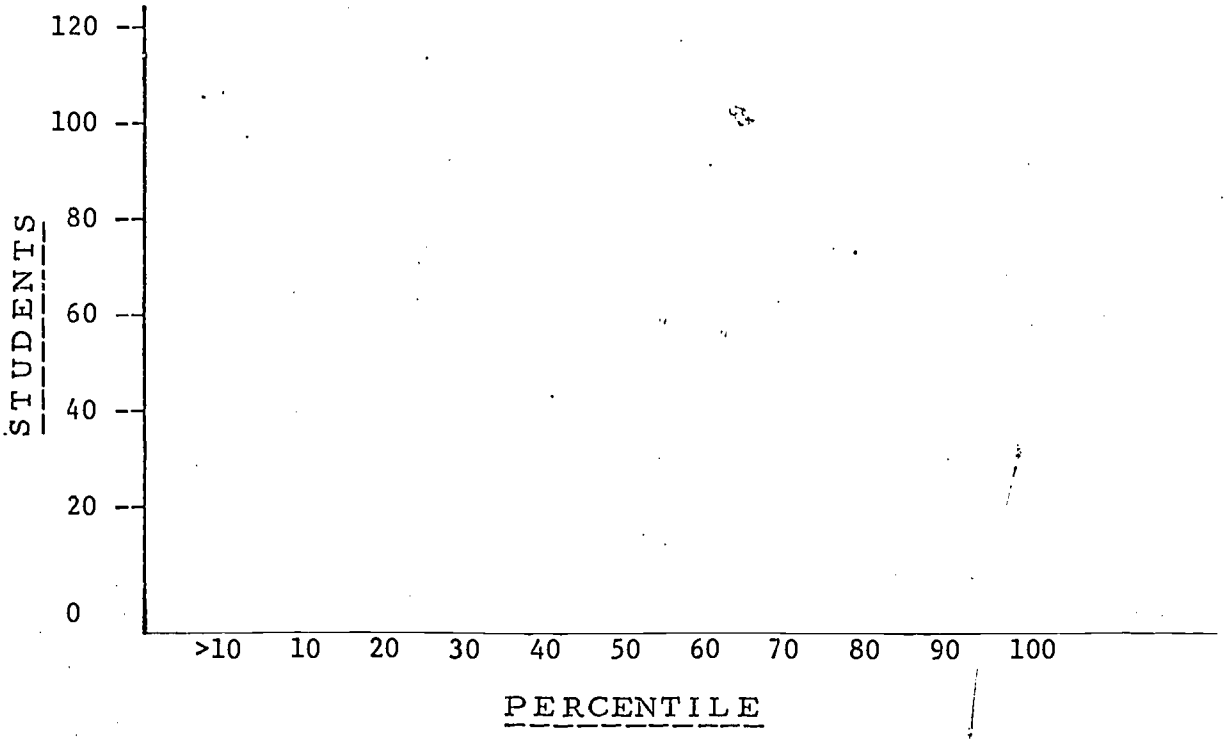
SAMPLE FORM

QUARTERLY DIAGNOSTIC - SCORE DISTRIBUTION

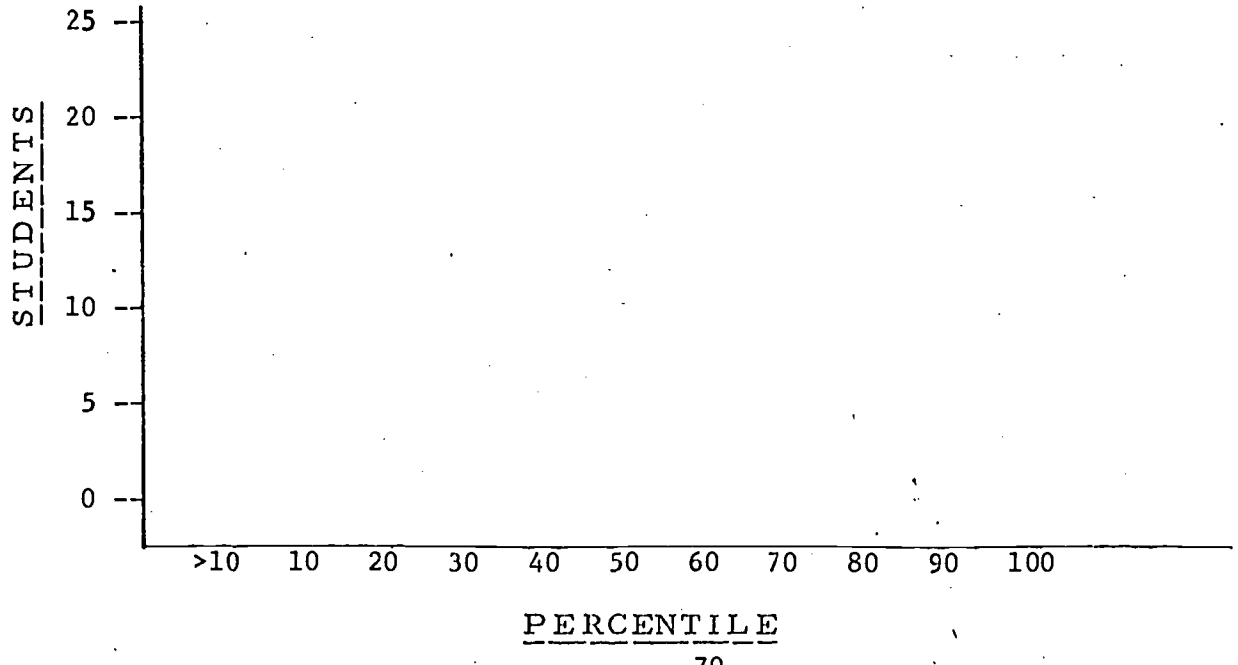
NAVY PHYSICS - PS211

DATE _____

ALL SECTIONS



SECTION ____



2.4.2.1 (Cont'd)

4. Study Guide

For a detailed listing of the multiple responses selected by all students, an item analysis report is available. Under CMI, the report is prepared via the computer and is described in the AIMS III User's Manual. Descriptions for the course revisions are contained in the Empirical Course Development Model and the Revisions Process Documentation.

Under CMI, Study Guide responses are also used in the determination of a student's understanding of a specific TO.

2.4.2.2 Report Descriptions

The non-CMI reports have been described in the preceding sections. The student oriented CMI reports available are briefly described below and are also contained in the AIMS III Systems Manual, and incorporated in this report as:

Exhibit "O"	Individual Student Analysis; student's performance on each individual TO.
Exhibit "P"	TO Remedial Summary; listing by TO of all students who performed above the error percentage set for a particular TO.
Exhibit "Q"	Remedial Session Lesson Plan; TOs assigned to a session (and instructor) according to the number of students who performed above the error percentage.
Exhibit "R"	Remedial Session Roster; a listing of students assigned to remedial sessions based on their TO error percentage.
Exhibit "S"	Volume Summary; a listing of all the total performance for all students by section.

EXHIBIT "A"

STUDENT BACKGROUND AND ENROLLMENT CARD

Column Number	Heading
1 - 25	Student Name
26 - 34	Academy Alpha Number
35 - 37	SAT - Math
38 - 40	SAT - Verb
52 - 53	Calculus
54 - 55	Chemistry
56 - 58	Math Achievement
61 - 63	Rank
64 - 78	Comments
78 - 80	Course Number (*)

(*) NOTE

If this number is input as zero, the system assigns the student a course number; if not, it considers this card an update.

EXHIBIT "B"

COURSE HEADER CARD

Column Number	Heading
2, 6, 8	Number of Selections
24, 26	Number of Questions
42, 44	Course Number
48, 50	Sequence Number
54, 56	Type Number
60, 62	Volume Number
66, 68	Segment Number
80	Single or Double

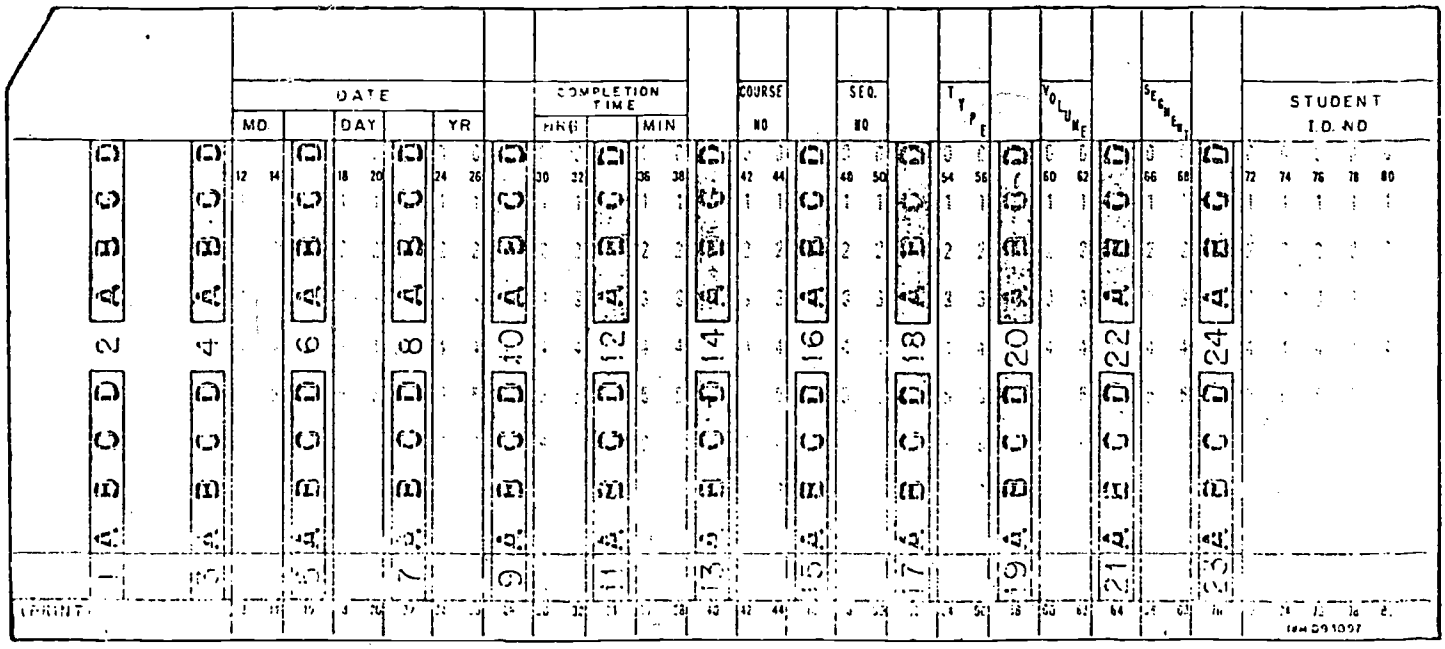


EXHIBIT "C"

QUESTION (MBO) DESCRIPTOR CARD

Column Numbers	Heading
1, 2	Volume Number
3	Segment Number
4, 5, 6	TO Number
7, 8	EO Number
9 - 42	MBO Description
43, 44	Learning Category
48	Type
49, 50	Question Number
51	Correct Answer
52 - 78	Prescription
79, 80	Course Number

STUDENT PERFORMANCE ANALYSIS FOR COURSE PHYSICS S211

VOLUME 8 POST TEST SEGMENT 1

CSN	NAME	ID NUMBER	SECTION	GROUP
6	[redacted]	[redacted]	1201	A

QUESTION	ANSWER	C/W	BEHAVIORAL OBJECTIVE	MESSAGE
1		C		
2		C		
3		C		
4		C		
5		W	FRICTION	
6		W	CENTRIPETAL FORCE	
7		W	WORK DONE BY A CONSTANT FORCE	
8		W	POWER	
9		C		
10		C		
11		C		
12		W	1-D, NON-RELATIVISTIC COLLISIONS	
13		C		
14		W	GRAVITATIONAL FIELD	
15		W	GRAV. POTENTIAL ENERGY	
16		C		
17		C		
18		W	CALCULATE ELECTRIC FIELD	
19		W	ELECTRIC FIELD/SUPERPOSITION	
20		W	WORK IN ELECTRIC FIELD	

YOUR GRADE IS 67

YOUR RAW SCORE IS 50.

YOU MUST SEE YOUR INSTRUCTOR THIS WEEK TO DISCUSS THIS TEST.

EXHIBIT "D"

EXHIBIT "E"

STUDENT TO KEY SHEET

SEGMENT NUMBER - CORE PROBLEM NUMBER*

NAME _____ ACADEMY NUMBER _____

TO	SEG. # - CORE PROB.
1	1-13
2	2-17
3	1-1
4	2-1; 2-6
5	2-10; 2-14
6	3-1; 3-6; 3-9
7	3-1; 3-6; 3-9
8	1-13
9	3-1; 3-6
10	3-17
11	2-14
12	3-12; 3-18
13	4-1; 4-2
14	4-5; 4-6
15	4-11
16	4-16
17	5-5
18	6-1; 6-2
19	6-9; 6-14; 6-15
20	7-2
21	7-1; 7-5
22	7-10
23	7-15
24	8-1
25	7-18
26	8-9
27	8-5; 8-18
28	9-1; 9-2
29	9-3
30	10-1; 10-5
31	10-13

*Core Problems Most Closely Keyed to Diagnostic Questions.
The TO number circled was answered incorrectly on the Diagnostic

*** CLASS ROSTER ***
COURSE, PHYSICS S211

STUDENT	ACADEMY NO.	COURSE STD.NO.
BITT JAMES C	2264	1
CKES BLAINE R	1629	2
MBLISS E Y	1358	3
FFORD JOHN D	2259	4
CK STEVE P	1694	5
CD THOMAS R	1799	6
SCH DANNY L	1932	7
STEPHEN D	2079	8
LONG E	2380	9
L BILL AA F	2702	10
NDCR LARRY C	1765	11
G MANTON A	1771	12
ER JOHN G	5996	13
CHELL R L	6064	14
PAVER AT J	6256	15
LES JACK S	6312	16
RT GORDON C	6317	17
KE JOHN G	6331	18
IELD R B	6337	19
M OF R C	6958	20
TOS ALAN	7014	21
RUBERT JERRY L	7060	22
LVSR R S	7425	23
TR EARL M	6036	24
SORSDEL R R	8030	25
KERSON JOHN A	8401	26
CURST TED L	8087	27
AMS GEORGE F	8052	28
SHOP PHILIP A	8338	29
RIER GUY S	1281	30
RISTENSEN S D	1393	31
LLNS RALPH E	1806	32
EE ARDWIA	2133	33
EWS ROBERT A	2170	34
CK DENNIS F	4026	35
RB N BRADLEY	1416	36
ISTETTER D E	1845	37
BARD GEORGE R	3871	38
SDEL GEORGE F	4550	39
ASKEN JOHN C	4998	40
RRENCE DAVID E	5047	41
HAM R S	5133	42
SUS STEPHEN J	5166	43
NDELAD M T	5256	44
EY STEPHEN L	5307	45
ENER D E	7149	46
TEVENS SCOTT H	8151	47
EEL RONALD F	8197	48

EXHIBIT "E"

*** AIMS COURSE ROSTER ***

JOB 210012 10/06/69 11.32.54
PAGE 1

NAME	ACAD NUM.	NO. CAP INDX.	SAT MATH	SAT VERB	CALC	CHEM	MATH ACH	RANK	COMMENTS	CRSE DROP	DATE ENTERED	DATE DROPPED
LAWRENCE DAVID E	4062	41 56	607	473	0	0	693	162		0	09/30/69	
INHAR R	5156	42 67	684	610	0	0	730	157		0	09/30/69	
OGUE STEPHEN J	5166	43 70	720	656	0	0	698	157		0	09/30/69	
UNDBLAD M T	5256	44 60	678	502	0	0	650	160		0	09/30/69	
CNEY STEPHEN L	7602	45 73	741	605	0	0	800	172		0	09/30/69	
ECKINGER D W	7749	46 63	659	518	0	0	680	252		0	09/30/69	
STEVENS SCOTT H	8504	47 72	732	522	0	0	740	347		0	09/30/69	
TEPLY JOHN F	8610	48 64	630	548	0	0	654	347		0	09/30/69	
BALLPARK W W	9114	49 74	678	644	0	0	698	440		0	09/30/69	
WATHOOD W S	9177	50 65	684	507	0	0	769	157		0	09/30/69	
VETTERLIN M S	9303	51 62	605	708	0	0	565	252		0	09/30/69	
GORLEY DENNIS L	9611	52 61	614	534	0	0	631	345		0	09/30/69	
AKERS CARL W	0056	53 64	704	589	0	0	611	167		0	09/30/69	
BALDWIN JAMES L	0020	54 59	627	498	0	0	643	255		0	09/30/69	
CARLSON GERALD P	1211	55 56	587	509	0	0	687	160		0	09/30/69	
CURTIS ROBERT C	1703	56 67	732	596	0	0	650	162		0	09/30/69	
GILL TIMOTHY J	2556	57 67	685	704	0	0	643	160		0	09/30/69	
HE[illegible] HRISTOP R	3601	58 71	694	637	0	0	654	345		0	09/30/69	
BIE LARRY A	3703	59 63	684	603	0	0	596	165		0	09/30/69	
HOF WILLIAM F	3903	60 64	636	692	0	0	639	162		0	09/30/69	
DUNN KENNETH F	3815	61 62	650	547	0	0	693	165		0	09/30/69	
JOHNSON GLENN L	4156	62 74	764	690	0	0	690	157		0	09/30/69	
KENNEDY T S	4460	63 69	705	534	0	0	753	250		0	09/30/69	
KRATSCHVIL D A	5776	64 68	732	548	0	0	736	157		0	09/30/69	
KUBOL LAWRENCE H	6002	65 74	756	642	0	0	736	180		0	09/30/69	
MITANI MICHAEL K	6057	66 58	623	605	0	0	574	170		0	09/30/69	
PERREAULT MARK D	6776	67 69	684	699	0	0	639	250		0	09/30/69	
PORLSTONE D R	7092	68 69	704	522	0	0	753	255		0	09/30/69	
RUSSOW GEORGE W	7676	69 65	678	551	0	0	610	345		0	09/30/69	
SMITH DAVID E	8029	70 83	732	628	0	0	720	640		0	09/30/69	
SMITH GARY E	8056	71 54	587	521	0	0	609	162		0	09/30/69	
STENDER R G	8323	72 75	742	573	0	0	753	345		0	09/30/69	
ZOKA MICHAEL A	8560	73 61	655	562	0	0	661	167		0	09/30/69	
ONL NEDWIN L	8759	74 75	723	656	0	0	775	250		0	09/30/69	
AUGHN DAVID R	8967	75 54	599	515	0	0	587	165		0	09/30/69	
ESSEL KENNETH J	9275	76 64	713	493	0	0	639	250		0	09/30/69	
GGE CONRAD J	9587	77 68	712	623	0	0	690	162		0	09/30/69	
DD CHARLES A	9588	78 55	588	582	0	0	574	167		0	09/30/69	
PELGATE J A	0101	79 61	614	618	0	0	620	250		0	09/30/69	
EDE ALBERT F	0249	80 62	655	507	0	0	598	345		0	09/30/69	

THERE ARE 182 RECORDS IN THE STUDENT FILE
OF THESE 182 STUDENTS REMAIN IN THE COURSE

EXHIBIT "H"

STUDENT DROP CARD

Column Number	Heading
1 - 20	Student Name
21 - 77	Blank
78 - 80	Student Number

*** AIMS COURSE DESRIPTION ***
PERMANENT FILE

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COURSE 21 LESSON 1 SEGMENT 1 TYPE 1 CONSISTS OF 1 CARD. RECORD 1
THERE ARE 12 QUESTIONS, EACH OF UP TO 5 ANSWERS. 12 WILL BE GRADED. THERE ARE 48 POSSIBLE SELECTIONS.

1	2	3	4	5	6	7	8	9	10	11	12
A	A	A	A	A	A	A	A	A	A	A	A

COURSE 21 LESSON 1 SEGMENT 1 TYPE 2 CONSISTS OF 1 CARD. RECORD 2
THERE ARE 16 QUESTIONS, EACH OF UP TO 5 ANSWERS. 16 WILL BE GRADED. THERE ARE 64 POSSIBLE SELECTIONS.

1	2	3	4	5	6	7	8	9	10	11
A	A	A	A	A	A	A	A	A	A	A
13	14	15	16							
A	A	A	A							

EXHIBIT "I"

COURSE 21 LESSON 1 SEGMENT 1 TYPE 4 CONSISTS OF 1 CARD. RECORD 3
THERE ARE 24 QUESTIONS, EACH OF UP TO 5 ANSWERS. 24 WILL BE GRADED. THERE ARE 96 POSSIBLE SELECTIONS.

1	2	3	4	5	6	7	8	9	10	11
B	C	C	D	A	D	C	A	B	B	D
13	14	15	16	17	18	19	20	21	22	23
D	C	B	C	A	B	B	C	D	C	A

COURSE 21 LESSON 1 SEGMENT 2 TYPE 4 CONSISTS OF 1 CARD. RECORD 4
THERE ARE 24 QUESTIONS, EACH OF UP TO 5 ANSWERS. 24 WILL BE GRADED. THERE ARE 96 POSSIBLE SELECTIONS.

1	2	3	4	5	6	7	8	9	10	11	12
C	B	B	A	C	B	C	A	C	A	D	C
13	14	15	16	17	18	19	20	21	22	23	24
A	D	D	A	C	A	D	D	B	D	A	C

COURSE STRUCTURE SUMMARY

COURSE NO. 32 COURSE NAME PHYSICS S211

VOLUME	SEGMENT	TYPE	QUESTION	TO	FO	DESCRIPTION	PRESCRIPTION	ANSWER
1	1	2	1	21	11	3045 G.C.F. 30-203-1-5/11-3-5/	50-91-1,2,5,7,8/40-59-1-8	B
1	1	2	2	21	12	3066 L.C.M. 11-8-14/40-69-2-3/	500-254-1-9/40-221-1-3	A
1	1	2	3	11	11	3055 NUMERATORS 40-219-1-6/	40-221-1-3/50-205-1-5	D
1	1	2	4	11	12	3056 DENOMINATORS 30-193-1-2/	30-192-1-5/50-237-1-3	C
1	1	2	5	12	21	3043 ORDERING LIKE FRACTIONS	30-186-1-4/500-214-1-5	D
1	1	2	6	12	23	3078 ORDERING UNLIKE FRACTIONS	11-9-16/40-149-1-5	C
1	1	2	7	12	22	3044 ORDERING LIKE FRACTIONS	30-187-1-4/11-1-2	A
1	1	2	8	21	14	3048 MULTIPLY BY ONE 11-2-3/	50-218-19-1-6	C
1	1	2	9	21	17	3051 LOWEST TERMS 50-218-20-1-8/	11-2-4/11-3-6/11-3-5	C
1	1	2	10	22	23	3083 ADD LIKE FRACTIONS	40-219-1-3/50-236-1-2	E
2	1	2	1	21	11	3045 G.C.F. 50-90-1-1-8/	11-3-6/50-87-1-3	D
2	1	2	2	21	12	3066 L.C.M. 50-253-1-11/	50-257 1-5/50-252-1-4	C
2	1	2	3	22	23	3083 ADDING LIKE FRACTIONS	50-237-1-3/30-201-1-4	A
2	1	2	4	12	23	3078 ORDERING UNLIKE FRACTIONS	11-9-16/50-215-1-4	C
2	1	2	5	12	21	3043 ORDERING LIKE FRACTIONS	30-193-1-7/50-210-1-4	B
2	1	2	6	12	22	3044 ORDERING LIKE FRACTIONS	11-1-2/30-186-7-1-4	E
2	1	2	7	21	14	3048 MULTIPLY BY ONE 50-221-1-6/	40-151-1-2/40-152-1-2	A
2	1	2	8	21	17	3051 FACTOR NUM. AND DENOM.	11-3,5/50-241-1-6	D
2	1	2	9	11	11	3055 NUMERATOR 50-203-2/	30-193-1-7/30-310-1-5	B
2	1	2	10	11	12	3056 DENOMINATOR 50-205 2-5/	30-327-1/30-192-1-5	D
3	1	2	1	21	18	3070 L.C.D. 30-206-7-1-6/	11-7-12/50-257-1-5/11-7-1	D
3	1	2	2	21	10	3093 EQUIVALENT FRACTION 11-2-4/	40-217-1-4/30-203-1-5	C
3	1	2	3	22	21	3088 ADDITION OF UNIT FRACTIONS	40-235-1-2/30-201-1-4	A
3	1	2	4	22	22	3087 ADD. UNIT AND COMMON FRACTION	30-207-4-6/20-82-1-7	B
3	1	2	5	22	23	3083 ADDITION OF COMMON FRACTIONS	50-250-1-2/400-221 1-3	D
3	1	2	6	22	24	3084 ADDITION OF COMMON FRACTIONS	40-224-1-6/50-239-1-5	A
3	1	2	7	22	25	3089 50-221-1-6/11-3-6/40-217-1-4/11-3-5		C
3	1	2	8	12	24	3080 ORDERING IMPROPER FRACTIONS	11-4-7/30-204-1/11-9-12	B
3	1	2	9	23	32	3085 CHANGE IMPROP.FRACT.TO MIXED&	50-230-1-5/40-224-1-6	A
3	1	2	10	23	35	3081 EQUIV. IMPROP.FRACT.&MIXED &	30-204-1-5/40-147-4-8	D
4	1	2	1	21	10	3093 EQUIVALENT FRACTIONS	30-185-1-6/11-2-4/11-2-3	B
4	1	2	2	21	18	3070 L.C.D. 30-184-1-3/11 8-15/	11 7-13/11 7-12	C
4	1	2	3	22	22	3087 ADD.UNIT FRACT.&COMMON FRACT.	60-248-1/30-201-1-4	E
4	1	2	4	22	21	3088 ADDITION OF UNIT FRACTIONS	50-235-1-3/40-219-1-3	C
4	1	2	5	22	23	3083 ADDING COMMON FRACTIONS	50-424-2/50-423-3-4	A
4	1	2	6	22	25	3089 SIMPLEST FORM 50-238-3-4/	30-188-1-6/11 3-5/11 3-6	D
4	1	2	7	22	24	3084 ADDING COMMON FRACTIONS	50-240-2-5/30-202-1-5	B
4	1	2	8	12	24	3080 ORDERING IMPROPER FRACTIONS	60-243-1-8/11-4-7	D
4	1	2	9	23	32	3085 CHANGE IMPROP.FRACT.TOMIXED&	50-240 1-4/50-238-1-4	D
4	1	2	10	3	35	3081 EQUIVALENT VALUES	50-240-2-5/50-238-1-4	A

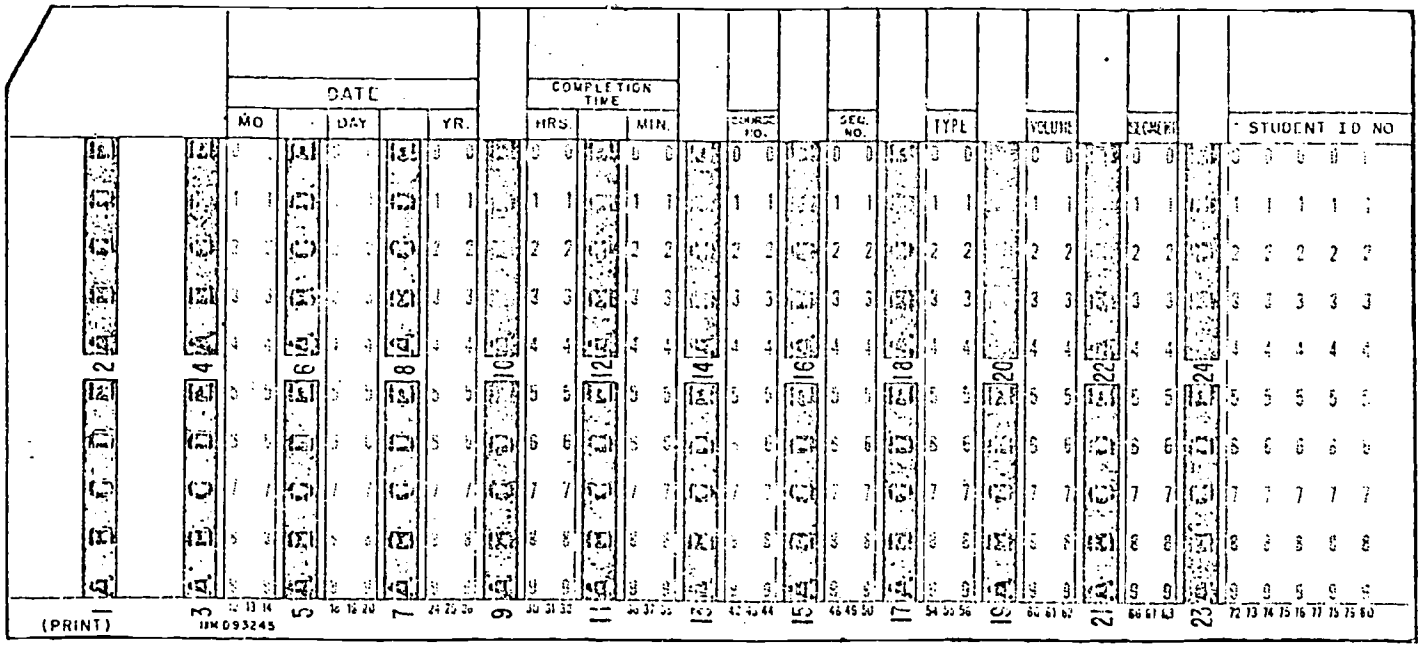
END OF PROCESSING

EXHIBIT "J"

EXHIBIT "K"

PORT-A-PUNCH

5 Choice Format



4 Choice Format

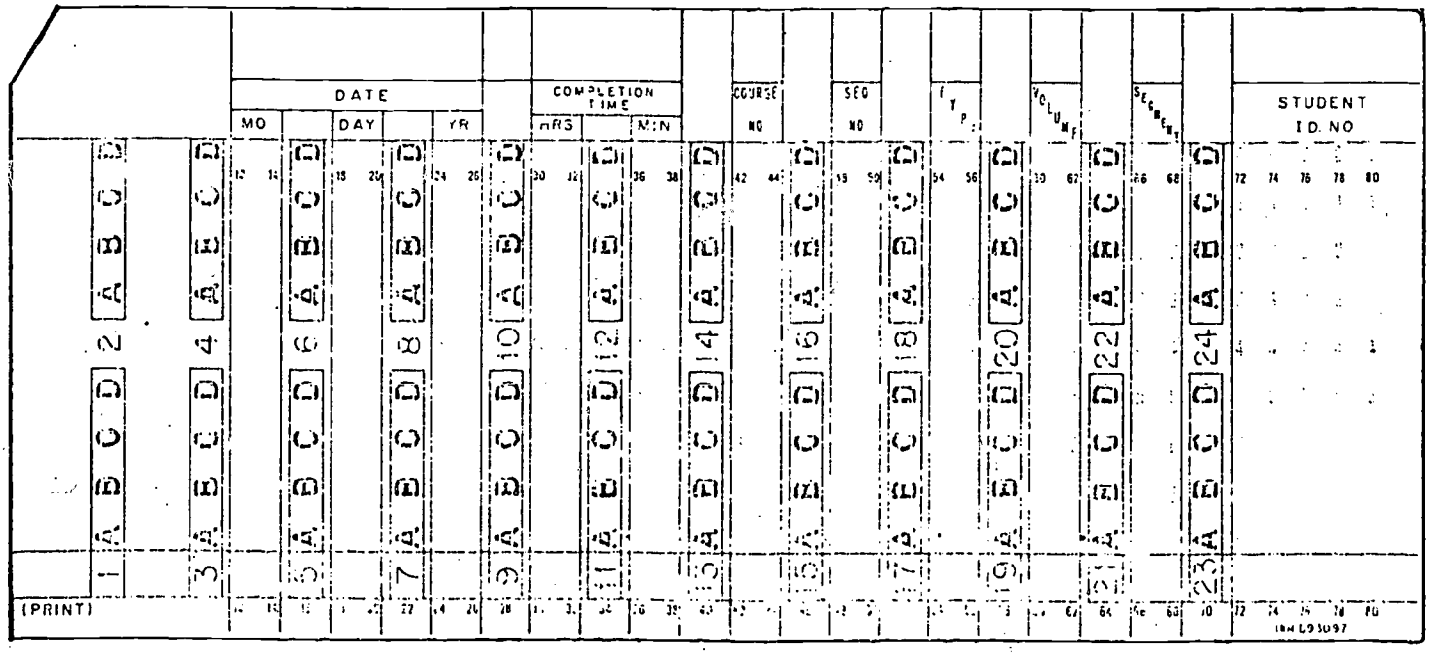


EXHIBIT "L"

PORT-A-PUNCH STUDENT RESPONSE CARD

Column Number	Heading
2, 6, 8	CSN (Course Student Number)
	Date
12, 14	Month
18, 20	Day
24, 26	Year
	Completion Time
30, 32	Hours
36, 38	Minutes
42, 44	Course Number
48, 50	Sequence Number
54, 56	Type
60, 62	Volume
66, 68	Segment
72, 74, 76, 78, 80	Student I.D. Number
Shaded Columns Between Columns of Data	Responses

The student's answer to each question is punched in the shaded column on the card.

EXHIBIT "M"

Student Response OpScan Form

DATA CONTENT

Student Name

Data

Social Security Number

Course Number

Completion Time

Volume

Segment

Type

Page Number

The student fills in the answer by marking the appropriate box (multiple choice) with a dark pencil.

EXHIBIT "N"

INSTRUCTIONS FOR COMPLETING
STUDENT DIAGNOSTIC ANSWER SHEET

(STUDENT RESPONSE)

(Sample attached)

1. Print name in space provided (last name first).
2. Write date in space provided.
3. Write Academy student number below name.
4. Write Section Number below data.
5. Familiarize yourself with the answer sheet. Record your answers in pencil by placing a mark in the appropriate box. Note that only the first 31 responses apply to this diagnostic.
6. If the multiple-choice answers are A, B, C, D, use box 1 for A; box 2 for B, etc.

STUDENT NAME

SOCIAL SECURITY NUMBER

COMPLETION TIME

VOLUME

COURSE NUMBER

TYPE

HOME WORK

ASSIGNMENT

AUDIO VISUAL

POST TEST

PRE TEST

1	6	11	16	21	
2	7	12	17	22	
3	8	13	18	23	
4	9	14	19	24	
5	10	15	20	25	
26	31	36	41	46	
27	32	37	42	47	
28	33	38	43	48	
29	34	39	44	49	
30	35	40	45	50	
51	56	61	66	71	
52	57	62	67	72	
53	58	63	68	73	
54	59	64	69	74	
55	60	65	70	75	
76	81	86	91	96	
77	82	87	92	97	
78	83	88	93	98	
79	84	89	94	99	
80	85	90	95	100	

EDUMATOR

[redacted] I.D. NUMBER [redacted]

STUDENT IDENTIFIED ABOVE HAS PERFORMED BELOW PRE-SET LEVELS OF PERFORMANCE ON TERMINAL OBJECTIVE(S) IN LESSON 1

PERFORMANCE DATA

T.O.	PERCENT ERR	CUTOFF LEVEL
21	8	33
22	8	33
33	14	33
41	10	33
43	8	33
51	27	33
52	50	33

EXHIBIT "O"

TERMINAL OBJECTIVE REMEDIAL SUMMARY

LESSON 1 TERMINAL OBJECTIVE 52 COMPOSED OF 4 QUESTIONS.

A TOTAL OF 1 STUDENTS PERFORMED BELOW THE CUTOFF LEVEL SET AT 33

FOLLOWING STUDENTS HAVE PERFORMED BELOW THE CUTOFF LEVEL-

NAME OF STUDENT	I.D. NO.	PERCENT ERROR
[redacted]	[redacted]	50

EXHIBIT 1

REMEDIAL SESSION - LESSON PLAN - LESSON 1

SESSION 1 PROF. AND/OR LOCATION PROFESSOR SMITH - ROOM 100

TERMINAL OBJECTIVE	CUTOFF LEVEL	NO. OF STUDENTS
52	33	1

EXHIBIT 'Q'

**** A.I.M.S. REPORT GENERATOR **** REPORT NUMBER 7 **** TIME - 14.48.45 DATE -04/28/70 PAGE NUMBER 1

REMEDIAL SESSION ROSTER

LESSON 1

SESSION 1

PROF AND/OR LOCATION- PROFESSOR SMITH - ROOM 100

TERMINAL OBJECTIVES

TERMINAL OBJECTIVE NUMBERS- 52

THRESHOLD LEVELS SET AT - 33

HE FOLLOWING STUDENTS HAVE BEEN ASSIGNED TO THIS REMEDIAL SESSION

STUDENT NAME	NUMBER	PERCENTAGE ERROR ON THE ABOVE TERMINAL OBJECTIVES
[redacted]	23	50

ND OF AIMS OUTPUT GENERATOR

EXHIBIT "R"

*** VOLUME SUMMARY ***

COURSE, 3 2)) VOLUME NO. 2

NOTE, THE ** SIGNIFIES THAT NO MATERIALS HAVE BEEN SUBMITTED FOR PROCESSING

STUDENT	CSN	PRE. TEST	STUDY GDE(1)	STUDY GDE(2)	STUDY GDE(3)	STUDY GDE(4)	STUDY GDE(5)	ASSIGN	HOME WORK	POST TEST	PERF. INDEX	CUM. AVE.	CAPL. INDEX
SKINS ANASTASIA	1	10.	76.	99.	74.	0.	0.	0.**	0.**	0.**	49.	41.	170.
EDWARD VALERIE	2	30.	98.	98.	98.	0.	0.	0.**	0.**	0.**	58.	36.	146.
PROUT GLENN	3	10.	93.	97.	91.	0.	0.	0.**	0.**	50.	56.	42.	139.
[illegible] MARC	4	10.	95.	85.	100.	0.	0.	0.**	0.**	10.	56.	4.	141.
PERRY REGINALD LEE	5	0.**	63.	30.	80.	0.	0.	0.**	0.**	60.	34.	59.	132.
NOONAN LORETTA CAROLYN	6	10.	84.	82.	82.	0.	0.	0.**	0.**	60.	49.	41.	143.
VILLE VIVIAN MADELINE	7	0.**	0.**	0.**	54.	0.**	0.**	0.**	0.**	40.	54.	21.	139.
S CRYSTAL	8	0.**	0.**	0.**	0.**	0.**	0.**	0.**	0.**	40.	0.	47.	157.
TAIS WAYNE DOUGLAS	9	0.**	96.	85.	98.	0.	0.	0.**	0.**	60.	55.	58.	142.
Y GARY XAVIER	10	0.	88.	92.	88.	0.	0.	0.**	0.**	30.	53.	32.	48.
ER WAYNA DENEASE	11	0.**	83.	95.	93.	0.	0.	0.**	55.	60.	54.	54.	144.
E BABES ARTHUR JR.	12	THIS STUDENT DOES NOT HAVE ANY MATERIALS TO BE PROCESSED											
E CONNIE JO.	13	0.**	100.	99.	99.	0.**	0.	0.**	0.**	40.	74.	35.	
SON ANGELA DEBORA	14	0.	89.	90.	99.	0.	0.	0.**	0.**	40.	55.	36.	
SON CORTIS BENJAMIN	15	20.	89.	0.**	94.	0.**	0.**	0.**	28.	20.	70.	20.	
COX CARL CRAIG	16	0.**	0.**	80.	91.	0.	0.	0.**	0.**	30.	42.	37.	
C ELDA DEBORAH	17	0.**	0.**	83.	88.	0.	0.	0.**	0.**	60.	42.	53.	
COX JAMES FLOYD	18	0.**	94.	81.	0.**	0.	0.	0.**	0.**	10.	43.	16.	
S ANTHONY GARY	19	0.**	0.**	0.**	0.**	0.	0.	0.**	0.**	20.	0.	27.	
[illegible] BARBARA JAE	20	40.	0.**	0.**	100.	0.	0.	0.**	0.**	20.	33.	28.	
ARD FAITH ISABELLE	21	0.**	69.	71.	42.	0.	0.	0.**	0.**	0.**	36.	26.	
PUTTLE ARDENIA	22	20.	0.**	15.	0.**	0.	0.	0.**	0.**	60.	5.	48.	
AY RAY R.	23	40.	0.**	0.**	0.**	0.**	0.**	0.**	0.**	0.**	0.	37.	
PAM CLARA ANN	24	60.	100.	0.**	97.	0.	0.	0.**	0.**	80.	49.	78.	154.
ASIEL STEPHEN LEROY	25	40.	76.	0.**	78.	0.**	0.	0.**	0.**	0.**	51.	27.	122.
LS VIOLET ISELLA	26	10.	97.	76.	70.	0.	0.	0.**	43.	30.	47.	43.	139.
T GREGORY WAYNE	27	0.**	0.**	0.**	50.	0.	0.	0.**	0.**	50.	16.	41.	125.
RANDALL LIGH	28	0.**	0.**	0.**	47.	0.**	0.	0.**	0.**	0.**	23.	43.	265.
BUCE RACHELLE G.	29	0.**	0.**	0.**	0.**	0.**	0.	0.**	0.**	60.	0.	33.	152.
MARY	30	30.	87.	95.	85.	0.	0.	0.**	25.	10.	48.	30.	133.
DIANE	31	20.	100.	10.	0.**	0.**	0.	0.**	0.**	10.	36.	21.	151.
[illegible]	32	10.	63.	54.	83.	0.	0.	0.**	0.**	0.**	40.	37.	131.
[illegible] TERESA	33	20.	77.	65.	81.	0.	0.	0.**	0.**	60.	44.	41.	144.
[illegible] VERNAL	34	40.	98.	87.	89.	0.	0.	0.**	0.**	50.	54.	53.	125.
[illegible] MARIE C	35	0.**	83.	74.	86.	0.	0.	0.**	37.	20.	46.	32.	151.
[illegible] VANDERVILLE	36	10.	0.**	80.	76.	0.	0.	0.**	0.**	40.	39.	34.	118.
[illegible] CECELIA	37	40.	74.	75.	97.	0.	0.	0.**	0.**	0.**	49.	30.	127.
[illegible] ELAINE	38	0.**	83.	90.	83.	0.	0.	0.**	0.**	60.	51.	58.	141.

3. PERFORMANCE DATA ANALYSIS FOR COURSE REVISION AND OPTIMIZATION

3.1 SYSTEMS DESCRIPTION

SYSTEM MANUAL

Annapolis Evaluation

I. INTRODUCTION

This document is intended to describe the structure and operation of the Evaluation System generated for use with Annapolis data files. The system has been designed to isolate, subject to constraint, desired variable subsets and to perform a wide range of statistical analyses and tests pertinent to evaluations of experimental results.

II. STRUCTURE

The Evaluation system consists of three major components.

Data Files - containing all information generated in the course of the experiment.

Accessing Routine - Program for generating any constrained subset of data from the files.

Statistical Routine - Permits user selection of desired statistical tests and summaries pertinent to data evaluation.

II.1 DATA FILES

All information gathered in the course of the experiment is contained in eight master data files. The structure of these files is listed in Table II.1 - II.8 as well as array dimensions needed to write out the fields and frequency of recording data (See Appendix 1).

II.2 ACCESSING ROUTINE

II.2.1 OPERATING CAPABILITIES

This segment can be defined as the interface between the user, the data files, and the statistical components of the system. Its purpose is to retrieve information from the files to the degree of specification or constraint required by the user. The system is able to:

A. Retrieve the observations stored on any one or more than one requested variable. These requested variables may be of:

   i. The same type; i.e., student average confidence for posttest A, for posttest C, and for posttest I--here student average confidence is the variable and there are three variables of the same type requested for each posttest.

   ii. Different types; i.e., retrieve average student confidence and the average student log confidence for posttest A--here there are two variables, average student confidence and average student log confidence.

B. Treat all constraints on variables sequentially in the order that they are imposed by the user. There are two types of constraints, descriptive constraints and limiting constraints. (The descriptive constraints should be specified first sequentially by the user.)

i. Descriptive constraints are constraints necessary to define the proper subset of the desired variable.

ii. Limiting constraints are necessary for isolating or partitioning the subset of the desired variable;

i.e., retrieve the posttest scores of the audiovisual group, for posttest D, for students who scored under 80 for that test and where IQ was in the range of 100 to 130 and whose SAT Math marks were under 100.

In this example the variable is posttest scores. There are two descriptive constraints, the group of students (audiovisual) and the particular posttest (posttest D) and three limiting constraints, the actual score for the test (only students who scored less than 80), the students IQ and the SAT Math scores.

C. The maximum number of constraints that can be placed on a particular variable is twenty (20). Any combination of descriptive and limiting constraints which add up to twenty or less will be acceptable.

II. 2.2 USER INPUT

The following is a definition of user input required for retrieval of data

X - the quantity X is the variable under consideration, for example, post scores or average student confidences

Z_i - where i can go from 1 to 20. The quantity Z_i is the ith parameter

either limiting or descriptive, to be held in constraint in a definition of the group X.

A_{1i} - the lower limit for the ith constraint

A_{2i} - the upper limit for the ith constraint such that

$$A_{1i} \leq Z_i \leq A_{2i}$$

For each variable, the user must provide a variable definition card containing the numerical value of X and alphanumeric information which will be a definition of X. For each constraint (limiting or descriptive) to be placed on that variable, the user must provide one card containing the numerical code for the Z_i and the upper and lower limits under which Z_i will be held, A_{1i} and A_{2i} and alphanumeric information descriptive of the constraint.

The above definitions are straightforward when the user requests a single set of data. When, however, he wishes to retrieve more than one group, each group must be separately defined by a variable definition card and a set of constraint cards pertaining to that group.

II. 3. STATISTICAL ROUTINE

II. 3.1 OPERATING CAPABILITIES

It is the purpose of this portion of the system to perform required statistical tasks on the accessed data as specified by user input. In the performance of these tasks the system will

A - set an output "Flag" if the user requests a listing of the accessed data

B - compile a list of statistics (i.e., mean, standard deviation, range, etc.) to be computed in the statistic generation routine. The sources of this list are the direct and indirect commands by the user.

i - The direct commands require a card input by the user identifying each statistic to be computed.

ii - The indirect commands result from the user specification of a statistical test to be performed (i.e., if the user determines that a "t" test should be performed on two sets of data then the means, standard deviations and sample sizes of each of the sets are computed and entered in the call statement for the "t" test subroutine. These three statistics will then be compared to the existing

list of statistics and added to that list as required).

C - Call the statistic generation routine, indicating in the call statement the statistics to be computed and whether or not a listing of the data is requested by the user.

D - Call each of the requested statistical subroutines, setting in the call statement the magnitude of the statistics which have been computed for that test.

II. 3.2 USER INPUT

There are three types of user input required for the selection routine:

A. A zero-one indication for "no-listing" of the data that is being processed.

B. A list of all statistics to be computed (this is required only for direct statistic specification described above). Table II.10 contains list of possible statistics that can be computed for a single variable, and Table II.11 those statistics applicable to two variables.

C. A list of statistical tests to be performed on the accessed data. Table II.12 contains a list of possible tests, as well as a summary of internal quantities calculated for each test and transmitted to the particular test subroutine.

TABLE II.10 - STATISTICAL COMPUTATIONS

- SINGLE VARIABLE

1 - Count - to count the number observations in a set

2 - Sum of the observations

3 - Sum of the squares of the observations

4 - Mean value of the set

5 - Variance of the set

6 - Standard deviation of the set

7 - Minimum and maximum values of the set

8 - Range of observations in the set

9 - Ranks of each observation in the set

TABLE II.11 - STATISTICAL COMPUTATIONS

- TWO VARIABLES

1 - Sum of crossproducts of two variables

2 - Correlation coefficient between two variables

TABLE II.12

AVAILABLE TESTS AND ASSOCIATED
INTERNAL STATISTICAL COMPUTATIONS

TEST DESCRIPTION	STATISTICS TO BE COMPUTED	ADDITIONAL DATA TRANSMITTED
Student's t Test	Sample size Mean Standard deviation	None
F Test	Sample size Standard deviations	None
One-Way Analysis of Variance	No. of groups to be tested; for each group: sample size sum of observations sum of the squares of observations	
Wilcoxen signed Rank Test	Sample size for each group	Set of observations to be tested
Kendall coefficient of concordance	No. of groups Sample size of each group The rank of observations within each group	
Chi-Square Test	No. of groups No. of cells in each group No. of observations in each cell	
Cochran's Test	Sample size Standard deviations	
Least Significant Difference Test	Sample sizes Means Variances	

II. 3.3 STATISTICAL SUBROUTINES

The following part of Section 3 contains the detailed specifications for each of the statistical subroutines listed in Section 3.2. The specification includes required input, computations made within the subroutine, and the output. In addition, a reference text for each statistical test is included.

(1) Student's t test

Reference: John E. Freund, Mathematical Statistics, Prentice Hall, 1963.

To test the hypothesis that two sampled means are equal

Input:

- $(\bar{x}_1, \bar{x}_2)$ the means for the two samples,
- (δ_1^2, δ_2^2) the variances for the two samples, and
- (n_1, n_2) the number of observations in each of the two samples.

Computations:

- Degrees of freedom of the test = $n_1 + n_2 - 2$
- The t statistic = $$\frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{n_1 + n_2 - 2}}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Output:

- The summary statistics (mean, variance, and sample size) for each of the two samples:
- Degrees of freedom of the test.
- The t Statistic.

(2) F test - for testing the hypothesis that two variances are equal

Reference: Same.

Input:

- (s_1^2, s_2^2) the variances for the two samples, and
- (n_1, n_2) the number of observations in each of the two samples.

Computations:

- F statistic = $\dfrac{\text{Maximum } (s_1^2, s_2^2)}{\text{Mininum } (s_1^2, s_2^2)}$
- Degrees of freedom of numerator = $n_i - 1$, where i is equal to one or two, corresponding to which of the two sampled variances is the largest.
- Degrees of freedom of the denominator = $n_i - 1$, where i corresponds to the smaller of the two.

Output:

- The summary statistics (mean and variance) of the two samples.
- The F statistics.
- The degrees of freedom of the numerator and denominator.

(3) One-way analysis of variance program

Reference: Johnson & Leone, Statistics and Experimental Design, John Wiley, 1967.

Input: Each of the h vectors to be compared

	t = 1	t = 2	...	t = h
i = 1	X_{11}	X_{21}	...	X_{h1}
i = 2	X_{12}	X_{22}	...	X_{h2}
n rows	.	.		.
	.	.		.
	.	.		.
i = n	X_{1n}	X_{2n}	...	X_{hn}

Compute:

- $\bar{x}_{1\cdot}, \bar{x}_{2\cdot}, \cdots, \bar{x}_{h\cdot}$ where $\bar{x}_{1\cdot} = \left[\sum_{i=1}^{n} X_{1i} \right] / n$

- $S_1 = \text{SQRT} \left[\sum_{i=1}^{n} (X_{1i} - \bar{x}_{1\cdot})^2 / \quad \right]$

- $GTI = \sum_{t=1}^{h} \sum_{i=1}^{n} X_{ti}^2 = X_{11}^2 + X_{12}^2 + \cdots + X_{hn}^2$

- $G = (nh)^{-1} \left[\sum_{t=1}^{h} \sum_{i=1}^{n} X_{ti} \right]^2$

- $GT = (n)^{-1} \left[\sum_{t=1}^{h} \sum_{i=1}^{n} X_{ti} \right]^2$

$$(n)^{-1} \left[(X_{11} + X_{12} + \cdots + X_{1n})^2 + \cdots + (X_{h1} + \cdots + X_{hn})^2 \right]$$

Output:

- Listing of data in columns, listing of mean and standard deviation of each column at the bottom of each column.
- Table of the analysis of variance as follows:

One-Way Analysis of Variance of the Measured Parameter

Source	Sum of Squares	Degrees Freedom	Mean Square	F-Ratio
Total	GTI-G	nh-1		
Between Groups	GT-G	h-1	$\frac{GT-G}{h-1}$	
Within Groups	GTI-GT	nh-h	$\frac{GTI-GT}{nh-h}$	$\left\{ \frac{\frac{GT-G}{h-1}}{\frac{GTI-GT}{nh-h}} \right\}$

(4) The chi-square test - for K independent samples

Reference: Siegel, Non-Parametric Statistics, McGraw-Hill, 1956.

Input:

K = No. of columns (no. of independent samples)

R = No. of rows (no. of categories)

X = a KR matrix with elements

$[X_{ij}]$ = No. of observations falling into the ith category of the jth sample

NOTE: X_{ij} is also called the observed frequency per cell

Compute:

- Degrees of fredom = (R - 1) (K - 1)

- Each row sum $RS_i = \sum_{j=1}^{K} X_{ij}$

- Each column sum $CS_j = \sum_{i=1}^{R} X_{ij}$

- Sum of all rows or columns

$$TS = \sum_{i=1}^{R} RS_i = \sum_{j=1}^{K} CS_j = \sum_{i=1}^{R} \sum_{j=1}^{K} X_{ij}$$

- Compute expected frequency per cell (E_{ij})

$$E_{ij} = \frac{(RS_i)\ (CS_j)}{TS}$$

- Compute the chi-square test statistic

$$\chi^2 = \sum_{i=1}^{R} \sum_{j=1}^{K} \frac{(t_{ij} - E_{ij})^2}{E_{ij}}$$

Output:

No. of independent samples (K)

No. of categories per sample (R)

Degrees of freedom

Chi-square test statistic

(5) Kendall coefficient of concordance - to compute the concordance (agreement) between K rankings of a set of information

Reference: Siegel, Non-Parametric Statistics, McGraw-Hill, 1956.

Input:

X-matrix - which can be entered as a set of K vectors of observations or ranks of observations. The number of observations in each vector must be equal.

N = No. of subjects ranked

K = No. of different rankings

NOTE: The numerical value of the elements will probably be something other than ranks (i.e., test scores).

Computations:

Convert each of the column vectors into a column vector of ranks; i.e., if X_{ij} (i^{th} element (row) in the jth column) is the minimum value in that column, then it is assigned a rank, $r_{ij} = 1$.

If X_{ij} is the maximum value in the column, then it is assigned a rank, $r_{ij} = N$.

The remaining rules for ranking and for settling ties are exactly the same as for the Wilcoxen signed rank test.

NOTE: Each column must be ranked independently of the other columns.

The resulting matrix (noted R) is

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1K} \\ r_{21} & r_{22} & \cdots & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ r_{N1} & \cdot\ \cdot\ \cdot & & r_{NK} \end{pmatrix}$$

Where r_{ij} is the rank of X_{ij} - the rank of the ith element in the jth column.

Compute:

$$R_i = \sum_{j=1}^{K} r_{ij}$$

$$\Delta_i = R_i - \frac{\sum_{i=1}^{N} R_i}{N} \quad \text{and} \quad (\Delta_i)^2$$

Compute:

$$T_j = \frac{\Sigma(t^3 - t)}{12}$$

t = no. of observations in a group tied for a given rank. The computation of T_j is best explained through an example:

$$R = \begin{array}{c|ccc} & j = 1 & j = 2 & j - 3 = k \\ \hline i = 1 & 1 & 2.5 & 2 \\ 2 & 4.5 & 1 & 1 \\ 3 & 2 & 2.5 & 4.5 \\ 4 & 4.5 & 4.5 & 4.5 \\ 5 & 3 & 4.5 & 4.5 \\ 6 & 7.5 & 8 & 4.5 \\ 7 & 6 & 9 & 8 \\ 8 & 9 & 6.5 & 8 \\ 9 & 7.5 & 10 & 8 \\ i = 10 = N & 10 & 6.5 & 10 \end{array}$$

For j = 1 there are two sets of rank ties, each containing two ties, i.e., 2 - 4.5's

2 - 7.5's

Therefore, $T_1 = \frac{(2^3 - 2) + (2^3 - 2)}{12} = 1$

For j = 2 there are three sets of rank ties, i.e.,

2 — 2.5's

2 — 4.5's

2 — 6.5's

Therefore, $T_2 = \frac{(2^3 - 2) + (2^3 - 2) + (2^3 - 2)}{12} = 1.5$

For j = 1 there are two sets of rank ties,

4 — 4.5's

3 — 8's

Therefore, $T_3 = \frac{(4^3 - 4) + (3^3 - 3)}{12} = 7$

- Compute $\sum_{j=1}^{K} T_j$

- Compute $S = \sum_{i=1}^{N} (\Delta_i)^2$

- Kendall rank coefficient of concordance

$$N = \frac{S}{1/12(K)^2(N^3 - N) - K \sum_{j=1}^{N} T_j}$$

- The test statistic is the chi-square

chi-square test statistic (C) = K(N - 1)W

degrees of freedom (DF) = N - 1

Output

- Alphabetic description of the data
- Listing of the input matrix X
- Listing of the ranked matrix R and the computations R_i, Δ_i, and T_j.

	j = 1	2	3	...	K	R_i	Δ_i
i = 1	r_{11}	r_{12}	r_{13}	...	r_{1K}	R_1	Δ_1
2	r_{21}				.	.	.
.	.				.	.	.
.	.				.	.	.
.	.				.	.	.
N	R_{N1}	.	.	.	r_{NK}	R_N	Δ_N
T_j	T_1	T_2			T_K		

- Kendall rank coefficient of concordance (W)
- Chi-square test statistic (C)
- Degrees of freedom (DF)

(6) Wilcoxen matched pairs signed rank test

Reference: Siegel, Non-Parametric Statistics.

Input:

Two vectors (sets) of numbers:

Set A	Set B
X_{11}	X_{21}
X_{12}	X_{22}
.	.
.	.
.	.
X_{1n_1}	X_{2n_2}

Computations:

Count the number of items in each set,

n_1 = no. in Set A; n_2 = no. in Set B.

NOTE: If $n_1 = n_2$ set $n_1 = N'$

If $n_1 \neq n_2$, terminate the subroutine with the following message and output:

ERROR MESSAGE: "SAMPLES A AND B ARE NOT OF EQUAL LENGTH - WILCOXEN SIGNED RANK TEST REQUIRES A COMPLETE SET OF MATCHED PAIRS OF DATA"

- Compute the differences (d_i) - where $d_i = X_{1i} - X_{2i}$
- Compute the absolute value of differences $|d_i|$
- Numerically order the $|d_i|$ by magnitude
- Compute dummy ranks by assigning 0 when $|d_i| = 0$ and by assigning the numerical count to the remaining ordered $|d_i| > 0$
- Compute actual ranks via the following rules:
  - If $|d_i| = 0$; rank = 0
  - If $|d_i| \neq |d_{i-1}|$ and $|d_i| \neq |d_{i+1}|$; rank = dummy rank
  - If $|d_i| = |d_{i-1}|$ or $|d_i| = |d_{i+1}|$ or both, count the number of d_i's that are equal to B, sum over the associated dummy ranks, then

$$\text{actual rank} = \frac{\text{sum over dummy ranks}}{B}$$

(see examples A and B on previous page)

- Signed ranks — associate the sign of the original difference (plus or minus) to the actual ranks
- Sum up the positive ranks = T_1
- Sum up the negative ranks = T_2
- Determine T = minimum (T_1, T_2)
- Determine N = N' - number of pairs having a zero difference
- Computer $\mu_T = \frac{N(N+1)}{4}$

$$\sigma_T = \frac{N(N+1)\ (2N+1)}{24}$$

$$Z = \frac{T - \mu_T}{\sigma T}$$

Output:

- List of the two input vectors X_1 and X_2
- The sample size for each vector
- Wilcoxen Signed Rank Test
- Data table:

Set A	Set B	Differences	Ranks	Signed Ranks
X_{11}	X_{21}	d_1	r_1	$\pm r_1$
X_{12}	X_{22}	d_2	r_2	
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
X_{1N}	X_{2N}	d_N	r_N	$\pm r_N$

- Number of pairs (N')
- Number of pairs with zero difference
- Test sample size (N)
- Sum of positive ranks (T_1)
- Sum of negative ranks (T_2)
- Small sample size test statistic (for cases when ≤ 25)
- Wilcoxen test statistic (T)
- Large sample size test statistic (N > 25)
- Mean (μ_T)
- Standard deviation (σ_T)
- Normal approximation - Wilcoxen test statistic (Z)

(7) Cochran's Test - to compare K variances for homogeneity.

Reference: Statistics and Experimental Design, Johnson & Leone, Wiley 1957.

To test the hypothesis that K sampled variances are estimates of the same populations variance.

Input:

- $(S_1, S_2, \ldots, S_K)$ - the standard deviations for each of the K samples
- $(n_1, n_2, \ldots, n_K)$ - the sample sizes for each of the K samples

Computations:

- Compare K sample sizes for equality.

$$n_1 = n_2 = \ldots = n_K = N$$

- Degrees of freedom = N - 1
- Cochran test statistic

$$C = \frac{\text{MAXIMUM } S_t}{\sum_{t=1}^{K} S_t}$$

Output:

- Summary statistics, sample size and standard deviations for each of the K samples
- The Cochran test statistic.

(8) Least Significant Difference Test - to compare K means for equality

Reference: Experimental Statistics, M.G. Natrella, AMCP 706-110.

Input:

- $(S_1^2, S_2^2, \ldots, S_K^2)$ - the variances for each of the K samples
- $(\bar{X}_1, \bar{X}_2, \ldots, \bar{X}_K)$ - the means for each of the K samples
- (n_1, n_2, n_K) - the samples sizes for each of the K samples

Computations:

- pooled variance $S_e^2 = \dfrac{(n_1 - 1)\, S_1^2 + \ldots + (n_K - 1)\, S_K^2}{(n_1 + \ldots + n_K) - K}$
- harmonic sample size $n_H = \dfrac{K}{(1/n_1 + \ldots + 1/n_K)}$
- degrees of freedom $\nu = \sum_{i=1}^{K} (n_i - 1)$

w = maximum difference between any two of the K means

q = maximum difference converted to units of the standardized range statistic

$$q = \frac{\sqrt{n_H} \times w}{S_e}$$

Output:

- Summary statistics including S_e^2, n_H, ν, w, and q.
- Table of differences between means.

APPENDIX 1

AIMS DATA FILES

TABLE II.1a - STUDENT BACKGROUND FILE I

QUANTITY	LENGTH	DIMENSION
SS No.	4	1
Acad. Id. No.	2	1
*Stud. Name	16	1
Group No.	1	1
Sect. No.	2	1
SAT Math	2	1
SAT Verbal	2	1
CEEB Math	2	1
CEEB Verbal	2	1
Rank	2	1
Sec. Sem. Qpr.	2	1
Thrd. Sem. Qpr.	2	1

One Such Record Per Student.

*This field is EBCDIC (the only non-binary field in all 8 files).

TABLE II.1b - STUDENT BACKGROUND II

QUANTITY	LENGTH	DIMENSION
OSPE	2	4
OSPE	2	4
OSPE	2	4
OSPE	2	4
Strong Sc 1	2	65
Strong Sc 2	2	65
•	2	65
•	2	65
•	2	65
Strong Sc 65	2	65
EPP 1	2	16
EPP 2	2	16
•	2	16
•	2	16
•	2	16
EPP 16	2	16
Results of Physics Validation Test	2	

This is a continuation of the first file.

One Such Record Per Student.

TABLE II.2 - STUDENT PERFORMANCE I

QUANTITY	LENGTH	DIMENSION
Stud. Id.	2	
Group No.	1	
Sect. No.	2	
Vol.	1	
No. Ques.	2	
Corr/Inc.	1	20
Conf.	2	20
Log Conf.	2	20
Diff.	2	20
Tot. Corr.	2	
Avg. Conf.	2	
Avg. Log Conf.	2	
Avg. Diff.	2	

Sort Stud. Id., Vol.

One Such Record Per Volume Per Student.

TABLE II.3 - STUDENT PERFORMANCE I.1

QUANTITY	LENGTH	DIMENSION
Stud. Id.	2	
Group No.	1	
Sect. No.	2	
Vol.	1	
No. Ques.	2	
Corr/Inc.		20
Conf.	2	20
Log Conf.	2	20
Diff.	2	20
Tot. Corr.	2	
Avg. Conf.	2	
Avg. Log Conf.	2	
Avg. Diff.	2	

Sort by Stud. Id., Vol.

One Such Record Per Volume Per Student

TABLE II.4 - STUDENT PERFORMANCE III

QUANTITY	LENGTH	DIMENSION
Stud. Id.	2	
Group No.	1	
Sect. No.	2	
Corr/Inc.	1	60
Tot. Corr. 1	2	6
Tot. Corr. 2	2	6
Tot. Corr. 3	2	6
Tot. Corr. 4	2	6
Tot. Corr.	2	6

Sort by Stud. Id.

One Such Record Per Student.

TABLE II.5 - MATERIAL RATING I

QUANTITY	LENGTH	DIMENSION
Vo.	1	
Div. Nos.	2	3
No Yes	2	
Term Obj.	2	20
Item Class	2	20
Cocc/prin	2	20

Sort by Vol., [illegible] No.

One Such Record [illegible] Question Per Volume.

TABLE II.6 - MATERIAL RATING NO. II

IDENTITY	LENGTH	DIMENSION
Vol.	1	
Div.	2	3
Vol. No.	2	
Item Obj.	2	20
Item Process	2	20
Conc/prin	2	20
No Fac.	2	
Rating Diff.	2	
No. Scoring 1	2	20
	2	20
	2	20
No. Scoring 7	2	20
No. Scoring Conc.	2	20
No. Scoring TO	2	20

Sort by Vol., Div. No.

One Such Record Per Question Per Volume.

TABLE II.7 - MATERIAL RATIONALE III

QUANTITY	LENGTH	DIMENSION
No. Ques.	2	
Term. Obj.	2	60
Ques. Type	2	60
Sub Id.	2	60
Corr. Ans.	2	60
Fac Mth	2	60
Fac Conc.	2	60
No Scor.	2	60

Sort by Term. Obj

One Such Record Per Question Per Volume.

TABLE II.8 - STUDENTS TIME [illegible]

QUANTITY	LENGTH	DIMENSION
Stud. Id. (Acad. No.)	2	
Group No.	1	
Week No.	2	
Stud. Time	2	
Mean Time	2	
Overall Time	2	

Sort by Stud. Id., Week, Group No.

One Such Record Per Volume.

3.2 USER'S DESCRIPTION

ANNAPOLIS EVALUATION SYSTEM

VOL. 2 - USER'S MANUAL

I. INTRODUCTION

This document is intended to provide the information necessary for the preparation of input to the Annapolis Evaluation System. For a description of the contents of the system as well as a description of the nature of the tests involved, consult the "System Manual — Annapolis Evaluation."

II. USER INPUT SPECIFICATION

A complete user input specification consists of two fundamental input data blocks.

Accessing Input - needed to define the constrained data subset to be used for evaluation.

Statistical Input - needed to define the statistics and/or tests to be performed.

II.1 ACCESSING INPUT

Accessing input consists of naming the desired variable as well as specifying the constraints which serve to define the data subset. For each constraint a separate card must be submitted. There is an allowable maximum of 20 different constraints for each vector of output data.

The first of each set of conditions is the wanted variable and each successive card defines one constraint. The format is as follows:

File	Columns:	1
AC	"	3 - 4
Dimension 1	"	6 - 7
Dimension 2	"	9 - 10
Minimum	"	12 - 14
Maximum	"	16 - 18
Volume	"	20 - 21

where File, AC, Dimension 1, and Dimension 2 are described on the following pages.

Minimums and maximums are the lower and upper bounds desired by the user. The computer will use the minimum as the lower bound and the maximum as the upper bound (i.e., they will be used in the test, and if one is hit, the test will be considered successful). Volume selection goes from 1—15 covering volumes A through O.

If an alphabetic character is wanted as either an upper or lower bound, its equivalent number must be used where A = 1, B = 2, ..., Z = 26, as in the volume designation.

To signify one set of tests is over, the user must put a nine in the file position and leave the rest of the card blank. This nine must be used even if the user is specifying the maximum number of tests (i.e., 20).

The following pages give the File, AC, Dimension 1, and Dimension 2 for each piece of information. A dash signifies that that particular field cannot be used in a test.

NOTE 1: The input cards must be in sequence order, ascending according to the files (i.e., first, all the tests for file 1, then file 2, etc.). However, the first card must designate the wanted variable regardless of what file it is contained in (i.e., this card is not included in the aforementioned sequence).

NOTE 2: For a given variable constraints can be defined on either files 1–6 or 7–9 (material rating files), but not both.

File	AC	Dim 1	Dim 2	Field
1	1			SS Number
1	2			Academy Number (Id.)
1	-			Student Name
1	4			Group Number
1	5			Section Number
1	6			SAT Math
1	7			SAT Verbal
1	8			CEEB Math
1	9			CEEB Verbal
1	10			Rank in Class
1	11			Second Semester Qpr
1	12			Third Semester Qpr
1	-1	1		OSPE #1
1	-1	2		OSPE #2
1	-1	3		OSPE #3
1	-1	4		OSPE #4
1	-2	1 - 65		Strong Scores (1 - 65)
1	-3	1 - 16		Edwards Personnel Preference (#'s 1 - 16)
1	13			Physics Validation Test Results

COMMENT:

This record occurs once per student and is sorted by student Id.

File	AC	Dim 1	Dim 2	Field
2	1			Student Id
2	2			Group Number
2	3			Section Number
2	4			Volume
2	5			Number Questions
2	-1	*1 - 24	1	Correct/Incorrect
2	-1	*1 - 24	2	Confidence
2	-1	*1 - 24	3	Log Confidence
2	-1	*1 - 24	4	Difficulty
2	6			Total Number Correct
2	7			Average Confidence
2	8			Average Log Confidence
2	9			Average Difficulty

*This corresponds to the question number since these four fields occur for each question.

COMMENT:

This record occurs once per question and is sorted by Student Id., Volume.

File	AC	Dim 1	Dim 2	Field
3	1			Student Id.
3	2			Group Number
3	3			Section Number
3	4			Volume
3	5			Number Questions
3	-1	*1 - 24	1	Correct/Incorrect
3	-1	*1 - 24	2	Confidence
3	-1	*1 - 24	3	Log Confidence
3	-1	*1 - 24	4	Difficulty
3	6			Total Number Correct
3	7			Average Confidence
3	8			Average Log Confidence
3	9			Average Difficulty

*This corresponds to the question number since these four fields occur for each question.

COMMENT:

This record occurs once per question and is sorted by Student Id., Volume.

File	AC	Dim 1	Dim 2	Field
4	1			Student Id.
4	2			Section Number
4	-1	*1 - 64		Correct/Incorrect
4	-2	1		Total Correct Subtest #1
4	-2	2		Total Correct Subtest #2
4	-2	3		Total Correct Subtest #3
4	-2	4		Total Correct Subtest #4
4	-2	5		Total Correct for Test

*This corresponds to the question number since this field appears for each question.

COMMENT:

This record occurs once per question and is stored by Student Id.

File	AC	Dim 1	Dim 2	Field
5	1			Volume
5	-1	1 - 3		Division Numbers
5	2			Number of Questions
5	-2	1		Question Number
5	-2	2		Form
5	-2	3		Terminal Objective
5	-2	4		Item Classification
5	-2	5		Concept/Principle Code

COMMENT:

This record occurs once per question and is sorted by Question #, Volume, Form.

File	AC	Dim 1	Dim 2	Field
6	1			Volume
6	-1	1 - 3		Division Number
6	2			Number of Questions
6	-2	1		Question Number
6	-2	2		Form
6	-2	3		Terminal Objective
6	-2	4		Item Classification
6	-2	5		Concept/Principle Code
6	3			Number of Faculty Rating Difficulty
6	-3	*1 - 7		Number Scoring Math Category # 1 - 7
6	-4	*1 - 7		Number Scoring Concepts (Physics)
6	4			Number Scoring Inappropriate for TO

*This corresponds to the category numbers.

COMMENT:

This record occurs once per question and is sorted by Question #, Volume, Form.

File	AC	Dim 1	Dim 2	Field
7	1			Number of Questions
7	-1	1		Question Number
7	-1	2		Terminal Objective
7	-1	3		Question Type
7	-1	4		Subtest Id.
7	-1	5		Correct Answer
7	-2	*1 - 7		Faculty Math Difficulty
7	-3	*1 - 7		Faculty Math Concepts
7	2			Number Scoring Inappropriate for TO

*This corresponds to the 7 categories.

COMMENT:

This record occurs once per question and is sorted by Question number.

File	AC	Dim 1	Dim 2	Field
8	1			Student Id.
8	2			Group Number
8	3			Week Number
8	4			Student Time
8	5			Mean Time
8	6			Overall Time

COMMENT:

This record occurs once per week and is sorted by Student Id, week.

II.2 STATISTICAL INPUT

Statistical input consists of selecting the desired tests and computations to be performed on the accessed data as well as naming the accessed variables to be used in each test.

The following contains the detailed instructions for use of the statistical package including a list of all required and optional data cards, variable definition, and card format.

NOTE: If the statistical generation routine is called, all of the single variable computations will be made, except for ranking and sorting. If the user desires ranking and sorting for each vector, he must set ICODE1 = 1 in card (4).

Card No.	Required	Cols.	Format	Variable Name	Variable Description
1	Yes	1 - 2	I2	N	The number of vectors to be included in this sequence of analysis.
		4	II	LIST	= 1 Print out a summary of the vectors to be analyzed and a complete set of summary statistics. = 0 Do not print out the above summary.
2	Yes	1 - 2	I2	IR(1)	The number of observations in Vector 1.
		4 - 5	I2	IR(2)	The number of observations in Vector 2.
		.	.	.	.
		.	.	.	.
		.	.	.	.
		(3N-2) - (3N-1)	I2	IR(N)	The number of observations in Vector N.
3	Yes	1 - 4	F4.0	X(I,J)	The Ith data print observation in the Jth vector where J = 1, ..., N and I = 1, ..., IR(J).
		5 - 8	F4.0		
		.	.		
		.	.		
		.	.		

NOTE: Data cards 2 and 3 will be included only when inputed from cards.

Code No.	Required	Cols.	Format	Variable Name	Variable Description
4	Yes	1 - 4	I4	IND	= 0003 Compute all of the summary statistics for each of the N vectors being analyzed. ≠ 0003 Do not compute the summary statistics for each of the N vectors.

NOTE: If a statistical test requires the computation of summary statistics, and IND ≠ 0003, the control program will set IND = 0003.

4	Yes	5 - 8	I4	ICODE1	= 0 Do not compute the ranks or sort each of the N vectors. = 1 Compute the rank of each observation in each vector and numerically sort each vector.
		5 - 12	I4	ICODE2	= 20 Do not compute the crossproducts or correlations between any of the vectors (called two-vector computations). = 21 Compute only the crossproducts between the vectors. = 22 Compute the cross-products and the correlations between the vectors.
		13 - 16	I4	INDIC1	= 0 The two-vector computations will be performed between all combinations of vectors (i.e., to give a complete correlation matrix). = No. of pairs. If INDIC1 ≠ 0 then it must be set equal to the no. of pairs of vectors for which the two-vector computations will be made.

Card No.	Required	Cols.	Format	Variable Name	Variable Description
5	OPTIONAL	2 - 3	I2	V(1,1)	The first set of vectors for which Pair 1 two-vector computations will be made.
		5 - 6	I2	V(1,2)	
		.		.	.
		.		.	.
		.		.	.
		(6INDIC1 -4) - (6INDIC1 -3)	I2	V(INDIC1, 1)	Pair INDIC1, the last set of vectors for which the two-vector computations will be made.
		(6INDIC1 -1) - (6INDIC1)	I2	V(INDIC1, 2)	

NOTE: Card No. 5 is optional. It is only required if INDIC1 ≠ 0.

6	YES	1 - 2	I2	NSTAT	The code no. for each of the statistical tests that can be performed per the following list: 40 - t-test 41 - F-test 42 - One-way analysis of variance 43 - Wilcoxen Signed Rank test 44 - Kendall Coefficient of Concordance 45 - Chi Square test 46 - Cochran's test 47 - Least Significant Difference test
6	YES	4 - 5	I2	NVECI	The number of the first vector to be tested. For statistical test routines 40 (t-test) and 41 (F-test). The number of vectors to be analyzed in each of the other test routines. For test routines (42-47).

Card No.	Required	Cols.	Format	Variable Name	Variable Description
	YES	7 - 8	I2	NVEC2	The number of the second vector to be tested for statistical routines (40 & 41). This field is blank for all of the other statistical test routines (42-47).
7	OPTIONAL	1 - 80	20A4	NAME	User supplied description of variables (vectors) being tested within a particular test routine

NOTE: The description is optional; a blank card must be substituted if user decides not to use the description option.

8	YES	3 - 4	I2	NN(1)	The number of each of the vectors to be included in the analysis for each of the statistical test routines.
		7 - 8	I2	NN(2)	
		.	.	.	
		.	.	.	
		.	.	.	
		(4NVEC1 -1) - (4NVEC1)	I2	NN(NVEC1)	

NOTE: If statistical test routines 40 or 41 are specified, do not include control card 8 or 9.

NOTE: Control card 9 is only required for statistical test routine 45 (Chi Square test). This card provides the user with option of defining the cell size for the Chi Square test or the option of selecting the number of cells to be used in analysis.

9	YES	1	I1	LL	= 1 If the user desires to define the limits for each cell (define the cell size). = 2 If the user does not define the limits for each cell.

Card No.	Required	Cols.	Format	Variable Name	Variable Description
		3 - 4	I2	K	The number of cells to be used in the Chi Square analysis. If LL = 1, K must be specified. If LL = 2, K need not be specified (see Chi Square note at end of this table.
		5 - 10	F6.0	LI(1,1)	Lower limit for the first cell if LI (1,1) = 99999. The lower limit for the first cell = -00
		11 - 16	F6.0	LI(1,2)	
		.	.	.	.
		.	.	.	.
		.	.	.	.
		(12K-2) - (12K+4)	F6.0	LI(K,2)	Upper limit for the Kth cell (interval), if LI(K,2) = 99999. The upper limit for the Kth interval is set to +00.

NOTE: On Chi Square card, if the user selects LL = 2 and sets K = 0, then the program will assume six cells for the Chi Square analysis by selecting the minimum (MIN) and maximum (MAX) observations from all of the observations available (under analysis) and define the cell width.

$$\Delta = \frac{MAX - MIN}{6}$$

and define each of the six cells as follows:

Cell 1		Cell 2			Cell 6	
Lower Limit	Upper Limit	Lower Limit	Upper Limit	...	Lower Limit	Upper Limit
MIN	MIN+Δ	MIN+Δ	MIN+2Δ		MIN+5Δ = MAX-Δ	MAX

If the user selects LL = 2 and specifies K (the number of cells) as some integer I then the cell width Δ will be defined in a like manner.

$$\Delta = \frac{MAX - MIN}{I}$$

and each of the I cells will be defined as follows:

Cell 1			Cell I	
Lower Limit	Upper Limit	. . .	Lower Limit	Upper Limit
MIN	MIN+Δ		MAX-Δ	MAX

Example Set of Control Cards

Test case given 10 vectors of data (J = 1, ..., 10) each of size IR(J):

1. Compute summary statistics and list.

2. Compute correlation for vector sets (1 and 2), (3 and 4), (5 and 6), (7 and 8), (9 and 10).

3. Perform t-test on vectors 2 and 4.

4. Perform Kendall Coefficient of Concordance on vectors 1, 3, 5, and 9.

5. Perform Chi Square [with 8 unspecified intervals (cells)] for all 10 vectors.

6. Chi Square test (same vectors with 3 specified intervals (0,10) (10,40) (40,00).

A coding sheet is attached with the 16 control cards necessary to perform the above analysis.

NOTE: Control (data) cards 2 and 3 for the number of observations in each vector have not been included.

BM

FORTRAN Coding Form

CONTROL CARDS FOR TEST CASE / ANNAPOLIS STAT. PACK

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

FORTRAN STATEMENT

```
10 1
    5        22    5
 01 02 03 04 05 06 07 08 09 10
40 02 04
T TEST CØMPARING VECTØRS 2 AND 4
44 4

  01   03   05   09
45 10
CHI SQUARE TEST CØMPARING ALL VECTORS (8 UNSPECIFIED CELLS)
  01   02   03   04   05   06   07   08   09   10
2  8
45 10
CHI SQUARE TEST CØMPARING ALL VECTØRS (3 SPECIFIED CELLS)
  01   02   03   04   05   06   07   08   09   10
1  3    0.   10.   10.   40.   40.99999.
```

3.3 SUPPLEMENT

ANNAPOLIS EVALUATION SYSTEM

VOL. 4 - SUPPLEMENTARY WORK - ITEM ANALYSIS, PMPG

I. INTRODUCTION

In the course of the Annapolis experiment, programs were generated to perform specific evaluative tasks not included in the main-line system (Annapolis Evaluation, Vols. 1, 2, and 3). It is the purpose of this document to describe the nature and use of these programs, the Item Analysis Program, and PMPG (Percentage Maximum Possible Gain) Program.

II. ITEM ANALYSIS

II.1 Program Description

The program performs the following analyses for student response data: a) for all students or keyed groups of students, and b) on all of the test questions or any keyed subset of questions.

A. Summary Statistics:

1. Counts the number of students taking the test.
2. Computes the raw score (no. of items correct) for each student. The raw score is computed based on the number of keyed items.
3. Computes the average raw score for all students (test average).
4. Computes the standard deviation of student scores.

B. Item Statistics (for each keyed item):

1. Computes the frequency and percentage of the upper 50% of students' responses for each category of response.

   Categories of Response

   Fill-in questions
   - X - Correct
   - 0 - Incorrect
   - M - Blank

   Multiple-choice questions
   - A, B, C, D, E — Standard multiple choice categories
   - M - Blank

2. Computes the frequency and percentage of lower 50% students for each category of response.
3. Computes the frequency and percentage over all students for each category of response.
4. Computes the difference in percentage between upper and lower students for each category of response.
5. Computes the average raw score for students who answered the question correctly (AC).
6. Computes the average raw score for students who answered the question incorrectly (AIC)
7. Computes the proportion of students who answered the question correctly (PPS).

8. Computes the item (question) standard deviation

$$S = [(PPS)\ (1.0 - PPS)]^{1/2}$$

9. Compute the point biserial correlation

$$PBC = (AC - AIC)\ \frac{S}{\text{Test standard \& deviation}}$$

Additional computations and processing:

1. Computes the Kuder-Richardson reliability (KR20)

$$KR20 \quad \frac{N}{N - 1.0} \cdot \frac{(SS)^2 - SSI}{(SS)^2}$$

N = number of keyed items.

Where : SS = test standard deviation

$SSI = \Sigma\,(PPS)\ (1.0 - PPS)$

2. Sorts the proportion passing for each keyed item into ascending order.
3. Sorts the point biserial correlation for each keyed item into ascending order.
4. Sorts all participating students into descending order by grade.

II.2 Program Use

The item analysis program was developed specifically for analysis of the Final Examination. The program via user control cards can perform an item analysis on any subset of keyed questions for all students or for groups of students. The program was written in Fortran IV for use on the IBM 360/65 under OS. The control and data cards for analysis of the Final Exam are as follows :

Card No.	Col. No.	Description
1	1-60	Literal description of the test to be analyzed.
2	1-2	Number of questions on the test.
	3 4 . . 62 .	The correct responses, one for each question on the test. The following are acceptable data values for each question: Fill-in question: X - symbolically for the correct answer. Multiple-choice question: A, B, C, D, or E - whichever is the correct response.
3 (one card for each student)	1-4	The section number of the students.
	7-10	The student's identification no.
	11-12	The raw score for the student (no. of questions answered correctly.
	13 14 . . .	Student's response to each question corresponding to the following categories: Fill-in questions: X - correct response, 0 - incorrect response, M - no response. Multiple-choice questions: A, B, C, D, or E - whichever the student responded, M - no response.

NOTE: After the last student card, a card with zero's in Columns 7-10 is required to indicate that the last student has been processed.

4	1-2	The number of questions to be analyzed
	5-6	The number of class sections to be included in the analysis.

NOTE: If all students are to be included in the analysis columns, 5-6 should be left blank.

5	1-2	The first question to be analyzed.
	3-4	The second question to be analyzed.
	.	.
	.	.
	.	.
	79-80	

NOTE: If all the question on the test are to be analyzed, card 5 is not required.

Card No.	Col. No.	Description
6	1-4	The first class section to be included in analysis.
	5-8	The second class section to be included in this analysis
	.	.
	.	.
	.	.
	77-80	

The card sequence (4, 5, 6) can be repeated as often as required by the user.

III. PERCENTAGE MAXIMUM POSSIBLE GAIN

III.1 Introduction

A computer program to calculate the percentage of maximum possible gain (PMPG) was developed per the specifications contained in a memo by Robert L. Brennan, entitled "Statistical Techniques for Measuring Effectiveness and Gain with Instructional Programs."

III.2 Program Description

The PMPG program computes the following statistics for student post- and pretest data for each week (or course unit)

A. Summary Statistics:

1. The number of questions on the test
2. The number of students taking each test
3. A frequency histogram of student scores for each test
4. The computed PMPG

B. PMPG Computation

As specified in the above referenced document, the percentage of maximum possible gain is computed from the following equation:

$$PMPG = 1 - \frac{\sum_{y=1}^{Ny} \sum_{i=0}^{y-1} \Psi y\,(i)}{\frac{1}{Nx} \sum_{x=1}^{Nx} \sum_{i=0}^{x-1} \Psi x\,(i)} \quad ; \quad 0 \leq PMPG \leq 1$$

where: Nx = no. of questions on the pretest

x (i) = P x = i = probability that a student scores i questions right on the pretest

Ny = no. of questions on the posttest

y (i) = P Y = i = probability that a student scores i questions right on the posttest.

III.3 Program Use

A. The PMPG program requires two magnetic tape files, one for pretest data and the other for posttest data. The program was written for the specific case of the pre- and posttest magnetic tape data files that were created for the Annapolis evaluation. The student records were sorted on tape alphabetically by volume (for volumes A through 0). In addition, a test value of -1 separated each volume (the student records for each volume from the student records for the next volume).

B. The program was written in Fortran IV for use on the IBM 360/65 under DOS.

C. The following are the input card and tape formats used:

1. Card Format

Card No.	Col. No.	Description
1	1	Vol. = The volume to be processed
	3-5	NPRE = no. of questions on the pretest
	6-8	NPOST = no. of questions on the posttest

2. Tape record format (for both post- and pretest tapes)

Record Format	Description
A2	The end of volume test value (= -1 indicates the last record for that volume has been processed
3X	
A1	The volume letter of the current record
140X	
A2	The student's score (no, of questions answered correctly for this volume.

3.4 COPIES OF PROGRAMS

Copies of the programs were submitted by contractural requirement on 1) a magnetic tape and 2) hard copy listings. Copies of the programs are referenced as Annapolis Evaluation, Vol. 3.