INTRODUCTION

Before beginning this discussion, I would like to make a few remarks concerning the Jet Propulsion Laboratory (JPL). The Jet Propulsion Laboratory is responsible to the National Aeronautics and Space Administration (NASA) for unmanned missions in deep space. A worldwide tracking network encompasses Goldstone, California; Madrid, Spain; Johannesburg, South Africa; and Woomera and Tidbinbilla, Australia. In addition to the deep space missions, there are a great number of scientifically oriented projects throughout JPL. The Laboratory has approximately 4,100 employees, as well as some support contractor personnel.

All levels of personnel in JPL, as well as contractor operations personnel, are involved with the educational programs, starting with “Introduction to Computing” through management training in the data processing field.

Within almost every government organization, and certainly within every NASA facility, a considerable workload rests within the administrative and financial operations. These are nonscientific endeavors which hopefully will lead toward improved management information system controls. A commercial enterprise, financial operations organization has a number of similarities.

To begin with, I have prejudices against classrooms of stand-up instruction only, or classrooms of video-taped lecturers only, or instruction in any single medium. Therefore, I will spend a few moments reviewing some of the products of educational firms today leading toward a multimedia approach to the education and training of commercial programmers, systems analysts, or obviously, into some of the scientific fields.

Let me cite a few examples of ideas that have come out of some commercial firms. For instance, there is one firm in Ohio that has developed a course titled “ADP Terminology.” This course consists of 16 audio tape cassettes and a small workbook for those who want to become familiar with data processing terms. One of the major banks in Arizona has required its 132 branch managers to review this course while traveling to and from work. It is also an excellent device to augment stand-up instruction for a new student. Several firms today have canned video-taped courses along with workbooks as a self-instructional means to replace the very widespread utilization of PI or programmed instruction textbooks. To my way of thinking, there is nothing more boring, and less motivating, than sitting down with a workbook, and saying I am going to learn by myself and teach myself something, whether it is data processing or any other area of interest.

Another firm, in addition to its video taped courses in basic computer programming—COBOL, FORTRAN, and so forth—has a considerable library of animated motion picture films, along with associated workbooks and other materials as a self-teaching means in support of standardized automatic data processing (ADP) curricula. Some of the films are excellent, and, in some cases, we have utilized them to augment our classroom course “Introduction to Computer Technology.” A firm in Illinois has developed a systems analysis course, as well as courses in operating systems (OS) with a thorough interaction between video tape, audio tapes, and workbooks—none of the media being used for more than 15 minutes at a time. There is a constant transfer from one medium to another which provides not only motivation but reinforcement. More of the physical senses are used in the absorption of educational material. Of course, motion picture films are also used; films themselves are a bit more cumbersome, but if intermixed with other media, may become a viable means of instructional transfer.

I believe that audio tapes, video tapes, motion picture films, and animated cartoons can effectively be used in a learning carrel. A carrel is nothing more than an enlarged desk with various devices in it; one can
instruct himself at his own speed, and hopefully, improve his motivation if he has a goal in mind (see Figure 1). This type of self-instruction is extremely worthwhile if it is also reinforced by a senior programmer or analyst. The multimedia approach will create greater motivation.

For a moment, let's look at the benefits. In classroom training, the teacher is usually responsible for maintaining a norm at the average class level. Very often the faster student becomes quite bored because he is ahead of the group, whereas the slower student is having a problem keeping up, and thus becomes rather discouraged. Most schools in the data processing field require the student to write, run, and debug test programs on whatever type of equipment that school may possess. There is a danger at times if the "school" has only the equipment of one manufacturer and is not able to provide good classroom direction where students can effectively learn the differences between equipment of various manufacturers—either small-scale computers or large-scale systems.

A list of the computer courses available at the Jet Propulsion Laboratory, along with the computer selection procedure, is given in Appendix A; a set of computer-related job descriptions from the Computer Education Directory published by Edutronics Systems International, Inc., Los Angeles, Calif., is presented in Appendix B.

COMPUTER-ASSISTED INSTRUCTION

Computer-assisted instruction, or CAI, is a relatively new medium to augment the other media I have discussed; however, I am certain all of us will be influenced by it over the next few years. I feel we are missing a very worthwhile and cost-effective tool. Helen Lakin at the University of Wisconsin noted there are 1,264 program descriptions in the publication *Index to Computer-Assisted Instruction*. These descriptions are from sources in the United States, Canada, Europe, and Japan, representing elementary and secondary school systems, colleges, and universities that have complete CAI courses for credit. As an example, the University of Southern California recently instituted a complete course in Programming Language I by CAI for three units of credit. Many universities are using CAI as a self-teaching method very successfully for both direct teaching and remedial education. In none of these situations does it mean that there is not a teacher available to answer questions or at least to cover the highlights that may be misunderstood. In the government area, certainly throughout the Department of Defense, there are any number of programs that are offshoots of simulation programs as well as specific courses in CAI. Many of the programs, however, are tailormade to the particular command or to the organization.

It is extremely important that data processing organizations thoroughly evaluate available software systems in today's market, whether they are proprietary or in the public domain. For the programmer or systems analyst, where it can be shown to be cost-effective, there is no better system than one with immediate feedback. From a motivational standpoint, the one-to-one relationship without outside distraction can be made a very viable and successful means of instruction in this field. It seems strange that there are not more schools or private firms teaching programming, systems analysis, or data processing management on a computer terminal.

Briefly, from the principal title of the session, let's consider the capability of the computer in CAI. In August 1970, a test project was instituted in the Communications Electronics School Battalion at the Marine Corps Recruit Depot in San Diego, California. Twelve terminals were connected by data link to a UNIVAC 1108 computer some 75 miles away. A stand-up class was run concurrently with the CAI classes. Individuals were psychologically matched, and each student proceeded through the course of instruction at his own pace. Of considerable importance, the Marine instructors wrote their own courses for the computer after
only two weeks of instruction from the manufacturer. A system of positive or negative reinforcement of learning experience was presented to the student immediately. The immediate benefits of the teaching experience were the objectivity, data collection and reduction, and standardization of instruction. Cathode ray tube terminals were employed. The results demonstrated substantially increased learning in the CAI class; and subsequent to the test, far greater retention was achieved. This demonstration has convinced Headquarters Marine Corps to initiate formal schools in CAI at the Marine Corps Station at Twenty-Nine Palms, California. Sixty terminals will be employed, course time will be reduced by 20 percent, and instructor requirements by 75 percent of instructor manpower.

In the universities, there is a strong tendency to tie CAI courses with other portions of the curricula. There is a major tendency, of course, to deal primarily with the fields of scientific uses of the computer, or, in other words, its applications to physics, chemistry, biology, genetics, etc., rather than to the straight business approaches; however, some universities are improving their curricula, from computer programming on into the area of management information systems. There is an excellent marriage between business management and the tools the computer can provide.

GOVERNMENT USE OF COMPUTERS

The government was the first major user of computers, in the late 1940s and early 1950s. Commercial data processing centers have become increasingly widespread. Subsequent to unbundling, the government agencies developed their own schools and separate series of grades within the Civil Service Commission to handle the various levels of computer programmers and systems analysts. One of the problems of government, as well as of all large business operations, is frequently a lack of communication among similar services and organizations. The Office of Management and Budgets in Washington is examining improvements in communication among similar elements of government, where both can utilize the same software, hardware, or systems approaches. Where there is coordination among government entities, cost savings are very substantial. Due to a low turnover, many large government entities also realize that their management personnel, as well as their programming personnel do not effectively utilize the tools available today.

Many of the leading computer manufacturers emphasize more now than before the need for improved management training which, in a sense, goes beyond the scope of this present paper. However, when speaking of education for computer programmers and systems analysts, we must consider the people who are directing the needs for this education and training. These needs definitely stem, and should stem, from a better understanding by management of their own specific needs. When management understands these needs and can define them, then indeed they will do a much better job in hiring personnel. This will establish the type of training curricula these personnel should have had before being hired.

As a lesson from the government's interest in this field, communicating between commercial firms possessing similar interests can assist industry in setting standards or norms of personnel. In Appendix B are a number of what I feel to be excellent definitions of programmers and systems analysts. There is a need throughout the United States today for an improvement in semantics of all facets of ADP terminology in the entire field. Personnel firms should seek for a common understanding, thus setting some type of definition of various grades of programmers for the systems analysts. In large industries, of course, these have been indicated. However, they vary considerably from industry to industry. By an improvement in definition, understanding, and attainment, the individuals in this field should become more professional in their community.

THE IMPORTANCE OF PRETESTS

Obviously, any paper may reflect the bias of the individual writing that paper, who may promote those things that are the most successful in improving his responsibilities. Both with beginning programmers or systems analysts, or with those who wish to enter this field, I am a firm believer in computer pretests. Large schools have pretests of one type or another. However, when they are selling courses, their pretests may not be as restrictive as a pretest would be within my organization or within other organizations depending upon a profit motive.

Pretests can aid in determining a person's ability to absorb a particular instructional level. He takes the test, analyzes the test himself, and, from the results, he himself should be mature enough to state whether he has the ability to go ahead as a computer programmer, as a systems analyst, or in some other field of data processing, or whether his capability in fact rests somewhere else, and not in the ADP field at all. Many of the personnel with whom I have been associated who have taken these pretests have suddenly decided they
should not take FORTRAN or COBOL, but rather should go back into a program we have titled "Introduction to Computers," or, in other words, the basic groundwork—"What is a computer, what does it do, how does it operate, how does it function, and what are the various fields to which it could be applied?" The next step (shown in Figure A-1) analyzes his particular functional responsibilities, and, from there, determines the type of course toward which he should direct himself: in other words, what computing system should he be addressing? This last step is extremely important, since a person who is completely educated in one type of equipment, and then is thrown into another organization with an entirely different type of equipment, normally has some problems adjusting. This can be prevented if his training is directed toward the type of equipment he is going to use in the first place. Within an organization, a person's immediate supervisor is responsible for determining whether company time should be devoted to such courses or whether the individual would improve himself by taking courses outside of his office hours.

FUTURE DEVELOPMENTS

Let's consider some probable areas where changes in technology should considerably influence ADP education in the next decade. Increasing capability in the multiprogramming aspects of large-scale computers will permit a more economical approach toward computer-assisted instruction. Initially, however, it should be treated primarily as an augmentation or reinforcement of courses rather than as the stand-alone desire of some CAI enthusiasts. There will be an increasing need for studies into the motivational aspects of all levels of individuals, whether students are from grammar schools or high schools, or are personnel in government or industry.

According to the ETV Newsletter of July 26, 1971, as an example of the future development (and one that I believe will be widespread some years from now), the MITRE Corporation of Bedford, Massachusetts, is conducting a feasibility study utilizing TV/CAI through cable TV distribution. In this instance, both the voice and the still pictures are transmitted via microwave and on cable TV to homes equipped with special terminal and TV set combinations. The company is using its time-shared interactive computer-controlled information television (TICCIT) system to display selective material on individual TV sets. Thus, 600 TV sets can receive separate information provided by the computer at a typical rate of one frame every 10 seconds. The viewer is then in a position to communicate back to the computer through a 12-button telephone. The overall software for the system is designed under the sponsorship of the National Science Foundation, which can provide individualized educational courses for home and school use. Over courses that have a broad-scale interest in the future, therefore, it is quite likely that up to 10,000 TV sets in one local area could conceivably be tied into one major system with a number of different programs being selectively addressed.

Microcomputers of the future, costing as low as $2 to $3 K with keyboard and tape cassette units and a small TV light display, could be utilized by a number of commercial and governmental operations where specific instruction is required.* I believe the cassette will play a large part in the future.

Along with educational programs, we consider the terminal hardware development. Keyboards have varied from the standard typewriter keyboard to color-coded keys for some special studies. It is possible the lightweight, touch-sensitive surfaces instead of keyboards may be utilized. Common phrases that could have a general application to a number of educational uses may be designed into either system.

Pictorial or handwritten input may be one area of the future, as well as the very early development of voice input (Culler Harrison, Inc., in Goleta, California, and the Bell Telephone Labs), and, lastly, one I am certain a number of you have seen demonstrated, the plasma array terminals developed by Dr. Donald L. Bitzer of the University of Illinois in conjunction with Owens Illinois Glass Co. As some of you may recall, the view plate which replaces the video tube consists of three layers of glass with gold wires and an X/Y axis, imbedded in an electrolyte containing neon gas. The dots of stimulated neon gas, 3600 per square inch, may display pictures without computer regeneration, allowing both the computer and the user to modify the display. A number of these terminals are presently in manufacture by The Magnavox Co. for the University. I feel this type of approach will contribute a great deal to the ability of fairly small computers having a capability to relate through educational systems to a number of terminals.

The software field also has a major impact upon the future of education and training to systems analysts and programming personnel, in that language capa-

bility should certainly be on higher level than it is at present, including switchable microprograms, very large memories, associative memories, and other variables at an economical cost which could contribute considerably to a multi-user access. In a sense, with the technological changes, both in hardware and software, the aspect of the present programmer training should change markedly from the existing languages and the present direction. One of the interesting fallouts in teaching FORTRAN to a group of high school students on the West Coast recently resulted in improved ability of the students in their other courses. Apparently there is some relationship to the logical display of FORTRAN which overlapped into an improved understanding by these students in other subjects within their curricula.

Another aspect of the future is the multitude of libraries of application programs available to all facets of industry, government, and the educational community. With improved library maintenance and cross correlation, hopefully, many users of the future will be prevented from "reinventing the wheel" concept, and will be forced to thoroughly review the application programs available before they attempt to develop training programs on their own. Therefore, extensive markets exist for personnel to improve the development of such a compendium. Along with these application programs, however, and one of the aspects that is not as thoroughly covered today, is that of computer costs associated with each application program. This type of data will definitely have to be included in any compendium of library programs (similar to COSMIC,* which is operated today).

In communications, I feel many of us have seen limitations in our present telephone equipment; however, in the near future, firms similar to DATTRAN, whose microwave towers will be completely devoted to data processing centers throughout the United States, as well as improvements in our present communication equipment and satellite interface, will aid considerably in the more economical aspects of computing, as well as the education and training in a CAI approach throughout major time-sharing networks.

In summary, there will be a considerable change in programming languages, major changes in terminals and hardware equipment, and a greater interest and acceptance of computers.

RECOMMENDATIONS

For the educational, governmental, or business organization involved with its own educational development, it is essential to seek a multimedia mode of educating personnel. Do not rely on self-instructional manuals for the individual to develop an ability on his own. Upon completion of internal or external schooling, maintain an open view to periodic reinforcement of whatever course the individual attends.

Whenever possible, seek or have developed pretests to determine the level of investment your organization would make with the individual. It is normally wiser to allow management personnel the prerogative for self-correcting to determine their level of instruction. I feel that senior and middle management are too often neglected in the general concepts of computer technology.

Be aware of the developments in the university and governmental areas in education and training as they may very often be obtained without cost to your organization. The NASA data bank (COSMIC) is an example of this.

Lastly, in returning to the major subject of this session, that of training of commercial programmers and systems analysts, a thorough review of the commercial school, in addition to the very excellent training offered by the major computer manufacturers, should be made. University or high school evening classes very often may be an economical advantage in this evaluation. Maintain an awareness of the development of CAI as it is being used in grammar schools, secondary schools, and universities. Most important of all, to the prospective programmer or analyst, be aware of the "state of the art" changes to prevent complacency.

ACKNOWLEDGMENTS

This paper presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under Contract No. NAS 7-100, sponsored by the National Aeronautics and Space Administration.

APPENDIX A—COMPUTER COURSES AT THE JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY

GENERAL INFORMATION

Definition of terms

Pretest. These are self-administered, self-graded tests whose purpose is to help the individual determine that

* The Computer Software Management and Information Center (COSMIC) is maintained for NASA by the University of Georgia and provides a national data bank of software programs developed and debugged by government agencies and in the public domain.
ARE YOU A SCF USER?

NO IBM COURSES

YES SCF PROGRAM LIBRARY

Figure A-I—JPL computer course selector

the course is correct and that the individual is neither underpowered nor overpowered for the course material. The pretest also provides a general feeling of course content.

Time distribution charts

Each pie chart indicates the approximate distribution of the total time of the course required both in and out of class. The symbol “I” refers to Instruction, “P” refers to Participation, and “H” refers to Homework.

Certification

Certificates of completion are issued and recorded in the personnel file. They are based either upon attendance or upon the demonstration of proficiency in the techniques or skills taught.

Survey

The courses were developed in response to the major needs expressed and measured through the Training Needs Survey.

Schematic

A diagram of the courses available is shown in Figure A-1.

INTRODUCTION TO COMPUTERS

For Whom: Those with little or no knowledge of computers. Quota limited.

Prerequisites: None.

Description: Description and explanation of computer purposes, parts and functions, computer languages, programming concepts, and the computers at JPL.

Objectives: To gain a general understanding of computer-related technology and terminology.

Text Provided: Handouts.

Pretest: Recommended.

Time Distribution:

Instruction: Lectures with audiovisuals.

Participation: Discussion.

Homework: Simple problem assignments.
Schedule: Four 2-hour sessions; 2 weeks. A new class to be held each month during the year.

PROGRAMMING FUNDAMENTALS

For Whom: Those with no computer programming background who plan to take other courses in computer languages. Quota limited.

Prerequisites: None.

Description: Introduction to computer programming, its logic, elements, terminology, and procedures. Preview of FORTRAN, COBOL, and X-BASIC.

Objectives: To gain general awareness of computer programming concepts and languages.

Text Provided: None.

Pretest: Recommended.


Schedule: Four 2-hour sessions; 2 weeks. Classes to be held each month during the fiscal year.

FORTRAN FUNDAMENTALS

For Whom: Beginning FORTRAN programmers who will use the Scientific Computing Facility. Quota limited.

Prerequisites: "Programming Fundamentals" course.

Description: Introduction to the elements of FORTRAN and the methods of writing programs in it. This course includes several illustrative problem assignments.

Objectives: To gain ability to write simple programs in FORTRAN.

Text Provided: FORTRAN IV primer—class notes.

Pretest: Recommended.


Schedule: Twelve 2-hour sessions; 6 weeks. Classes to be given on a bimonthly basis.

FORTRAN V

For Whom: Scientific Computing Facility users. Quota limited.

Prerequisites: FORTRAN Fundamentals and "Beginning EXEC-8" courses and experience using the UNIVAC 1108.
BEGINNING COBOL

For Whom: Those who will use the Administrative Computing Facilities. Quota limited.

Prerequisites: "Programming Fundamentals" and "Introduction to Computers" courses or equivalent.

Description: Introduction to the elements of COBOL and methods of writing programs. Several illustrative problem assignments are included.

Objectives: To gain ability to write simple programs in COBOL.

Instructor: Self-study program with group discussion.


Pretest: None.

Time Distribution:

Schedule: Four hours self-study approximately, plus 1-hour group discussion per week; 7 weeks. Four classes per year scheduled.

BEGINNING EXEC-8 CONTROL LANGUAGE

For Whom: Beginning users of the Scientific Computing Facility. Quota limited.

Prerequisites: Ability to use X-BASIC, FORTRAN, or COBOL.

Description: "Introduction to EXEC-8," the Command Language of the UNIVAC 1108 System. Preparation of run streams, compilation of programs, assignment and manipulation of files.
Objectives: To gain ability to prepare simple jobs for running on the UNIVAC 1108.

Text Provided: EXEC-8 Student Handbook.

Pretest: None.

Schedule: Four 1½ hour sessions; 2 weeks; classes to be held each month.
Time Distribution:

Instruction: Lecture.
Participation: Discussion.
Homework: None.

Schedule:
Five 2-hour sessions; 2½ weeks;
two classes/year.

ADDITIONAL COVERAGE IN ADP COURSE CAPABILITY

1. Systems Analysis and Design Course: This is a 30-hour course of self-study, utilizing textual, audio, and video media (no single medium over 15 minutes at one specific period). It is an extensive, self-study program to develop skills in systems work for data processing personnel (DELTAK, Schiller Park, Illinois).

2. ADP Terminology: This is a course completely in audio, on audio tapes for personnel who wish to become familiar with data processing terminology. One of the recommendations for taking this course is to utilize a tape unit in a car going to and from work, listening and repeating the words, as well as the explanation following. This course was developed by a firm in Ohio, and is being utilized throughout the United States (DYNAPHONICS, Dayton, Ohio).

3. JPL/OS: The operating system for IBM's 360/75 computers. This program is completely on video tape for self-instruction or reinforcement, primarily to be used by the computer personnel having advanced knowledge of computer programs.

4. FORTRAN Fundamentals: In addition to the classroom presentation, this course can also be taken on a self-instructional basis by video tape.

5. Additional Courses: Additional courses are given in integrated circuit design, computer-aided circuit analysis, integrated circuit application, speed reading, telephone practice, computer concepts, and techniques, utilizing audio/video (animation) program, and workbooks on various subjects in the computer field in self-study mode, self-study audio cassette/workbook in BASIC, FORTRAN, and a computer technology course put out by the AIAA discussing computer technology media in the next decade.

APPENDIX B—COMPUTER-RELATED OCCUPATIONAL DESCRIPTIONS*

OCCUPATIONAL DESCRIPTIONS

The occupations described on the following pages are considered to be the basic occupations most directly concerned with electronic computing. These occupations, however, are still fluid.

Hiring requirements and qualifications for employment have not yet been fully standardized. As a consequence, a certain amount of overlap and duplication of job duties and responsibilities will be noted among the various occupational descriptions. The occupational data, however, were assembled from many different sources and are a reflection of the existing situation. Since the data reflect the occupational situation as it exists in varied localities and establishments, the descriptions must be considered as composites of jobs, and cannot be expected to coincide exactly with any job in a specific organization. It will be necessary, therefore, to adapt descriptions to fit individual jobs before they can be used with complete accuracy.

The job descriptions are arranged in seniority order of their main titles. The wording of the title that appears at the head of each description is a reflection of common usage. Other titles, by which the job is known, also appear at the head of each description in small type. Between the main and alternate titles appears the code number which identifies the job within the present classification structure of the U.S. DICTIONARY OF OCCUPATIONAL TITLES.

The narrative portion of each job description is arranged as follows:

Occupational Definition—This provides a brief description of the duties involved in a particular occupa—

tion. It provides an understanding of the tasks that are performed, and the skills and knowledge that are necessary to the performance of those tasks.

Education, Training, and Experience—This section provides an indication of the amount of education and the level of training and experience usually required by management for employment in the occupation. As previously mentioned, the various occupations and the qualifications are not standardized, and considerable variation exists among employers as to required education, training, and experience. However, an attempt was made to indicate the range of such hiring requirements.

Special Characteristics—This section provides some estimate of the worker trait requirements pertinent to the specific occupations. It has long been believed that the ability of an individual to adjust to specific types of work situations is as significant as the education and training qualifications he brings to the occupation. This seems particularly significant when dealing with a group of relatively new occupations. Consequently, judgments have been in terms of a number of components consisting of aptitudes, interests, temperaments, physical activities, and environmental conditions to which individual workers have to adjust.

Aptitudes—These are the specific capacities or abilities required of an individual in order to facilitate the learning of some task or duty. This component is made up of 11 specific aptitude factors, and is a modification of the aptitudes contained in the General Aptitude Test Battery developed in the U.S. Employment Service. Those aptitudes were selected which seem to be significant in the occupation and were identified in terms of specific work situations. The factor of intelligence, however, was not rated because of the difficulty in writing meaningful descriptive statements.

Interests—This component is defined as a preference for a particular type of work experience. It consists of five pairs of bipolar factors, arranged so that a preference for one factor in a pair generally indicates a lack of interest in the other factor in the pair. Those factors were identified which seemed to be significant to the job in question, and were identified in terms of specific worker situations.

Temperaments—The temperament component consists of 12 factors defined in terms of specific work situations that suggest different temperament trait requirements. Each work situation describes a type of activity that demands a different adjustment on the part of individual workers. Those temperament factors were selected that appeared to be significant in the occupation, and were identified in terms of specific work duties.

Physical Activities and Environmental Conditions—This refers to (a) the physical activities required to be met by the worker; and (b) the physical surroundings which make specific demands upon a worker's physical capacities. There are six physical activities factors and seven environmental conditions factors. Those factors were selected that were significant in the occupation in the sense that they met established criteria for successful performance.

MANAGER, DATA PROCESSING—(169.168), DIRECTOR, DATA PROCESSING

Occupational definition

Directs and coordinates planning and production activities of electronic data processing division. Consults with management to define boundaries and priorities of tentative projects, discusses equipment acquisitions, determines specific information requirements of management, scientists, or engineers, and allocates operating time of computer systems. Confers with department heads involved with proposed projects to ensure cooperation and further defines nature of project. Consults with SYSTEMS ENGINEER, ELECTRONIC DATA PROCESSING to define equipment needs. Reviews project feasibility studies. Establishes work standards. Assigns, schedules, and reviews work. Interprets policies, purposes, and goals of organization to subordinates. Prepares progress reports to inform management of project development and deviation from predicted goals. Contracts with management specialists or technical personnel to solve problems. Revises computer operating schedule to introduce new program testing and operating runs. Reviews reports of computer and peripheral equipment production, malfunction, and maintenance to ascertain costs and plan operating changes within his department. Analyzes data requirements and flow to recommend reorganization or departmental realignment within the company. Participates in decisions concerning personnel staffing and promotions within electronic data processing departments. Directs training of subordinates. Prepares proposals and solicits purchases of analysis, programming, and computer services from outside firms.

Education, training, and experience

Two years of formal post-high school training in data processing with courses in business administration and
accounting or engineering, or equivalent practical experience is necessary for small computer installations. College graduation with major in one or more of the above fields is preferred for large installations. Experience in systems analysis, programming, and computer operations is desirable. In installations offering more sophisticated services, such as operations research and engineering simulation, a college mathematics major coupled with experience listed above is desirable.

**Special characteristics**

**Aptitudes:**

Verbal ability to translate technical terminology into terms understandable to management and department heads.

Numerical ability to apply knowledge of linear or differential equations in evaluating work of department, preparing reports and proposals for management, and selling services to outside users.

Spatial ability to read engineering drawings, charts, and diagrams; to understand presentations, proposed solutions, and progress reports of business or engineering problems.

Form perception to see pertinent detail in drawing charts, diagrams, and other presentations.

Clerical perception to detect and avoid errors in reading and preparing reports.

**Interests:**

An interest in scientific and technical subjects to cope with wide range of technical and scientific problems processed through computer.

A preference for business contacts with people in directing activities of computer department and to sell ideas or services.

**Temperaments:**

Must be able to direct, control, and plan the operations of the division, bringing together knowledge of operations and information needs of departments, such as accounting, purchasing, engineering, sales, and inventory control.

Required to deal with people such as management, department heads, and manufacturers' representatives to exchange information and ideas, discuss equipment and their uses, elicit information from departments, and to answer inquiries from department heads.

Ability to influence management and department heads to enlist their support for acceptance, expansion, and sophistication of computer systems; and ability to sell excess computer time and services to outside clients.

Required to make judgmental decisions concerning equipment needs, scope of assignments, allocation of computer time, and organization of departments.

Required to make decisions based on factual data to evaluate progress or success of computerized projects.

**Physical Activities and Environment:**

Work is sedentary.

Occasionally walks to various departments and offices; stands during conferences and discussions with management, department heads, and supervisor of computer operations.

Talking and hearing required in conferences and during exchanges of information.

Near visual acuity and accommodation required for reading reports and charts.

Work is performed inside.

**PROJECT DIRECTOR, BUSINESS DATA PROCESSING (020.168), BUSINESS-SYSTEMS COORDINATOR; LEAD ANALYST; PROGRAM MANAGER; PROJECT PLANNER; SENIOR SYSTEMS ANALYST, BUSINESS**

**Occupational definition**

Plans, directs, and reviews business electronic data-processing projects, coordinates planning, testing, and operating phases to complete project with maximum balance of planning and equipment time, man hours and new equipment expenditures. Prepares project feasibility and progress reports. Confers with department heads who provide input and use output data to define content and format. Schedules and assigns duties to OPERATIONS RESEARCH ANALYSTS based on evaluation of their knowledge of specific disciplines. Coordinates activities of workers performing successive phases of problem analysis, solution outlining, solution detailing, program coding, testing, and debugging (error elimination). Reviews output data and related reports, applying knowledge of systems, procedures, methods, and data requirements of management and other output users to ensure adherence to predetermined standards and devise techniques for improved performance on similar future projects. Directs revision of continuous control project to adapt it to new data requirements or improve operations by using new techniques or equipment.
Education, training, and experience

A bachelor's or master's degree in business administration, with extensive course content in accounting and mathematics or statistics often is required. Employers frequently waive academic training requirements for currently employed workers with extensive systems analysis, design and followup responsibility in electronic data processing, and supervisory experience in tabulating-machine departments. Employers frequently require a degree or equivalent experience either in industrial engineering, or the engineering discipline most directly related to their manufacturing processes, when expanding business data processing to an integrated system that includes production forecasting, planning, and control.

Background knowledge and experience usually include a minimum of one to three years' experience in systems analysis and concurrent familiarization with structure, work flow requirements, and standards of the employing organization.

Current trend is toward greater mathematical sophistication than previously expected of workers at this level. The need for advanced mathematics becomes more urgent as computer applications become involved not only with normal business data-processing, but also with the involved problems of operations research.

Special characteristics

Aptitudes:
Verbal ability to elicit information and discuss project intentions, problems and progress, and to prepare reports.

Numerical ability to analyze problems and develop systems statements in form capable of being programmed. Mathematics varies from arithmetic and algebra for simple, single-purpose systems design to differential equations and mathematical statistics for complex systems involving optimization, simulation, or forecasting.

Spatial ability to develop, interpret, or integrate operational workflow diagrams and charts.

Clerical perception to recognize pertinent detail and avoid perceptual errors when working with verbal material, which often is in highly contracted and conventionalized form.

Interests:
A preference for prestige-type activities, and for business contact with others to participate in conferences with management, advise and inform others regarding the potentialities, limitations, and alternative methods of data processing, supervise analysts and coordinate their activities.

A preference for activities that are technical in nature to read and keep informed of computer development and, new or more refined systems and procedures techniques.

Temperaments:

Ability to perform a variety of duties involving frequent change, ranging from direct involvement in problem analysis to coordination of subsequent work processes until each project is operational.

Must be able to direct and plan an entire area of work activity, assigning subordinates on the basis of knowledge of individual specializations and abilities, and control activities through personal contact and reports.

Must be able to deal with people in nonsupervisory situations requiring considerable tact, to secure cooperation from management and all personnel affected by project.

Required to make decisions on a judgmental basis when supervising others and developing approaches to problems on basis of past experience. Evaluates fixed cost, time, manpower allocation, and output specifications to judge efficiency of project development and operation.

Required to make decisions based on factual data, as in planning proposed system around capabilities and limitations of a specific computer system.

Physical Activities and Environment:

Work is sedentary, with occasional standing and walking required.

Occasionally lifts and carries books, charts, diagrams, and other records seldom exceeding 10 pounds.

Talking and hearing to discuss problems and progress.

Near visual acuity to work with reports, charts, and diagrams and other printed or written records.

Work is performed inside.

SYSTEMS ANALYST, BUSINESS DATA PROCESSING—(012.168), COMMERCIAL-SYSTEMS ANALYST AND DESIGNER; DATA-METHODS ANALYST; SYSTEMS AND PROCEDURES ANALYST, BUSINESS DATA PROCESSING

Occupational definition

Analyzes business problems, such as development of integrated production, inventory control and cost

From the collection of the Computer History Museum (www.computerhistory.org)
analysis, to refine its formulation and convert it to programmable form for application to electronic data processing system. Confers with PROJECT DIRECTOR, BUSINESS DATA PROCESSING and department heads of units involved to ascertain specific output requirements, such as types of breakouts, degree of data summarization, and format for management reports. Confers with personnel of operating units to devise plans for obtaining and standardizing input data. Studies current, or develops new systems and procedures to devise workflow sequence. Analyzes alternative means of deriving input data to select most feasible and economical method. Develops process flow charts or diagrams in outlined and then in detailed form for programming, indicating external verification points, such as audit trial printouts. May work as member of team, applying specialized knowledge to one phase of project development. May coordinate activities of team members. May direct preparation of programs.

**Education, training, and experience**

College graduation with courses in business administration and accounting usually is required for entrants without prior experience in data processing. Some employers, while requiring a college degree, do not require a specific major or course content. A successful college record is regarded as proof of ability to reason logically which is considered more important for successful performance than knowledge of techniques acquired in any specific area. Many employers waive the formal education requirements for those workers employed in their establishments who have had several years' manual and machine systems experience prior to computer conversion. Business programmers without a college degree can, through experience, acquire a background in business systems and procedures and may thereby advance into systems analysis. Currently, the trend is to require a knowledge of advanced mathematics because of the rapidly increasing sophistication of business systems. Continuing education, through specialized courses, self-study, and participation in activities of professional associations, is the rule rather than the exception in this occupation, as in all higher level occupations related to the computer.

**Special characteristics**

**Aptitudes:**

Verbal ability to discuss problems and progress, prepare reports, and make annotations for graphic representations of work.

Numerical ability to select from alternatives to develop optimum system, procedures and methods. Mathematical investigation of such factors as variation in volume of input data, and frequency of appearance of exceptions to normal workflow in processing is often necessary. Level of mathematics varied from business arithmetic and algebra to differential equations.

Spatial ability to visualize, prepare, and review two-dimensional graphic representations of workflow.

Form perception to identify nonverbal symbols on records such as block diagrams and flow charts.

Clerical perception to avoid perceptual errors and recognize pertinent detail in the recording and identifying of letters and numbers that often occur in abbreviated or acronymic combinations.

**Interests:**

A preference for activities that are technical and analytical, and those that are abstract and creative in nature to devise new or to modify standardized computer-oriented systems to meet the specific needs of an organization.

**Temperaments:**

Ability to confer with personnel from other departments, develop flow charts, devise workflow sequence, and prepare reports.

Required to deal with people in conference and interview situations.

Required to make judgmental decisions to select from alternatives when devising optimal system.

Required to make decisions on basis of factual data to design system within machine capability.

**Physical Activities and Environment:**

Work is sedentary, with occasional standing and walking. Occasional handling of source documents, books, charts, and other records that seldom exceed 10 pounds.

Talking and hearing to discuss and confer with management and technical personnel.

Near visual acuity to prepare and review workflow charts and diagrams.

Work is performed inside.

**OPERATIONS RESEARCH ANALYST—(020.088), MANAGEMENT-OPERATIONS ANALYST; OPERATIONS ANALYST**

**Occupational definition**

Formulates mathematical model of management problems by application of advanced mathematics and research methods to provide quantitative basis for planning, forecasting, and making decisions. Analyzes
problems in terms of management information requirements. Studies problem, such as selecting from competitive proposals a plan that affords maximum probability of profit or effectiveness in relation to cost or risk. Prepares mathematical model of problem area in form of one or several equations that relate constants and variables, restrictions, alternatives, conflicting objectives, and their numerical parameters. Gathers, relates, and identifies data with variables in model by applying personal judgment and mathematical tests. Specifies manipulative and computational methods to be applied to formulations and refers to data processing division for solving equations, programming, and processing. Reviews operations and testing of model to ensure adequacy or determine need for reformulation. Prepares written, nontechnical reports to management, indicating problem solution or range of possible alternatives in rank of desirability and probability of success when there is no single solution. Writes followup reports, evaluating effectiveness of research implementation. May specialize in research and preparation of contract proposals specifying the competence of an organization to perform research, development, or production work. May develop and apply time and cost networks, such as Program Evaluation and Review Technique (PERT), to plan and control large-scale business projects. May work in areas associated with engineering, as when analyzing and evaluating alternative physical systems, such as production processes, in terms of effectiveness and cost. May work alone or as member of a team.

Education, training, and experience

College degree with emphasis on advanced mathematics and statistics is usually the minimum educational requirement. A combination of advanced degrees in mathematics and business administration is especially desirable. A doctorate in mathematics is frequently required. Specific training in operations research at the graduate level is rapidly becoming a standardized requirement, as more schools offer courses in this interdisciplinary occupational area. Many workers have acquired the necessary background in mathematics through education and experience in engineering and the physical sciences, and knowledge of specialized techniques through self-study and participation in activities of professional organizations.

Special characteristics

Aptitudes:
Verbal ability to understand technical languages of various professional disciplines such as engineering and accounting, to give oral reports and to prepare written reports on results of research in lay terminology to management.

Numerical ability to understand and work with such mathematical specializations as game, queuing, and probability theory, and statistical inference to prepare formulations, specify manipulative methods and evaluate effectiveness.

Spatial ability to prepare and interpret charts, diagrams, graphs, and maps.

Clerical perception to recognize pertinent detail in compilation and analysis of statistical data, and to avoid perceptual errors in working with higher forms of mathematics.

Interests:
A preference for activities that are technical in nature to apply analytical, experimental, and quantitative techniques in the solution of management problems such as long-range forecasting, planning, and control.

Interests in devising mathematical equations, analyzing the methods used for their manipulation, and evaluating their practical effectiveness.

Temperaments:
Requires ability to perform a variety of tasks related to the solution of various problems on all departmental levels. This involves conversing in several professional disciplines with personnel at all operating levels to gather and relate data and opinions relevant to problem under study.

Must possess ability to make judgmental decisions such as probability of continuity or change in conditions, and assign arbitrary weights and values to problem factors when conventional statistical methods are not applicable.

Must possess ability to make decisions based on verifiable data, such as tabular records of previous organizational experience.

Physical Activities and Environment:

Work is sedentary, and occasionally involves lifting and carrying books, ledgers, and statistical tabulations seldom exceeding 10 pounds.

Talking and hearing to discuss organization goals and priorities with management and acquire data pertinent to the problem from other organizational personnel.

Near visual acuity to read and work with a variety of data from many sources, and to refer to texts and technical papers.

Work is performed inside.
CHIEF PROGRAMMER, BUSINESS—(020.168), COORDINATOR, COMPUTER PROGRAMMING; LEAD PROGRAMMER

Occupational definition

Plans, schedules, and directs preparation of programs to process business data by electronic data processing equipment. Consults with managerial and systems analysis personnel to clarify program intent, indicate problems, suggest changes and determine extent of automatic programming and coding techniques to use. Assigns, coordinates, and reviews work of programming personnel. Develops own programs and routines from workflow charts or diagrams. Consolidates segments of program into complete sequence of terms and symbols. Breaks down program and input data for successive computer passes, depending on such factors as computer storage capacity and speed, extent of peripheral equipment, and intended use of output data. Analyzes test runs on computer to correct or direct correction of coded program and input data. Revises or directs revision of existing programs to increase operating efficiency or adapt to new requirements. Compiles documentation of program development and subsequent revisions. Trains subordinates in programming and program coding. Prescribes standards of terminology and symbology to simplify interpretation of programs. Collaborates with computer manufacturers and other users to develop new programming methods. Prepares records and reports.

Education, training, and experience

Graduation from a technical school or college with training in business administration, computer programming, data processing mathematics, logic, and statistics is the usual educational requirement. Usually, a minimum of two years' experience in programming for same or similar computer system, on broadscape and complex projects is required. Experience should indicate knowledge of organization structure and workflow, and also reflect proven ability to supervise others and coordinate work activities of the group supervised with that of other organizational units.

Special characteristics

Aptitudes:
Verbal ability to present oral and written reports and recommendations and to read technical literature about changes in techniques and equipment.

Numerical ability to program at level of linear and Boolean algebra (logic) to minimize expensive programming and debugging time. Mathematics at level of differential equations and probability theory frequently required when an organization is developing or using sophisticated, integrated management information and forecasting systems.

Spatial ability to interpret systems statement, develop general and detailed computer flow charts, and prepare block diagrams that indicate hardware configuration.

Form perception to see pertinent detail in charts, diagrams, and code sheets composed of symbols.

Clerical perception to refer to manuals and written instructions and to review own work. This requires accurate identification of numbers, letters, words, and acronyms as well as ability to grasp general content.

Interests:
A preference for activities that are technical in nature to apply mathematics and logic in converting proposed business systems to computer-processable form.

Temperaments:
Ability to perform a variety of duties, covering problems from different but related areas of business activity such as production and inventory control, and sales analysis.

Must be able to direct, control, and plan development of business data processing programs that will meet current and future needs. This involves direction of activities, such as program testing and revising, and coordination of all phases of business programming activities to meet schedules.

Required to deal with subordinates for purposes of control and coordination, and with systems analysis and management personnel to resolve questions of intent and programming difficulties.

Required to make judgmental decisions based on experience to assign personnel and select and apply techniques that will produce least cost, fastest, or most flexible programs.

Required to make decisions based on factual data to evaluate adequacy of completed program by comparing program, test and operating runs with prescribed standards of terminology, and time.

Physical Activities and Environment:
Work is sedentary. Lifts and carries source and output data, books, charts, and diagrams seldom exceeding 10 pounds.
Stands, walks, talks, and hears in instructional and conference situations.
Near visual acuity to prepare, integrate, or modify complex programs, using a variety of charts, diagrams, and handbooks.
Work is performed inside.

PROGRAMMER, ENGINEERING AND SCIENTIFIC—(020.188), PROGRAMMER, TECHNICAL

**Occupational definition**

Converts scientific, engineering, and other technical problem formulations to format processable by computer. Resolves symbolic formulations, prepares logical flow charts and block diagrams, and encodes resolvent equations for processing by applying knowledge of advanced mathematics, such as differential equations and numerical analysis, and understanding of computer capabilities and limitations. Confers with engineering and other technical personnel to resolve problems of intent, inaccuracy, or feasibility of computer processing. Observes or operates computer during testing or processing runs to analyze and correct programming and coding errors. Reviews results of computer runs with interested technical personnel to determine necessity for modifications and rerun. Develops new subroutines for a specific area of application, or expands on applicability of current general programs, such as FORTRAN, to simplify statement, programming, or coding of future problems. May supervise other programming personnel. May specialize in single area of application, such as numerical control, to develop processors that permit programming for contour-controlled machine tools in source-oriented language.

**Education, training, and experience**

College degree with major in mathematics or engineering is usually the minimum educational requirement. A master's degree or doctorate in mathematics or engineering is a common requirement where analysis or programming is extremely complex or where work duties involve basic research in mathematics or programming. From two to four years of on-the-job training, with gradually decreasing amounts of supervision and with increasingly complex work assignments, are regarded as necessary for the worker to become familiar with at least one class of computer, programming language, and applications area. Short (one to four weeks) training sessions are given by employers and computer manufacturers to provide basic training and (later) specialized training. Current trends toward simplification of programming languages and greater applicability of generalized programs, and requirement of basic computer orientation and programming courses for college degree in physical sciences or engineering will reduce on-the-job training time.

**Special characteristics**

**Aptitudes:**
Verbal ability to discuss problems and equipment requirements with other technical personnel, to prepare computer flow charts, written records, reports, and recommendations and to read technical publications.
Numerical ability to interpret mathematical formulation, to select from alternative computational methods, to frame program within limitations of the computer to be used, prepare logical flow charts and diagrams, to convert program steps to coded computer instructions, and to review work. Level of mathematics may vary from arithmetic and algebra to advanced differential equations in the course of writing a single program, and may also include applications of numerical analysis.
Spatial ability to prepare logical flow charts specifying sequences of operating instructions and flow of data through computer system, to design input and output forms, and to interpret detailed drawings, diagrams, and other graphic data.
Form perception to see pertinent detail in charts, diagrams, and drawings, and distinguish symbols in subject matter areas such as physics and electrical engineering.
Clerical perception to avoid perceptual errors in recording of alphanumeric and special symbologies.
Motor coordination to operate calculator or computer.

**Interests:**
A preference for activities technical in nature to use mathematics to reduce formulations to computer-processable form.

**Temperaments:**
Required to make decisions on a judgmental basis, using past experience and knowledge to select best method of programming and coding a problem and thereby avoiding costly, time-consuming analyses of alternate techniques.
Required to make factual decisions, such as evalua-
tion of program accuracy by computer acceptance, presence of error messages or obvious output distortions. Must be able to conform to accepted standards and techniques in developing and testing programs, and in writing instructions for digital-computer operator.

**Physical Activities and Environment:**

Work is sedentary, requiring occasional lifting and carrying of source data, books, charts and diagrams seldom exceeding 10 pounds.

Talking and hearing to confer and collaborate with other technical personnel.

Near visual acuity to prepare logical flow charts from lengthy mathematical statements of problem, and to convert program steps to coded computer instructions.

Work is performed inside.

**PROGRAMMER, BUSINESS—(020.188), DIGITAL-COMPUTER PROGRAMMER**

**Occupational definition**

Converts symbolic statement of business problems to detailed logical flow charts for coding into computer language. Analyzes all or part of workflow chart or diagram representing business problem by applying knowledge of computer capabilities, subject matter, algebra, and symbolic logic to develop sequence of program steps. Confers with supervisor and representatives of departments concerned with program, to resolve questions of program intent, output requirements, input data acquisition, extent of automatic programming and coding use and modification, and inclusion of internal checks and controls. Writes detailed, logical flow chart in symbolic form to represent work order of data to be processed by the computer system, and describe input, output, arithmetic, and logical operations involved. Converts detailed, logical flow chart to language processible by computer (PROGRAMMER, DETAIL). Devises sample input data to provide test of program adequacy. Prepares block diagrams to specify equipment configuration. Observes or operates computer to test coded program, using actual or sample input data. Corrects program error by such methods as altering program steps and sequence. Prepares written instructions (run book) to guide operating personnel during production runs. Analyzes, reviews, and rewrites programs to increase operating efficiency or adapt to new requirements. Compiles documentation of program development and subsequent revisions. May specialize in writing programs for one make and type of computer.

**Education, training, and experience**

Minimum requirements are high school graduation with six months to two years of technical training in computer operations and in general principles of programming and coding, or equivalent job experience in these areas. Current trend is to hire college graduates for promotional potential with training in accounting, business administration, and mathematics, and provide them with a year of on-the-job training to qualify them for programming. In installations concerned with the application of the computer to more complex areas such as market research and statistical forecasting, a college degree in mathematics is preferred.

**Special characteristics**

**Aptitudes:**

Must possess verbal ability to understand and analyze oral or written statements concerning a variety of business problems and to discuss them with others.

Must possess numerical ability to interpret workflow charts, program problems, and understand machine logic. Level of mathematics varies from arithmetic and algebra for simple business data processing problems to differential equations and mathematical statistics for involved problems such as forecasting or optimization.

Must possess spatial ability to interpret diagrammatic representations of workflow, and to visualize flow of data through computer system to prepare computer block diagrams and logical flow charts.

Must possess form perception to see pertinent detail in symbols when reading, interpreting, or preparing charts, diagrams, and code sheets.

Clerical perception to detect errors in letters, words, and numbers recorded on charts, diagrams, and code sheets.

**Interests:**

An interest in activities technical in nature to effectively analyze problems, and to design logical flow charts and block diagrams.

An interest in activities that are carried out in relation to processes, techniques, and machines to plan sequence steps, to prepare instructions, and to test programs.

**Temperaments:**

Required to make judgmental decisions to plan logical sequence of steps and prepare logical flow chart for a project, keeping in mind capacities and limitations of computer and integrated machine units.

Must be able to conform to accepted standards and
techniques in developing and testing programs, and writing instructions for computer operators to follow.

Physical Activities and Environment:
Work is sedentary, requiring occasional lifting and carrying of such items as source materials, run books, and documentations seldom exceeding 10 pounds.
Talking and hearing to communicate with systems, program coding, and operating personnel.
Near visual acuity and accommodation required to review statistical data and interpret charts and diagrams.
Work is performed inside.

PROGRAMMER, DETAIL—(219.388),
JUNIOR PROGRAMMER; PROGRAM CODER

Occupational definition
Selects symbols from coding system peculiar to make or model of digital computer and applies them to successive steps of completed program for conversion to machine-processable instructions. Reads and interprets sequence of alphabetic, numeric, or special characters from handbook or memory for each program step to translate it into machine language or pseudo (symbolic) code that can be converted by computer processor into machine instructions. Records symbols on worksheet for transfer to punchcards or machine input tape. Marks code sheet to indicate relationship of code to program steps to simplify debugging of program. Confers with programming personnel to clarify intent of program steps. Usually works as understudy to PROGRAMMER, BUSINESS performing such additional tasks as converting flow charts and diagrams of simple problems from rough to finished form, or making minor changes in established programs to adapt them to new requirements.

Education, training, and experience
Must be high school graduate. Some training in programming, coding, and computer operations at technical school level is desirable. Experience in computer operations is preferred, but six months of job experience, most often in a clerical capacity, to become familiar with company operations, workflow, standards, and terminology is the minimum requirement. One to four weeks classroom training in coding for specific computer is usually provided by employer or computer manufacturer. Some employers favor college graduates in order to enhance the worker’s promotion potential.

Special characteristics

Aptitudes:
Verbal ability to recognize programming and coding language consisting of abbreviated words, grouping of numbers, symbols, or mnemonics. Numerical ability to convert decimal numbers to binary or other number systems. Form perception to recognize and remember graphic symbols (arrangement of lines and curves). Clerical perception to select from handbooks codes acceptable to computer, which involves accurate identification and recording of numbers, letters, and words.

Interests:
A preference for activities of a routine, concrete and organized manner to code programs, using standardized codes.

Temperaments:
Ability to perform repetitive tasks according to set procedures, to refer to source books for symbologies and select appropriate codes for each detailed step in program. Steps may number into the thousands. Required to work to precise and established standards of accuracy in recognition of steps of detailed program and in selecting and recording codes. Any mistake can introduce error into programs and either prevent processing or distort output of program when processed.

Physical Activities and Environment:
Work is sedentary. Work sheets and code books seldom exceed five pounds.
Continuously handles pencils, work sheets, and code books while interpreting program steps, finding representative coding, and posting codes to work sheets. Near visual acuity to select correct alphabetical, numerical, or special symbols to convert detailed program to machine-processable form.
Work is performed inside.

SUPERVISOR, COMPUTER OPERATIONS—(213.138), CHIEF CONSOLE OPERATOR;
SENIOR CONSOLE OPERATOR;
SUPERVISOR, DATA PROCESSING;
SUPERVISOR, ELECTRONIC DATA PROCESSING

Occupational definition
Supervises and coordinates activities of workers who operate electronic data processing machines. Assigns
personnel and schedules workflow to facilitate production. Directs training or trains personnel in operation of computers and peripheral and off-line auxiliary equipment. Works with programming personnel in testing new and revised programs. Develops operating methods to process data, such as devising wiring diagrams for peripheral equipment control panels, and making minor changes in canned (standardized) programs or routines to modify output content or format. Directs insertion of program instructions and input data into computer, and observes operations. Aids operators in locating and overcoming error conditions. Makes minor program and input data revisions through computer console to maintain operations. Notifies programming and maintenance personnel if unable to locate and correct cause of error or failure. Revises operating schedule to adjust for delays. Prepares or reviews records and reports of production, operating, and down-time. Recommends changes in programs, routines, and quality control standards. Consults with MANAGER, ELECTRONIC DATA PROCESSING about problems, such as including new program testing and operating runs in schedule and arranging for preventive maintenance time. Coordinates flow of work between shifts to assure continuity. May supervise personnel engaged in key-punching, data typing, and tabulating.

Education, training, and experience

High school graduation is the minimum requirement. Usually a minimum of one to three years' experience in operating computers, peripheral, and off-line equipment is required. A familiarization with programming and coding techniques usually gained through experience in computer operation or a course in programming are additional prerequisites. However, a two-year post-high school training course in electronic data processing may reduce experience requirements. Training in business administration, mathematics, and accounting is regarded as particularly desirable. Some employers require a college degree, particularly in large installations where work duties are largely administrative, and also in order to enhance the worker's promotion potential. Experience in supervising personnel is desirable.

Special characteristics

Aptitudes:

Verbal ability to train and supervise subordinates, confer with other supervisory and technical personnel, and prepare records and oral or written reports.

Numerical ability to level of arithmetic and algebra to cope with error or stoppage situations in computer operations; to plan operating changes; and to prepare variety of reports, often on a daily basis such as revision of average time requirements for processing data or cost allocations to departmental users.

Spatial and form perception to prepare wiring diagrams, wire control panels for peripheral machines, and operate equipment.

Clerical perception to review records of production, operating and down-time, and recognize pertinent detail in computer printout dumps.

Interests:

A preference for business contact with others to confer with management, technical personnel, suppliers of input data, and users of computer output, and to supervise and train subordinates.

A preference for activities that are technical in nature to keep informed of new techniques for operation of current machines.

Temperaments:

Ability to perform a variety of tasks subject to frequent change, such as training and assigning personnel, accommodating changes in production schedules to meet priority runs, maintaining records, and developing new operating procedures.

Must be able to direct, control, and plan the activities of computer operators, satellite input-output computer operators, on-line and off-line peripheral equipment operators, and tape librarians.

Required to deal with people such as other departmental supervisors to resolve problems concerned with the scheduling, adequacy, and accuracy of input data.

Required to make decisions on a judgmental basis to set up work assignments that make maximum use of workers' knowledge and ability, and most effective and economical use of computers and peripheral equipment.

Required to make decisions on a factual basis when developing schedules for processing programs, relating such factors as date of program receipt, priority assignment, estimated run time, and available computer time. Compares output requirements against available equipment, and existing programs, routines, wiring diagrams, and control panels to determine need for developing or modifying operational methods, or altering operating schedule.

Physical Activities and Environment:

Work is light, requiring frequent standing and walking and occasional lifting and handling of reels of tape,
decks of punchcards, and control panels weighing up to 20 pounds.

Talking and hearing to give oral instructions, assign work, and train personnel. Confers with management and others, discussing such items as budget requirements and staffing, machine capability, and production problems.

Near visual acuity to frequently analyze records, prepare reports, study program run books, and read technical literature.

Work is performed inside.

COMPUTER OPERATOR—(213.382)
COMPUTER OPERATOR; CONSOLE OPERATOR

**Occupational definition**

Monitors and controls electronic digital computer to process business, scientific, engineering, or other data, according to operating instructions. Sets control switches on computer and peripheral equipment, such as external memory, data communicating, synchronizing, input, and output recording or display devices, to integrate and operate equipment according to program, routines, subroutines, and data requirements specified in written operating instructions. Selects and loads input and output units with materials, such as tapes or punchcards and printout forms, for operating runs, or oversees operators of peripheral equipment who perform these functions. Moves switches to clear system and start operation of equipment. Observes machines and control panel on computer console for error lights, verification printouts and error messages, and machine stoppage or faulty output. Types alternate commands into computer console, according to predetermined instructions, to correct error or failure and resume operations. Notifies supervisor of errors or equipment stoppage. Clears unit at end of operating run and reviews schedule to determine next assignment. Records operating and down-time. Wires control panels of peripheral equipment. May control computer to provide input or output service for another computer under instructions from operator of that unit.

**Special characteristics**

**Aptitudes:**

Verbal ability to comprehend technical language of operating instructions and equipment manuals and to explain clearly any operating problems and difficulties in interpreting program intent.

Numerical ability at level of arithmetic to prepare operating records, time computer runs, and adhere to fixed operating schedule. While not always an operator requirement, an understanding of data processing mathematics (the number systems used, algebra and logic) is almost essential to discuss operating difficulties with programming personnel, and to progress from routine production runs to the testing of new programs.

Spatial perception to wire control panels for peripheral equipment.

Form perception to identify flaws in input and output materials.

Clerical perception to avoid perceptual errors in preparing operating records, and to recognize alphabetic, numeric, and mnemonic symbols.

Motor coordination, to rapidly set up machines and to move keys and switches to quickly correct errors or stoppages.

**Interests:**

A preference for working with machines and processes to continuously operate and monitor the equipment that comprises the computer system.

Interest in activities of concrete and organized nature to operate machines according to specific and detailed instructions.

A high school education meets the minimum educational requirements of some employers, but an increasing number of employers are demanding an additional several months to two years of technical school training in data processing. This training usually includes such courses as data processing mathematics, accounting, business practices, elementary programming, and operation of computers, peripheral equipment, and tabulating machines.

The employer or computer manufacturer usually provides one to three weeks of formal instruction for the specific computer system the worker will operate. Length of subsequent on-the-job training and experience required to achieve adequate performance ranges from a few months to one year because computer systems and equipment vary in complexity and need for operator intervention. Except in small units, a minimum of three to six months prior experience in operation of peripheral equipment frequently is required.
Temperaments:

Work situation requires ability to perform a variety of work tasks subject to frequent change in the simultaneous operation of a console and a variety of peripheral equipment, the integration of which varies from program to program, or even during a single operating run, and which demands rapid transfer of attention from one piece of equipment to another.

Accuracy required to operate system effectively and minimize down-time and rescheduling of runs. Carelessness in following written and oral instructions can cause extensive rebuilding of program or input data, or even lead to irrecoverable loss of data.

Physical Activities and Environment:

Work is light. Lifts, carries, and positions tape reels, punchcard decks, output forms, and control panels seldom exceeding 20 pounds.

Stands and walks frequently when loading and monitoring machines.

Reaches for and fingers switches and keys on console and peripheral machines. Wires control panels, loads and removes input and output materials.

Talking and hearing to frequently exchange information concerning program and system requirements with other workers and to receive or give instructions.

Near visual acuity and accommodation to follow detailed operating log, monitor computer and peripheral machines for signs of malfunction, and analyze console messages or high-speed printer output for cause of error or stoppage.

Color vision to distinguish between colored wires when wiring control panels, to identify color-coded cards or forms and to monitor colored display lights if used.

Work is performed inside.

COMPUTER-PERIPHERAL-EQUIPMENT OPERATOR—(213.382), ASSISTANT CONSOLE OPERATOR; TAPE HANDLER

Occupational definition

Operates on-line or off-line peripheral machines, according to instructions, to transfer data from one form to another, print output, and read data into and out of digital computer. Mounts and positions materials, such as reels of magnetic or paper tape onto spindles, decks of cards in hoppers, bank checks in magnetic ink reader-sorter, notices in optical scanner, or output forms and carriage tape in printing devices.

Sets guides, keys, and switches according to oral instructions or run book to prepare equipment for operation. Selects specified wired control panels or wires panels according to diagrams and inserts them into machines. Presses switches to start off-line machines, such as card-tape converters, or to interconnect on-line equipment, such as tape or card computer input and output devices, and high-speed printer or other output recorder. Observes materials for creases, tears, or printing defects and watches machines and error lights to detect machine malfunction. Removes faulty materials and notifies supervisor of machine stoppage or error. Unloads and labels card or tape input and output and places them in storage or routes them to library. Separates and sorts printed output forms, using decolator, to prepare them for distribution. May operate tabulating machines, such as sorters and collators.

Education, training, and experience

High school graduate. Post-high school training in operation of electronic or electromechanical data processing equipment is desirable. Employers frequently regard worker as understudy to computer operators and apply same education and aptitude standards to them.

Special characteristics

Aptitudes:

Verbal ability to read written instructions and handbooks and to communicate with supervisor about operating functions.

Spatial ability to follow diagrams to wire control panels, position and thread tapes onto spindles or position decks of cards in hoppers.

Clerical perception to identify and record, without error, data such as dates, program numbers, departments, and routings on forms.

Motor coordination and finger and manual dexterity to load and unload machines quickly and minimize down-time, to thread ribbons of tape over guides and through rollers, and to handle cards and tapes deftly without bending, tearing, or otherwise damaging them.

Interests:

An interest in activities concerned with machines, processes, and techniques to operate various machines. Preference for activities of a routine and organized nature to follow well-defined instructions for any of several different machines.
Temperaments:
Worker must be adept at performing a variety of tasks requiring frequent change to operate a number of machines in varying combinations and sequences.

When operating peripheral equipment, must adhere to established standards for accuracy, such as observing printer output forms for defects in alignment, spacing, margin, and overprinting. Immediate response to indication of error in operation of peripheral equipment is vital.

Physical Activities and Environment:
Work is light, involving frequent standing and walking when operating machines and lifting and carrying tapes, cards, and forms not exceeding 20 pounds.
Reaches, handles, and fingers to mount tapes onto spindles, position decks of cards in hoppers, and thread tape through guides and rollers of peripheral units or wire control panels.
Near visual acuity to read labels on reels, to wire plug boards from diagrams, to scan printout for error, and to read operating instructions and handbooks.
Color vision to distinguish between various colors of wires to ensure correct wiring of control panels.
Work is performed inside.

CODING CLERK—(219.388)

Occupational definition
Converts routine items of information obtained from records and reports into codes for processing by data-typing or key-punch units, using predetermined coding systems. Manually records alphabetic, alphanumeric, or numeric codes in prescribed sequence on worksheet or margin of source document for transfer to punch-cards or machine input tape. May be designated according to trade name of computer system as CODING CLERK, UNIVAC; IBM CODER.

Education, training, and experience
High school graduation usually is required. Training of a day or two in a classroom situation or under the direction of an experienced worker usually is provided by the employer. Achievement of adequate speed, and particularly the development of a high degree of accuracy, takes from one to three months. Achievement of speed involves memorization of many of the codes. Familiarization with standard business terminology and abbreviations, and with special conventions used by the employer can reduce the time necessary to achieve adequate performance.

Special characteristics

Aptitudes:
Verbal ability to understand written and oral instructions, business terms, abbreviations, and mnemonic contractions, and to explain difficulties to supervisor.
Clerical perception to scan and extract pertinent detail from source documents, and to avoid and detect perceptual errors.

Interests:
A preference for activities of a routine, concrete, organized nature to code according to a predetermined, standardized system.

Temperaments:
Work activities are repetitive and short cycle in nature. Converts each item into the equivalent code in the allowable time cycle of a few seconds.
Must follow specific instructions to convert items to their coded equivalents which are indexed in tables or handbooks.

Physical Activities and Environment:
Work is sedentary. Reaches for, lifts, and handles handbooks, papers, and forms seldom exceeding five pounds.
Near visual acuity to read and convert items to codes.
Work is performed inside.

TAPE LIBRARIAN—(223.387)

Occupational definition
Classifies, catalogs, and maintains library of magnetic or punched paper tape or decks of magnetic cards or punchcards used for electronic data processing purposes. Classifies and catalogs material according to content purpose of program, routine or subroutine, and date on which generated. Assigns code conforming with standardized system. Prepares index cards for file reference. Stores materials and records according to classification and catalog number. Issues materials and maintains charge-out records. Inspects returned tapes or cards and notifies supervisor if worn or damaged. May maintain files of program developmental records and operating instructions (run books). May operate key-punch to replace defective punchcards and produce data cards to identify punchcard decks. May work in computer room performing such tasks as loading and removing printout forms, reels of tape, and decks of cards from machines.
Education, training, and experience

High school graduate, preferably with commercial background. Three to six months experience as catalog clerk, file clerk, mail clerk, or messenger with the company is desirable.

Special characteristics

Aptitudes:
Verbal ability to read information on labels describing contents of decks of cards and reels of tape and read catalogs that contain standardized codes and abbreviations.
Numerical ability to count, add, and subtract numbers to perform inventory functions.
Clerical perception to note pertinent detail on labels, cards, or work schedules, and in code books to detect error and avoid misinterpretation.

Interests:
A preference for working with things and objects, following routine and organized patterns to classify, catalog, store, and fill requests for cards and tapes.

Temperaments:
Follows specific instructions and established procedures to receive, store, issue, and purge materials.

Physical Activities and Environment:
Work is light, involving frequent standing and walking to carry reels of tapes or trays and drawers of cards weighing less than 20 pounds between desk, handtruck, file cabinets, and racks.
Reaches for and handles tapes and cards to store them.
Near visual acuity to read and assign identification symbols and inspect materials for damage.
Work is performed inside.

KEY-PUNCH OPERATOR—(213.582), CARD-PUNCH OPERATOR, PRINTING-CARD-PUNCH OPERATOR, PRINTING-PUNCH OPERATOR

Occupational definition

Operates alphabetic and numeric key-punch machine, similar in operation to electric typewriter, to transcribe data from source material onto punchcards and to reproduce prepunched data. Attaches skip bar to machine and previously punched program card around machine drum to control duplication and spacing of constant data. Loads machine with decks of punchcards. Moves switches and depresses keys to select automatic or manual duplication and spacing, selects alphabetic or numeric punching, and transfers cards through machine stations. Depresses keys to transcribe new data in prescribed sequence from source material into perforations on card. Inserts previously punched card into card gage to verify registration of punches. Observes machine to detect faulty feeding, positioning, ejecting, duplicating, skipping, punching, or other mechanical malfunctions and notifies supervisor. Removes jammed cards, using prying knife. May tend machines that automatically sort, merge, or match punchcards into specified groups. May key-punch numerical data only and be designated KEY-PUNCH OPERATOR, NUMERIC.

Education, training, and experience

High school graduate preferred with demonstrated proficiency in typing on standard or electric typewriter. High school or business school training in key-punch operation is desirable. Frequently, one week of training is provided by employer or manufacturer of equipment.

Special characteristics

Aptitudes:
Verbal ability to understand oral and written instructions, such as manufacturers' operating manuals, and to learn operation of machine.
Clerical perception to perceive pertinent detail in tabular material consisting of combinations of letters and numbers, and avoid perceptual error in transferring this data to punchcards.
Motor coordination to read work sheets and simultaneously operate keyboard of approximately 40 keys to punch data on cards.
Finger dexterity to move switches on machine.

Interests:
Preference for organized and routine activities to transfer data onto punchcards.

Temperaments:
Must be able to perform repetitive duties of operating key-punch machine.
Ability to follow specific instructions and set procedures to transfer data onto punchcards.
Required to work to precise and established standards of accuracy to key-punch data at high rate of speed.

**Physical Activities and Environment:**
Work is sedentary with infrequent lifting of decks of cards when loading machine.

Reaches for and handles code sheets, business records, and decks of cards; fingers switches and keys to operate machine.
Near visual acuity to read copy when key-punching.
Work is performed inside.