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ELECTRONIC DATA PROCESSING IN ENGINEERING, SCIENCE, AND BUSINESS. SUGGESTED TECHNIQUES FOR DETERMINING COURSES OF STUDY IN VOCATIONAL AND TECHNICAL EDUCATION PROGRAMS.

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INFORMATION IS PROVIDED TO HELP THE STATES ORGANIZE AND OPERATE PROGRAMS UNDER TITLE VIII OF THE NATIONAL DEFENSE EDUCATION ACT OF 1958. IT EXPLAINS HOW BASIC OCCUPATIONAL INFORMATION RESULTING FROM JOB ANALYSIS IS USED TO DETERMINE RELATIONSHIPS AMONG JOBS IN ELECTRONIC DATA PROCESSING, THE TECHNICAL KNOWLEDGE REQUIRED FOR SUCCESSFUL JOB PERFORMANCE, AND HOW SUCH INFORMATION IS THEN USED TO ESTABLISH THE COURSES OF STUDY REQUIRED TO PREPARE STUDENTS FOR A CLUSTER OF CLOSELY RELATED JOBS OR FOR A SPECIFIC JOB WITHIN A CLUSTER. HISTORICAL BACKGROUND, THE FUTURE OF DATA PROCESSING, THE FIELDS OF WORK, AND THE RELATIONSHIPS BETWEEN JOBS ARE DISCUSSED. JOB DESCRIPTIONS ARE INCLUDED FOR THE COMPUTING ANALYST, BUSINESS DATA PROCESSING PROGRAMER, AND SYSTEMS ANALYST. A TRAINING REQUIREMENTS ANALYSIS FORM ILLUSTRATES METHOD FOR RECORDING KNOWLEDGE AND ABILITY REQUIRED FOR EACH OCCUPATION. STEPS ARE GIVEN FOR CURRICULUM CONSTRUCTION IN TECHNICAL EDUCATION WITH SPECIAL REQUIREMENTS FOR POST-HIGH SCHOOL TECHNICAL CURRICULUMS. THE APPENDIX INCLUDES A LIST OF BUSINESS COURSES, DATA PROCESSING COURSES, MATHEMATICS COURSES, SCIENCE COURSES, AND A SAMPLE CURRICULUM OUTLINE. REFERENCE MATERIALS ARE LISTED. THIS DOCUMENT IS AVAILABLE AS GPO NUMBER FS 5.280--80030 FOR 30 CENTS FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402. (PS)

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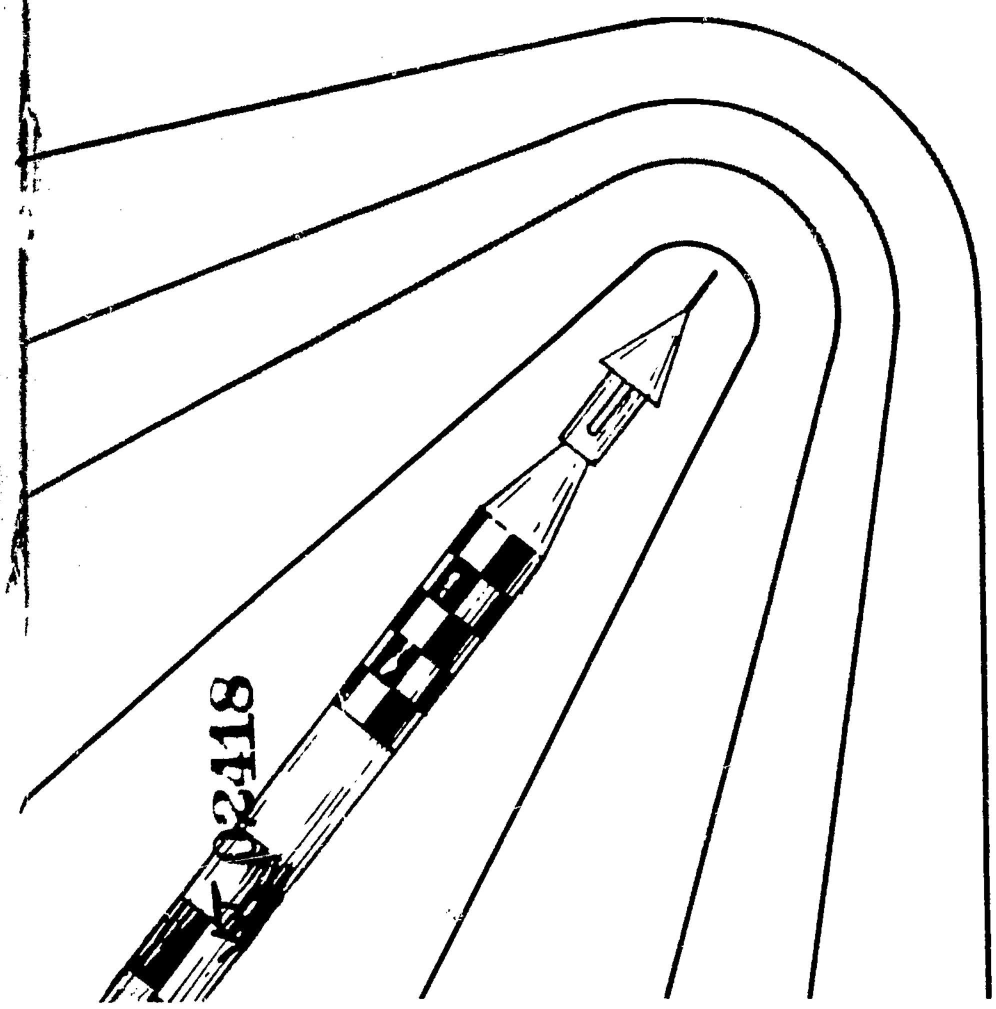

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HEALTH, EDUCATION, AND WELFARE . . . . ANTHONY J. CELEBREZZE, Secretary
Office of Education . . . . FRANCIS KEPPEL, Commissioner

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FOREWORD

This publication on electronic data processing is the sixth in a series designed to provide information to help the States organize and operate programs under Title VIII of the National Defense Education Act of 1958, Public Law 85–864. The other publications in this series are: Mechanical Drafting and Design Technology (OE–80000), Electrical and Electronic Technologies (OE–80004), Mechanical Technology—Design and Production (OE–80014), Chemical and Metallurgical Technologies (OE–80016), and Civil and Highway Technology (OE–80018).

These programs, conducted under State plans prepared by State Boards for Vocational Education and approved by the U.S. Office of Education in keeping with the provisions of Title VIII of the National Defense Education Act of 1958, offer instruction in fields of work essential to the national defense. The programs are open to anyone qualified to benefit from such training. As used in this publication, the terms "technician" and "technical worker" refer to scope of training and work capabilities rather than to employment classification.

Each publication in this series indicates how job analysis and job relationship techniques can be used to facilitate the planning of training programs. Each publication contains the following information and suggestions:

1. General information about a technology or broad field of work.
2. A procedure for determining the relationship among jobs in order to develop homogeneous groups or clusters of occupations for which training may be given.
3. A method for determining the courses of study required to prepare students for a cluster or group of closely related occupations or for a specific occupation within a group.

The occupations discussed in this document are typical of those found in the field of electronic data processing, but are not meant to be all-inclusive. They represent typical areas of activity in which technically competent workers are engaged and should not be considered in all cases as entry jobs. Students who have received instruction in an organized training program for a specific technology are provided with the technical knowledge and skills of this field of work, but they usually serve a period of internship in order to learn how to apply their knowledge to technical problems likely to be encountered in the specific job to which they are assigned.

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Assistant Commissioner for
Vocational and Technical Education.

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INTRODUCTION

This publication explains how basic occupational information resulting from job analysis is used to determine relationships among jobs in electronic data processing and the technical knowledge required for successful job performance; and how such information is then used to establish the courses of study required to prepare students for a cluster of closely related jobs or for a specific job within a cluster.

Accurate information about jobs is fundamental to the planning of any occupational training program. The nature of the job information required varies according to the program contemplated. Regardless of its ultimate use, however, the data must be up to date, accurate, and presented in usable form.

The process of obtaining and reporting pertinent information concerning the nature of a specific job is called "job analysis"—the technique used in determining the actions, skills, knowledge, abilities, and responsibilities required of a worker for successful performance of his job, and in identifying the tasks or elements which differentiate the job under study from all others.

Basically, there are three parts to the analysis of any job: (1) the job must be completely and accurately identified; (2) the duties and actions required of the worker to perform the job must be complete and accurate; and (3) the knowledge and skills required for each element or task within a job must be specified.

After the needs for technical manpower have been determined, it will be necessary, in most cases, to analyze the various jobs for which training is contemplated. There are several methods for making a job analysis. Some widely used methods of job analysis are described in the *Training and Reference Manual for Job Analysis*, prepared by the U.S. Department of Labor. A recent publication of the Department of the Navy—*Handbook for Naval Occupational Analysis*—also contains helpful techniques for analyzing jobs. (See Appendix C.)

This report does not describe the methods and techniques of job analysis but assumes that this function will be performed by personnel experienced in the field. It is recognized that the States may not have experienced personnel on their staffs who can devote sufficient time to make the necessary job analyses, but the information needed may be available from other sources. In some cases, industry or labor has job analysts who can provide detailed information about the significant factors of each job or who can make necessary analyses. Also, the State Employment Security Agency may have such information in its files or may assign an occupational analyst to work with educators in gathering these data.

Because of the specialized nature of technical jobs, it is essential that data regarding educational and training requirements be as complete and informative as possible. For example: (*a*) *Basic knowledge of statistical processes and procedures with emphasis on probability, principles of sampling, correlation and regression analysis, and analysis of variance* is more meaningful and specific than *knowledge of statistics*; and (*b*) *must have a working knowledge of basic* *algebra, the number systems, fixed and floating point numbers, linear equations and Boolean algebra* is more meaningful than *uses mathematics in solving problems*.

Most of the information about technical occupations must be obtained through interviews with the worker and his supervisor, with little opportunity for observing the job. Some of these jobs are in areas which are classified for security reasons, or the end product being worked on may be classified. In such cases, it may be necessary to conduct the interview with the worker in a nonclassified area under whatever security regulations may be in effect in the establishment where the study is being made.

A successful training program requires detailed information concerning the nature, duties, responsibilities, significant job elements, educational requirements, and related factors of each occupation for which training is contemplated. The content of the curriculum and the selection of trainees depend on a thorough analysis of each job.

Historical Background.—Data processing is not a new activity. It had its origin in ancient times when man's activities became more and more complex and the limitations of the human mind were recognized. The purpose of data processing is to provide information upon which decisions, present or future, are based.

Processing of data, which usually involves some computation, may be accomplished manually, mechanically, electrically, or electronically. The trend, from the earliest attempts to make determinations by mathematical processes, has been toward the reduction of mental and manual effort and an increase in the speed with which determinations are made.

The earliest device used for calculating was the abacus, invented more than 2,000 years ago, and still more widely used throughout the world than any other calculating device. Among the early calculating devices were Napier's "bones" (1617), Pascal's calculator (1642), Grillet's calculator (1689), Thomas' arithomometer (1820), Fuller spiral slide rule (1879), the Felt comptometer and the Edmondson calculator (1885). These devices were used primarily in scientific and other computations and secondarily as an aid in calculating operations of data processing.

Beginning as far back as the early 1900's a new concept was introduced into the field of data processing—the punched-card system. In this system holes punched in the cards are arranged in a pattern to represent significant data to be processed. Although the punched-card method was new in the field of data processing, it had been used previously for other purposes. It was conceived as early as 1801 by Joseph M. Jacquard of France who developed a loom which produced elaborate designs on textile fabrics. The weaving was performed according to a punched-card pattern. The same principle was applied to the player piano. In this case, music was produced by mechanically activating the keyboard of the piano according to the pattern of holes punched on the sheet or music roll.

Herman Hollerith, an employee of the Census Bureau, applied the punched-hole principle to cards and sorted them mechanically for the 1890 census. Holes punched in various sections on a card represented individual items of information. The cards were fed into a machine that made electrical contacts through the punched holes.

Prior to World War I, manually operated office machines were used to make rapid calculations and to provide information needed by management for carrying out the various activities of a business enterprise. Shortly after World War I, electromechanical machines came into general use. They accomplished four basic operational steps: recording, summarizing, calculating, and, to a limited extent, sorting. These machines were not automatic and they required some form of action by an operator, such as depressing a key, bar, or lever, to perform each processing operation.

In 1944, Dr. Howard Aiken completed the Automatic Sequence Controlled Calculator commonly called the Harvard Mark I Computer. The Mark I was an electromechanical computer using relays instead of mechanical wheels for number storage.

The Electronic Numerical Integrator and Computer (ENIAC) was completed in 1946 at the Univerity of Pennsylvania. It represented a major advance in computer equipment as it was the first all electronic system and much faster than previous computers.

The Electronic Discrete Variable Automatic Computer (EDVAC) was completed at the University of Pennsylvania in 1949. At about the same time, the Standards Eastern Automatic Computer (SEAC) was developed at the Bureau of Standards. These were the first stored program-type digital computers and represented the latest advances in computing system logic.

Since 1949, the major advances in computer design have been increased speed, greater and more flexible storage capacity, and miniaturization of component parts. Some of the new computers are small enough to be mounted on a desk.

Prior to the advent of the electronic computers, electromechanical machines had been used extensively by Government and business organizations to maintain and record data concerned with inventories, sales, payroll, billing, and other business transactions. Such machines processed data at the approximate rate of 100 punched cards per minute. The speed of similar equipment currently available and in use, is 200–300 cards per minute.

Electronic computers now in use process data in terms of milliseconds (thousandths of a second). Magnetic tape having a capacity of more than 4 million digits is used to record data by means of electronic impulses. In most cases, this tape is used in lieu of punched cards for entry into the computer.

The Future.—The following excerpt from *A New and Growing Field—Electronics in the Business World,* prepared by the Prudential Insurance Co. in cooperation with the Vocational Division of the New Jersey State Department of Education, indicates future opportunities in the field of data processing.

> In the years to come it is expected that more and more clerical work in business firms and in the government will be taken over by electronic computing systems. This does not mean *fewer* jobs but *different* jobs. The basic problem confronting employers today is the necessity of processing a load of office work which grows heavier as business expands. In addition, functions such as accounting, budgeting, and marketing are be-

coming more and more complex. As we have already seen, the computers can perform this work more economically and with greater speed and accuracy than a large clerical staff. Certainly, as time goes by, many more companies will shift more and more office functions to computers. This gradual shift from clerical work to automation in the office will take place not only in the large companies able to afford the large, complex installations, but also in the smaller ones as smaller and less expensive computer systems are developed.

For example, computer personnel and Electronic Data Processing Machine (EDPM) systems will replace the less advanced mechanical bookkeeping methods, just as those methods replaced hand bookkeeping. Such shifts will increase the demand for workers familiar with electronic data processing equipment. Satisfying this demand will be slow because of the time required to train new people and develop them into productive workers in the EDPM field. Certainly, as more and more people become qualified, new EDPM applications will be found. It is inevitable that the demand for additional workers in this field will continue to grow.

Programer and other EDPM personnel will be better paid than they would in most "desk jobs," in recognition of the higher level skills they will have developed through training. And a successful Programer with leadership abilities may find the way open to management responsibilities and rewards.

The new science of automatic programing seeks to make programing easier and more manageable. The goal is to build and program computers so that they accept instructions in everyday English.

Another development points to further mechanization in engineering design work. Computers will eventually assume routine engineering tasks, freeing engineers for more creative work. In the not too distant future, engineers should be able to use computers for the design of highly complex systems. All that will be required is a statement of the engineering problem in mathematical equations.

CHAPTER I

FIELDS OF WORK

ELECTRONIC DATA PROCESSING (EDP) means using electronic computers and related equipment for processing large masses of business and scientific data. Computers are also used for other purposes such as the numerical control of machines and processes in manufacturing operations, quality and production control, flow of materials, and engineering and scientific computations.

No figures are available as to the number of workers needed in electronic data processing activities during the next 10 years. However, in a recent publication of the National Science Teachers Association, the following statement appears:

> There are presently fewer than 1 million people directly involved with electronic data processing. In 1970 there will be about 3 million.

A rapid rise in the number of systems analysts and programers is likely to take place during the next 10 years—an increase which industry spokesmen think may reach 200,000 by 1970. However, new developments in computer technology may result in important changes in the nature of the work to be done by programers. Much of the time-consuming and routine work associated with writing programs may be eliminated, and more analytical work will be required of people in these jobs.

All of the new jobs require more technical proficiency and, in most cases, more mathematics and science than the jobs which have become obsolete because of automation and other scientific developments. This must be considered when planning training and retraining programs for the Nation's work force.

It was recognized early in the study of technical education for occupations in the field of data processing that training must be provided for two distinct areas: (1) business data processing and (2) scientific and engineering applications. Although electronic computers are used for other purposes as in the numerical control of machines, processes, and other manufacturing operations, occupations in this field of work are not included in this publication.

BUSINESS DATA PROCESSING

As business organizations become larger, the problem of communication becomes increasingly difficult. In this rapidly changing technological era management decisions must be made quickly and accurately, if a business is to survive and prosper. These decisions depend upon up-to-date information which clearly identifies and defines the various factors in which management is interested. The number of clerical workers needed to prepare reports and other communication tools has increased tremendously in the past 15 to 20 years. The cost of paperwork has also increased because of the demand for more and more records.

Fundamentally, the business world is composed of two major areas: those organizations which produce goods and those which render service. Manufacturing is the product-producing area of modern business. A manufacturing business may change basic raw materials into finished products or into intermediate products which are used in producing other goods. Service organizations include such businesses as insurance, appliance or automobile repair, moving and hauling, warehousing, banking and financing, retail merchandising, and public utilities.

Both types of business may use computers for management information and decisions. In service organizations the computers are used for such activities as payroll, personnel and other accounting, inventory control, and billing. In manufacturing companies, computing systems are used for such functions as sales forecasting, requirements determination, inventory management, production scheduling and control, materials handling, and product distribution.

Technological advances are taking place constantly in the computer and in the auxiliary equipment used in conjunction with it. Languages are being developed which can be translated readily by the machines. Storage units are being modified and miniaturized to the point where an entire system can be installed on top of a desk.

Several jobs requiring technical education are involved in electronic business data processing (EBDP):

a. ***The Programer,*** who develops and prepares diagrammatic plans for the solution of business problems and prepares instructions to control the automatic data-processing equipment.

b. ***The Systems Analyst,*** who devises computer system requirements and layout, and develops procedures to process data by means of electronic data-processing equipment.

c. ***The Project Planner,*** who plans and directs the installation, modification, and operation of data-processing systems.

SCIENTIFIC AND ENGINEERING APPLICATIONS

Electronic computation is used to expedite the solution of scientific, engineering, and statistical problems encountered in many kinds of laboratories, research institutions, and industrial establishments. It multiplies man's ability to solve mathematically such engineering problems as design and development, scientific problems involved in operations research, and such manufacturing problems as materials handling and process control.

Many problems having to do with engineering design require a large amount of computation. The design of an aircraft or missile requires a tremendous number of calculations of stresses, strains, and other forces on each part of the structure. Although the mathematics of the physical situation is well understood, the only way of solving intractable mathematical equations is through numerical measurement, calculations, and approximations.

In physics, extensive computation is needed in many areas. In nuclear physics, for example, an investigation may be desired of the effects of a beam of neutrons on living tissue. The mathematical equations are far too involved and time-consuming to be solved by an individual.

Mathematical-type problems arise in engineering and in the physical sciences. Scientific work of this nature may involve the evaluation of polynomials or complex formulas, making mathematical tables (logarithms and trigonometric or Bessel functions) or solving systems of equations. A good example is the orbital calculations required for the prediction of satellite behavior.

Technical personnel engaged in this field of work perform a variety of mathematical computations concerned with design, development, trajectory, time, speed, deflection, vibration, statistics, and other variables. In complex computations requiring considerable time, they develop equations from engineers' and scientists' mathematical formulas and translate them into flow charts and procedures for solving the problems on an electronic computer.

CHAPTER II

JOB RELATIONSHIPS

BEFORE TECHNICAL CURRICULUMS can be established, the individual occupations for which training is needed should be identified. The next step is to analyze each of the jobs and prepare brief job descriptions covering the typical work activities, functions, and performance requirements for each occupation.

The occupations should then be arranged in homogeneous groups or clusters, and the kind and amount of basic and applied science, mathematics, and technical know-how required to prepare workers to perform the duties of each job should be specified. Training curriculums which grow out of such analyses and groupings are commonly called "cluster-based" curriculums.

The procedure used in determining the similarities in jobs and the common knowledge and abilities involved is called the job relationship technique. The criteria used by industry for establishing job relationships vary. However, all or most of the following factors are used in establishing the homogeneous groups or job clusters referred to in this bulletin:

1. Similarity of work performed.
2. Abilities and knowledge required of the worker for successful job performance.
3. Personal characteristics required by the job, such as high degree of accuracy, above-average mental application, creative ability, and use of independent judgment.
4. Tools, machines, instruments, or other equipment used on the job; also the reading and interpreting of blueprints, or the use of special measuring devices.
5. Basic material worked on or with: occupations may involve working with more than one material or with the same material in different forms.

In a cluster of related jobs, most of these factors should be present and, though not exactly matched, should be analogous. For example, in developing the relationships of jobs found in the broad field of drafting and design, it is readily apparent, when using the criteria shown above, that the electrical draftsman and the mechanical draftsman have one factor in common—that of drawing. The mechanical draftsman prepares drawings for mechanical devices. He knows how to calculate engineering details such as strength-weight ratios, tolerances, and elements of practical machine design. He is familiar with the working properties of metals, metal alloys, and other materials, as well as with machine shop operations and practices. The electrical draftsman, on the other hand, prepares plans and wiring diagrams. His knowledge encompasses electricity and magnetism, circuitry, and other factors related to electrical engineering. It is evident, therefore, that these two jobs are not closely related and do not belong in the same cluster or major grouping. The same conclusion might be drawn regarding construction and architectural drafting.

The Job Factor Comparison Form on page 10 suggests a procedure for establishing clusters of related jobs by comparing the characteristics or factors of a number of occupations. No attempt is made to place a relative value on any of the factors. Furthermore, a relatively higher number of factors does not necessarily imply greater skill.

A preliminary analysis was made of a number of jobs which seemed to belong in the field of electronic data processing. Included in the analysis were clerical, operational, and analytical occupations. The characteristics or significant factors of the jobs under consideration were identified. Of all the jobs analyzed, it was decided to choose only those which are concerned with programing and analysis and which require specialized training. Of these, three were selected for comparative purposes in order to determine their interrelationships. It is recognized that other jobs might have been chosen; those selected merely illustrate how the job relationship technique is used.

The Job Factor Comparison Form provides a graphic illustration of the relationship among these three jobs. Job factors A–1 through A–8 are generally considered characteristics of the specialized occupations in business data processing, while factors B–1 through B–5 are found in engineering and scientific applications.

A close look at the form shows that job factor A–5—"Ability to design flow charts and develop machine instructions for processing data by means of electronic data-processing equipment"—is the only one common to the three jobs. Five of the business application factors (A–1,2,3,5 and 6) are present in job A and all of them (A–1 through A–8) are present in job B. Therefore, these jobs are closely enough related to be in the same family.

Job C—Computing Analyst (Programer, Scientific and Engineering)—has only one factor in common with Programer, BDP (Job A), which indicates that Computing Analyst requires an entirely different background than the Programer, BDP, or the Systems Analyst.

The job relationship technique can also be used in selecting workers who can become qualified to handle closely related jobs in a comparatively short time. It provides a method for making maximum use of available skills in an organization. For example, a Programer, BDP, who has had a year or more in programing experience, can perform the functions of the Systems Analyst with a minimum of additional training.

JOB FACTOR COMPARISON CHART

Significant characteristics	Electronic data-processing occupations: Programer, BDP (A)	Systems analyst, BDP (B)	Computing analyst (Programer, engineering and scientific) (C)
A. BUSINESS APPLICATIONS:			
1. Ability to understand and interpret oral and written statements concerning business problems and to discuss them intelligently with others.	■	■	
2. Understanding of office practices—recordkeeping, payroll, billing, etc.	■	■	
3. Ability to apply algebra and accounting mathematics to solution of business problems.	■	■	
4. Knowledge of statistical methods and ability to apply them to business problems.		■	
5. Ability to design flow charts and develop machine instructions for processing data by means of data-processing equipment.	■	■	■
6. Ability to prepare mathematical statement of common business problems to facilitate programing procedures.	■	■	
7. Ability to analyze and present methods for solution of uncommon and complex business problems.		■	
8. Ability to develop techniques and devise procedures for processing business data.		■	
B. SCIENTIFIC AND ENGINEERING APPLICATIONS:			
1. Knowledge of engineering and physical science principles.			■
2. Ability to understand and analyze oral or written statements concerning complex engineering and/or scientific problems and to discuss them intelligently with professional personnel.			■
3. Ability to apply advanced mathematics, such as differential equations and numerical analysis to solution of engineering and scientific problems.			■
4. Ability to analyze a project in terms of machine capabilities, costs, and man and machine hours involved to determine feasibility of processing data electronically, mechanically, manually, or by a combination of methods.		■	■
5. Ability to develop mathematical equation required to test or further develop theories advanced by an engineer or scientist.			■

CHAPTER III

JOB DESCRIPTIONS

THE JOB DESCRIPTIONS included in this chapter are given as examples of the kinds of occupations found in the field of work described in this publication. They are developed from data in *Occupations in Electronic Data-Processing Systems,* prepared by the U.S. Employment Service, U. S. Department of Labor, and studies made by the author.

Since these job descriptions are based on source data assembled from studies made in various parts of the country, they may be considered as composites and may not coincide exactly with a specific position in a specific organization.

The job descriptions are given as examples of jobs found in the field of electronic data processing; they cannot be considered as standards for setting hours and wages, for settling jurisdictional matters, or for use in formal job evaluation systems.

The following job descriptions, which present the principal duties of each job, should be useful in identifying technical jobs in electronic data processing. Also, they may be used for comparative purposes when making analyses of related jobs. In many cases, job studies may reveal only minor differences from those indicated in one of these job descriptions. In such an event, only the differences in job content and in the performance requirements need be considered. Care should be exercised so that courses of study resulting from the job analyses will not be limited to local conditions. Actually, instruction for a technology should be broad enough to fit the training needs on a national basis as well as the needs of industry at the local level.

COMPUTING ANALYST

(Programer, Scientific and Engineering)

Formulates mathematical statement of scientific, engineering, and technical problems and devises procedures for solution of such problems by means of automatic data-processing equipment. Confers with engineers, scientists, or other officials concerned to determine whether problem can be solved by a computer, it is adequately formulated, and the type of answer required is clearly stated. Analyzes various problems, such as distribution of airplane wing stresses, statistical analysis of psychological data, calculation of tensor forces between nuclear particles, and analysis of structures to simplify design. Prepares charts, tables, and graphs to assist in the analysis, working with a variety of scientific and engineering tables and using mathematics often at the level of differential equations. Restates the problem in terms of algebraic equations to indicate mathematical relationships; resolves the equations to be sure they apply; and devises more efficient methods for preparing the data for computer processing, keeping in mind the capacity and limitations of the equipment, operating time, and for desired results. Evaluates results of machine calculations to determine if data meets the needs of the problems. If necessary, develops mathematical formulas and procedures to provide more efficient machine operation. Usually prepares programs.

Employers usually require a bachelor's or master's degree with a mathematics major for this job. However, graduates of 2-year post-high-school education with emphasis on higher mathematics may qualify for entry jobs in this field of work. The course should include mathematics through integral and differential equations, physics, statistics, and programing techniques.

PROGRAMER, BUSINESS DATA PROCESSING

Develops and prepares diagrammatic plans for solution of business problems by means of automatic data-processing equipment. Analyzes problems outlined by Systems Analyst in terms of such factors as type and extent of information to be transferred in the system, variety of items to be processed, extent of sorting, and format of final printed results. Designs detailed programs, flow charts, and diagrams indicating arithmetical computations and sequence of machine operations necessary to copy and process data and print solution. Verifies accuracy and completeness of programs by preparing sample data, and testing data on computer by operating console or by directing such operations. Corrects program errors by revising instructions or altering sequence of operations. Prepares instruction sheet to guide Console Operator during production run. Evaluates and modifies existing programs to take into account changes in procedures or types of reports desired. May translate detailed flow charts into coded machine instructions. May assist in determining causes of machine stoppages. May confer with technical personnel in planning programs. Responsible for adequate documentation of the steps followed to solve the problem for later reference.

Some employers require a college degree with a mathematics major for this job but many programers find employment now with 2 years of post-high-school education. The education usually includes elementary business management, basic numerical analysis, use of electric accounting machines, and programing techniques.

SYSTEMS ANALYST, BUSINESS DATA PROCESSING

Devises computer system requirements and layout, and develops procedures to process data by means of automatic data processing equipment. Confers with Project Planner or other technical personnel to obtain clear understanding of the problem and type of data to be processed. Analyzes problem in terms of equipment capability to determine techniques and formulate computer system requirements most feasible for processing data. Prepares definition of problem together with recommendations for equipment needed for its solution from which the Programer prepares flow charts and computer instructions. Devises data verification methods, and establishes standards for preparation of operating instructions. May schedule data processing activities. May supervise preparation of programs.

College graduation with courses in mathematics, statistics, accounting, and business administration are usually required for this job. Some employers consider 3 years of generalized experience in administrative, professional, technical, or investigative work, and 1 year of specialized experience in organizational analysis, workflow planning, or work simplification and improvement as a substitute for part or all of the educational requirement.

CHAPTER IV

TRAINING REQUIREMENTS

IF THE PURPOSE of a training program is to prepare workers for a single occupation, the content for such a program may be derived from an analysis of that specific job. However, if the program is designed to train workers for a cluster of occupations, the content should be derived from analyses of all the jobs in the cluster. In either case, it is necessary to determine the significant elements or characteristics of all of the jobs found in the field of work, to ascertain the skills and knowledges required for their performance, and to develop a reasonably complete list of the subject-matter areas required to train workers to perform in these occupations. From this list, the specific courses of study which make up the curriculum are developed.

It should be recognized that instruction for a specific job may require greater depth and emphasis on certain aspects of the training than would be required for a broad field of work. The highly specialized training required for a particular job may be given through extension courses after the individual has entered employment and has gained some experience and understanding in his field of work. Methods and procedures for determining requirements for extension training programs are described in *Determining Requirements for Development of Technical Abilities through Extension Courses*, OE–80010.

In the preparation of this publication, the author made a study of the functions and duties of the various occupations included in this publication and of the courses of study used by selected educational institutions in training in specific subjects, such as accounting, business administration, programing, mathematics, and physics. By this method, he discovered the subject-matter areas generally recognized as significant in preparing workers to perform satisfactorily in the several occupations covered in this document. Those occupations are shown in chart form on the Training Requirements Analysis Form on page 16.

The Training Requirements Analysis Form illustrates a method for recording the knowledge and ability required for each of the occupations. The first column lists the subject-matter areas which are considered basic in training for the occupations listed in columns marked A, B, and C on the form. Other subject-matter areas might have to be added as the requirements of these work activities vary from plant to plant, among industries, and in different parts of the country. The determination of the subject matter required to equip the student for successful performance in a particular job depends upon the adequacy of the source data obtained and the ability of the person preparing the form to interpret these data.

The second column shows, by number, the courses in which the subject matter is found. These courses (see appendix A) are based on a study of a number of courses given in various schools throughout the country. They should be considered as composites and may not coincide exactly with courses offered in any given educational institution. Care should be exercised in using these courses and they should be adapted to fit the training situation as it exists locally. It should be recognized that the numbering system used for these courses is for identification purposes only and is not suggested as a classification structure for use by a school offering courses for the occupations covered in this publication.

If the job descriptions indicate that a knowledge or skill is essential, the letter "E" is entered. If it is not absolutely essential, but advisable for a worker to receive instruction in a specific area, the letter "A" is entered.

The nature of the work and the industry in which the jobs under study are found usually suggest to an experienced analyst other subjects which might be helpful to a worker in a particular field of work. In some cases, it may be found that industry supplies training in some of the areas, and in other instances the limited demand for such skills in the labor market or lack of facilities in the school make it inadvisable for the school to set up special courses.

The completed form (Training Requirements Analysis Form) serves the following purposes:

1. Indicates the technical knowledge and abilities needed by workers to perform the duties of various occupations found in a given field of work.
2. Identifies the subject-matter areas that are common to the several work activities.
3. Provides, in convenient form, a list of the subject-matter areas and courses of study that should be considered when building the training curriculum.

TRAINING REQUIREMENTS ANALYSIS FORM

[Symbols: A—Advisable; E—Essential]

Subject-matter area	Course number	Occupation: Programer, BDP (A)	Occupation: Systems Analyst, BDP (B)	Occupation: Computing Analyst (C)
MATHEMATICS				
Binary Arithmetic and Applied Logic	M–620, 621	E	E	E
Algebra:				
Beginning	M–601	E	E	E
Advanced	M–602	------	E	E
Numerical Analysis	M–632	------	A	E
Vector Analysis	M–630	------	------	E
Calculus:				
Introduction	M–630	------	A	E
Differential	M–631	------	------	E
Integral	M–632	------	------	E
SCIENCE				
Physics	S–702, 703	------	------	E
OTHER KNOWLEDGES				
Accounting:				
Elementary	B–110	E	E	------
Advanced	B–111	A	E	------
Office Procedures	B–120	A	E	------
Business Organization and Management	B–121	A	E	------
Introduction to Data Processing	DP–200	E	E	------
EAM Machines	DP–201	E	E	------
Computer Programing	DP–202, 203	E	E	E
Statistics	B–130	A	E	A
Systems Analysis	DP–210	------	E	------
Systems Development and Design	DP–211	------	E	------
Oral and Graphic Communications	*	------	E	E
Economics	*	------	E	------
Report Writing	*	------	E	E

*These courses are not included in the Appendix as they vary greatly from school to school.

CHAPTER V

DEVELOPING THE CURRICULUM

WHEN THE AREA for which training is to be provided has been clearly defined, and the training requirements have been identified, then the curriculum and individual courses of study required to equip students to perform the various job duties may be prepared.

A curriculum may be defined as a systematic group of courses of study designed to prepare students for a field of work or for a specific occupation. It is an organized body of content for the training program—all that the school offers for reaching desired educational goals.

The title should clearly identify the curriculum and the range of content should be suitable for mastery of the subject matter in the time specified. A substantial portion of the content should be made up of courses designed to equip the student with the knowledges, skills, and abilities peculiar to the field of work for which training is given.

Curriculums can be developed in several ways. The simplest method is to use the curriculum of another institution without modification. The hazard of such an approach lies in the possibility that the curriculum may not be a good one, or even though it was satisfactory for the original institution, it may not fit into the conditions of the setting where it is to be used. For example, each institution has specific entrance requirements which vary from State to State and from one institution to another. A second method is to study a number of curriculums from other institutions and to develop from them a composite curriculum embodying the best points of all of them. The difficulty sometimes encountered with this method is that the resultant program is made up of a group of subjects which may not constitute a complete, integrated curriculum.

Probably the most effective method is to use the approach outlined in this pamphlet: The development of a curriculum based on up-to-date information about the work activities with which the program is concerned. As a check against this method, it is usually helpful to study other curriculums for structure and content.

In undertaking the construction of a curriculum, the first task is to prepare a composite list of all the knowledges and skills required for effective performance in all of the occupations in the particular field of work. In the preceding chapter the techniques for developing a list of subject-matter areas has been described. The job descriptions in chapter III represent typical jobs found in the various fields of work and are not meant to be all-inclusive. Therefore, the fields should be explored further to ascertain what other jobs should be included in the field of electronic data processing. These occupations should be analyzed and the findings checked against the present lists to determine whether additional subject-matter areas are necessary. Thus, a reasonably complete list of items for the proposed curriculums is assured.

A curriculum would not usually include all of the items which appear on a Training Requirements Analysis Form. Students may be expected to have attained certain knowledges and skills previously. For example, if the curriculum is on the post-high-school level, admission requirements may specify high school graduation; completion of certain subjects undertaken while the student was in high school; or attainment of satisfactory scores on achievement or aptitude tests. In other cases, the list might include certain items which might be learned after the student is employed.

On the other hand, the curriculum designer might find it necessary to include some items which did not appear on the list found in a Training Requirements Analysis Form. For example, analysis of a job might have led to the conclusion that proficiency in mathematics was not required in the training program because the duties of the job did not include mathematical calculations. Such a conclusion would have overlooked the need for mathematics as a learning and communications tool, adversely influencing curriculum and course design.

In theory, one might take the content and the courses shown on the Training Requirements Analysis Form, select the methods to be used for instruction, list the equipment needed, plan the space required, set up the standards for student admission and for the instructional staff, and determine the length of the program, without regard to details of the setting in which the program is to operate. But, it does not work out that way. There are many factors to be taken into account. For example, the program may be one of several given by a large institution which imposes conditions on admissions, length of school year and school day, budget, and space, all of which would affect curriculum planning. Therefore, the curriculum should be broad enough to provide adequate preparation for successful performance of entry occupations identified as belonging to a specific work activity.

After the subject-matter areas have been selected for inclusion in the curriculum, they are divided into groups which become courses. Next, the courses are arranged in a pattern which recognizes psychological sequence, time allocation, and relative importance of each course. Modifications are then made to adjust all of these considerations so that the final curriculum is a well-balanced and integrated program.

TECHNICAL CURRICULUM OBJECTIVES

Three basic objectives for a technical education curriculum should be considered. It should prepare the graduate to:

1. Be employable and immediately productive in one of several entry jobs in a technological field.
2. Be able to progress to positions of increasing responsibility.
3. Be able to increase his technical skills by means of advanced technical study.

STEPS IN CURRICULUM CONSTRUCTION

In the ideal curriculum everything would be presented to the student just as he needed it, and all avenues of knowledge would open up before him at the proper psychological moment.

Usually, the curriculum is a compromise which strives to achieve the same objectives. The decisions in curriculum construction are important because any compromise with the ideal curriculum lessens its effectiveness. It calls for experience, understanding, and vision.

Curriculum construction should follow the steps listed below, but not necessarily in the order given:

1. *Establish needs.*—There is no point in offering a curriculum without having first established the local and national need for workers in the field of work for which the curriculum is designed.
2. *Set objectives.*—The objectives, among other things, should identify the occupations for which training is to be offered, the level at which the training is to be given, and the entrance requirements.
3. *Determine the subject matter.*—Analysis of the jobs or work activities should include the competencies required and should be stated in sufficient detail as to have meaning for a curriculum.
4. *Resolve material into subjects.*—This step, which overlaps and depends upon the preceding one, is the key to good curriculum construction. The purpose is to resolve the different learnings into discrete subjects without previous notions as to what such a subject should include or how much time should be devoted to it.

The resolution of subject matter into subject titles will include the indication of necessary and desirable learnings; the relationships; the level of the subject matter; the method of instruction (whether recitation, demonstration, laboratory, or shop); and, finally, the time allotment.

5. *Blocking.*—There has already been some discussion about some of the problems involved in this step. It should be evident by now that there is a body of knowledge and skill which must be learned and that this body has been divided into subjects. The problem now is to get this information into a realistic program.

This is one of the most difficult steps in curriculum planning and one which requires careful analysis and, in many cases, compromises. Each school has rules regarding the number of hours to be assigned to classroom, shop, and laboratory instruction. Also, a definite number of hours must be allotted to general education and homework. When the hours are totaled for each semester or quarter, it may be found that some changes must be made to keep within the prescribed schedule.

We must know the time to be devoted to the entire curriculum and how this time is to be divided into quarters or semesters. The subject matter must fit into this time schedule. Some considerations to be borne in mind are:

1. A realization of the abilities of beginning students.
2. A recognition of the psychological procedure in learning as contrasted with the logical.
3. Provision for proceeding from the easy to the more difficult.
4. A reasonable workload in hours, in the ratio of recitation to laboratory time and to study time.

5. An early introduction of the technology or field of work to motivate the student.
6. An integration or relationship of subjects so that "tool subjects" such as mathematics will be covered at the proper time.
7. A frontal approach which will enable spiral teaching without exact repetition.
8. A reasonable schedule that will fit the school's program of time, teachers, and facilities.

Finally, it must be recognized that no curriculum is ever finished. This is particularly true today when technological advances sometimes make the material obsolete while it is being prepared.

The entire faculty should be organized to take part in the curriculum planning or revision. This involves meetings and rescheduling and, in some cases, the re-writing of courses of study. A time schedule should be set up for complete revisions and the new curriculum must be reproduced and issued to each faculty member to keep him advised of changes.

Such procedures will produce a curriculum which is up to date; one which represents a reasonable workload for the students and faculty; one which, at each step, capitalizes on previous learning; one which satisfies the needs of the labor market; and one which achieves the desired outcome in the most efficient manner.

SPECIAL REQUIREMENTS FOR POST-HIGH-SCHOOL TECHNICAL CURRICULUMS

One of the most significant features of technical education is its appeal to the individual who is intensely interested in a specialized field of work. This person comes to the technical program because of its positive values—not because he cannot do anything else. He comes to learn electronics, or drafting and design, industrial chemistry, or data processing. Furthermore, the typical student in a technical program may have worked for a year or two since leaving high school, and it is not unusual for individuals with one or more years of college study to enroll.

If the technical curriculum is to attract and hold this type of student—and this type usually includes some of the best—it must include in the first term a substantial introduction to the specialized field of study. If the first term consists only of general education subjects, it may fail to hold the full interest of capable students. In many technical curriculums, technical courses make up half of the first term of study. Mathematics and communications, being "tool subjects," should also be introduced in the first term. Social sciences, humanities, and physical sciences can be deferred to the following terms.

A second factor operates to advantage when technical courses are introduced in the first term. It is possible, by this means, to obtain more depth in the specialized field of study during the final stages of the program. In a four-semester program, for example, if the introduction to the specialized field is deferred, even for one term, it is impossible to cover both the range of basic principles in the technology and the more advanced concepts needed for success as a technician.

In this connection, the so-called "core curriculum" in which students in several technologies take a common first term can be deceptive. Economically, it is an attractive compromise. But, is it educationally sound? Does it sacrifice quality for expediency? The same dangers exist in trying to meet both transfer credit and occupational objectives in a single curriculum. A strong, well-planned curriculum in which the technology is the central focus can best meet occupational objectives as well as attract and hold students.

Special requirements for technical curriculums may be summarized in the following measures for evaluating a curriculum:

1. Does the curriculum have at least 30 credit hours of specialized technical course work, and from 15 to 20 credit hours of mathematics and science?
2. Are there no more than five courses which require extensive outside preparation in any single term of the curriculum?
3. Is the total class and laboratory load no more than 28 clock hours per week?
4. Is the specialized course work introduced in the first term by one or two major courses?
5. Does the mathematics and science course work appear to be correlated with the technical study during the first year of the curriculum?
6. Are auxiliary technical courses included to support and broaden the students' understanding in the technology?
7. Is provision made for individual work during the final phases of the program in the form of problem-solving?

These are some of the factors that can be determined from the usual descriptive material in school catalogs. Obviously, this sort of an approach is only the first step in program evaluation. Nevertheless, it does provide a framework for such evaluation. In cases where one or more of the seven requirements are not present, some justification should be required for their absence. There may be good and sufficient reasons for operating educational programs without meeting some of these requirements. But, none of them should be overlooked if the program is to provide technical education for qualified technicians.

This chapter reviews the general problem of curriculum designing briefly, assuming that the reader is familiar with pedagogical practice and with curriculum building.

The subject-matter areas and the courses of study listed on the Training Requirements Analysis Form are not arranged as they will appear in the curriculum but they indicate the areas of knowledge which should be covered. Analysis of these items is an important step in developing the curriculum. From these lists the curriculum builder selects, by careful analysis, those subjects essential to the field of work.

Another step in curriculum construction is the development of instructional units which convey the necessary instruction and provide the trainee with the desired learnings. The instructional unit may take the form of a typical task to be performed, the principles to be mastered, a shop or laboratory experiment to be carried out, a problem to be solved, a case to be discussed, or a malfunction to be analyzed. The type of instructional unit depends upon the educational objectives, the school facilities, and many of the factors discussed heretofore.

The techniques in this publication, together with the chart and form, provide basic information regarding techniques that can be used in organizing curriculums which will meet specific training needs in the fields of work covered in this publication. (See appendix B for a sample curriculum outline.)

The techniques in this document were used in developing the suggested 2-year post-high-school curriculum for computer programers and business application analysts—*Electronic Data Processing—I,* OE–80024, and will be used in developing part II of this guide.

APPENDIX A

COURSES OF STUDY

BUSINESS COURSES

B–110 ACCOUNTING—Emphasize the principles, techniques, and tools of accounting. As the mechanics of accounting become well formulated, it is usually found practical to introduce the use of data processing equipment as used in industry in performing the accounting functions. The course includes basic accounting concepts; the accrual concept and the income statement; bookkeeping (the mechanics of accounting); accounts receivable and fixed assets; capital stock, surplus, and bonds; with a final review of accounting functions as performed on computing machines. Usually requires 4 class hours per week.

B–111 ACCOUNTING (prerequisite B–110)—Emphasizes management uses of accounting information. Emphasis should be on accounting as a source of data for management control rather than on bookkeeping skills. Includes management's use of accounting information; overall reporting and analysis—the funds flow, and ratios and percentages, challenges to conventional accounting concepts; control—general considerations and analysis of cost accounting variances; period planning or budgeting; and project planning. Usually requires 4 class hours per week.

B–120 OFFICE PROCEDURES—Designed to give the student a general understanding of office functions; the role the office plays in the management of a business enterprise; control functions directly related to inventory, production, cost accounting, sales, and other business activities; data processing for control purposes; and case studies of actual situations encountered by executives in business management. Usually requires 2–3 class hours per week.

B–121 BUSINESS ORGANIZATION AND MANAGEMENT (prerequisite B–120)—A continuation course which includes the study of management as a science; scientific management; organizational structures; the purpose, role, and construction of the organization chart; delegation and decentralization of functions; the well-managed corporation; office automation; and social and economic experimentation. Field trips and practice in solving actual business problems by means of data processing. Usually requires 4 class hours and 3 laboratory hours per week.

B–130 STATISTICS—Acquaints the student with the theory of statistics and its application in business. He will obtain experience in associating and using mathematical models to interpret physical phenomena and predicting, with reasonable certainty, the outcome of experiments related to practical business problems. Includes the field of statistics; elementary number usage techniques; probability; principles of sampling; sampling methods in auditing; bivariant data and regression analysis; correlation and the analysis of variance; statistical quality control in production and management; statistical analysis of time series data; index numbers; forecasting and market research. Usually requires 4 class hours per week.

DATA PROCESSING COURSES

DP–200 An introduction to digital computers which includes: basic principles; systems theory, decimal system, binary system, and octal system; systems conversions; arithmetic operations; self-complementing codes and other coding systems; computer logic; systems components; general block diagram and program functions; high speed memory; programing essentials and solution of simple data processing problems. Usually requires 2 class hours per week.

DP–201 E.A.M. Machines—A study of electric accounting machines; illustrating the need for machines in accounting and recordkeeping, and the concept, power, and flexibility of the unit record. Includes the unit records, machine functions, elements of a machine, the card punch and verifier, interpreter, sorter, reproducing punch, collator, tabulators, and calculators. Usually requires 3 class hours and 5 laboratory hours per week.

DP–202 Programing Fundamentals (prerequisite DP–200)—A study of the functions and capabilities of electronic data-processing machines which familiarizes the student with some of the tools and raw material necessary for becoming a programer. Includes computer applications, organization of the data processing system, instruction—card system, methods of program debugging, housekeeping techniques, loops and indexing, and subroutines. Usually requires 2 class and 2 laboratory hours per week.

DP–203 Advanced Programing (prerequisite DP–202)—A continuation of DP–202. The principles presented in the first course will be employed repeatedly in this course. Includes subroutine, programing a tape system, macro-programing, job timing, programing a random access device, and program testing. Usually requires 3 class hours and 4 laboratory hours per week.

DP–210 DP Systems—Familiarizes the student with the purpose and function of the various types of programing systems. Includes basic concepts, assembly programs and compilers, macro-generators, report generators, utility programs, data scheduling systems, soft-merge, monitors and high-level languages. This course usually requires 3 class and 1 laboratory hour per week.

DP–211 DP Systems (prerequisite DP–210)—A course in business systems design and development designed to guide the student through the three stages in the evolution of a system: analysis of present information flow, system specifications and equipment selections, and implementation of the system. Includes the approach, requirements of a system, developing the solution, data controls, system controls, system evaluation, finalizing the system, and system implementation. Usually requires 3 class and 2 laboratory hours per week.

MATHEMATICS COURSES

M–601 Equivalent to the algebra usually taught at the high school level. Usually includes literal numbers; positive and negative numbers; addition, subtraction, multiplication, and division of algebraic expressions; simple equations; an introduction to simultaneous linear and quadratic equations; the Binomial theorem; and ratio, proportion, and variation. Usually requires 3 class hours per week.

M–602 The first part of this course is usually devoted to a review of arithmetic and high school algebra, including factoring, clearing of fractions, and decimals. Instruction is given in the use of the slide rule. The second and longer part of the course usually includes fundamental algebraic operations, equations, and formulas; introduction to analytic geometry and graphing; simultaneous equations; exponents, radicals, and complex numbers; quadratic equations in one unknown; ratio, proportion, and variation; logarithms; and introduction to trigonometry. This course usually requires 5 class hours per week.

M–620 Provides the necessary foundation for study of business data processing. Usually includes the concepts of notation; binary arithmetic; representation of a number with an arbitrary base; fixed and floating point numbers; precisions and significance; and linear equations. This course usually requires 3 class hours per week.

M–621 (Prerequisite M–620)—Usually given as a continuation of M–620 in which number systems, forms, and methods basic to data processing are continued and extended. Includes concept of an iterative process; solution of simultaneous linear equations; basic and applied logic; Boolean algebra; applications of numerical solutions to physical problems; classification of errors in numerical solutions of a problem. This course usually requires 4 class hours per week.

M–630 (Prerequisite M–602)—In this course trigonometry, analytic geometry, and algebra are continued and expanded to more advanced phases of mathematics as required in the field of work for which instruction is given. Graphical analysis is used wherever possible. Calculus is incorporated in a manner emphasizing concept and principle rather than facility in its use. Included in the course are solution of right and oblique triangles; trigonometric functions for any angle; vector analysis applied problems; trigonometric identities and equations; trigonometric graphing; complex numbers and vectors; sequences and series; calculus and graphic analysis. Usually requires 4 class hours per week.

M–631 (Prerequisite M–630)—Usually includes graphic methods of calculus; functions; differentiation; differentiation of higher order; integration; additional trigonometric functions in calculus; logarithms and exponential functions; hyperbolic functions; mathematical series; and La Place transforms. Usually requires 4 class hours per week.

M–632 (Prerequisite M–631)—A course in numerical analysis which provides the student with an introduction to the theory and practice of the solution of equations, interpolation, numerical differentiation, and integration of the numerical solution of ordinary and partial differential equations; integral equations; how to express physical problems in the form of integral equations, the theory of integral equations, and methods for solving such equations. Usually requires 5 class hours per week.

SCIENCE COURSES

S–702 PHYSICS—Equivalent to the physics usually taught at the high school level. It usually includes mechanics; forces; motion; gravitation; work, energy, and power; machinery; heat, sound, and light; electricity; and magnetism. Usually requires 3 hours per week of class and one period (2–3 hours) of laboratory work.

S–703 PHYSICS (Prerequisite S–702)—A more advanced course in physics which includes basic measurement; properties of solids, liquids, and gases; statics; rectilinear motion and momentum; angular and simple harmonic motions; work, energy, and power; heat and temperature; thermodynamics; hydraulics and pneumatics; and optics. Strength of materials is usually taught in a laboratory situation. This course usually requires 4 class hours and 6 laboratory hours per week.

APPENDIX B

SAMPLE CURRICULUM OUTLINE

To show how a curriculum can be developed from the techniques in this publication, two jobs which are in the same job family—Jobs A and B on the Training Requirements Analysis Form—are used. The following steps were followed in developing the sample curriculum outline.

1. *Analyze the purpose of business data processing.*

Basic to practically all business data processing applications is the control function. Business records are maintained and processed to control expenditures and income and to show the financial condition of a business. Many management decisions depend upon the control of accounts, inventory, sales, and other business functions. To carry out this work, the student in this field needs accounting, business organization and management, statistics, and mathematics.

2. *List the essential subject-matter areas shown on the Training Requirements Analysis Form under Jobs A and B.*

Job A	*Job B*
MATHEMATICS:	
M–601	M–601
M–620	M–602
M–621	M–620
	M–621
OTHER KNOWLEDGES:	
B–110	B–110
	B–111
	B–120
	B–121
	B–130
DP–200	DP–200
DP–201	DP–201
DP–202	DP–202
DP–203	DP–203
	DP–210
	DP–211

PRELIMINARY CURRICULUM OUTLINE, BY YEAR AND SEMESTER

Course, by year and semester	Hours per week			
	Class	Laboratory	Study [1]	Total
FIRST YEAR				
First Semester (17 weeks)				
M–601 Basic algebra	3	0	6	9
DP–200 Introduction to digital computers	2	2	4	8
DP–201 E.A.M. machines	3	5	6	14
B–110 Elementary accounting	4	0	8	12
Communication skills	3	0	6	9
Total	15	7	30	52
Second Semester (17 weeks)				
M–620 Algebra and trigonometric functions	3	0	6	9
DP–202 Programing fundamentals	3	4	6	13
B–120 Office procedures	2	0	4	6
B–111 Advanced accounting	4	0	8	12
Communication skills	3	0	6	9
Total	15	4	30	49
SECOND YEAR				
First Semester (17 weeks)				
DP–203 Advanced programing	3	4	6	13
M–621 Computer mathematics	4	0	8	12
B–130 Statistics	4	0	8	12
DP–210 Data processing systems	3	2	6	11
Social science	3	0	6	9
Total	17	6	34	57
Second Semester (17 weeks)				
B–121 Business organization and management	4	0	8	12
DP–211 Systems design and development	3	2	6	11
M–602 Advanced mathematics	5	0	10	15
Industrial applications—field projects	0	3	0	3
Social science	3	0	6	9
Total	15	5	30	50

[1] Two study hours for each class hour.

3. *List the subject-matter areas shown on the Training Requirements Analysis Form under Job A, which are considered advisable, but not essential.*—They may be used in the curriculum if there is room for them or as elective courses.
   B–121
   B–130

4. *List the general education subjects which are required by law in the State where the curriculum will be used or which help to broaden the student's education.*
   Communication Skills
   Social Science
   Economics, Oral and Graphic Communications, and Report Writing may be included in this group.

5. *Determine other courses which may be required as learning or communication tools.*—Bearing in mind that the subject-matter areas in the Training Requirements Analysis Form represent only those subjects needed to perform the duties of the job.
   None required

6. *Arrange the courses in a pattern which represents psychological sequence, time allocation, and relative importance of each course.*—It is important to set up one course which will motivate and maintain student interest right from the start. For example, a student applying for admission to a course in electronics should start working immediately with a radio chassis or similar electronic device. This is his real interest. He will soon discover that mathematics and other subjects which were distasteful to him are necessary if he wishes to make a career in electronics.

The preliminary curriculum outline on page 28 was developed in accordance with the steps outlined above. It is usually necessary to make some changes to achieve balance and to give adequate time to each course.

Analysis of the preliminary schedule revealed that a Programer, BDP, could be trained in three semesters of 17 weeks each, which means that such a training program can be set up under the provisions of the Manpower Development and Training Act. In order eventually to become a Systems Analyst, however, the student would be required to take the full four semesters. This could be done at one time or the courses in the second semester of the second year could be taken as extension courses while employed.

In this particular job family the line of progression is as follows: The student who completes the first three semesters would usually start in an entry job—Junior Programer, BDP. He would then progress, after a few months of work experience, to the job of Programer, BDP. In order to eventually progress to Systems Analyst, BDP, he would usually need the courses offered in the last semester or on-the-job training and experience or a combination of all three.

The preliminary outline on page 28 is not in balance. The total student workload in the first semester of the second year is 57, which is 14 percent higher than the average workload in the other three semesters. Also, the mathematics used in programing should be completed before the course in programing is given.

As stated previously in this publication, some compromises have to be made in developing a curriculum. For this job family, there would usually be a prerequisite that the entering student would be a high school graduate or equivalent with at least one year of algebra. Therefore, review of arithmetic and algebra could be held to a minimum. It was decided, therefore, to give all of the mathematics in the first two semesters with four class hours in each semester. Inasmuch as the Programer, BDP, can be trained in three semesters, it was decided to increase the class and laboratory hours in programing to four and six. In order to balance the workload in the first semester, the class hours in communication skills were reduced slightly. The revised outline on the next page illustrates how these changes affect the curriculum.

In this curriculum, two courses, *Introduction to Digital Computing* and *Programing Fundamentals*, introduce the more interesting and practical elements of the study program in the first semester.

REVISED CURRICULUM OUTLINE, BY YEAR AND SEMESTER

Course, by year and semester	Hours per week			
	Class	Laboratory	Study[1]	Total
FIRST YEAR				
First Semester (17 weeks)				
Computer mathematics I (comb. 601, 602)	4	0	8	10
Introduction to digital computers	2	2	4	8
E.A.M. machines	3	5	6	14
Elementary accounting	4	0	8	12
Communication skills	2	0	4	6
Total	15	7	30	50
Second Semester (17 weeks)				
Computer mathematics II (comb. 620, 621)	4	0	8	12
Programing fundamentals	3	4	6	13
Office procedures	2	0	4	6
Advanced accounting	4	0	8	12
Communication skills	3	0	6	9
Total	16	4	32	52
SECOND YEAR				
First Semester (17 weeks)				
Advanced programing	4	6	8	18
Statistics	4	0	8	12
Data processing systems	3	2	6	11
Social science	3	0	6	9
Total	14	8	28	50
Second Semester (17 weeks)				
Business, organization, and management	4	0	8	12
Systems design and development	3	2	6	11
Advanced mathematics	5	0	10	15
Industrial applications—field projects	0	3	0	3
Social science	3	0	6	9
Total	15	5	30	50

[1] Two study hours for each class hour.

APPENDIX C

REFERENCE MATERIALS

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