ABSTRACT

This handbook was prepared to accompany a series of programmed study guides for first-year algebra. It presents the rationale and development of the program; gives an itemized summary of the strategies and logistics involved in installing and operating the program as an individualized, self-paced, computer-managed course of instruction; and specifies the principles and procedures followed in creating the program. Three texts are cross-referenced to the material in this series: the core text, "Modern Algebra - Book I" by Dolciani, Berman, and Freilich; the enrichment text, "Algebra I" by Dodes and Greitzer; and the remedial text, "Comprehensive Ninth Year Mathematics" by Dressler. (Related documents are SE 015 855 - SE 015 870.) (DT)
PROGRAMMED MATH CONTINUUM

level one

ALGEBRA

NEW YORK INSTITUTE OF TECHNOLOGY
OLD WESTBURY, NEW YORK

HANDBOOK
PREFACE

This Handbook has been prepared to accompany the 18 Volume series

entitled

PROGRAMMED MATHEMATICS CONTINUUM

LEVEL 1

IT HAS THE MULTIPLE FUNCTION OF PRESENTING:

- THE RATIONALE AND DEVELOPMENT OF THE PROGRAM
  - FOR EVALUATION

- THE STRATEGIES AND LOGISTICS OF THE PROGRAM
  - FOR INSTALLATION

- THE PRINCIPLES AND PROCEDURES SUGGESTED
  - FOR REPLICATION

It is one exhibit in the demonstration of a model
developed under the direction of
the U.S. Department of Health Education and Welfare
OE Project 8-0157

at the
New York Institute of Technology
Westbury, New York
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*NOTE CONCEPT CATALOG
DETAILED MBO LIST

In separate booklet C

**ERIC**
PROGRAMMED MATHEMATICS CONTINUUM
LEVEL I

HANDBOOK

CHAPTER I

THE RATIONALE AND DEVELOPMENT
OF THE PROGRAM

FOR EVALUATION
GENERAL BACKGROUND:

ORIGIN OF PROGRAM:

The New York Institute of Technology submitted to the U.S. Commissioner of Education, under the provisions of Public Law 531, in the last quarter of the year 1967, a basic and applied research proposal entitled:

A SYSTEM FOR INDIVIDUALIZING AND OPTIMIZING LEARNING THROUGH COMPUTER MANAGEMENT OF THE LEARNING PROCESS

This proposal was accepted and resulted in the letting of

Contract Number: OEC -0-8-080157-3691 (010)
Office of Education, Bureau of Research
Project Number 8-0157
to
New York Institute of Technology

OBJECTIVES:

The Major Objective of the proposal was to organize, develop and refine a model computer-based system for the management of the educational process by means of a systems' engineering technique.
OUTCOMES:

This management system would have to be operational and economically cost effective.

The system would be applied to different subject matter areas which would be developed simultaneously with the computer system into formats susceptible to management by the program.

The individual courses would be installed on the New York Institute of Technology campuses for experimental purposes.

The courses would also be installed on other school campuses as a demonstration of the ability of the program to handle varied management decision making situations.

CONDITIONS:

Immediate and constant feedback would result in course improvement. Individualized analysis of records would result in tailoring the course independently for each student in a self-paced mode.

Correlations generated by the computer would form a basis for individual and group counselling.

The principles, techniques, and findings of the project would be made available to the educational community.
PROCEDURES:

In order to accomplish the objectives of this proposal an "action research" program was prepared. It outlined:

**First:** the development of the management system.

**Second:** the testing and refinement of the management system through application to a specific environment in four subject matter areas.

**Third:** the repetition of the system in another context so as to demonstrate replicability.

**Fourth:** the training of appropriate members of the educational community who will be involved operationally in this effort.

**Fifth:** the dissemination of the findings of this study to the educational community at large.

PROJECT COMPONENTS:

Procedurally, the "action research" program may be considered to encompass several interrelated categories of activities.

MANAGEMENT SYSTEM:

An initial, and continuing category of activities covers the design and development of the computer-based management system itself, through which the assessment, revision, restructure, optimization and validation of the instructional system is to be accomplished.
Since the system is self-generating and self-correcting, these activities involve empirical implementation and observation under actual living school conditions, and testing, modification and retesting in such a viable situation.

COURSE DEVELOPMENT:

Therefore, a concurrent category of activities addresses itself to the development of subject matter courses, with all appropriate support material, and their testing, revision, restructure and ultimate optimization and validation.

These activities are governed within the instructional management area of the system.

The method of attack, the step-by-step procedure whereby the courses are behaviorally defined, structured, refined and validated, evolves directly from the system design, and is controlled and directed by the computer-based management system.

COMPONENT INTER-RELATION:

These major categories of activities go on to a certain extent, concurrently, and one cannot proceed to culmination without the other.

The course development activity, particularly as it reaches the implementation and assessment stage, depends entirely upon the management system, with its immediate feedback and analysis.
COMPONENT INTER-RELATION: (CONT.)

The management system, conversely, requires the course development activity as its "test bed" upon which it bases its own growth and shape.

Final validation of both the course and the management system depends upon the experiences of the replication experiment.

COURSE SELECTION:

For the purposes of this program, New York Institute of Technology utilized as course areas: computer sciences, mathematics, physics, and electronic technology. These subject matter areas were chosen because:

They form entities which are relevant to the philosophies expressed in a recent appropriate Office of Education position paper as falling within an area of national need; the Institute possesses demonstrated expertise in these subjects.

They have relevance to secondary educational levels; prepared as is intended.

They can serve as remedial or preparatory materials for more advanced programs.

As end courses, themselves, they possess potential for wide use.

PROJECTED COMPLETION TIME:

The total program has been scheduled over a period of three years, in Phases I, II, and III, each with a consecutive period of approximately 12 months.
The material has been written in accordance with the guidelines set up by the Curriculum Development Committee of the High School Division of the Board of Education of the City of New York, as exhibited in the publication "Mathematics, Ninth Year, 1965." This publication, in turn, reflects the influence of the thinking in the field of mathematics education by the New York State Board of Regents and the School Mathematics Study Group.

THE SCHEDULE:

This essentially a full year course in the first year of academic mathematics in preparation for the study of calculus. However, because of the interface with the computer and its consequent application to a self-paced individualization of the learning process the time schedule may vary considerably.

The material is divided into 18 major units, or Volumes, each covering a major unit of the material and corresponding to the amount of material that would be covered in a normal two-week period in a regular classroom situation.

Each Volume is subdivided into five parts, or Segments, and together with the reading and paralleled homework assignment comprise the material that would normally be covered in two class days. There are, therefore, a total of 90 segments which can be covered in the usual 180 day school year; or in a variety of other possible time spans.

REFERENCE TEXTS:

Three textbooks have been chosen from among the many because they are above average in meeting the purposes assigned to them.

The "Core Text" Modern Algebra, Book I
Dolciani, Berman, and Freilich
Houghton Mifflin, 1965

The "Enrichment Text" Algebra I
Dodes and Greitzer
Hayden Book Company, 1967

The "Remedial Text" Comprehensive Ninth Year Mathematics
Dressler
Amsco School Publications, 1966

TEXT INDEPENDENCE:

The material in the Study Guides is not limited to the three referenced texts. With a minimum of analysis another set of texts could be readily cross-referenced to the material.

The PMC can be converted to a "stand alone" text-independent course by augmenting the supplementary notes prefaceing each segment.

A set of problems could be prepared to replace the existing Remedial Prescriptions.
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CHAPTER II

STRATEGIES AND LOGISTICS
OF PROGRAM

- FOR INSTALLATION
STRATEGIES FOR INSTALLATION
OF
PROGRAMMED MATHEMATICS CONTINUUM
LEVEL 1
AS
SPECIAL EDUCATION M 3012

ABSTRACT: This is an itemized summary of the strategies and logistics involved in the installation and operation of the PMC as an individualized, self-paced, computer managed course of instruction with provision for course optimization, open-ended scheduling and a consequent cost effective motivation for concentrated individual effort.

NOTE: This outline is directed towards the installation of the PMC as Special Education Course 3012 on the NEW YORK INSTITUTE OF TECHNOLOGY CAMPUS.

With appropriate modifications contingent upon local circumstances similar instructions can be devised for installation in other school programs.
1. CURRICULUM:

1.1 DATA:

1.11 The PMC comprise the material outlined in the New York State Syllabus for ELEMENTARY ALGEBRA NINTH YEAR (level i) and is in conformity with recommendations for curriculum content as promulgated by the Standing Committee on Mathematics, NYC and the School Mathematics Study Group, (SMSG).

1.12 The NYIT Catalog stated that Math 3012 is an intensive course involving the algebraic concepts identical with those of the PMC (level 1).

1.2 CONCLUSION:

1.21 The PMC is suitable for Math 3012.

2. COMPUTER ARTICULATION:

2.1 DATA:

2.11 Each concept has been cast into the MEASURABLE BEHAVIORAL OBJECTIVE format.

2.12 Each MBO is coded by Volume, Segment, Terminal Objective or Enabling Objective.

2.13 Each question and each answer in every component of the course is assigned an MBO code.

2.2 CONCLUSION:

2.21 The student's progress through the PMC can be constantly monitored by the AIMS/VICAR program.

2.22 Reference is made to the full report on VICAR I and VICAR II as well as the AIMS report.
3 COURSE COMPONENTS:

3.1 PRE-TEST:

3.11 One test per volume.
3.12 Test administered individually, in class, when student has met requirements of previous volume.
3.13 Ten questions on 2 or 3 mimeographed sheets.
3.14 Multiple-choice format, with one answer and four distractors;
3.15 Answers recorded on Punch Card with Stylus and Port-A-Punch
3.16 Scored by computer;
3.17 Statistics for individual and for group compiled;
3.18 Provision possible for exempting student from following Volume if score is above a certain level.

3.2 STUDY GUIDE:

3.21 Eighteen Volumes for entire course; scrambled and programmed;
3.22 Five Segments per Volume; each Segment comprises approximately Twenty questions;
3.23 Questions are in multiple choice format, with one answer and three distractors;
3.24 Student progresses from question to answer choice by recording choice on either Punch Card and Program Control device, or on Mark Sense Sheet which records the choice and reveals the page to which the student must turn.
3.25 A separate answer matrix is required for each Segment.
3.26 Correct answers are sometimes re-enforced by a complete demonstration of the solution and the direction to proceed to the following question.
3.27 Readings in the basic text are prescribed and must be completed before beginning each Segment.
3.28 Homework Assignments are prescribed.
3.3 WORK OUTSIDE OF CLASS:

3.31 READING ASSIGNMENT:

3.311 The Study Guide specifies a certain section of the core text, (MODERN ALGEBRA, Dolciani) that should be read and studied by the student before he begins each Segment. A complete listing is given at the beginning of the Volume and individual listings are given at the beginning of each Segment.

3.312 Each Segment is designed to cover a two-day lesson including the Reading and Study Guide.

3.32 HOMEWORK ASSIGNMENT:

3.321 The complete assignment for the entire Volume is given on one page in the Study Guide.

3.322 Each Segment makes reference at its completion to the parts of the Homework that the student should then be able to do.

3.323 The entire Homework assignment must be completed before the student is allowed to take the Post-Test.

3.324 The Homework Assignment is marked by the instructor, with the marks recorded on a Punch Card.

3.325 A complete description of the Homework marking principles and the resulting printouts is found in the VICAR I report.
3. POST-TEST PRESCRIPTION:

3.331 The Computer Printout of the results of the Post-Test includes a prescription of extra problems that relate to the error made.

3.332 The problems are found in the Remedial Text: Comprehensive Ninth Year Mathematics; Dressler.

3.333 The Prescription must be completed before the student can begin the cycle for the following Volume.

3.34 TUTORIAL SESSION:

3.341 In some cases the Computer Printout will indicate that the student must report to the instructor for a tutorial session, because of a difficulty detected.

3.342 The Computer Printout will be distributed by the instructor in class. At that time an appointment can be arranged.

3.343 This session can be conducted in class while the others are working individually in their Study Guides.

3.344 The session could be arranged at a mutually convenient time outside of the class hour.

3.4 POST TEST:

3.4.1 One Post Test per Volume;

3.4.2 Form and Content are equivalent to the Pre-Test;

3.4.3 Incorrect answers are accompanied by a Prescription of additional problems in the Review.

3.4.4 The prescription must be completed before the student can advance;

3.4.5 Tutorial sessions can also be prescribed.

3.4.6 Under the AIMS/VICAR program statistics of individual and group performance are compiled and printed.
3.5 MID-TERM EXAMINATION:

3.51 A 20 question multiple choice format

3.52 Based on the Terminal Objectives of Volumes 1-9

3.53 Each question will have 5 forms, all equivalent.

3.54 A large variety of individual tests will be possible by choosing the alternate forms at random.

3.541 If the CAI program is ready, then the student can take the test individually when he is ready, with certain time periods with the computer, randomly selecting the permutations or question variations as well as scoring the performance.

3.542 If the program is not ready, as a back-up system, the 100 question test can be presented in mimeo form together with directions to choose a certain random selection of predetermined permutations.

3.6 FINAL EXAMINATION:

3.61 Similar to the Midterm as discussed above;

3.62 It will cover the TOs from Volumes 10 to 18, principally.

4. TIME CONSTRAINTS:

4.1 DATA:

4.11 The PMC is designed as a year course for secondary schools; i.e. a maximum of 180 days, 40 minutes per session (120 hours).

4.12 A realistic assessment of actual instruction hours reduces the time to approximately 100 hours.

4.13 Trial runs by good/average students, making few errors, indicate that a Volume can be in 3 hours; this is exclusive of the time spent reading and studying the core text.

4.14 The Pre-Test and the Post-Test each take \( \frac{1}{2} \) hour.
The Text ± Assignment, Studying, Homework Assignment, Post-Test, and Tutorial Sessions are
considered outside of the regular class schedule.

4.16 The minimum projection for the completion of the 18 Volume 72-hour outside work would range from 1 1/2 to 2 hours more per Volume.

4.17 Math 31 is scheduled to meet for 14 weeks at 4 hours per week, totaling 56 hours.

4.18 A Math 31 student would have to complete a Volume and all of the outside work in 3 class hours, beginning the following Volume in each hour.

4.2 CONCLUSION:

4.21 The PMC can be installed as the Math 301 course only if the Math can be considered "open ended," that is, it can go to the second semester.

4.22 The Program have to be individually self-paced. This will answer the question as to how long it takes a student through the course with the out-of-class work and the computer management.
5.1 REQUIREMENTS:

If the Punch Card Office Controls is to be used the classes will be held in the Automated Lab where the services are located; Additional sections at different times are needed if the registration exceeds the room capacity. (and the number of controls 34)

The Mark Sense sheets are used there is no need for a tutorial room. However, the room should be located near the Automated Lab (which will be used as a supervised individual study lab for the students who wish to do extra work on their

section can be scheduled at any time.

Software

Records

6. PERSONNEL REQUIREMENTS:

6.1 INSTRUCTION:

6.1.1 An instructor must be assigned to each regular class session for supervision of the operation of the course.

6.1.2 Distribution of printouts with attention given to results.

6.1.3 Individual instruction when requested.

6.1.4 Processing of Homework Assignments (possible in the presence of a student for individual attention.

6.1.5 Observation of individual work; maintenance of security.
6.2 PROCEDURES

6.21 All students must be on duty in the Audio Lab for the
issuing of collecting or the volumes and other software
needed. The students who are working on their own Report
must be kept of the students progress and the materials be
Security must be maintained.

6.3 COMPUTER OPERATION

6.31 A member of computer operations staff must be assigned
to process the copy received from the FMC.

6.32 All input is processed on an overnight basis;
(i.e. input received on one day must be processed and the
output received for pick-up the following morning before 9:00)

6.4 COORDINATION

6.41 A Master Scheduling Coordinator is needed to supervise the complete
operation of the FMC in Math 302:

6.411 Responsibility figures

6.412 Scheduling Schedules

6.413 Book Activities (Cooperation with Bookstore)

6.414 Material distribution: directions to instructors

6.415 Material operations with Computer:

delivery of input to computer center
inspection of operation of computer program
pickup of output from computer

delivery of all output to Program Director
Maintain a flexible tutoring schedule to suit student needs and to do the tutoring.

Make periodic reports of the entire program to the Program Director and to the Director of Special Education.

STUDENT PROGRESS:

CONTROL SHEET:

A single control sheet (attached) has been used to monitor the student's progress through the program.

Each item of software will be numbered for easy identification.

When a software item is issued to a student it should be entered into the software register number must be entered.

When the item is returned (same day) the software is entered.

SEQUENCE OF ACTIVITIES:

PRE-TEST:

Taken in class under supervision of instructor whenever student is ready;

Answers recorded on Punch Card/Port-A-Reader

Card collected and delivered to Computer

Printout delivered to Instructor/Student at beginning of next session;

Printout indicates whether student is exempt from remainder of Volume.

VOLUME/SEGMENT:

Volume is issued to student together with Answer Matrix for Segment. (If Program Control Device used, student also requires Punch Card.)

Numbers of software are entered on Control Sheet.
Mark Sense as the forms are used, the paper material can be delivered to the class or to the Lab.

When completed, the material is returned to the secretary; the test (section) is recorded on the Control Sheet.

The Response Sheet or Punch Card is delivered to the Computer.

7.23 READING ASSIGNMENT:

7.231 The Reading is done outside of class prior to the class on the Segment.

7.24 HOMEWORK ASSIGNMENT:

7.241 The Homework is done outside of class simultaneously as the student progresses through the Volume.

7.242 The Complete Homework Assignment must be handed in to the Instructor upon completion of the Volume, it is prerequisite for taking the Volume Post-Test.

7.243 Entry of the completion is made on the Control Sheet.

7.244 The Homework is marked by the Instructor on a Punch Card.

7.245 A special feature is to have the student present while the homework is being marked; it gives an opportunity for the instructor to give personal attention to the student.

7.25 PRACTICE TEST:

7.251 Taken in class under supervision of instructor, when student is ready;

7.252 Answers on Punch Card/Port-A-Plung

7.253 Cards collected and delivered to computer;

7.254 Entry made on Control Sheet of issuance and correction;

7.255 Printout delivered to instructor and student.

31
7. **MEDICAL PRESCRIPTION:**

- Post Test for Test includes a Remedial prescription;
- Prescription must be completed outside of class and submitted to the Instructor;
- Prescription includes a recommendation to report for a tutoring session either with class instructor or with Math Coordinator.

7.1 **TUTORIAL SESSION:**

- Assign by means of computer program upon analysis of error count.
- Can be assigned, with agreement of student, either during available class time (with instructor available) or at other time with Math Coordinator.
- If a tutorial session has been assigned, it must be held and attended successfully before student is permitted to advance in the program.
- Entry of assignment and completion is made on Control Sheet.

8. **MOTIVATION**

8.1 **TIME VARIATION:** INDIVIDUALIZATION:

- Each student makes progress through the course making few errors and covering the material at his own learning pace.

8.2 **REMEDICATION:**

- The students having difficulty is helped:
  - Remedial pages in the Study Guide;
  - Personal interview while Homeworl is being marked;
  - Remedial prescriptions in Post Tests or with reference to a different text for remedial instruction.
  - Tutorial session with class instructor or with Mathematics Coordinator for personalized attention.
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The schematic diagram on the facing page is designed to show the function and interrelation of the several software and hardware items that comprise the information flow resulting in the various printouts.

There is provision for AV support when it is incorporated into the program.

3 INPUT INTERFACE:

3.1 PUNCH CARD:
The original PNC employed the four specially designed Punch Cards. For the Study Guide, the Punch Card required an ANSWER MATRIX and the PROGRAM CONTROL LIGHT PANEL to negotiate the Scrambled Pagination and at the same time to record suitable input for computer analysis.

3.2 LATENT-IMAGE MARK SENSE SHEETS:
Subsequent to the beginning of the PAC Study Guide production, a latent image (invisible ink) process sheet was devised to serve the same purpose as the Punch Card.

It proved to be cost effective because it eliminated the need for a separate answer matrix, the PROGRAM CONTROL LIGHT PANEL, and the more expensive Punch Card.

The one sheet, with the matrix imprinted invisibly upon the application of a special ink, revealed the page number of the Study Guide at the same time that it recorded the answer choice for direct computer input and analysis.

3.3 For consistency, all references to the Response Device continued to use the words "PUNCH CARD," "ANSWER MATRIX," etc. although either method of response could be employed.
Input: 4 Specially Designed IBM Punch Cards

Output: 4 Separate Sets of Printouts (6 Copies Each) for Item Analysis and Course Optimization
INFORMATION FLOW CHART

FIELD SCHOOL COORDINATOR

CURRICULUM DEVELOPMENT

BACK-UP SERVICES

PROGRAM OPERATION

PROGRAM STRUCTURE

PUNCH CARD BATCH

COMPUTER PROCESSING

COMPUTER MEMORY

DATA UPDATE

UPDATE MATERIALS AND PROCEDURES

FEEDBACK

INSTRUCTION FOR REMEDIAL MEASURES

PRINTOUT

TRANSMISSION LOGISTICS

PROCESSING DATA UPDATE
INFORMATION FLOW CHART

TRANSMISSION LOGISTICS

(1) INSTALLATION OF COMPUTER AT FIELD SITE

(2) LOCAL FIELD SCHOOL

(3) DISTANT FIELD SCHOOL

PHYSICAL DELIVERY OF MATERIALS TO COMPUTER

Note:
In case (1) where the computer is on site, and case (2) where the Field School is nearby, the Punch Card input is delivered directly to the Computer.

In case (3) where the Field School is remote and a sophisticated system of Input transmission and Printout return is necessary.
1. **STUDY GUIDE:** (For each segment)
   1.1 Completes READING ASSIGNMENT in CORE TEXT and in ENRICHMENT TEXT
   1.2 Reads SUPPLEMENTARY NOTE
   1.3 Reads QUESTION
   1.4 Chooses ANSWER
   1.5 Receives REMEDIAL INSTRUCTION (if DISTRACTER chosen)
   1.6 Receives REINFORCEMENT (if CORRECT ANSWER)
   1.7 Response device submitted
   1.8 PUNCH CARD: (latent image sheet) analyzed by computer

2. **HOMEWORK ASSIGNMENT:**
   2.1 Partially done at conclusion of each SEGMENT
   2.2 Marked by instructor or RESPONSE DEVICE when completed
   2.3 Analyzed by computer

3. **TEST A:**
   3.1 Test on M.B.O.'s of entire volume
   3.2 RESPONSE DEVICE submitted
   3.3 Analyzed by computer
   3.4 REMEDIAL PRESCRIPTIONS provided by computer
   3.5 Students above cut-off point move to next VOLUME

4. **REMEDIAL INSTRUCTION:**
   4.1 Student scoring below cut-off point reports for individual or group instruction (live)
   4.2 Available support materials arranged
   4.3 G.M.I. SESSIONS scheduled by computer

5. **TEST B:**
   5.1 Test similar to TEST A
   5.2 Response device submitted
   5.3 Analyzed by computer
   5.4 Evidence of additional learning made with comparison to TEST A scores
   5.5 Score above cut-off point allows student to proceed to next VOLUME

6. Score below cut-off point refers student to counseling, additional instruction; and possible repetition of volume or course adjustment
STUDENT PROGRESS THROUGH VOLUME - PLAN B

1. TEST A: ("BEFORE" TEST)
   1.1 Test on MBO's of entire Volume
   1.2 Response device submitted
   1.3 Analyzed by computer
   1.4 Score above cut-off point allows student to proceed to next VOLUME
   1.5 Score below cut-off point directs student to begin Volume

2. STUDY GUIDE: (For each segment)
   2.1 Completes READING ASSIGNMENT in CORE TEXT and in ENRICHMENT TEXT
   2.2 Reads SUPPLEMENTARY NOTE
   2.3 Reads QUESTION
   2.4 Chooses ANSWER
   2.5 Receives REMEDIAL INSTRUCTION (if DISTRACTOR chosen)
   2.6 Receives REINFORCEMENT (if CORRECT ANSWER)
   2.7 Response device submitted
   2.8 PUNCH CARD or (latent image sheet) analyzed by computer

3. HOMEWORK ASSIGNMENT:
   3.1 Partially done at conclusion of each SEGMENT
   3.2 Marked by instructor on RESPONSE DEVICE when completed
   3.3 Analyzed by computer

4. TEST A: ("AFTER" TEST)
   4.1 Test similar to TEST B
   4.2 Test on MBO's of entire volume
   4.3 RESPONSE DEVICE submitted
   4.4 Analyzed by computer
   4.5 REMEDIAL PRESCRIPTIONS provided by computer
   4.6 Students above cut-off point move to next VOLUME

5. 5.1 Student scoring below cut-off point reports for individual
    or group instruction (live)
    5.2 Available support materials arranged
    5.3 G.M.I. SESSIONS scheduled by computer
STUDENT ACTIVITY

1. The chart on the facing page itemizes the differentiated learning activities that the student experiences in the PMC and correlates them with the:

Text
Software component
Input interface
Computer printouts

2. The PMC is key to the individualization of the learning process through self-pacing in the following areas:

Study
Question analysis
Error correction
Problem solving
Testing
Remedial instruction

3. Group activities complement the individualization in:

Group remedial instruction
Group testing

4. Supplementary General sessions can offer:

Orientation
Enrichment
Summarization
CHAPTER III

PRINCIPLES AND PROCEDURES SUGGESTED

— FOR REPLICATION
PRODUCTION OF THE STUDY GUIDE

This is the chronological sequence that should be followed by the writer.

PRELIMINARY ACTIVITY:

1. Read parts of SYLLABUS relating to the SEGMENT (SEG)

2. Read MEASURABLE BEHAVIORAL OBJECTIVES LIST (MBO LIST)
   2.1 Check MBO list against SYLLABUS for validity
   2.2 Enter MBO codes in MBO CODE REFERENCE LIST (CORE REF) (75)

3. Read pages of CORE TEXT relating to MBOs
   3.1 Write READING ASSIGNMENT
   3.2 Check concepts in CORE TEXT against MBO LIST
      3.21 Note omissions in CORE TEXT
      3.22 Note omissions in MBO LIST

4. Read pages of ENRICHMENT TEXT relating to MBOs
   4.1 Check for concepts omitted from CORE TEXT
   4.2 Note alternate explanation of concepts
   4.3 Note items suitable for motivational references.
5. Write SUPPLEMENTARY NOTES (NOTES)

5.1 Check NOTES for coverage of MBOs omitted from CORE TEXT

5.2 Give alternate explanation of difficult concepts

Write NOTEBOOK INSTRUCTIONS:

6.1 List definitions

6.2 List formulas

7. Create a lesson plan

7.1 Relate each step to an MBO

7.2 Record MBO LIST according to lesson plan

7.3 Consider developmental sequence

7.4 Group ENABLING OBJECTIVES (EOs) supporting TERMINAL OBJECTIVES (TOs)

STUDY GUIDE MANUSCRIPT:

8. Write QUESTION-PROBLEM for each MBO in multiple-choice form,

8.1 Enter question number on MBO Cross Reference List

8.2 Determining LEARNING CATEGORY (LC)

8.21 Choose appropriate BEHAVIORAL VERB

8.22 Enter LC on MANUSCRIPT ANSWER MATRIX (AMX)

9. Solve Problem - specify ANSWER

9.1 Determine probable errors

9.2 Choose DISTRACTORS

9.3 Relate DISTRACTORS to CATALOG CODE

9.4 Choose ANSWER - DISTRACTORS array permutation for multiple choice format
10. Choose DISTRACTER STRATEGY

10.1 Write REMEDI page according to STRATEGY for DISTRACTER

10.2 Enter REM on AMX

10.3 Enter DISTRACTER STRATEGY CODE on AMX

10.4 Complete DISTRACTER STRATEGY FLOWCHART

11 Prepare HOMEWORK ASSIGNMENT (HW) for SEC

11.1 Allot one fifth of the HOMEWORK ASSIGNMENT FOR ALUME to each of the 5 SEGs

11.2 Relate to TOs of MBO LIST

11.3 Enter QUESTION NUMBER on MBO CROSS REFERENCE LIST

TEST CREATION:

12. Write POST TEST (FORM A) 10 QUESTION-PROBLEMS

use TEST QUESTION work sheet

12.1 Relate each question to TOs of MBO LIST

12.2 Enter QUESTION NUMBER on MBO CROSS REFERENCE LIST

12.3 Enter MBO code on TEST ANSWER MATRIX

12.4 Solve PROBLEMS

12.5 Determine probable errors

12.51 Choose 4 DISTRACTORS per QUESTION

12.52 Enter CONCEPT CATALOG CODE for each DISTRACTER choice

12.6 Choose ANS-DISTRACTER array permutation

12.61 Enter array on TEST ANSWER MATRIX

12.62 Enter CONCEPT CATALOG CODE for each DISTRACTER choice

12.7 Choose REMEDIAL PRESCRIPTION from REMEDIAL TEXT for each DISTRACTER choice

12.71 Enter PRESCRIPTION on TEST ANSWER MATRIX

12.8 Enter LEARNING CATEGORY on TEST ANSWER MATRIX
13. Write POST TEST (FORM B) TO QUESTION WORKSHEET
   use TEST QUESTION WORKSHEET

   13.1 Create a VALID parallel test

   13.11 Retain form by substitution of equivalent numbers
        and letters

   13.12 Retain exact concept

   13.2 Re-order the question numbers

   13.3 Follow same steps as outlined for Test A 12.1 - 12.6

   13.4 Remedial Prescription is omitted

EVALUATION;

14. Examine MBO CROSS REFERENCE LIST for thorough coverage alignment

   of MBO to:

   14.1 SG questions

   14.2 HW assignment

   14.3 Test A

   14.4 Test B

15. PROOF READ all copy.

COURSE COMPONENTS

16. The diagram on the facing page is a schematic summary of
    the components of the course (just previously described) as they are met by the course writer.
The course writers prepare questions for the five areas of instruction and testing:

1. Study Guide - MBO List
2. Homework Assignments
3. List A
4. Remedial Assignment
5. Test B

For research purposes, it is required that each question be classified according to the categories listed. As an aid to determining the classification, it is required that the verb chosen be from the limited list.

In general, the questions in a given segment will be arranged in the same order as their rank starting from level one, "definition," and progressing through "computation," "analysis," "deduction," "synthesis," and "extrapolation." By constant reference to the chart, an unusually high concentration of question types of any one particular level can be avoided.

<table>
<thead>
<tr>
<th>Learning Category</th>
<th>Symbol</th>
<th>Definition</th>
<th>Behavioral Verb Assign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RR</td>
<td>Recall and Recognition Statement of Formula</td>
<td>Primary: Define</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Statement of Rule of Operation</td>
<td>Secondary: Recognize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Definition of a Mathematical Concept</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>BM</td>
<td>Basic Computation</td>
<td>Primary: Perform</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fundamental Arithmetic Operations</td>
<td>Secondary: Check</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use of Tables</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>AN</td>
<td>Analysis of Principle</td>
<td>Primary: State</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Choice of Applicable Formula</td>
<td>Secondary: Choose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selection of Proper Formula</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Choice of Strategies</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>DD</td>
<td>Deduction from Principle</td>
<td>Primary: Prove</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proper Application of Principle</td>
<td>Secondary: Apply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logical Step-by-Step Procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaluation</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SN</td>
<td>Synthesis to Principle</td>
<td>Primary: Determine</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary: Relate</td>
</tr>
<tr>
<td>6</td>
<td>XT</td>
<td>Extrapolation Beyond Principle</td>
<td>Primary: Propose</td>
</tr>
</tbody>
</table>

Test questions should be keyed to the appropriate level by careful choice of the behavioral verbs assigned to that level. The weight of each question should be determined by the level of difficulty as exhibited in the chart above.
QUESTION PLACEMENT CORRELATION STRATEGY:

There are five avenues for questioning specific MBO's; namely, the Pre-Test, Study Guide, Homework, Post Test, and Remedial Prescriptions. The synthetic charts below correlate the Learning Difficulty of the question with the sequence of Enabling Objectives (EO) and Terminal Objectives (TO) and when viewed together indicate the multiple checking of the several criteria as employed in the separate media.

TEST B:

<table>
<thead>
<tr>
<th>Learning Category Range</th>
<th>MBO SELECTION</th>
<th>L.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 4</td>
<td>Some</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MBO: 11 12 13 14 10 21 22 23 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO   EO EO TO EO EO EO TO</td>
</tr>
</tbody>
</table>

STUDY GUIDE:

<table>
<thead>
<tr>
<th>Learning Category Range</th>
<th>MBO SELECTION</th>
<th>L.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 4</td>
<td>All</td>
<td>6</td>
</tr>
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<td></td>
<td>All</td>
<td>5</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>MBO: 11 12 13 14 10 21 22 23 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO   EO EO TO EO EO EO TO</td>
</tr>
</tbody>
</table>

HOMEWORK ASSIGNMENT:

<table>
<thead>
<tr>
<th>Learning Category Range</th>
<th>MBO SELECTION</th>
<th>L.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 - 6</td>
<td>Some</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MBO: 11 12 13 14 10 21 22 23 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO   EO EO TO EO EO EO TO</td>
</tr>
</tbody>
</table>
TEST A:
Learning Category Range: 3 - 4 6
MBO Selection: EO: Some 5
TO: All 4 * *
3 * * *
2 * * *
1 * * *
MBO: 11 12 13 14 10 21 22 23 20
EO EO EO EO TO EO EO EO TO

REMEDIAL PRESCRIPTION:
Learning Category Range: 1 - 4 5
MBO Selection: EO: All 4 * *
TO: All 3 * * *
2 * * *
1 * * *
MBO: 11 12 13 14 10 21 22 23 20
EO EO EO EO TO EO EO EO TO

The coverage of the MBO's varies from one course component to another. In general, the fundamental EO's are explored in the Study Guide and Remedial Prescriptions; while the more important EO's and all the TO's are covered in every component.

The Learning Level of difficulty varies with the lowest being employed in the Remedial Prescriptions and Study Guide, while the highest are reserved for the Homework Assignment.
The outstanding characteristic of the PC is its fundamental dependence upon the QUESTION as the thought directive device. The lengthy didactic presentation is avoided.

The Reading

The Reading refers the student to a standard presentation on a recognized textbook, and this is supplemented by additional notes in the beginning of each SEGMENT. Nevertheless, the chief strategy is the carefully devised question.

Questions appear in:
- The Pre Test (Test B)
- The Study Guide
- The Homework Assignment
- The Post Test (Test A)

Except for the HOMEWORK ASSIGNMENT (which, in the present course, is a reference to standard questions as presented in the CORE TEXT and which are marked subjectively by the instructor later to be recorded by the computer) the questions are in multiple choice form and are created by the course writer.

The essential difference between the test questions in both tests and the STUDY GUIDE questions is in the treatment that the incorrect answer receives.

The PRE TEST (TEST B)

The PRE TEST (TEST B) incorrect answers are merely tallied by the computer in the process of grading the student's prior knowledge of the material in the related VOLUME. Item analysis and Histogram prints as well as correlations with similar results in the POST TEST (TEST A) are made by the computer. Each question is keyed to an M30.

The POST TEST (TEST A)

The POST TEST (TEST A) has a detailed analysis of each DISTRACTER relating it to a CATALOG NUMBER. Each incorrect choice is accompanied by a particular REMEDIAL PRESCRIPTION drawn from the REMEDIAL TEXT. The computer has several routines described in other parts of this report that analyze the students' response patterns.

The STUDY GUIDE

The STUDY GUIDE has the most detailed analysis of each response. Not only is each question related to a Learning Category and an M30, but each DISTRACTER is accompanied by a detailed analysis of the cause of the error with hints or direct aids for the student to effect the proper solution.

The following pages outline one phase of this area, that of question creating and the detailed analysis of the relationship to the appropriate M30, the appropriateness of the distractors offered, etc., as discussed more completely in the TEST EVALUATION CHECK LIST on Page 70.
PRINCIPLES OF CREATING A SET OF CRITERION CHECKS

COUNTABILITY REQUIREMENT:
The course design requires a statistical analysis of the responses made by each student to each criterion check in the

PRE-TEST  
STUDY GUIDE  
POST-TEST

for correlation with background information and individual remedial prescriptions. The responses are summarized for an item analysis of question-response experience by the entire population for

COURSE OPTIMIZATION  
GENERAL REMEDIAL SESSION ORGANIZATION

OBJECTIVITY REQUIREMENT:
An off-line operation cannot accept unanticipated responses and relate them to a particular list of concepts for error analysis. However, a predicted set of typical errors (referred to as DISTRACTORS) can be devised for each question. Therefore, each QUESTION is related to a specific MEASURABLE BEHAVIORAL OBJECTIVE by coded number. Each DISTRACTOR is related to a coded CONCEPT CATALOG entry.

MULTIPLE CHOICE FORMAT:
To maintain control over the student's response patterns, each question is cast into the MULTIPLE CHOICE format.

Certain precautions must be taken to avoid the major objection made to multiple choice question-answer arrays, that of telegraphing the answer.

1. The problem worksheets for the STUDY GUIDE and TESTS (see Pages 62, 67) indicate that each problem must be created to illustrate and test a specific MBO.

2. Each step of the solution must be examined for the possibility of the occurrence of a typical error. The error identified by CONCEPT CATALOG must be incorporated into the solution. This solution becomes a DISTRACTOR.
3. If DISTRACTORS are chosen without a specific error in mind, the accuracy of analysis is affected.

4. Other devices to disguise the actual value of the DISTRACTOR to avoid frustrating the purpose of the problem by merely substitution of the various choices can be employed, as for example:

- $x$ is one member of the set \{17, 19, 21, 23, 25\}
- $y$ is a negative number $\geq -17$
- $a$ is larger than $b$
- $c$ is a prime number
- $10 < d < 20$
- $e$ is odd and $f$ is even.

5. If it is found that the number of distractors that can be properly assigned to a particular question exceeds four (not including the answer) it is advised to replace one of the distractor choices with the all inclusive, "NONE OF THESE" and to test the same MBO in a subsequent question with a different array of distractors. The cross referencing made possible by this strategy will produce a meaningful result.

6. If it is found that the question chosen to illustrate a specific well-defined principle is so elementary that only one or two distractors can be devised, it is suggested that two such questions be combined into one problem with the truth values of each paired into four combinations.
DISTRACTOR STRATEGY:

The design of the Study Guide with a similar publication (1. Pages 4-40) und questions structured in a multiple choice format with an answer array to the student of four choices: one, the correct answer and the other three, incorrect. The three incorrect are devised to illustrate the outcome resulting from a typical misapplication of a fundamental principle and as such are referred to as DISTRACTORS.

The course writer has several options available for the handling of the answer choices.

STRATEGY A:

The correct answer choice is referred to a page where the simple statement, "Your answer choice is correct, please proceed to the next question below." This strategy is generally reserved for questions with a Learning Category level of 1, 2, or 3.

Each of the DISTRACTORS is referred to a separate page (OK PAGE) (REM PAGE) where the error is explored in detail and then the student is advised to "Return to page ___ and reconsider the question."

STRATEGY B:

The correct answer is handled by an OK PAGE as in STRATEGY A. But because of the similarity of the nature of the mistakes exhibited in the DISTRACTORS, two or all three of the incorrect choices are handled by the same comments, and so they are referred to only one or two REM PAGES.
STRATEGY C:

The correct answer choice is referred to a page (Q.E.D. PAGE) where a complete review of the solution is exhibited for the student's benefit. This will reinforce the student's understanding of the principles and processes involved and demonstrate an approved method of solution. This strategy is applied to questions with a Learning Category above Level 3.

Each of the DISTRACTORS is referred to a separate REM PAGE as in STRATEGY A.

STRATEGY D:

The correct answer choice is referred to a Q.E.D. PAGE as it is done in STRATEGY C.

The incorrect answers are referred to only one or two REM PAGES as in STRATEGY B, and for the same reasons.

This analysis can be summarized in chart form:

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>CORRECT ANSWER</th>
<th>DISTRACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>O.K. PAGE</td>
<td>Separate REMS</td>
</tr>
<tr>
<td>B</td>
<td>O.K. PAGE</td>
<td>Combined REMS</td>
</tr>
<tr>
<td>C</td>
<td>QED PAGE</td>
<td>Separate REMS</td>
</tr>
<tr>
<td>D</td>
<td>QED PAGE</td>
<td>Combined REMS</td>
</tr>
</tbody>
</table>

DISTRACTOR STRATEGY FLOW CHART:

The form on the facing page is designed to allow the course writer to illustrate the sequence of the student's response activity with a minimum amount of construction. The form has dotted lines which can be adjusted to follow the particular strategy chosen for each question. The MBO for each QUESTION and the EO and CATALOG NUMBER are to be placed in the appropriate boxes provided.
NOTE: Choose appropriate strategy; Complete distractor return lines accordingly
STUDY GUIDE QUESTION CREATION

MBO REFERENCE:
The question must be created to exhibit a specific MBO. This must be noted on the form opposite along with the actual statement of the MBO. If a text was the source, then this is to be noted for reference.

LEARNING CATEGORY:
The question must be phrased to indicate the appropriate Behavioral Verb associated with the level of difficulty.

SOLUTION:
The problem must be solved step-by-step with detailed explanations if the answer is to be handled by a QED PAGE.

DISTRACTORS:
The distractor must be chosen by examining the solution for steps that generally result in misapplications of principles. They must be realistic errors. REM PAGES must be written to give the required remedial aid to the student.

The permutation of the positioning of the four choices must be randomly made to avoid the appearance of a patterned answer array.

This form is a work sheet, and the final information is later incorporated into the STUDY GUIDE answer matrix.
REVIEW GUIDE

QUESTION WORK SHEET:

RELATED TO MBO:

MBO STATEMENT:

STATEMENT OF QUESTION:
SOURCE: BOOK: PAGE:

SOLUTION:

AUTHORITIES (EO)

( + )

DISTRactors:

(A)

(B)

(C)

DISTRACTORS STRATEGY

* REM PAGE TO BE WRITTEN

* QED PAGE TO BE WRITTEN

AUTHORITIES IGNORED: MISAPPLIED

APPROVED: CHECKED: WRITER:

63
STUDY GUIDE MANUSCRIPT ANSWER MATRIX:

The form on the facing page was devised to record the information necessary for the scrambled pagination and for the answer matrix. It also serves as the program control as well as the information necessary for the computer study guide analysis.

LEARNING CATEGORY:
The level of difficulty of the question is noted. This allows complete analysis which correlates the question difficulty response against any item of the background information on each student or the entire population enrolled in the course.

DISTRACTOR STRATEGY:
The analysis of the error rate on each type of distractor strategy will indicate which study guide REM PAGES will have to be re-written because of unusual frequency of errors recorded.

BEHAVIORAL OBJECTIVES:
The correspondence of the question to each MBC and whether it is a TO or an EO is noted. This information is made available for computer analysis. It is essential to the selection of an answer choice pattern.

REFERENCE SHEET (See 146-86).

ANSWER CHOICE:
The CORRECT ANSWER and the REM PAGES are recorded under the selected answer permutation. This allows for a randomizing of the answer choice pattern to foil the discovery of any "pattern" in the answer choice array.

CATALOG NUMBER:
The CATALOG NUMBER giving the generic description of the cause of the error is recorded. This will also appear in the computer PRINTOUT for easy referencing of error incidence.

SCRAMBLED PAGINATION:
This becomes the work sheet for the process of scrambling the pages of the STUDY GUIDE. Reference is made to Pages 71 to 75 for a detailed account of the procedure.
<table>
<thead>
<tr>
<th>MANUSCRIPT PAGINATION</th>
<th>FINAL SCRAMBLED PAGINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DEFINE</td>
<td>RECOGNIZE</td>
</tr>
<tr>
<td>2. PERFORM</td>
<td>CHECK</td>
</tr>
<tr>
<td>3. STATE</td>
<td>CHOOSE</td>
</tr>
<tr>
<td>4. PROVE</td>
<td>APPLY</td>
</tr>
<tr>
<td>5. DETERMINE</td>
<td>RELATE</td>
</tr>
</tbody>
</table>
TEST QUESTION WORK SHEET:

This sheet should be completed in such detail that another writer could follow all of the reasoning involved in the question—answer—distractor decisions.

1. The test number should be entered.

2. The question number should be entered.

3. The MBO NUMBER relating to the question should be entered.

4. The complete MBO STATEMENT should be added after the lead, "The student should be able to..."

5. The TEST QUESTION should be stated completely. Reference should be made to form QUESTION PLACEMENT CORRELATION STRATEGY for the rationale of the EO, and TO criterion checks and choice of question difficulty.

6. The LEARNING CATEGORY should be indicated. Reference should be made to form entitled "LEARNING CATEGORIES" for the proper choice of the BEHAVIORAL VERB.

7. The ACTUAL COMPUTATION involved in the arrival at the erroneous answer should be made.

8. The MBO relating to the error should be entered.

9. The REMEDIAL PRESCRIPTION should be carefully chosen to present proper practice work in the deficiency area. Book, page, and problem numbers should be indicated. A ten minute assignment for each error is considered normal.

10. The DISTRACTORS STRATEGY should be chosen after the problem with its solutions and distractors has been completed.

11. The work must be checked by the editor.

12. The complete material should be approved by the Project Coordinator.
### Test Question Work Sheet

**Test:**

**Question:**

**Related to XE0:**

**Criterion:**

**The student should be able to:**

<table>
<thead>
<tr>
<th>Learning Category</th>
<th>Distractor 1</th>
<th>Distractor 2</th>
<th>Distractor 3</th>
<th>Distractor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Catalog Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Statement of Test Question:**

<table>
<thead>
<tr>
<th>Answer Choice</th>
<th>Remedial Prescription</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Solution:**

<table>
<thead>
<tr>
<th>Distractor 1</th>
<th>Distractor 2</th>
<th>Distractor 3</th>
<th>Distractor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Approved:**

**Checked:**

---

67
THE TEST ANSWER MATRIX

This form comprises the information that is forwarded to the computer as a basis for the test marking function. It is used for both forms of the test.

The LEARNING CATEGORY and MBC associated with each question is indicated.

The CATALOG NUMBER, with its brief description, is related to each DISTRACTOR.

The REMEDIAL PRESCRIPTION, (which will be part of only the POST TEST (TEST A) printout is indicated. It becomes part of the course master file of the computer memory.
<table>
<thead>
<tr>
<th>QUES</th>
<th>LOC</th>
<th>MEQ</th>
<th>ANS</th>
<th>CAT. NO.</th>
<th>DESCRIPTION</th>
<th>REMEDIAL PRESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>B</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td></td>
<td></td>
<td>C</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
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<td>D</td>
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<td>10</td>
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<td>E</td>
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</tr>
</tbody>
</table>
TEST EVALUATION:

The form on the facing page is a compact check list of items that must be evaluated by the course editor before approval of the test.

MBO REFERENCES:

Each question and each of the DISTRACTORS must be properly related to the MBO intended. They should be designed to test the specific objective precisely.

MATHEMATICAL CONSIDERATIONS:

The language level employed, the accuracy of terminology, the adequacy of instructions and diagrams, must be examined and approved.

The array of answer choices, the permutation of correct answer placement, and the presentation of realistic distractors must also be considered.

The remedial prescriptions must be analyzed for their relevance.

Every problem must be solved, and its answer verified before final approval is given.
### TEST EVALUATION CHECK LIST

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tbody>
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</tbody>
</table>

### DISTRACTOR 1
- REALISTIC
- CAT. REFERENCE
- PRESCRIPTION

### DISTRACTOR 2
- REALISTIC
- CAT. REFERENCE
- PRESCRIPTION

### DISTRACTOR 3
- REALISTIC
- CAT. REFERENCE
- PRESCRIPTION

### DISTRACTOR 4
- REALISTIC
- CAT. REFERENCE
- PRESCRIPTION

PREPARED BY: 71
HOMEWORK ASSIGNMENT WORK SHEET:

On the facing page is the form used by the course writer for the recording of the problems chosen for the HOMEWORK ASSIGNMENT.

One strategy is to have the CORE TEXT used as a source of problems for this assignment. In this way the student is subtly influenced to re-read the basic text. The problems should be chosen with care and in an increasing order of difficulty.

MBO REFERENCE:

Each question must be chosen to correspond to a particular MBO. Complete coverage of the MBOs is more likely to be achieved when specific notation must be made. Refer to Page 53 for the principles of question placement and to Page 74 for an overview discussion of the MBO cross reference sheet.

TEXT INDEPENDENCE:

To achieve a degree of independence from any one particular textbook, the course writers could devise a list of homework problems specifically created for the MBO criterion check. However, this form would still serve the purpose as a check on the completeness of coverage.
<table>
<thead>
<tr>
<th>QUESTION NO</th>
<th>PAGE NO.</th>
<th>EXAMPLE NUMBER</th>
<th>REFERENCE</th>
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MBO STRATEGY AND CROSS REFERENCE SHEET:

The purpose of this form is to record the spread of questions under the four media across the MBO list.

Reference is made to the QUESTION PLACEMENT CORRELATION STRATEGY on Page 53 for further analysis.

The major consideration is to have each MBO covered by at least one question in some media form. The preparation of this cross referencing form is the last action in the creation of the program. If, however, it is maintained while the course is being created, an even distribution of MBO coverage will be achieved.
<table>
<thead>
<tr>
<th>MBO NUMBER</th>
<th>CATALOG NUMBER</th>
<th>S C</th>
<th>P M</th>
<th>PRE TEST</th>
<th>POST TEST</th>
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SCRAMBLED PAGINATION FOR STUDY GUIDE

1. INTRODUCTION

1.1 The purpose of the STUDY GUIDE (SG) is to direct the student in his reading of a recognized textbook without the supervision by a teacher being necessary (although there may be provision for a teacher - classroom format used as part of the overall learning program).

1.2 In essence, the SG format consists of Supplementary Notes, Reading Assignments, Homework assignments, a V. References and a battery of Questions.

1.3 The questions are presented in multiple choice form with provision for tracking the student's answer patterns by means of a punch card record and a device known as a Program Control. Both the question and the answer choices are keyed to a finely devised list of measurable behavioral objectives that comprise the course content.

1.4 Each answer choice is discussed in some detail. If the answer chosen is wrong, the student is referred to the question again (REM PAGE).

If the choice is correct, he is either referred to the next question without comment (OK PAGE), or with a presentation of the complete solution (QED PAGE).

1.5 The elements of this BRANCHING PROGRAM are therefore: QUESTION, REM, OK and QED.

2. DESCRIPTION

2.1 To allow the student to answer each QUESTION, only after he answers the precious question correctly, the PROGRAM CONTROL directs him to a page where he discovers whether or not he is correct. By having these pages in a scrambled order, he is unable to locate the answer to the questions by merely turning the pages of the book. The only identification of the answer pages is made through the PROGRAM CONTROL and the ANSWER MATRIX. This page number is hidden from view until a punch card entry is made on the PROGRAM CONTROL.

2.2 By placing each question after the OK or the QED, the student is forced to arrive at the correct answer for the previous problem before he can even find the following question.

2.3 Since, in general the REMS are less than one-half of a page, in length, further scrambling is effected by placing two unrelated REMS to a page.
3. COMPONENTS

There are four components that are involved in the recording of the scrambling pages.

3.1 ANSWER MATRIX

This form (giving the manuscript numbering system for the four answer choices for each question of a SEG and indicating the correct choice as a check or as a QED) is complete for the page assignment.

3.2 PAGINATION

This form is blank. On it the assignment of REMS will be entered. The top half of the page will be designated as /1 and the bottom as /2.

3.21 Questions will be indicated by SEG and Question: e.g. Segment 2, Question 6 will be coded: 2-6.0

3.22 REM pages will be indicated by SEG, Question and Answer choice; e.g. Segment 2, Question 5, Answer Choice 4 will be coded: 2.5.4 (note decimals).

3.3 QUESTION SHEET:

Each question (capable of standing alone) is on a sheet with generous spacing between questions to allow for separating the questions after the scrambled page entries have been made. Each question must present four answer choices. Each answer choice must be related to a REM (not necessarily different, dependent upon the strategy chosen).

3.4 REM PAGES:

Each Answer choice is referred to a REM, of which there are three types:

3.41 Wrong Answer: There is a comment followed by the direction to return to the question and choose another answer.

3.42 Check: This is a simple statement that the answer choice was correct. There is a direction to proceed to the next question which follows immediately and which shares the same half page.

3.43 The QED: This is a presentation of a complete solution to the problem. It is followed by the direction to proceed to the next problem which is presented below it. The QED must, therefore, be in the upper half of the page, with the following question in the lower half.
PROCEDURE

4.1 PAGE-COUNT:
Determination of number of pages required:

Multiply the number of questions by 4.
Add the number of QEDs.
Add the number of special pages.
Subtract the number of duplicate REMs.
Divide this number by 2.

4.2 Begin with Question 1, continue with the REMs for question 1, and then go on to Question 2 and the REMs for 2, and so on.

In general assign one question to one decade, or row of pages, the first REM to the next decade, the second REM to the following decade, and so forth.

4.3 ENTRIES:

<table>
<thead>
<tr>
<th>TYPE ENTRY</th>
<th>WHERE ENTERED</th>
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</thead>
<tbody>
<tr>
<td>QUESTION PAGE NUMBER</td>
<td>QUESTION SHEET—next to question</td>
</tr>
<tr>
<td>REM PAGE NUMBER</td>
<td>EACH REM PAGE in &quot;return space&quot;</td>
</tr>
<tr>
<td>QUESTION NUMBER</td>
<td>ANSWER MATRIX—under REM number</td>
</tr>
<tr>
<td></td>
<td>REM PAGE—next to the REM</td>
</tr>
<tr>
<td></td>
<td>PAGINATION MATRIX—under page number</td>
</tr>
<tr>
<td></td>
<td>REM PAGE—after an OK</td>
</tr>
<tr>
<td></td>
<td>REM PAGE—after a QED</td>
</tr>
<tr>
<td>REM NUMBER</td>
<td>PAGINATION MATRIX</td>
</tr>
</tbody>
</table>

4.4 SEQUENCE OF OPERATIONS:

4.4.1 1 Put question number on PAGINATION MATRIX under a certain page.
2 Put the page number next to the question on question page.
3 Put the same page number on all related REM PAGES in the space indicated in the phrase, "return to page ___ and try the question again."

NOTE: (a) If the previous REM was an OK (i.e., it was a simple statement that the answer was correct with no other explanation) then the following question should share the same half page.

(b) If the previous REM was a QED (i.e., it was a correct choice and was supported by a complete solution) then the following question should be placed in the lower half of the page. Such QEDS must, therefore, be placed in only the upper half of the page.
4.4 SEQUENCE OF OPERATIONS:
(Continued)

4.41 4. Put REM NUMBER on PAGINATION MATRIX under a certain page.

(Note: Each REM should be located several pages away from the QUESTION and the other related REMS.)

5. Put the PAGE NUMBER next to the REM on the REM PAGE.

6. Put the same PAGE NUMBER in the ANSWER MATRIX under the proper REM NUMBER.

5. EXAMPLES OF THIS PROCEDURE are now given. Please refer to the illustrations on the following page.

5.1 REM 2.4.4 was a "CHECK" and had been assigned to page 51 at the top of the page. 2.4.4 was placed on the PAGINATION MATRIX in the top half of row 5 under 1.

On the REM PAGE 2.4.4 the page number 51 was written.

5.2 QUESTION 2-5 shares the same half page with the previous REM (since REM 2.4.4 was a CHECK) 2-5 was placed on the PAGINATION MATRIX in the top half of row 5 in the column headed 1.

On the QUESTION PAGE the page number, 51 was written after QUESTION 2-5.

On each of the REMS for Question 2-5, where the answer choice was wrong, the page 51 was written in the space provided in the instruction, "Return to and choose another answer. (See page 2.)

5.3 REM 2.5.4 was placed on page 61; the entry "2.5.4" was made on the PAGINATION MATRIX and 61 was written next to that REM on the REM PAGE. This same entry was made on the ANSWER MATRIX under "b" in row "5".

5.4 The correct answer 2.5.3 was a QED. As such it required a complete half page and had to be placed in the top half of the page. There, 2.5.3 was assigned to 50.

The question that followed 2.5.3 was QUESTION 2-6. It was properly placed in 50 on the PAGINATION MATRIX.
6. EXCERPTS FOR ILLUSTRATION:

6.1 PAGINATION MATRIX

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<td>2.9.2</td>
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6.2 ANSWER MATRIX

<table>
<thead>
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<td>49/1</td>
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<td>61/1</td>
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</tbody>
</table>

6.3 QUESTION SHEET

VOL 13 SEG 2:
QUEST. 5:---------------------------------------- 51

QUEST. 6:---------------------------------------- 50

6.4 REM PAGE

2.4.4 Your answer is correct. Proceed to Question 5 which follows. 51

2.5.4 Wrong answer......................... 51
Return to page 51 and choose another answer 1

2.5.3Q ...(complete explanation)............... 50
Proceed to question 6 below 1

7. PREPARATION FOR TYPING:

7.1 Separation of sheets

7.1.1 Separate the questions

7.1.2 Separate the REMS

7.2 Sort according to page number

7.3 Collate according to page number (including both halves) and staple together.

7.4 The typist then can prepare a complete page.
The SCHEMATIC DIAGRAM on the opposite page shows the FUNCTIONS of

PROGRAM CONTROL:
- PUNCH CARD
- ANSWER MATRIX

or the equivalent:
- LATENT IMAGE (MARK SENSE)
- RESPONSE SHEET

in the directing of the student through the

SCRAMBLED PAGINATION of the STUDY GUIDE

Specific references are made for illustration of continuity of step sequence.

1. STUDY GUIDE:
   Student reads question 4 on page 20/1 which relates to Vol. 5, Seg. 3

2. PUNCH CARD:
   Student solves problem and picks answer choice A (DISTRACTOR). He records his choice by punching out perforations on a punch card which has been inserted in PROGRAM CONTROL. This action causes a bulb to light up on light panel. The light shows through the prepared ANSWER MATRIX revealing the page in the STUDY GUIDE to which he should turn. (51/1)

3. REM PAGE:
   He receives remedial instruction on the nature of his error which is referenced to the concept catalog number and he is directed to return to the question (page 20/1)

4. REM-LOOP:
   This process is repeated. If he chooses:
   - DISTRACTOR B (where he is referred to page 28/2) or
   - DISTRACTOR C (where he is referred to page 39/2)

5. QED PAGE:
   When he chooses the correct answer (in this example, D) he is referred to page 40/1 where he receives further reinforcement in reviewing a complete demonstration of the solution of the problem.

6. NEXT QUESTION:
   He is then directed to the bottom of the same page 40/2, for question 5 and the process is repeated. Note that he doesn't see the next question until he has located the previous correct answer.

7. The PUNCH CARD (or LATENT IMAGE MARK SENSE RESPONSE SHEET) is forwarded to the computer for input and analysis.

8. The ANSWER MATRIX (or LATENT IMAGE SHEET) is replaced for each SEGMENT.
MULTIPLE BRANCH STRATEGY:

PROGRAM CONTROL

PUNCH CARD

STUDY GUIDE

A

B

C

D

1

2

3

4

51/1 28/2 39/2 40/1

CATALOG NUMBER

COMMENT

GO TO:

QUEST. 4

20

1

5-3-4-1

5-3-4-2

5-3-4-3

5-3-4-4

5-3-4-5

5-3-4-6

REM PAGES