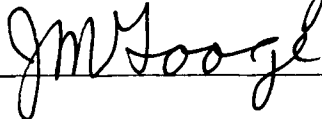


To the Graduate Council:

I am submitting herewith a thesis written by David Gordon Sweet entitled "A Comprehensive Guide to the Design and Implementation of a Two-Year Degree Program in Computer Technology." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Electrical Engineering.


Dr. R. E. Bodenheimer, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

A COMPREHENSIVE GUIDE TO THE DESIGN AND IMPLEMENTATION
OF A TWO-YEAR DEGREE PROGRAM IN
COMPUTER TECHNOLOGY

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

David Gordon Sweet

June 1981

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ABSTRACT

This guide identifies technicians, states job requirements, and describes special problems in designing, implementing, and operating post-high school programs in computer technology. The following areas are discussed: 1) the computer technician (job descriptions and skill requirements); 2) the curriculum (content and relationship of courses); 3) laboratory facilities; 4) program administration (student recruitment, placement, co-op, faculty development, and teaching methods); 5) resources (financial, physical, and library); and 6) case study of the Mini/Micro-computer Technology program at Roane State Community College. A bibliography is appended, as are course syllabi, listing of lab equipment, industrial support, letters, and other pertinent materials.

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INTRODUCTION

The rapid growth of computer technology has made it necessary to provide educational opportunity for a large number of students who seek careers as skilled computer technicians. This requirement has caused a rapid growth in existing programs and in the demand for new programs which will prepare computer technicians in public junior and community colleges, technical institutions, and area vocational and technical schools.

Guidelines for establishing quality programs for computer technicians are needed to assist post-secondary administrators who desire to establish such programs but who are unfamiliar with the technical areas involved or who seek the methodology required for effective program implementation. This suggested guide indicates technician types, states specific job requirements, and describes special problems in defining, initiating, and operating computer technology programs. The material presented has been tested and proven in a successful minicomputer technology program.

Institutions making use of this guide may find it desirable to undertake modifications in order to accommodate local job market conditions and institutional resource limitations. In such cases the advice of local advisory committees should be sought so that the modified program will be suitable to local needs.

This material is designed to assist federal, regional, state, and local technical educators in initiating new high quality computer technology programs or in improving programs already in progress. It will also assist teachers, educators, program evaluators, employers of technicians, guidance counselors, and others interested in technical education.

CHAPTER I

NEED FOR PROGRAMS IN COMPUTER TECHNOLOGY

It has been said that the major restrictions which the computer possesses are the imagination of the human mind and the limitations imposed by the lack of sufficient numbers of technically trained personnel needed to guide this remarkable tool to the limits of its potential. Predictions concerning the growth of the computer industry have been historically on the low side, often to the extreme. Today's society is becoming increasingly aware of the fact that computers play, and will continue to play a significant role in our lives, our businesses, and our economy. Experts forecast continued expansion in computer use and further advances in computer technology. These developments will have a major impact on manpower with thousands of additional computer personnel, many with changing job skills, required to effectively use and maintain the capabilities of computer systems over the next several years.

Minicomputers are the fastest growing segment of the computer industry. Estimated growth in minicomputer systems is projected to be at least twenty percent annually (BLS Bulletin 2063, 1980, p. 26). There will be an increasing number of applications for minicomputers and to some extent they will replace large computers. Much of this usage will be in the dedicated applications area such as process control, data collection and assimilation, and environmental control. Substantial growth is also predicted for minicomputers and microcomputers as intelligent terminals and teleprocessors. Mainframes are becoming more compact and economically feasible, establishing a growing marketplace and broadening application

areas. According to the U.S. Department of Labor, this growing variety and complexity of applications, together with the advances in hardware and software, will necessitate even better educated and technically trained personnel.

The burgeoning number and types of computers and computer related equipment in use has created a tremendous demand for computer service technicians to install, maintain, and repair computers and peripheral equipment, engineering technicians to assist in the design of new computer devices and insure production performance, and software technicians to provide support in the design or debugging of sophisticated software systems. This demand is expected to intensify not only because of continuing high levels of computer equipment productions and proliferation, but also because of more complex computer equipment configurations and greater geographic dispersion. As a result, employment of computer technicians is expected to grow much faster than the average for all occupations through the 1980's (BLS Bulletin 2075, 1980).

As the industry grows and a traditional source of technical personnel, the military, dwindles, computer companies are becoming concerned about a growing present and predicted future shortage of computer technicians. One solution has been to train technical personnel in company educational centers or through in-house training programs. This has also been true of industrial sites with high concentrations of computer systems. However, these programs have become extremely costly, especially as the need increases, and the companies are forced to take less trained and less qualified candidates.

Within the last few years, the trend has been toward two-year colleges as a source of needed manpower. Companies are not only recruiting at two-year colleges and technical institutions in a manner similar to its college-level headhunting for engineers, but are also cultivating relationships with selected two-year schools in order to assist in the establishment or upgrading of computer technology programs.

On a national basis, according to Bureau of Labor Statistics' figures, computer service technicians are expected to have the fastest growth of all computer occupations, increasing from approximately 36,000 in 1970 to approximately 72,600 in 1980 to an estimated 150,000 by 1985, an increase of over 100 percent. Although most job openings will result from rising demands for their services, many will also occur as experienced technicians advance to more responsible jobs or separate from the labor force. This results in a total projected requirement of more than 4,000 openings per year. As with most projections concerning the computer industry, these figures are conservative at best (BLS Bulletin 2066, 1980).

Our national need for computer technicians imposes unique demands on the educational community. The technical knowledge required by computer service technicians and computer engineering technicians has been acceptably identified. It is incumbent on the educational process to provide students with opportunities to gain knowledge of applied computer principles, equipment techniques, and instrumentation together with the ability to serve as assistants to engineers and other professional personnel in the field.

CHAPTER II

THE COMPUTER TECHNICIAN

The occupational activities of the computer technicians is, to a large extent, affected by factors within his realm of control. Variables surrounding his job requirements are dictated by superior personnel or equipment characteristics. However, the approach and performance of these requirements are uniquely enacted in accordance with personal attributes and abilities. This offers a maximum opportunity to exercise self-developed concepts and methods limited only by the operational parameters which are generated by problem characteristics rather than procedural standards.

Occupational requirements of the computer technician are characterized by diversity. Development of computer interfaces and utility programs, analysis of system faults and engineering specifications, and response to customer complaints and hardware failures are all within his realm of responsibility. Job descriptions and duties in the field of computer technology are fluid, as is to be expected in an area where many of the current personnel designations were non-existent a decade ago.

The diversification of industrial, scientific, and business applications has created the demand for new types of technicians and, as a result, new demands on education. An analysis of current occupational activities in the computer industry indicates three distinct and separate technician classifications: minicomputer service technician, computer engineering technician, and system support technician.

Whether the actual job environment is a region of diversified customer applications or a corporation housing a variety of computer types and designs, the minicomputer service technician's primary responsibility is to maintain the proper functioning of computer equipment. When equipment failure occurs, he must utilize whatever tools and resources are available to enact repair procedures, generally involving module replacement, sometimes component replacement. Knowledge of the design and operation of the various computer elements, as well as effective use of test equipment and diagnostic software is necessary. Service technicians often assist in new equipment installation, a task which demands an understanding of component relationships and system check-out procedures. Preventive maintenance is a routine job function which requires inspection, adjustment, and alignment of solid state and electromechanical devices. As generally the service technician is not the equipment user, he must also communicate with the operator to more fully understand the fault symptoms as indicated through improper system operation.

As varied as these job junctions are, so too is the skills inventory required of the computer service technician. An entry level technician must be proficient in the following specific technical abilities:

1. Ability to determine when a system is not functioning within acceptable limits.
2. Ability to visually recognize defects or marginal items.
3. Ability to select, load, run, and interpret the output of diagnostic programs; the ability to use these outputs as guides for further troubleshooting; and the ability to relate diagnostic instructions to particular device registers.
4. Ability to adjust electrical levels and align and adjust mechanical assemblies.

5. Ability to successfully use one or more of the common analysis techniques to determine the nominal operating characteristics of basic d.c. (control and power supply) circuits, small signal a.c. (control and signal) circuits, and a.c. power supply circuits (discrete and I.C.)
6. Ability to develop and use personal logical troubleshooting procedures common to electronic and electromechanical devices, and must be able to adopt these procedures as required.
7. Ability to interpret the operation of electrical, electronic (analog and digital), and electromechanical components, circuits, and subassemblies from drawings, prints, and diagrams.
8. Ability to locate in the computer device components, circuits, subassemblies, test points, and terminals identified on drawings, prints, and diagrams.
9. Ability to perform basic operations on the system including power-up and power-down, boot, load, assemble, compute, write and read from memory and registers, and transfer data to and from peripheral devices and from a specific location on the device's recording media.
10. Ability to properly use an oscilloscope, including the ability to determine if the scope is operating correctly and is in calibration, to calibrate the scope, to prepare it to take readings, to determine if a reading is correct (or within acceptable range); and the ability to use single sweep, check for pulse levels, use delayed sweep, dual trace, expander, and external sync.
11. Ability to differentiate whether a system fault is sourced in the hardware or software.
12. If in the hardware, once the faulty element is located, the ability to determine the nature of the fault and to as permanently as possible eradicate the fault by replacing, aligning, or adjusting the defective item, at the level which is most effective.
13. Ability to wire-wrap and unwrap, solder and desolder from terminals and single layer modules, and to remove and replace modules and subassemblies.
14. If the fault is sourced in the software, the ability to determine if the fault is located in firmware (microcode), the user's program, or the operating system.

15. The ability to describe in general the nature and location of the software fault to the customer or user and the software specialist so as to gain their understanding and assistance.

In addition to these skills, the service technician should have a solid foundation in basic computer architecture and logic, electronic circuits, and device characteristics from which to build higher levels of technical competence. As computer equipment is upgraded and redesigned, the technician must be able to learn new principles and procedures. Often he will be trained specifically for one category of computer component, and therefore he must possess a technical aptitude for high-level, product-specific education. Such a technician will rapidly advance to the level of support specialist in which capacity he is responsible for assisting field technicians with problem situations.

The computer engineering technician is principally responsible for assisting an engineer in completing design projects, testing new systems, and procuring necessary components and subassemblies for the engineering staff. He is a major component of the engineering team and must interface well within it while effectively using his technical knowledge and skills.

Often he is required to construct digital assemblies from engineering specifications, test the resulting systems, and report on the test results. On certain occasions he must design simple interface or supplemental subassemblies to operate in conjunction with the major assembly. Once the product prototype is prepared, the computer engineering technician must establish criteria for the testing and maintenance of the product and prepare written specifications accordingly. This responsibility may be extended to include the design of

necessary test circuitry. In the production environment, he is generally required to insure proper assembly and performance of assembled systems and to locate and remedy problem areas when performance criteria is not met.

In order to efficiently perform his required duties, the computer engineering technician must be able to:

1. Interpret engineering drawings and specifications; relate these specifications to actual hardware implementation.
2. Recognize and obtain components and devices from logistics as required by design specifications and understand the operation of these devices within the system.
3. Wire-wrap, solder, or otherwise assemble prototype systems according to engineering design.
4. Enact test procedures to check for proper operation of the prototype assembly and relate test results to designed performance criteria.
5. Determine fault characteristics as to whether sourced in design inaccuracies, improper assembly, or device failure; and perform remedial procedures including engineering consultation, reassembly, component replacement, or simple adjustment.
6. Effectively use an oscilloscope as described in computer service abilities.
7. Design and build circuitry as required or as indicated for proper operation and coordination of subassemblies or subunits. These activities may or may not be directly supervised by an engineer.
8. Assist in the development of manuals describing test and maintenance procedures and general operational characteristics.
9. Understand structure, design, and assembly procedures of computer components in order to assure that finished products are properly assembled and operational according to test specifications.
10. Understand the operation of complex devices such as memory arrays, latch-driver devices, microprocessors, and the bus structures which interconnect these elements so as to be effective in dealing with designs of this type.

Relative to fault location and repair, the occupational responsibilities are not dissimilar to those of the service technician and, in fact, they are performing the same function requiring the same abilities. The theoretical background obtained by the engineering technician enables him, as well, to pursue further education which provides a vehicle through which to obtain the position and responsibilities of a computer engineer.

The software support technician is a relatively new breed of specialist who combines knowledge and skills from both the hardware and software areas. The need for such a technician has arisen as a result of the complex interrelationship of computer hardware and software. Software support technicians generally respond to problems not clearly sourced to hardware or software. An understanding of data processing systems, business and industrial software applications, operating systems, and programming languages enable the software technician to address all aspects of the software system. The hardware background is necessary to allow the technician to communicate with field engineering, if the system fault appears to be hardware oriented, as well as to provide a clearer, more comprehensive understanding of customized software systems running on particular hardware configurations.

Many firms develop their own hardware-software systems for special applications. This requires highly trained technical personnel to assist in the development of application programs and/or operating systems which will coordinate the unique hardware structure. The software specialist becomes involved in the design, checkout, and troubleshooting stages. Hardware problems are generally handled by a technician who is more hardware oriented.

The specific skills requirements of the software support technician are similar to those of a quality data processing technician, many of which are currently being trained in two-year institutions. However, few of these graduates have any depth in computer organization and operational principles. The software support technician, as trained in the software option of the computer technology program, is provided with a detailed understanding of basic logic, microprogramming, computer architecture, and the functional organization of peripheral devices. This foundation also allows for more efficient and more detailed I/O programming.

Establishing curriculum objectives which are directly related to the technical skills requirements as described for each employment area is a critical responsibility of the institution. The correlation must be close and it must be consistently maintained. Because of the broad-based technical backgrounds provided the graduates of a program as described in this guide, the career opportunities are extended into other areas such as marketing and sales. Since minicomputers are based on the same concepts and principles as are large mainframe systems, technicians trained in programs utilizing minicomputer systems are virtually unrestricted in their career paths within the computer industry.

CHAPTER III

PROGRAM DEVELOPMENT

Provided a local needs assessment indicates that the institution should take positive action in initiating a program in computer technology, the institution should enter into a comprehensive program development procedure. This will include a more detailed study of the technical job requirements of the local and regional computer industry, as well as an analysis of the institutional resources available to implement such a program. No program should be considered for further development unless it can be fairly assured of success. Once program objectives are defined, curriculum design and course preparation may begin together with an identification of additional resources necessary and methods for their acquisition. Procedures must be established for program implementation so that an educational environment conducive to producing highly skilled and knowledgeable technicians and insuring their occupation effectiveness is consistently maintained.

As with any major project, the coordination of activities has a major bearing on the outcome. A well-planned and well-defined timetable is essential for both the development and implementation stages and will contribute significantly to the early success of the program.

Institutions already offering successful programs in Computer Science Technology or Electronics Technology may find it more practical to incorporate computer technology courses into one of the existing

curriculums as an option. Although not providing as comprehensive and high-level a training program as would be the case if the curriculum were dedicated toward the computer technology area, such an arrangement would be highly beneficial to those students in Computer Science or Electronics. The program would also place less a demand on the resources of the institution while allowing students to acquire valuable skills and knowledge. As with the two-year curriculum, the approach to the development of a computer technology option must be a carefully planned and coordinated effort to insure program effectiveness. Further curriculum development in computer technology may be appropriate at a later date once the option has established a secure base and is well supported.

Feasibility Study

Consideration of implementing the program should begin with a comprehensive state, regional, and local area study in order to establish a basis from which to derive feasibility criteria. This can be accomplished with the assistance of an advisory committee composed of people who are familiar with the areas in which computer technology is applied or is expected to be utilized. This procedure is necessary in order to determine educational needs, identify community and industrial support, and evaluate available student population. Based on the results, a decision should be formulated as to whether or not to offer the program. The program should not be undertaken unless there is substantial evidence that it will be required for a minimum of ten years, a factor generally not in question in the computer technology field.

Before program development is initiated, the institution should consider some specific questions such as the following:

1. Does the program represent an educational objective which is aligned with the purpose and objectives of the institution?
2. Does the program meet a need of the state or community and can it be effectively implemented at a reasonable cost?
3. Does the existing faculty include qualified computer technology personnel for program administration and instruction and if not, can such personnel be obtained?
4. Can adequate financial support be obtained to provide the program with necessary physical facilities as well as to maintain the high quality of the program by providing the proper laboratory and test equipment, instructional materials, and reference resources?
5. Can provisions be established for an effective guidance and placement service for program graduates?
6. Is the projected student population sufficient to justify the program?
7. Is there another educational facility in the institution's service area which already offers a similar curriculum and will it affect the success of this program?

While it can be reasonably assumed that employment opportunity exists and will probably increase in the computer technology field, the range of opportunity is related directly to the qualifications of the job candidate. For this reason, it is the responsibility of the institution to insure that the program developed and initiated will adequately serve the needs of the students and the local job market.

Curriculum Design

Particular attention must be given to the design of a program that is expected to produce graduates with the characteristics and proficiency required of a competent computer technician. Each course not only must

be directed toward equipping the student with expertise in its subject matter, but it must also be designed as a functional element of the total program. The correlation of courses within the program is essential in order for students to acquire the in-depth understanding that their employers will require of them.

Curriculum Content and Relationships

Functional competence in computer technology is derived from at least three basic premises around which the curriculum must be formulated. These include:

1. The training must prepare the graduate to be a productive employee in an entry-level position.
2. The formal program, together with a reasonable amount of experience, should enable the graduate to advance to positions of increasing responsibility and technical activity.
3. The foundations provided by the training must be sufficiently comprehensive to enable the graduate to pursue further study and thereby broaden and intensify his technical skills repertoire. This study may involve reading journals, studying text material, or enrolling in formal courses.

A two-year program has certain unusual requirements that influence the content and organization of the curriculum. Some of these requirements are imposed by the occupational functions that graduates are expected to perform; some requirements result from the personal capabilities and objectives of the students enrolled in the program; while others develop from the limited time available to produce a competent technician in such a fluid field.

The sequence of courses in the two-year curriculum is a crucial as the content, if the limited time available is to be used with maximum effectiveness. In general, the subject matter is coordinated carefully

into groups of concurrent courses arranged to move the student smoothly from one plateau to the next. The concepts should build upon one another as well, so that the principles at one level provide a basis for the technical complexity of the next. Students thus gain a deeper understanding of basic principles while broadening their grasp of the many facets of computer technology.

In technical curricula such as this, it is mandatory that specialized course work be introduced in the first term. Deferring this introduction, even for one term, imposes serious limitations on the effectiveness of the total curriculum. Several important advantages accrue from early introduction of this technical specialty:

1. Student interest and motivation are enhanced by the practical aspects of instruction. If the first term consists entirely of general subjects (mathematics, English, social science), students often lose interest. Since the student is enrolled to study computer technology, it is important to begin actual training in this area immediately.
2. A greater depth of understanding in specialized, high-level subjects is possible in the latter stages if the computer technology concepts have been maturing gradually over an extended period of time.
3. Students can see an immediate application of the principles they study in other supportive areas such as electronics.

The relationship between laboratory time and class lecture or theoretical study time is of great importance. There must be coordination between the scientific and technical material presented in the "theory" classes and that taught in the laboratory. Laboratory work can begin when the student is acquainted only in part with the underlying theory. As additional theory is taught and understood, it can be incorporated into the laboratory work.

In the computer technology program, it is vital that the student gain hands-on experience with computing equipment to which he may be exposed to upon graduation. This permits not only an understanding of the practical application of operational principles, but also allows for skill development in diagnostic and repair activities. Laboratory exercises should be developed which require the student to transpose technical concepts into practical procedures. The student's creativity as expressed in original design projects may be re-enforced by successful laboratory implementation.

Curriculum Outline

Successful post-high school computer technology curriculums concentrate on primary needs that are realistic and pragmatic. The program suggested in this guide has been designed to provide maximum technical instruction in the time that is allowed, while still encouraging students to explore areas of interest that will nourish and strengthen their technical potential. The computer technology program often seems somewhat rigid and restrictive to students who attempt to enter the curriculum in the latter stages. Unless the student has a background encompassing early subject matter, entry into the curriculum should be made at the first level due to the technical progression of the courses.

The precise curriculum content should be derived from the decisions and recommendations of the advisory committee and based on the needs of the local computer industry and the institutional resources. It is recognized, however, that most institutions will be considering a program which will prepare mini-computer service technicians, since these

jobs are presently in greatest demand. A suggested curriculum outline for minicomputer service technology is presented along with an outline for a computer hardware/software specialist and a computer engineering design technician. These additional areas may need to be considered later as options within a base computer technology curriculum once the primary curriculum has been established and proven successful. Local needs will dictate these program variations together with the institutional resources for implementing these options.

In order to indicate the necessary structure and progression of the subject matter, the curriculum is presented as a flow diagram. Each module is representative of related subject material with connecting lines indicating knowledge flow. This organization is necessary for the comprehensive development of the student from elementary basics to high-technology skills.

The course outlines are concise and are intended as guides rather than as specific instructional assignments. Each institution should develop detailed course outlines for each subject area which are consistent with the scope and objectives of the program, while maintaining indicated development patterns.

The curriculum may be offered according to a quarter or semester system. However, especially in the semester system, certain subject areas may need to be combined into a single comprehensive course. It is expected that the principles outlined in these courses will be reinforced with well-developed laboratory exercises.

Minicomputer Service. This category is probably the most difficult career for which to prepare, as well as the most lucrative. The computer service technician must have strong backgrounds in electronics, computer concepts, and electromechanical theory. Software must also be included in the curriculum as the operating systems and user programs are an integral part of the computer system.

For the most part, minicomputer service technician performs repair procedures by module replacements requiring a knowledge of basic computer architecture and an ability to analyze fault characteristics and diagnostic outputs, with component replacement seldomly required. However, it has been shown that the technician who can demonstrate a thorough understanding of the principles and concepts involved in the computer system and an ability to effectively apply these principles wherever necessary will advance much more rapidly to positions of greater responsibility.

As can be seen by the course flow paths in Figure 1, the first year can be divided into four basic subject areas; computer concepts, electronics, software, and mathematics. The effective correlation of these subject areas provides a substantial conceptual basis from which to derive maximum benefit from the highly practical and technical subjects in the second year.

A comprehensive overview of the principles involved in minicomputer technology, as presented in *Introduction to Minicomputers*, provides an early introduction to the technical concepts carried throughout the curriculum. This provides a foundation from which to build in numerous courses to follow, thus allowing the subsequent courses to begin at a

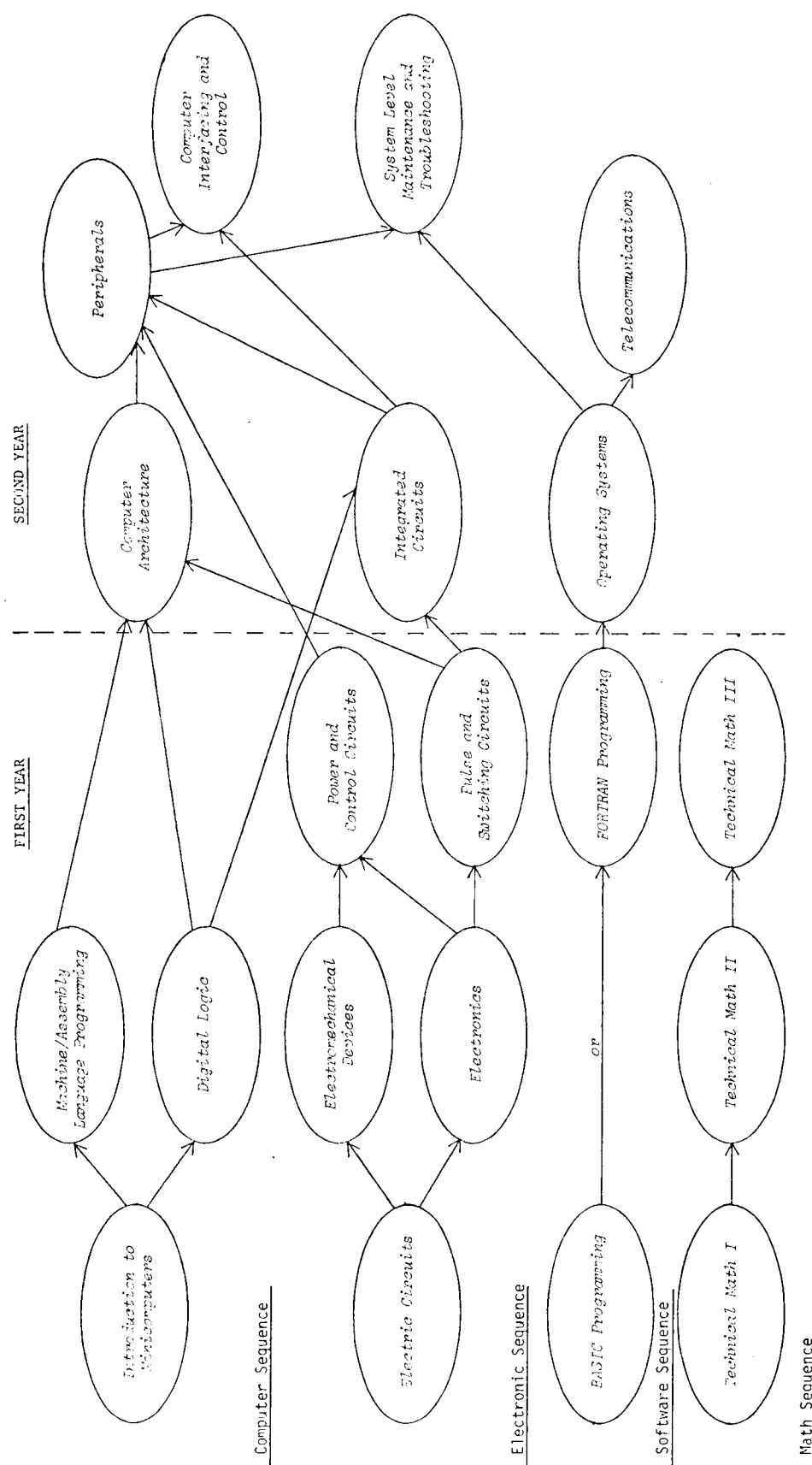


Figure 1. Minicomputer Service Curriculum Flow Diagram.

more advanced level. An introductory course such as this is an appropriate time to have industry representatives discuss career opportunities and job market needs in the computer field. This allows students entering the program with limited computer backgrounds, to make more responsible decisions concerning their career objectives and also enables students from other disciplines to obtain a basic understanding of computers.

Machine/Assembly Language Programming continues to develop the concepts of computer operation and organization and the hardware/software interrelationships. Together with *Digital Logic*, which carries the student from basic gates to ALU's and memories, the student has the background necessary to enter into an in-depth examination of the elements comprising the CPU and main memory, as presented in *Computer Architecture*, and the organization and operation of peripheral devices such as terminals, mass storage units, and interface devices which are studied in *Peripherals*.

The electronics sequence begins with *Electric Circuits*, which develops the principle of DC and AC circuit components and circuit analysis techniques, and continues into *Electronics* where semiconductor concepts are introduced in terms of the operation and practical usage of diodes and transistors. At this point, the student is able to proceed into *Pulse and Switching Circuits*, which examines pulse waveforms and the circuits that produce them, and *Power and Control Circuits*, which develops concepts utilized in power supplies and electromechanical control. This last course should be preceded by *Electromechanical Devices*, a study of the operational principles of elements such as transformers and motors of the type found in various peripheral devices.

The basic electronic foundation now complete, the student uses the concepts of *Electromechanical Devices* and *Power and Control Circuits* to more fully comprehend the design and operation of the devices studied in *Peripherals*. The principles of *Pulse and Switching Circuits* allow for a better understanding of the timing and control circuitry in the processor, and, together with digital logic concepts, establishes the basis from which to investigate integrated circuit devices and the high-level technology associated with their design and manufacture. The functional operation of linear devices, many of which are used in system power supplies and peripheral devices is also covered in *Integrated Circuits*.

The software sequence in the Minicomputer Service Technology curriculum is brief, yet it is an integral part of the overall development scheme. A study of system software components, their functions and interrelationships, as encompassed by *Operating Systems*, must be preceeded by the development of programming skills in a language such as BASIC or FORTRAN in addition to Assembly Language. *Operating Systems* also provides an understanding of intrasystem software which is included in *Telecommunications* together with line and satellite communication.

The final course in the curriculum should challenge the student to assimilate concepts from the areas of computer design, electronics, and software. This is the objective of *Computer System Maintenance and Troubleshooting*, a course in which the student develops skills in analyzing, isolating, and enacting repair procedures of system level faults. *Computer Interfacing and Control* also depends on proficiency in computer concepts and electronics to design and build interfaces which provide the computer

a means for the acquisition of analog data or the control of electromechanical elements through A/D and D/A channels. The service technicians may encounter specialized interfaces of this type in certain computer applications.

The importance of practical hands-on experience and theory reinforcement cannot be overemphasized. Each of the courses in the computer, electronics, and software area should include carefully prepared laboratory exercises which are closely correlated with lecture concepts and extend the principles involved as well. Students should not be limited in their access to laboratory facilities and should be encouraged to pursue independent investigations beyond the required activities.

Mathematics is a necessary corequisite to the development of the theoretical concepts of electronics and logic design. Students may wish to take the first level of *Technical Math* or remedial math prior to entry into the program in order to prevent comprehension difficulties in *Electric Circuits*.

Design Option. The design option of the computer technology curriculum, as shown in Figure 2, is only slightly different from the Minicomputer Service curriculum, an indication of the level of training in digital logic provided to the prospective service technician as well as the depth of study of practical computer design required of the design technician. Graduates from either curriculum are thus afforded maximum flexibility and range of opportunity upon job entry. As with any program option or curriculum derivative, utilization of common courses wherever possible prevents the over-taxing of program resources.

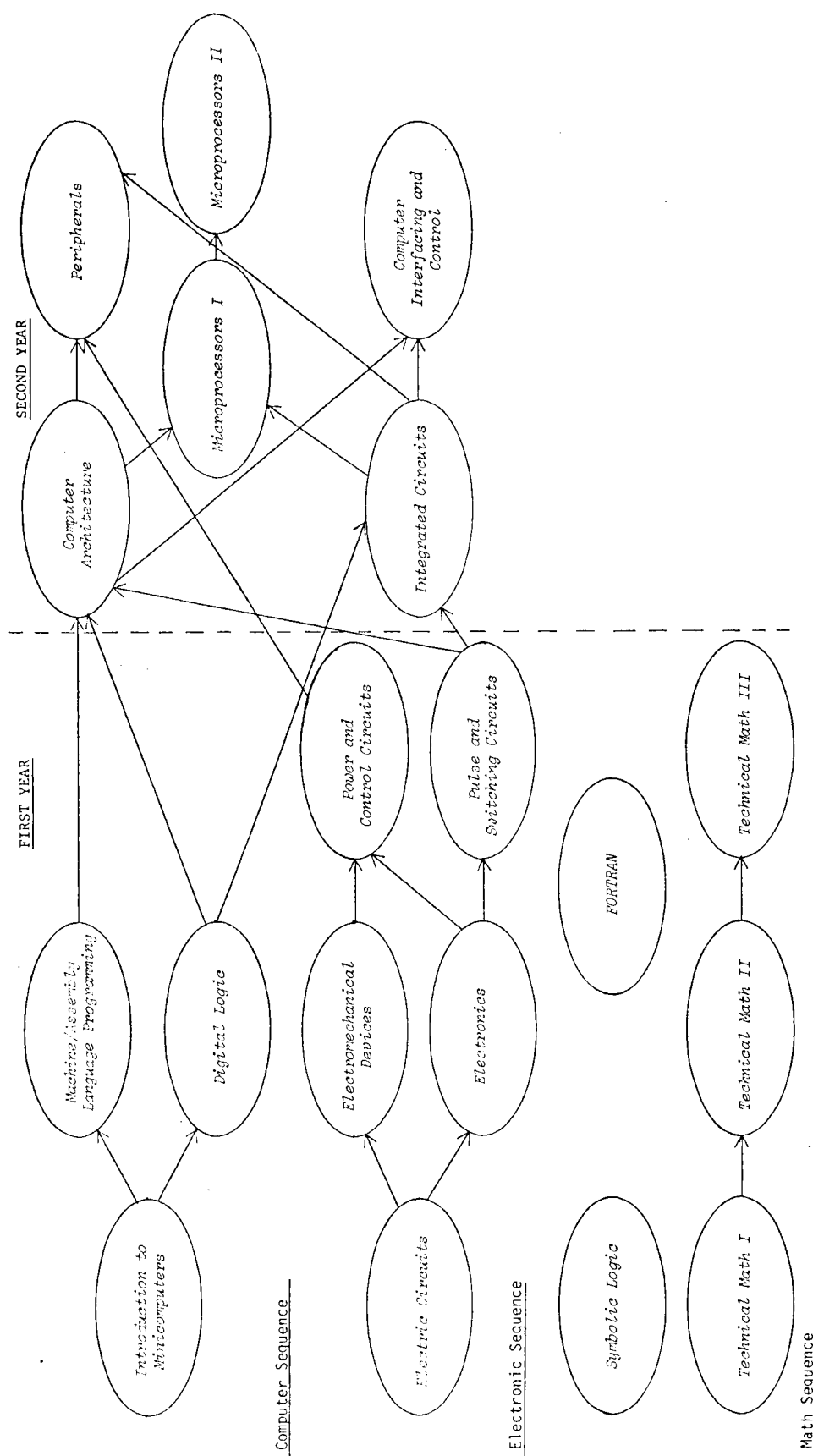


Figure 2. Design Option.

The microprocessor courses, required in the design option, allow for a detailed analysis of complex microprocessor based digital systems similar to those of increasing popularity in industry. Since these courses are reached following a comprehensive development of digital logic and computer design concepts, the students may immediately approach the microprocessor at a highly technical level.

Microprocessors I familiarizes the student with the functional organization and operation of the microprocessor system through an analysis of programming techniques and system support devices. Lab experiments involve code development and simple interfacing. The material provides added insight into the operation of certain microprocessor based peripheral devices such as video terminals. *Microprocessors II* expands the concepts developed in the first course with more complex, project-oriented system studies. Use of system development tools such as logic analyzers and device emulation maximize practical and pertinent instruction.

The software sequence in the design option is limited to *FORTRAN* to develop a general programming background. *Assembly Language*, required in the computer sequence, provides an understanding of hardware/software interrelationships as does the topic of microprogramming in *Computer Architecture*.

Software Option. As indicated in Figure 3, the software option emphasizes a mix of the computer and an expanded software sequence. This gives the student a comprehensive background in computer organization and operation while providing extensive skills in software development. It is assumed here that the institution has a previously established Computer Science program from which to utilize needed software courses.

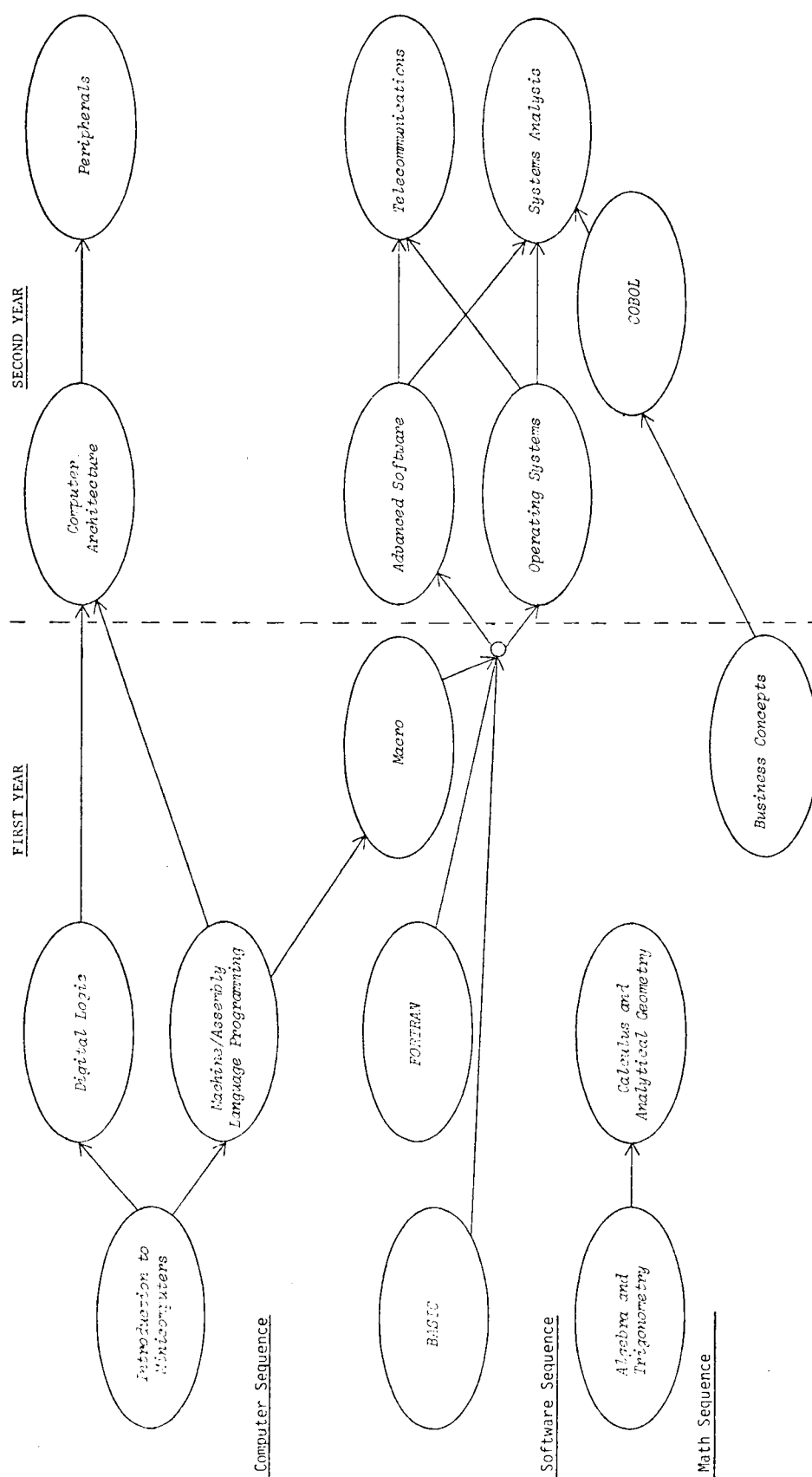


Figure 3. Software Option.

The programming languages and techniques studied in *BASIC*, *FORTRAN*, *Macro*, and *COBOL* are intensified in *Advanced Software*, a project oriented course in which the student must utilize one or more of the basic languages to accomplish sophisticated software tasks. *Operating Systems*, including topics of program development and taken as a corequisite of *Advanced Software*, establishes the needed foundation for *Telecommunications* and *Systems Analysis*.

The mathematics requirement is intensified so as not to limit programming capabilities of the graduate in areas involving high-level math. *Business Concepts* provides a basic understanding of the principles and concepts of a business system to be further developed in *Systems Analysis*.

In cases where the institution offers programs in electronics and computer science, attempts should be made to maximize resource sharing between computer technology and the others. Overlapping courses should be avoided to more effectively use institutional resources.

For all curriculum sequences, outside study is a significant part of the total program. In this program, two hours of outside study for each hour of scheduled class time is suggested. Also, for the computer and electronics sequences, organized laboratory activities should at least match the class time with allowances made for continued investigations as well. Provisions should be made wherein students receive credit for independent project activities.

By the end of the first year, adequate instruction has been provided to equip the student with employable skills. At this point, the student may be considered for a cooperative education or work-study arrangement.

A certain amount of practical field experience should be required in all option areas.

In curriculum development, it is critical to maintain the interrelationships and the technical progression of the courses in order to bring the student to the high level of technical proficiency required. A successful computer technology curriculum must aim to develop specialized persons who are able to perform tasks requiring precision and skills and who approximate the profession in education, aptitude, and competence.

The technician must also be capable of working and communicating directly with engineers, scientists, and other personnel as well as satisfactorily performing work assignments and growing into positions of increased responsibility. In addition, the graduate technician should have a foundation for developing as an active, well-informed member of society. For these reasons, social science and humanities courses should be integrated into the curriculum to provide social awareness and communication skills. Most public institutions must comply with state guidelines which generally are specific as to the core curriculum requirements involving non-technical courses.

The courses suggested in this guide constitute a proven approach to instruction in a field of employment which is in a state of constant transition. The instructor is offered the challenge and responsibility to maintain constant vigilance on the development of new techniques and procedures and to offer curriculum modification where justified.

The program, as such, is not intended to make individual students proficient in all duties they might be asked to perform. Proficiency to a highly specialized work will come only with practice and experience.

It is as impossible to forecast the exact requirements of the duties that may be assigned to any graduate technician as it is difficult to predict accurately the course or rate of change of his responsibilities. This program will, however, provide the student with skills sufficient to develop, adjust, and perform as required.

Laboratory Equipment

Student access to appropriate state-of-the-art equipment for hands-on technical training is absolutely essential for achieving the curriculum objectives of a computer technology program. The amount and level of sophistication of the equipment selected will naturally be closely related to the depth and scope of the courses offered, the number of students served, and the financial resources of the institution. Valuable insights can be gained by utilizing the professional advice and recommendations of the advisory committee, local and national employers of computer technicians, and educational consultants.

Obviously there are many system configurations which will meet the minimum requirements for a program such as described in this guide. A recommended approach to developing laboratory work and equipping laboratories is to determine what activities and experiences are needed for each course. Exercises then should be designed, so far as possible, using standard equipment representative of that currently used in industry. This approach requires staff time and effort but, because the laboratory equipment has been assembled to demonstrate some principle or to make a specific experimental determination with clarity and precision, it usually results in the best instructional presentation.

Equipment selection is a consideration of prime importance to the effectiveness of the curriculum. Minicomputers and peripherals are abundant in numbers and variations. Concerning the educational effectiveness of the equipment, several factors should be closely examined. These include:

1. The equipment contained in the laboratory should be reliable. Inoperable computer components are of little educational value and deter the development of competence in the student involved in investigation or repair procedures.
2. The equipment should be similar in architecture to that which is commonly used in industry. This allows for the principles developed through experiments on this equipment to be sufficiently up-to-date and directly applicable to the industrial environment.
3. Laboratory computer systems should include the type and variety of computer components most common in an industrial application. In memories, both core and semiconductor are still widely used although semiconductor is generally more popular. Mass storage devices should certainly include both disk and magtape storage with both video and hardcopy teleprinters representative of terminal devices.
4. Computer components should be conducive to hands-on activities such as signal sampling, module replacement, adjustment and alignment, and if scope of curriculum allows, chip replacement. Certain types of processors and peripheral devices do not facilitate instructional usage because of multi-layered boards, obscure test points and signal lines, and sensitive modules which are easily damaged upon removal.
5. Sufficient manuals and engineering drawings should be currently in print for the equipment utilized. The theory of operation, organization descriptions, and maintenance procedures should be clearly and accurately detailed. This will provide valuable instructional materials as well as facilitate actual maintenance procedures.
6. Spares and replacement components must be readily available at a reasonable cost. This is especially true in facilities where self-maintenance is performed.

Two complete minicomputer systems is the minimum lab requirement for sufficient hands-on training. One system should be dedicated to

hardware studies and should include a variety of peripheral devices such as disk, mag tape, paper tape, and terminals. Provisions must also be incorporated into the system for special devices resulting from design projects.

The other system will support software activities such as program development and system software analysis. Devices included in the system are limited mainly to mass storage and terminals. Main memory size should be adequate to support a fairly sophisticated operating system.

If financial resources permit, additional systems should be obtained to provide a better equipment-to-student ratio and creating a more educationally effective laboratory environment. These systems should contain a smaller mix of peripheral devices than the hardware system yet should include devices of particular emphasis in peripheral studies. Interfacing activities are generally directed toward this type of configuration. The software of these systems should also support limited program development such as assembly language or Macro. An ideal equipment configuration is shown in Figure 4 with eight or more systems and appropriate peripherals contained within.

Computer equipment is expensive by nature. A major task of program developers is therefore to acquire system components necessary to support the objectives of the curriculum while using financial resources most effectively. Vendors who offer educational discounts should be the primary consideration as sources for the equipment. Some computer manufacturers provide used or refurbished equipment at substantial price reductions. Although these items are not state-of-the-art, they are generally based on modern design principles and

Figure 4. Optimum Computer Laboratory.

Legend

A Laboratory Tables	H File Cabinet
B Instructor's Stand	I Work Desk
C Storage Cabinet	J Terminals
D Bookcase	L Storage Shelves
E Swivel Chairs	M LCS Board
F Lab Stools	N Electrical Outlets
G Lab Assistant's Desk	

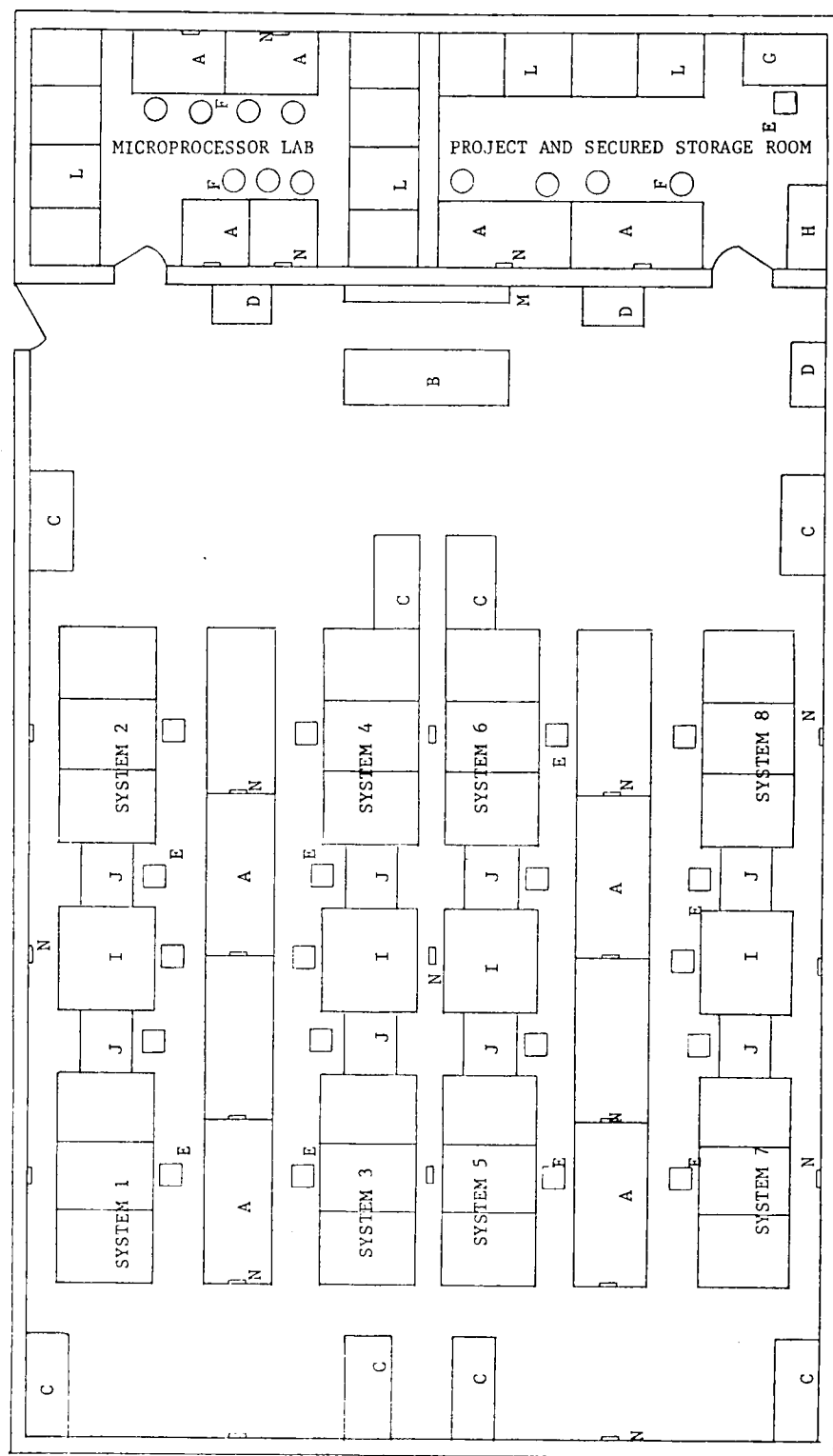


Figure 4. Optimum Computer Laboratory

are still educationally effective. Equipment modifications should not be necessary but may be warranted for increased instructional benefit.

Donations of computer equipment must be encouraged and is generally likely to occur in active programs due to the rate of replacement and upgrade of industrial systems. No aspect of the curriculum should be based on such likelihoods but certain curricular adjustments should be made if donations are procured.

Test equipment, tools, spares, and replacement modules, and other maintenance items are vital to effective utilization of the computer components. The recommendations of field and service engineers should weigh strongly in the selection of these items. Oscilloscopes should have sufficient bandwidth and rise times to accurately observe and measure all data, timing, and control signals in the system. Dual channel with delayed trigger and trigger view is suggested for increased instructional enhancement. Logic probes used in the determination of logic levels are convenient but not necessary. Quality multimeters should also be available in the lab. Some test equipment manufacturers may offer educational discounts as well as "demo" equipment at reduced costs. Needed replacement components and spares should be determined by the degree of self-maintenance, statistics on component reliability as provided by the equipment manufacturer, and instructional maintenance activities.

To be instructionally effective, the computer systems must be in good operating condition at all times. Faults will occur in any computer component periodically. Student activities, although carefully controlled and supervised, generally increase the incidence of component

failure. As much self-maintenance should be performed as possible without over-burdening the faculty. Students, especially those in the more advanced levels of the program, may be used in problem diagnosis and repair. This provides realistic situations and valuable experience for the student while avoiding costly service calls. However, it is recommended that the students gain their primary troubleshooting and repair experience through controlled faults, inserted by the instructor, which allow for more accurate student performance evaluation. Selected items, the operation of which are essential to a course or subject area, may be placed on service contract to eliminate disruptive down-time.

Other instructional equipment such as digital trainers are necessary for the development of digital concepts and should be carefully examined for practical effectiveness. Black boxes which perform logic functions do not allow students to gain experience in dealing with actual components. Microprocessor trainers and microcomputer development tools should be purchased as justified by the nature and scope of the program and objectives of the curriculum. Recommendations of the advisory committee should determine, for the most part, the amount and type of equipment to be purchased. As with the minicomputer systems, students should gain practical hands-on experience with equipment and components which are up-to-date and industry representative. Many microprocessor training units based on popular microprocessors such as the 6800, 6502, and 8080/85 types, are on the market. "Black boxes" should be avoided in this area also.

Non-Traditional Programs

In recent years the non-traditional student has become a significant aspect of student enrollment figures, especially in two-year institutions. The curriculum in guides such as this may be modified by schools and their advisors to serve the needs of employed adults who wish to upgrade their skills and technical abilities or students who, because of financial or other personal reasons, wish to spend less than two years in formal study. As dictated by the needs of the local community and industry, the institution may wish to offer night and/or non-degree programs.

Although at most institutions a daytime schedule will be emphasized, night classes should be considered, as well, in order to allow currently employed persons to attend formal classes. It is important that consistency be maintained between the day and night classes with respect to course content and depth of presentation. Provisions should be made so that night students have sufficient access to laboratory equipment and are not restricted in their "hands-on" laboratory activities.

Certificate programs are generally designed to provide as much knowledge and skills development related to a specific occupational area as possible within a period of one year. In the case of computer technology programs, the certificate sequence must allow the student to progress to a point where they have developed marketable skills yet not demand that the student have a prior background in computers. A certificate program for computer technology might include the following courses:

Computers: *Introduction to Minicomputers*
 Machine/Assembly Language Programming
 Digital Circuits
 Computer Architecture

Electronics: *Electric Circuits*
 Electronics
 Pulse and Switching Circuits
 Integrated Circuits

Software: *BASIC or FORTRAN*
 Operating Systems

Mathematics: *Technical Math I, II*

This one-year curriculum would provide a technical background which the student could utilize to develop more specific, high-level skills. With additional in-house training and experience, the graduate could perform as an effective and competent computer technician.

Similarly, institutions may offer concentrated short sequences which present a comprehensive study of a selected technical area such as micro-processors or peripheral devices. These sequences would require that the student have a prior knowledge of computers and electronics sufficient to allow comprehension of the subject matter and normal progression through the courses. This type of program offering should be directed toward currently employed adults who wish to update their skills and knowledge in their field of specialty or who wish to acquire skills which will allow them to move into new areas. The courses involved will generally be the latter ones in a subject area sequence which involve topics more prone to continual development. The prerequisites or background necessary for entry into such a sequence should be clearly outlined. Sequences within the earlier, foundation courses may also be developed to provide technicians with the means to understand the principles and concepts involved in their current occupational activities.

The type and extent of non-traditional curriculum development should be closely controlled and constantly evaluated. Such programs should be discontinued if the requirements of the industrial community changes or if continuation of the non-traditional programs cause an over-burdening of the institutional resources and a weakening of the primary program.

CHAPTER IV

INSTITUTIONAL RESOURCES

Irregardless of the depth and detail of program planning and curriculum development, the success of the program will depend largely on the resourcefulness of the institution in its procurement and utilization of institutional resources. These factors will also play a large part in determining the scope and bounds of the program since no insitution should attempt to initiate a program which cannot be adequetly and consistantly supported.

Faculty

Any program's effectiveness depends largely on the skills and enthusiasm of the instructional staff. The specialized nature of the computer technology program necessitates that its faculty demonstrate special competence based both on practical industrial experience and proficiency in the technical subject matter. It is also important that all members of the faculty understand the goals, directions, and unique requirements of the program.

To be maximally effective, members of the faculty responsible for the program must have interests and capabilities which transcend their areas of specialization. Particularly, they should be reasonably well informed of the requirements for study in computer hardware, software, and system utilization so they may use field examples and illustrations to support subject areas within their courses.

A minimum of two full-time faculty members in addition to two or three part-time instructors is generally required to teach the technical courses in a typical computer technology curriculum. Entering classes of 20 to 30 students can be taught in lecture sessions but may have to be divided into sections of 12 to 15 for laboratory work. One of the full-time instructors is usually recognized as the head of the program and can be expected to devote roughly half-time to program administration.

The department head must be technically competent in computer technology on a broad base, able to effectively plan and equip the laboratory facilities, capable of developing and initiating the curriculum, able to inject new concepts and subject matter into the program as dictated by industrial developments and needs, able to provide the necessary leadership in student recruitment and graduate placement, and qualified to coordinate the departmental teaching effort which will result in completeness and excellence in the program. This individual should work with the program advisory committee and should in other ways lead the program with the support of the school administration. The department head must be employed one year prior to program implementation for course and laboratory development. An additional instructor should be hired during the first year of the program with part-time faculty or an additional full-time faculty position secured in subsequent years as necessary. Care must be taken throughout the duration of the program that the instructional staff is not overloaded with teaching requirements and their teaching effectiveness reduced. This will also allow for time to be spent in assisting student and in developing courses and effective laboratory exercises.

A weekly departmental meeting to encourage development and experimentation with teaching methods is recommended. At these sessions, instructors could verify that coordination of concurrent courses is maintained as well as course content of prerequisite courses. In addition, staff meetings can provide for interchange of ideas on teaching techniques found to be useful and on recently developed laboratory projects which seem to be particularly successful. Furthermore, the meetings provide a forum for discussion of scientific and technical journal articles which may enhance classroom material or which may present new information which needs to be injected into a course.

Even the most competent faculty members must remain alert to new methods, materials and equipment. They must continue to read, study, and maintain contact with the rapidly changing concepts in computer technology, and visit industrial sites and training programs. While individual efforts toward self-development are considered to be ordinary characteristics of a professional attitude, such activities should be fully supported by administrators. Funds budgeted for faculty members to travel to selected professional conferences and training seminars can produce significant increases in program effectiveness.

To help assure that the training provided within the computer technology program is current and relevant, it is recommended that the one or two faculty members primarily responsible for delivering the computer technology curriculum, participate in summer internships with local computer firms. A variety of activities should be involved to gain maximum exposure to the types of work activities and responsibilities the students will meet both in co-op and in permanent employment

upon graduation. The internship may be informal, wherein the objective is to gather pertinent information and hence no remuneration will be considered. Formal internship will involve a contribution by the faculty member to the financial objectives of the company and, therefore, salary arrangements should be made.

Institutions should promote professional development further by encouraging faculty members to participate as active members of professional and technical societies. Such societies are an important source of instructional materials and provide, through their publications and meetings up-to-date reports and continuing discussions of new concepts, processes, techniques, and equipment. Membership will also enable instructors to maintain a closer liaison with both employers of computer technicians and key industrial representatives in the computer field. Some institutions pay all or part of the costs of membership dues and attendance at local or national meetings in order to encourage participation.

Students should also be invited to become acquainted with the benefits and resources of technical and scientific societies. They should also be encouraged to join those which offer student memberships.

Library Facilities

Part of the strength of any program is indicated by the quality of its library as characterized by the qualifications of the librarian; the facilities; the quality, quantity, and relevancy of content; and the staffing and organization.

Dynamic developments causing rapid changes in computer technology make it imperative that the students learn to use a library work for their various courses, both to develop the habit of using the library as a tool in learning and to help foster a professional attitude which regards libraries as a source for keeping abreast of new developments in the field.

Instructors of all courses should inform their students that library use is an important aspect of the program. Planned assignments that require the use of the library to prepare reports on pertinent subjects or to procure additional information on classroom topics will enable students to understand the resources available and their impact on their educational experience.

For this reason, a central library under the direction of a professional librarian is important to the success of the program. Most instructors have private libraries in their offices from which they may select books of special interest to discuss in their personal conferences with students and thereby stimulate their interest in related literature. In addition, it is often necessary to maintain a collection of reference materials such as equipment manuals, component data books, and software guides within easy access to students performing laboratory exercises. For the most part, however, a centralized library insures the acquisition and cataloging of library materials according to accepted library practices and provides systematic card files that facilitate the location of reference materials. It also provides a controlled and orderly lending system typical of libraries which the students might use later as technicians.

A well-equipped library/media center should also have some type of duplicating services available so that copies of library materials may be easily obtained by both faculty and students. Such a service allows for the building of up-to-date files of current information appropriate to the courses in the program. Suitable study space should also be provided students for use of reference materials.

A library must not only provide adequate literature on the information encompassed by all subjects in the program, but also extend somewhat beyond the degree of complexity and depth of the presentations which students encounter in the classroom. The library should also meet the needs of both full-time and part-time students who are taking supplemental courses to upgrade or update their occupational knowledge and skills. In addition, it should serve the daily requirements of the instructors in their aim to keep their own technical knowledge abreast of the new developments within the computer field.

The faculty and the library staff should cooperate in determining what print materials are to be acquired and should be responsible for the final selection of the materials which support their courses. The initial size of the acquisition for the program will depend on the library budget, the enrollment anticipated, and the current library content. The faculty must take the initiative in recommending materials to keep the library current, pertinent, and useful. Instructors should be supplied by the library staff with periodic lists of recent acquisitions complete with call numbers.

Library content may be classified as basic encyclopedic and reference index material, reference books pertinent to the technology,

periodicals and journals, and visual aids. The importance of periodicals and trade journals should be emphasized as they represent the most authoritative, most recent, and most nearly complete presentation of new knowledge and new applications of principles to a given area of applied computer technology. Technical or trade journals should either be circulated among the teaching staff or placed in a staff reserve section for a brief time before they are made available for general library use. It is essential that both instructors and students make frequent use of such literature to keep their technological information up-to-date. Appendix A contains a suggested list of technical journals and periodical which would be desirable in the library.

Often students have difficulty in assimilating new concepts of a highly technical nature. For this reason it is recommended that audio-visual materials be available for outside-classroom study. These may be in the form of self-paced, individualized learning modules, prerecorded video lecture materials, or synchronized slide/cassette tape presentations. In some cases, CAI programs may be developed for tutorial support of certain subject areas. Audio-visual material, however, should be utilized bearing in mind that the information is supportive of lecture topics and in no way can provide the technical skills acquired through well-planned laboratory exercises.

Physical Facilities

Proper design and usage of laboratory and classroom building areas can have a very positive influence on instructional effectiveness and

should be given careful attention. That is true whether the institution plans to utilize existing space with appropriate modifications or intends to implement the program in new building facilities.

The area of primary importance is the computer laboratory containing the computer systems, trainers, test equipment, and other related items. As justified by the scope and level of technical sophistication of the courses and the financial resources of the institution, the amount and type of equipment included in the lab are the primary factors in determining space requirements. Floor area should be sufficient to provide adequate space for easy access to computer components during laboratory exercises and equipment maintenance. Other important considerations in the selection or modification of space for the lab are:

1. Availability and location of proper and adequate power.
2. Ceiling height, outside wall and glass area, and other factors related to ease of maintaining required environmental conditions such as temperature and humidity.
3. Space for additional air conditioning if necessary.
4. Traffic flow to and from other areas.
5. Floor loading capacity.
6. Adequate safety and fire prevention procedures.

Space and Layout

A suggested computer laboratory layout is shown in Figure 4, page 32. The physical arrangement of the computer systems not only allows for easy access to the systems but also provides a means for laboratory lectures and instructional guidance from a central point in the front of the room. Space is allowed in front of the computer cabinets for extension

of computer components and adequate work area, and in back of the cabinets for rear access.

Laboratory work tables are provided in close proximity to the computer system for placement of engineering drawings, test equipment, disks, tapes, computer modules, and other items used during lab exercises. Storage cabinets containing logic modules, replacement parts, test equipment and other items for each system allow for a unitized concept for each system. Bookcases, located at convenient points, hold engineering drawings, handbooks, and other reference documents. The LCS (liquid chalk system) chalkboard provides a dustless means for instructional guidance.

The small storage room provides office space for a laboratory technician or student assistant, secured or controlled storage of selected parts and equipment, and work tables for equipment repair, component replacement, and module assembly for special projects. Another small adjacent room contains lab tables, storage, and appropriate electronic equipment to be used for microprocessor/microcomputer experiments. Both rooms have windows to the main computer lab to provide an open effect.

Initial site planning and layout should provide allowances for program growth. System additions or modifications should not be restricted in future years by inadequate laboratory design.

Most computer equipment manufacturers provide pre-site engineers to assist with preinstallation planning as well as a comprehensive site planning guide. Factors specifically related to the computer

equipment such as power and grounding requirements and necessary temperature and humidity controls should be carefully considered.

Power Distribution

Most minicomputer components, including processors, mass storage devices, and input/output devices likely to be incorporated in a computer technology program, require only 115 volt, 60 hertz, single-phase AC power. However, considering the amperage requirements together with the need for line isolation to reduce noise, it is generally advisable to install a dedicated power distribution system for the computer system.

If possible, new three-phase lines should be routed from the main transformer to a distribution box with breakers of sufficient amperage. One or more single-phase, three-wire lines should be run to the computer receptacles with systems divided evenly between distribution lines. Power distribution should also be provided for laboratory work tables and additional wall receptacles.

The ultimate goal of computer system grounding is to maintain equipment protection and operation while insuring personnel safety. To be effective, earth grounding must provide a low-impedance path, at all frequencies, to a zero-potential ground plane. This will eliminate all undesirable ground signals, ground loops, and ambient radiation. Most computer components have ground straps to insure the integrity of the safety/logic ground of the system and should be kept tightly secured. Other considerations such as RF interference, lightning protection, and power line fluctuations and protection should be made as needs and/or local power characteristics demand.

Environmental Control

Computer area environment (temperature and humidity) can have a substantial effect on the overall reliability of a system. These requirements are usually determined by the most restrictive category of the computer system. Computer components dissipate heat and are cooled internally by means of forced air circulation from top to bottom. Due to the large amount of heat generated in a relatively small space, it is not generally possible to provide for adequate heat removal without the use of air-cooling equipment.

The ideal computer room therefore should contain an air-conditioning system which is capable of heating the room with all equipment off, cooling the computer system at maximum operation on the warmest day expected, and humidifying/dehumidifying to within specified limits under all anticipated weather conditions. The air-conditioning system should also provide filtering to reduce dust and other particulate matter to a reasonable level. A positive pressure within the computer lab will also help minimize particle entrance. If salt air, corrosive gasses, or other air pollutants are present, special filtering arrangements may be necessary.

The recommended method of supplying cool air is to use overhead cooling air supply plenums and return air intakes located low on side walls of the room. Adequate air volume supplied through suitably adjusted diffusers should maintain the entire computer lab space at a relatively constant ambient temperature. The following factors should be considered when determining the air-conditioning capacity necessary for an installation:

1. Machine heat dissipation
2. Personnel
3. Latent heat
4. Fresh air introduction
5. Entrance of heat through outer walls
6. Ceiling, floor, door openings, and partitions
7. Possible reheat

It may be desirable to arrange the air-conditioning system so that it can provide ventilating air in emergency circumstances to facilitate firefighting.

Other Considerations

Computer laboratory lighting should be at least as intense as that which is recommended for normal classroom activities so as to facilitate the locating of extremely small and often obscure test points within the computer. Engineering drawings, often referenced during a laboratory exercise, generally contain fine print and must be easily and accurately read. Direct sunlight should be avoided due to its heating effect and its adverse effect on light sensing devices.

The noise level in computer laboratory especially with multiple systems, can be sufficient to interfere with nearby classroom activities. Sound-absorbing materials on walls and ceilings and/or sound barriers may need to be considered.

Certain practices should be established to maintain computer lab cleanliness and equipment protection. These include: forbidding smoking, drinking, and eating in the lab area; keeping tape, disk packs, and

logic modules in closed cabinets when not in use; and restricting casual traffic through the laboratory. Safety considerations should also be a factor influencing the choice of room location, building materials, storage of combustibles, adherence to electrical safety codes, and fire protection equipment.

Classroom facilities should be arranged to provide an environment conducive to the learning experience. The classroom space can be of any size, but care should be taken to insure a variety of room sized to accommodate both large introductory sections and smaller advanced groups. They should also be within close proximity to the lab facilities to allow for periodic demonstrations during lecture sessions.

In certain situations it may be feasible for institutions to share a common lab facility or for an institution to provide off-campus lab facilities by developing a mobile lab. Computer equipment is generally not conducive to periodic movement, however, and special considerations must be made before such an arrangement is implemented, especially with respect to the selection of laboratory components.

Financial Considerations

A major limiting factor in the establishment of the program at any technical level is cost. Depending on the depth and scope of the program and the corresponding selection of laboratory components, a program in computer technology certainly has the potential of being the most expensive program established by the institution. Therefore it is of primary importance that careful financial planning constitute a major portion of preliminary program development. The institution should make every effort to investigate and take full advantage of every possible

source of funding not only for initial implementation but for continued financial requirements and program growth as well.

The first task in the financial planning and development of a computer technology program should be a detailed cost analysis of all aspects of the program. This procedure is facilitated by the subdivision of costs into major cost areas. The following is a list of these divisions and associated cost items within each:

1. Computer Laboratory Equipment
 - a. Minicomputer hardware components
 - b. System software
 - c. On-site spares and replacement parts
 - d. Other instructional lab equipment such as digital logic or microprocessor trainers
 - e. Test equipment and tools
 - f. Computer storage media
2. Laboratory and Classroom Facilities
 - a. Construction and/or renovation of laboratory and classroom space
 - b. Power and environmental control
 - c. Laboratory and classroom furniture such as tables, chairs, desks, cabinets, etc.
 - d. Teaching aids
3. On-Going Costs
 - a. Computer system maintenance
 - b. Expendables such as paper, disposable storage media, electronic components
4. Indirect Costs
 - a. Library acquisitions
 - b. Faculty training and professional development
 - c. Educational and engineering consultants
 - d. Student assistants

Once a careful analysis of each cost area has been completed, the institution should undertake a determination and investigation of possible funding sources.

Each institution will have a formal procedure for obtaining state funding through its governing board or higher education commission. The funds are generally in the form of program start-up costs and are obtained via the proposal necessary for formal approval of the curriculum. Continuing program costs are budgeted into the computer technology program account.

State funds, especially at the present, are generally minimal and tightly restricted. It is therefore imperative for the institution to seek external sources in order to acquire sufficient funding for a comprehensive computer technology program.

Public institutions, being non-profit organizations, are in the position to approach the industrial sector concerning contributions and donations in terms of tax benefits for the companies. In addition, local companies which may employ graduates of the program are likely to provide support in the form of equipment discounts or donations, co-operations, scholarships, or fiscal gifts and should be contacted as early as possible regarding this matter if not already done during the needs assessment stage. Larger companies, Digital Equipment Corporation¹ and Intel, have established corporate educational support programs on a national basis and others are likely to follow suit.

¹See Appendix B for details of Digital Equipment's program.

The institution's Director of Development should be able to supply information concerning foundations which may be regarded as potential program funding sources. A comprehensive source of information of this type is the Foundation Center (888 Seventh Avenue, New York, New York, 10019), an educational organization established to acquire, organize, and disseminate information about foundations and the grants which they award. Research libraries located in several major cities together with a network of regional centers provide free public access to information on foundations with particular emphasis on services to the grant-seeking public. The Foundation Center also publishes a number of reference books, such as the Foundation Directory, which may be used by the institution to identify local, regional, and national funding organizations.

A highly viable source of federal program funding is the National Science Foundation. The Division of Science Education Resources Improvement (SERI) is one of a group of related programs under the Directorate of Science Education and is the most likely area within NSF to provide program support. Within SERI, there exists three specific programs, CAUSE, ISEP, AND LOCI, which are designed to provide funding for projects such as the development of a computer technology curriculum.

The CAUSE (Comprehensive Assistance to Under-Graduate Science Education) program has the greatest funding potential of the NSF programs. CAUSE awards are intended to support integrated, carefully planned projects to improve an institutions science education programs. Eligible two-year institutions include junior, community and technical colleges.

As the name implies, CAUSE is a comprehensive program providing support for a variety of development activities including the purchase of technical equipment, construction and/or renovation, faculty development, and release time for curriculum development. CAUSE will supply up to two-thirds of the total cost of a project to a maximum of \$250,000 for a three-year period. Aside from the merits of the project, it is often the proposal's coherence, clarity, and adherence to the guidelines, as described in the Guide for the Preparation of Proposals and Projects and Award Management, which is the deciding factor in project support. Of particular importance is the ability of the institution to clearly show the need for the project, the consequential relevancy of project objectives, detailed descriptions of each project activity and corresponding cost justifications, and the institutions commitment and ability to accomplish all indicated project activities.

First time proposal writers should consider seeking advice from experienced colleagues, consultants, or from the CAUSE program staff. It is also advisable to review successful proposals concerning similar projects. These are available through the National Science Foundation.

Another likely funding source within NSF is the Instructional Scientific Equipment Program (ISEP), which provides support for the acquisition of scientific equipment required for program development or enhancement. ISEP will provide up to \$20,000 to the institution on a matching 50-50 basis. As with CAUSE proposals, grants are awarded on a competitive basis and depend largely on the clarity and completeness of the proposal in its explanation of the need and effective utilization of the equipment.

Through the Local Course Improvement program (LOCI), awards are made to individual faculty members, or small groups of faculty, to make relatively short-term, concentrated efforts at enhancing particular educational programs. Projects typically focus on the design, preparation, and evaluation of new materials and/or laboratory experiments. Projects supported by LOCI must not exceed \$40,000 in budget costs, \$25,000 of which may be provided by NSF.

Also under the Science Education Directorate is the Division of Scientific Personnel Improvement (SPI). It includes programs such as the Science Faculty Professional Development Program which the institution may also wish to consider. These programs emphasize the development of the individual rather than the institution.

A very positive factor in the submission of proposals to NSF is the encouragement received by NSF from Congress to provide assistance to two-year institutions and, as a result, the significant increase in grants made to two-year institutions over the past few years both in number and in award amounts. In addition, programs in computer technology will continue to receive significant attention as to their role in science education.

CHAPTER V

PROGRAM IMPLEMENTATION

A well-developed, pragmatic approach by the institution to the implementation and administration of the computer technology program is a major contributing factor to its effectiveness and overall success. Careful attention should be focused on developing an implementation strategy which will facilitate the actual start-up of the curriculum. Procedures must also be established for monitoring and evaluating the program to insure technical relevance in skill development. The students, who are a principal part of any program, must be considered in terms of adequate guidance and placement procedures as well as sources for constructive feedback to insure technical competence.

Advisory Committee

The success of post-high school education programs in computer technology depends largely on the support of advisory committees. Thus, when an institution considers the advisability of initiating such a program, the dean of technology or selected program administrator should appoint an advisory committee as one of the first activities of program development.

The special advisory committee for the computer technology program should be comprised of representatives of employers, scientific and technical societies, and associations in the computer field, together with knowledgeable computer design and field engineers. The committee may consist of from five to twelve members with the program administrator

serving as chairman. Certain primary members should serve as long as they are willing in order to maintain continuity in program direction. Others should serve for only a one- or two-year period allowing new members the opportunity to inject fresh concepts into the program.

The initial duties of the advisory committee will be to assist in surveying and defining the need for technicians, the knowledge and skills they will require, employment opportunities, the available student population, the curriculum, the faculty, laboratory equipment and facilities, the extent of local support, and the cost and financing of the program. When the studies indicate that a computer technology program should be initiated, the committee's help in its planning and implementing is invaluable.

Frequently, an advisory committee provides substantial support to school administrators in requesting appropriations, raising public funds, and obtaining state or federal support for the program. In addition, industry representatives directly involved in program development are generally more eager to initiate supportive activities within their companies such as funding assistance, equipment donations, and scholarships.

When the first few classes of students graduate and seek employment, the committee assists with their placement and helps to evaluate their performance. Minor modifications are often made in the program as a result of these evaluations.

The continuous support of an advisory committee has shown to be a constant source of strength and growth for the program and the most reliable means of sustaining a successful, high quality, and up-to-date program. Maintaining direct contact with industry representatives

provides faculty with an accurate source of informative input concerning developments in equipment design and product lines, and assures relevancy in program content to the skills inventory required of a computer technician.

Student Recruitment and Selection

It cannot be assumed that students entering the program will be of adequate numbers and academic backgrounds to insure continued returns from institutional investments into the program. Both characteristics, quantity and quality, are necessary in order for graduating classes to be of sufficient size and vocational effectiveness. Considering the relatively high attrition rate normal in technical programs such as this which must maintain high academic standards, class sizes will fall to below acceptable levels in latter quarters if entering students lack the necessary mental and emotional qualities. Although entry into the program should not require a background in computer technology, it is recommended that activities be initiated which will attract students who are not only seeking highly marketable skills, but are also capable of assimilating new technical concepts.

One such activity which has been shown to be effective is the establishment of relationships with area secondary schools. The guidance office at each school should be made aware of the various aspects of the program and the resulting opportunities for the computer technician. This provides a direct source of information for the secondary school students as well as a basis for additional recruitment activities such as presentations at the high schools by institution representatives to interested students and

visits by selected classes or groups of students to the institution to observe program facilities and discuss the curriculum with faculty members.

Industrial contacts including those established through the program's advisory committee, may be called upon to assist in the coordination of a career day at the institution or the inclusion of computer technology to existing career day activities. This joint venture allows for prospective students to visit with both program and computer industry representatives and develop a clearer perspective of career paths and educational requirements. The personnel offices within companies hiring computer technicians should be informed of the program in order that applicants for such positions who are underqualified may be directed toward the program.

Posters displayed at key area locations such as schools, civic centers, employment offices, and shopping centers are likely to attract both the traditional and non-traditional student. The posters should illustrate program facilities as well as career opportunities and should have pre-paid mail-in cards attached to request further information. All indications of interest, whether by mail-in cards or personal communication, should receive a response in the form of a letter and/or brochure. It is also advisable to have brochures or information sheets available for distribution at functions such as science fairs and computer club meetings. Local television and radio talk shows and paid radio and newspaper advertisements are additional methods of establishing public awareness of the program.

While these activities will generally provide sufficient numbers of prospective students, concern must be maintained that they are adequately prepared. It is recommended that the institution utilize screening and

testing procedures in order to identify those students who would be better advised to review their educational and occupational objectives or who, because of their technical backgrounds, should be encouraged to challenge certain introductory level courses. Aptitude tests are useful, in this respect, in assisting counselors in student selection, placement, and guidance. Some of the major computer companies such as IBM have used their extensive resources to develop effective specialized aptitude tests which may be useful to the institution.

In addition to institutional entrance requirements, prospective students should have completed two secondary units of mathematics including algebra and plane geometry, at least one secondary unit of science, and be able to clearly demonstrate a capability in reading comprehension and oral communication. Many institutions having technical programs provide assistance to students not meeting such requirements by offering pre-technical instruction up to a full year's duration. This affords promising but underprepared students the opportunity to enter the computer technology program with a high probability of successfully completing it. Thus, fewer students experience the harmful effects of academic failure and gives the promising students an opportunity limited only by their ability and determination to develop marketable job skills.

The students ultimately admitted to the program should have similar backgrounds and capabilities and should exhibit some evidence of maturity and seriousness of purpose. Wide ranges of abilities among students can create an ineffective teaching situation and prevent the program from progressing at the necessary rate and maintaining the required depth and scope. The amount of material to be presented and the principles to be mastered

require students who are not only well prepared in formal course material, but who also have the personal motivation to complete a difficult program and to develop their capabilities to the limit.

Cooperative Education

An educational program in computer technology is particularly adaptable to organized classroom and laboratory study in school, combined with carefully planned and coordinated paid employment experience in the computer field at appropriate intervals in the curriculum. A cooperative program, well planned and supervised can contribute significantly to the education of a competent computer technician.

Cooperative programs for technicians offer special advantages to the student. Scheduled during a summer period or concurrently with normal academic studies, the co-op program does not necessarily extend the length of the organized preparatory program in a two-year curriculum. If interspersed between quarters (or semesters), the overall extension is generally less than one year. Their principal benefit is that they provide real working practice in an environment the technician will experience after graduation. Cooperative programs make it possible for students to use the equipment and perform the processes and services required of their specialty under close supervision and with responsibility commensurate with their capabilities.

The cooperative experience must be planned and supervised according to a formal agreement with the organization where the student is to work. The agreement provides for a programmed sequence of duties to be performed by the student with supervisory responsibilities clearly defined for the educational elements of the work.

Generally, two or possibly three work experience projects scheduled at appropriate times offer the best advantage for the student's learning process. The financial reward for the work can help the student meet the cost of a significant part of the program.

Cooperative programs keep the total curriculum up to date and realistic because of the necessarily close relationship with employers. They also insure an almost automatic and highly effective avenue for graduate placement and provide motivation for students in the form of monetary returns while they learn their technical specialty and develop confidence in their competence on the job.

Some special administrative considerations in cooperative programs are:

1. Employment opportunities must be found with organizations sincerely interested in providing educational work experience for the student. Agreements must be negotiated for scheduled work, supervision, rates of pay, and performance evaluation.
2. Students should not be accepted into the co-op program until such time that they have acquired sufficient knowledge and skills to allow them to be productive in their work environment. At this level the students will also be in a better position to maximize their learning process.
3. Students must be available and ready when needed to fit into the employer's organization to perform scheduled work. When feasible, rotation schedules involving two or more students should be developed in agreement with the employer's needs. Ideally, one student would assume the project duties of another student who would then resume his role in the classroom and laboratory.
4. Close supervision by co-op coordinative staff is required to help the students adjust to the work and meet reasonable expectations of the employer. The work situation must be evaluated realistically and never be allowed to become routine production or service work with little new experience in the technical specialty. It must be a learning process as well as an earning opportunity.

5. Students should be required to do a limited amount of organized study while on the job. Often this is a daily journal of work activity, an account of the week-by-week development of some technical aspect of the job, or a detailed analysis of the progress of some project to which the student is assigned.
6. An evaluation of the student's performance and attitudes must be provided by the employer in order to establish a basis from which to assist the students, maintain satisfactory cooperative relationships with the employer, and intelligently counsel students in the important aspects of success in an employment situation.

The aforementioned considerations should be integrated into a coordinated co-op program with a concern for flexibility. Guidelines for each co-op activity must be adjusted as dictated by the circumstances surrounding both student and employer. Further information concerning cooperative programs may be obtained from the National Commission for Cooperative Education, 8 West 40th Street, New York, New York, 10018.

Graduate Placement and Follow-up Studies

Graduates of the computer technology program should be assisted in every way possible in locating and securing suitable employment. The placement office should work in coordination with the program's advisory committee in assessing the needs of the region's computer technology job market and acquainting prospective employers with the general qualifications of the graduates. The placement function is an extremely valuable service to the student, the institution, and the employers. An excellent placement record is important in attracting new students into the program.

Second year students should be encouraged to have personal resumes prepared at least one full quarter before graduation. Resume guides and example resumes should be available to facilitate resume development. Regional employment personnel should be informed of pending graduations

and class compositions in order for recruiting officers to make arrangements to visit the campus and conduct personal interviews. The scheduling and coordination of interview sessions must also be a function of the placement office. In many cases, students will then be invited to participate in further employment discussions with company representatives at the company site.

The primary indication of the success of an educational program is the competency and proficiency displayed by the graduate upon entering the work environment. A follow-up evaluation procedure should be implemented in which records will be maintained as to each graduate's employment location so that the graduate's supervisor may be contacted concerning the graduate's job performance. An objective evaluation should be made at two periods following graduation:

1. At 10 to 12 weeks. This will determine the initial effectiveness of technical skills developed during the student's academic experience.
2. At one year. This will provide an indication of the student's ability to acquire new skills as a result of learned principles and theoretical concepts in the technical subject areas.

Studies of these evaluations by the program faculty and advisory committee can provide valuable indications of how the program or teaching techniques can be improved or adjusted to match current employment requirements and trends.

Instructional Methods and Materials

Effective teaching is essential to the successful presentation of the program. Technical subject matter in areas unfamiliar to the student is inherently difficult to comprehend. Teaching procedures should be carefully

examined with respect to facilitating the learning process in both the classroom and laboratory.

Individual teaching methods are dictated in part by the characteristics of the particular instructor as well as the subject material. Experienced and competent teachers will try various techniques, ascertain the effectiveness of each, and make necessary adjustments to achieve an optimum instructional performance. It is imperative that the administration not restrict the academic freedom of the faculty members by discouraging the implementation of non-traditional methods which may be effective. High technology concepts and hardware dependent courses often lend themselves to such non-traditional methods.

If the scope and depth of training are to be adequate, programs for highly skilled computer technicians must be a series of well integrated courses. Therefore, careful consideration must be given to the timing and the introduction of new concepts. This may, perhaps, be best accomplished through "team teaching", in which the faculty is organized into coordinated teaching units. Teaching assignments are then made on the basis of the individual member's special training and talents. Concurrent courses are closely coordinated by team members to best utilize the student's time while they are moved on to progressively higher levels of understanding.

Team teaching, like any sound instructional technique can be developed and nourished only by a supportive teaching staff. A periodic departmental meeting to encourage development and experimentation with teaching methods is recommended. It is also important that procedures be employed for effective instructor evaluation by students, peers, and program administrator.

The evaluation results should also be discussed in faculty meetings and any significant indications carefully considered.

As in any technological field, textbooks, references, visual aids, and other teaching materials must be reviewed and supplemented constantly in light of the rapid development of such fields. This is especially true of the computer technology field where the impact of the development of whole new areas of theoretical and applied scientific knowledge is demanding and producing new textbooks and reference materials.

Textbooks will reflect current methods of teaching technical principles and applications as rapidly as research in education proves appropriate. It is mandatory therefore that instructors constantly review new texts, references, and visual materials as they become available and adapt them when they represent an improvement over those currently in use.

Instructors undertaking to prepare any course contained in the curriculum should familiarize themselves with the texts and references currently available.¹ Publishers are generally very cooperative in providing examination copies of texts. The instructor will then be able to select materials which best meet their particular needs and best promote a lucid, high-level technical presentation to their students.

The course scope and objective as developed by the program faculty and advisory committee, should never be altered to conform to the textbooks' content or organization. It may be the case, especially in the more technically advanced or hardware specific courses, that computer manuals, engineering drawings, articles from scientific and technical journals, or

¹See Appendix C for a categorical listing of suggested texts.

other appropriate hand-out materials may be more effective than a formal text. Such materials may also be used in conjunction with a required text. These materials should be constantly updated as well to maintain up-to-date standards. Students should be provided with library references applicable to the particular subject area.

It has been shown that visual displays enhance the learning process and compensate, somewhat, for the inherently difficult subject matter. Visual materials are particularly adaptable to computer technology courses and should be utilized whenever possible. These may be in the form of charts, slides, A/V tapes, or overheads and, for the most part, will be developed for the course by the instructor.

CHAPTER VI

CASE STUDY: ROANE STATE COMMUNITY COLLEGE

The Mini/Microcomputer Technology program at Roane State Community College was established following the basic guidelines recommended in this guide. Although relatively new, the program has proven to be one of the more successful computer technology programs in the country producing highly skilled and competent minicomputer technicians.

The College

Roane State Community College (RSCC) is an institution of higher education of the Tennessee State Board of Regents. The college is a multi-purpose, coeducational, state assisted two-year institution offering career education and transfer programs on the associated degree and certificate levels along with a broad range of non-credit courses. The purpose of RSCC is: 1) to serve those who wish to transfer and complete a four-year college education, 2) to serve those who wish to complete their formal education upon graduation from Roane State, and 3) to serve the entire community through an adult education program based on community needs and demands. The main campus, in Harriman, is located off Interstate 40 about 35 miles west of Knoxville.

Roane State was authorized by the Tennessee General Assembly in 1969 and began serving the community in 1971. In its first eight years of operation, the number of students enrolled in credit classes increased by 900 percent, making Roane State one of Tennessee's fastest growing institutions. The enrollment for 1980-81 is 3,571 (head count) with a

full-time faculty of 88 and a large part-time faculty which varies in number. In recent years, Roane State has expanded its services to the community by offering classes in Oak Ridge and eleven neighboring counties. With an academic calendar organized on the quarter system, the college currently offers over 40 different associate degree programs in both transfer and career education.

The job market in the Roane State Community College service area is dominated by high technology companies including Union Carbide Corporation/ Nuclear Division, Tennessee Valley Authority, EG&G ORTEC and numerous small engineering and consulting companies. Branch offices for several major computer companies such as Digital Equipment Corporation and IBM are located in Knoxville, each having substantial field engineering departments. Within this job market, a large number of activities involve the use of minicomputers, microprocessors, and other digital systems in a variety of applications.

Program Development

In January, 1977, Roane State was formally approached by Digital Equipment Corporation (DEC) concerning the establishment of a resource sharing relationship between the corporation and the institution. Roane State was selected by DEC due to the degree of computer activity in the region and the subsequent need for well-trained minicomputer service technicians. The premise of DEC's Minicomputer Technology Program (MTP)¹ is to support the establishment of well designed and controlled technical programs in order to alleviate the growing shortage of minicomputer

¹See Appendix B for description of DEC's MPT program.

minicomputer technicians while providing substantial savings to the corporation in terms of training costs.

The receptiveness of the institution to the MTP relationship was enhanced by the fact that the Engineering Technology Department was actively in the process of strengthening the digital electronics offerings. Tentative guidelines for MTP coordination and support were prepared and preliminary development procedures begun. With the feasibility study indicating that such a program was needed in the area and could be adequately supported by the institution, curriculum objectives were established, course sequences and outlines finalized, and institutional resources identified. A proposal for an Associate Degree of Science with a major in Mini/Microcomputer Technology was prepared and submitted to the Tennessee Higher Education Commission in Winter 1978. Subsequent approval allowed Roane State to implement the program in Fall 1978, producing the initial graduating class in Spring 1980.

The Curriculum

The primary objective of the Mini/Microcomputer Technology program is to provide highly-skilled minicomputer technicians to satisfy the job market requirements in the service or field engineering area. As shown, the curriculum is designed according to the guidelines of Chapter III to provide students with the skills inventory necessary for proficiency as minicomputer service technicians as outlined in Chapter II. The structure of the curriculum is such that students advance progressively quarter by quarter to courses of increasing complexity and technical level drawing from the concepts and principles developed in previous courses. Careful

organization of the courses allows for high-level training in the principles and concepts of mini/microcomputer technology together with the development of efficient techniques in servicing and maintaining mini-computers and the associated peripheral devices within the computer system.

Being aware of changes in industry trends and manpower requirements, Roane State is restructuring the Mini/Microcomputer Technology curriculum to include a service option, a design option, and a software option. The service option is basically the original curriculum while the software option as listed, in which a number of students are enrolled, is an effective combination of MCT courses with selected Computer Science courses. The primary objective of the design option is to provide an intensive program in digital design methodology focusing in the final year on micro-processor architecture, interfacing techniques, practical applications, and software development. Final implementation of the design option is contingent upon grant funding from the National Science Foundation.

Hands-on training is essential to maximize the learning experience in the program. Laboratory exercises are designed to challenge the student to apply concepts and principles of classroom subject materials. The technical complexity of each experiment increases progressively from initial activities which familiarize the student to the structure and organization of the equipment to troubleshooting problems requiring the correlation of operational principles and device characteristics in order to isolate and correct instructor inserted faults. These controlled faults are entered by signal path disruption (taping module contact fingers), requiring module level troubleshooting, or by inserting of devices with known defects requiring component level troubleshooting.

Associate of Science
Mini/Microcomputer Technology
Service

First Year

Fall Quarter

CST	1020	Introduction to Programming	3
EDU	1000	Orientation to College	1
EET	1010	Electric Circuits I	3
EET	1015	Electric Circuits I Lab	1
ENG	1010	Composition I	3
MAT	1010	Technical Math I	3
MCT	1100	Introduction to Minicomputers	3
			<u>17</u>

Winter Quarter

EET	1020	Electric Circuits II	3
EET	1025	Electric Circuits II Lab	1
EET	1310	Electronics I	3
EET	1315	Electronics I Lab	1
MAT	1020	Technical Math II	3
MCT	1210	Machine/Assembly Language Programming	3
			1
			<u>15</u>

Spring Quarter

EET	2550	Electrical Machinery	3
CST	2210	FORTAN Programming	3
MCT	1810	Pulse & Switching Circuits	3
MCT	1815	Pulse & Switching Circuits Lab	1
MCT	2310	Digital Circuits I	3
MCT	2315	Digital Circuits I Lab	1
MAT	1310	Symbolic Logic	3
			<u>17</u>

Summer Quarter

MCT	2000	Computer Service Internship	<u>2 - 6</u>
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First Year 51 - 55

Second Year

Fall Quarter

ENG 2820	Technical Writing	3
MCT 2210	Operating Systems	3
MCT 2350	Computer Architecture	3
MCT 2355	Computer Architecture Lab	1
MCT 2700	Integrated Circuits	3
MCT 2705	Integrated Circuits Lab	1
	Physical Education	1
	Social Science Elective	3
		<u>18</u>

Winter Quarter

EET 2710	Industrial Electronics and Control I	3
ENG 1020	Composition II	3
MCT 2410	Peripherals I	3
MCT 2415	Peripherals I Lab	1
MCT 2420	Peripherals II	3
MCT 2725	Peripherals II Lab	1
	Social Science Elective	3
		<u>17</u>

Spring Quarter

MCT 2610	Computer Systems Maintenance/Troubleshooting	4
MCT 2810	Data Communication and Interface Design	4
MCT 2850	Microprocessors	4
	Physical Education	1
	Social Science Elective	3
		<u>16</u>

 Second Year 51

 102 - 106 Total

Associate of Science
Mini/Microcomputer Technology
Design Option

First Year

Fall Quarter

MCT	1100	Introduction to Minicomputers	3
EET	1010	Electric Circuits I	3
EET	1015	Electric Circuits I Lab	1
MAT	1050	Algebra and Trigonometry	5
ENG	1010	Composition I	3
CST	1020	Introduction to Programming	3
			<u>18</u>

Winter Quarter

EET	1020	Electric Circuits II	3
EET	1025	Electric Circuits II Lab	1
EET	1310	Electronics I	3
EET	1315	Electronics I Lab	1
MCT	1210	Machine/Assembly Language Programming	3
MAT	1500	Pre-Calculus	5
		Physical Education	1
			<u>17</u>

Spring Quarter

MCT	1810	Pulse and Switching Circuits	3
MCT	1815	Pulse and Switching Circuits Lab	1
MCT	2310	Digital Circuits I	3
MCT	2315	Digital Circuits I Lab	1
ENG	2820	Technical Writing	3
EET	1320	Electronics II	3
EET	1325	Electronics II Lab	1
		Social Science Elective	3
			<u>18</u>

Summer Quarter

MCT	2000	Internship	<u>2 - 6</u>
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First Year 55 - 59

Second Year

Fall Quarter

MCT	2210	Operating Systems	3
MCT	2350	Computer Architecture	3
MCT	2355	Computer Architecture Lab	1
MCT	2700	Integrated Circuits	3
MCT	2705	Integrated Circuits Lab	1
		Social Science Elective	3
		Physical Education	1
			<u>15</u>

Winter Quarter

MCT	2750	D/A, A/D Conversion and Interface Techniques	4
MCT	2850	Microprocessors I	4
ENG	1020	Composition II	3
EET	2510	Power and Control Circuits	3
		Technical Elective	3
			<u>17</u>

Spring Quarter

MCT	2860	Microprocessors II	4
MCT	2810	Data Communication	3
MCT	2900	Advanced Topics	3
		Social Science Elective	3
		Physical Education	1
			<u>14</u>

 Second Year 46

 101-105 Total

Associate of Science
Mini/Microcomputer Technology
Software

First Year

Fall Quarter

CST	1020	Introduction to Programming	3
EDU	1000	Orientation to College	1
EET	1010	Electric Circuits I	3
EET	1015	Electric Circuits I Lab	1
ENG	1010	Composition I	3
MAT	1010	Technical Math I	3
MCT	1100	Introduction to Minicomputers	3
			<u>17</u>

Winter Quarter

EET	1020	Electric Circuits II	3
EET	1025	Electric Circuits II Lab	1
EET	1310	Electronics I	3
EET	1315	Electronics I Lab	1
MAT	1020	Technical Math II	3
MCT	1210	Machine/Assembly Language Programming	3
			<u>17</u>

Spring Quarter

CST	2210	FORTTRAN Programming	3
ENG	2820	Technical Writing	3
MAT	1310	Symbolic Logic	3
MCT	2310	Digital Circuits	3
MCT	2315	Digital Circuits Lab	1
		Physical Education	1
		Social Science Elective	3
			<u>17</u>

Summer Quarter

MCT	2000	Computer Technology Internship	<u>2 - 6</u>
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First Year 53 - 57

Second Year

Fall Quarter

CST	2520	Advanced Computer Programming	3
MCT	2210	Operating Systems	3
MCT	2350	Computer Architecture	3
MCT	2355	Computer Architecture Lab	1
		Physical Education	1
		Social Science Elective	3
		Elective	3
			<u>17</u>

Winter Quarter

CST	2220	COBOL Programming	3
CST	2310	Introduction to Systems Analysis	3
MCT	2410	Peripherals I	3
MCT	2415	Peripherals I Lab	1
MCT	2420	Peripherals II	3
MCT	2425	Peripherals II Lab	1
		Elective	3
			<u>17</u>

Spring Quarter

CST	2410	System Analysis	3
MCT	2810	Data Communication and Interface Design	4
MCT	2850	Microprocessors	4
		Physical Education	1
		Social Science Elective	3
			<u>15</u>

 Second Year 49

 102 - 106 Total

MINI/MICROCOMPUTER SERVICE TECHNOLOGY

- MCT 1100 Introduction to Minicomputers** 3 Credits
Introduces the student to the basic organization and operation of a digital computer. Includes an introduction to computer logic hardware and software, movement of data within a computer, identification of major hardware components and their interaction, concepts of programming, as well as the basic structure and applications of computer systems.
- MCT 1210 Machine/Assembly Language Programming** 3 Credits
An introduction to computer instruction repertoire. Student develops understanding of machine language instructions and programming through hands-on use of the computer for program execution. An analysis of assembly language programming and analysis of one and two pass assemblers is included. (Prerequisite: MCT 1100)
- MCT 1810 Pulse and Switching Circuits** 3 Credits
A course in the analysis and design of circuits with generate and shape digital wave-forms. Included in this study are passive wave-shaping circuits, delay lines, solid state switching characteristics, logic circuits, and multivibrators. (Prerequisite: EET 1310)
- MCT 1815 Pulse and Switching Circuits Lab** 1 Credit
The student completes laboratory exercises designed to emphasize lecture material through the design, construction, and evaluation of pulse circuits. (Lab to be taken concurrently with MCT 1810)
3 hours laboratory
- MCT 2000 Internship** 6 Credits
Student works with computer service technician to gain practical, on-the-job experience in computer servicing and maintenance. Periodic reports will be made to advisor from both student and service technician. (Students must have conference with MCT advisor before registering for the course.)
- MCT 2210 Operating Systems** 3 Credits
A study of the interrelationships of hardware and software at the system level, and the functional operation and utilization of compilers, operating systems, and user-type programs. Emphasis is placed on the ability to discern between hardware and software faults and the use of operating systems and customer software to debug hardware sourced faults in systems. (Prerequisite: MCT 1100 or consent of instructor)
- MCT 2310 Digital Circuits I** 3 Credits
Principles of digital logic theory and circuits. Presents such topics as number systems and codes, Boolean algebra, reduction techniques, and basic logic gates. Emphasis is placed on the ability to analyze the performance of a logic circuit and to carry a digital design problem from logic requirement to final logic device diagram. (Same as EET 2310)

- MCT 2315 Digital Circuits I Lab 1 Credit
 Use of digital devices to impliment and verify logic circuits performance as presented in lecture. (Lab to be taken concurrently with MCT 2310.) (Same as EET 2315)
 3 hours laboratory
- MCT 2350 Computer Architecture 3 Credits
 An in-depth study of the design and organization of the computer processor with emphasis on minicomputers. Areas of study include arithmetic and logic unit, timing and control, memory elements, bus characteristics and I/O operation and control. (Prerequisite: MCT 1210, MCT 2310 or EET 2310)
- MCT 2355 Computer Architecture Lab 1 Credit
 Lab sessions emphasize and enforce lecture topics as well as initiating the development of troubleshooting techniques. (Lab to be taken concurrently with MCT 2350)
 3 hours laboratory
- MCT 2410 Peripherals I 3 Credits
 A study of the architecture and functional operation of computer peripherals of the card stock, paper, and visual media, such as card and paper tape readers and punches, console writers, TTY's, and display terminals. Emphasis will be on the processor/peripherals control dialogue and data transfer. (Prerequisite: MCT 2350)
- MCT 2415 Peripherals I Lab 1 Credit
 Lab sessions provide practice in electromechanical alignment and troubleshooting techniques. (Lab to be taken concurrently with MCT 2410)
 3 hours laboratory
- MCT 2420 Peripherals II 3 Credits
 A study of the architecture and functional operation of mass storage and direct memory access devices including magnetic drums, disk, and tape units. The function of I/O programming and control will be emphasized. (Prerequisite: MCT 2350)
- MCT 2425 Peripherals II Lab 1 Credit
 Provides practical experience in the maintenance and troubleshooting of peripheral devices under analysis. (Lab to be taken concurrently with MCT 2420)
- MCT 2610 Computer Systems Maintenance/Troubleshooting 4 Credits
 A final course of study in computer hardware and software. Emphasis is on the determination of either hardware or software failures with extensive lab time utilizing equipment with simulated or actual failures along with concentration on the use of diagnostic programs to identify and isolate a faulty device or sub-system, as well as preventive maintenance at the systems and component level. (Prerequisite: MCT 2410, MCT 2420, MCT 2350, MCT 2210)
 3 hours lecture - 3 hours laboratory

- MCT 2700 Integrated Circuits 3 Credits
Provides the student with an understanding of the operation and practical applications of linear and digital integrated circuits. Efficient hardware implementation and evaluation techniques are developed thru analysis of manufacturer's specifications and design criteria. (Prerequisite: MCT 1810)
- MCT 2705 Integrated Circuits Lab 1 Credit
Classroom subject areas are continued into the lab for practical, hands-on design and analysis experience. (Lab to be taken concurrently with MCT 2700)
3 hours laboratory
- MCT 2750 D/A, A/D Conversion and Interface Techniques 4 Credits
An examination of the basic concepts of computer interfacing and A/D and D/A conversion techniques. Primary areas of study include the characteristics and operation of bus structures and the design requirements for hardware interfaces to the bus. Block diagrams and flowcharts are used for the understanding and troubleshooting of various interfaces. The accompanying lab is project oriented. (Prerequisite: MCT 2700, MCT 2350)
3 hours lecture - 3 hours laboratory
- MCT 2810 Data Communication 3 Credits
A study of various types of data communication systems and the principles of operation of system components including communication lines, modems, and network structures. Also examined are transmission codes and multiplexing methods.
3 hours lecture
- *MCT 2850 Microprocessors I 4 Credits
An analysis of basic microprocessor architecture. The design and operation of various popular microprocessors is covered along with programming fundamentals, microcomputer system components, and simple interfacing.
3 hours lecture - 3 hours laboratory
- *MCT 2860 Microprocessors II 4 Credits
Microprocessors II is concerned primarily with the development of a microcomputer system with emphasis on hardware and software design necessary in order to implement specific functions. Interfacing techniques involved in peripheral interfaces and data collection are examined.
3 hours lecture - 3 hours laboratory
- MCT 2900 Advanced Topics 3 Credits
This course investigates computer types and configurations of an advanced nature such as user microprogrammed processors, multiple processor systems, and computer networking. (Prerequisite: consent of instructor)
3 hours lecture

*Course implementation dependent on funding of NSF grant proposal.

The Computer Architecture exercises included in Appendix E are typical of the experiments within the curriculum which are educationally effective on multiple levels. The first lab allows the student to become familiar with the hardware organization of the processor while performing hands-on activities involving module removal and replacement. In the second, the student gains valuable practical experience in using an oscilloscope, finding signals and test points in the computer, developing techniques to generate signals necessary for analysis, interpreting signal displays and relating them to computer operation, and using laboratory findings combined with technical principles to formulate specific operational parameters.

A laboratory activity on a peripheral device is illustrated in Appendix E. The student must utilize previously developed knowledge of machine level programming as applied to peripheral device registers to perform maintenance procedures. Details of the operational characteristics of this device, the RK05 disk drive, are also brought forth.

Software experimental activities are similar in the instructional approach. A software laboratory, also included in Appendix E, requires the student to use monitor commands to enact complex system generation procedures while developing an understanding of the modules which compose the operating system.

The Laboratory

Laboratory equipment was carefully chosen because of respective instructional effectiveness of each component. The laboratory systems listed in Appendix F and shown in Figures 5-9 are utilized in a manner which best achieves the educational objectives of the curriculum. The equipment

Figure 5. Mini/Microcomputer Laboratory.

Legend

A Laboratory Tables	H File Cabinet
B Instructor's Stand	I Work Desk
C Storage Cabinet	J Terminals
D Bookcase	K Student Desks
E Swivel Chairs	L Storage Shelves
F Lab Stools	M LCS Board
G Lab Assistant's Desk	N Electrical Outlets

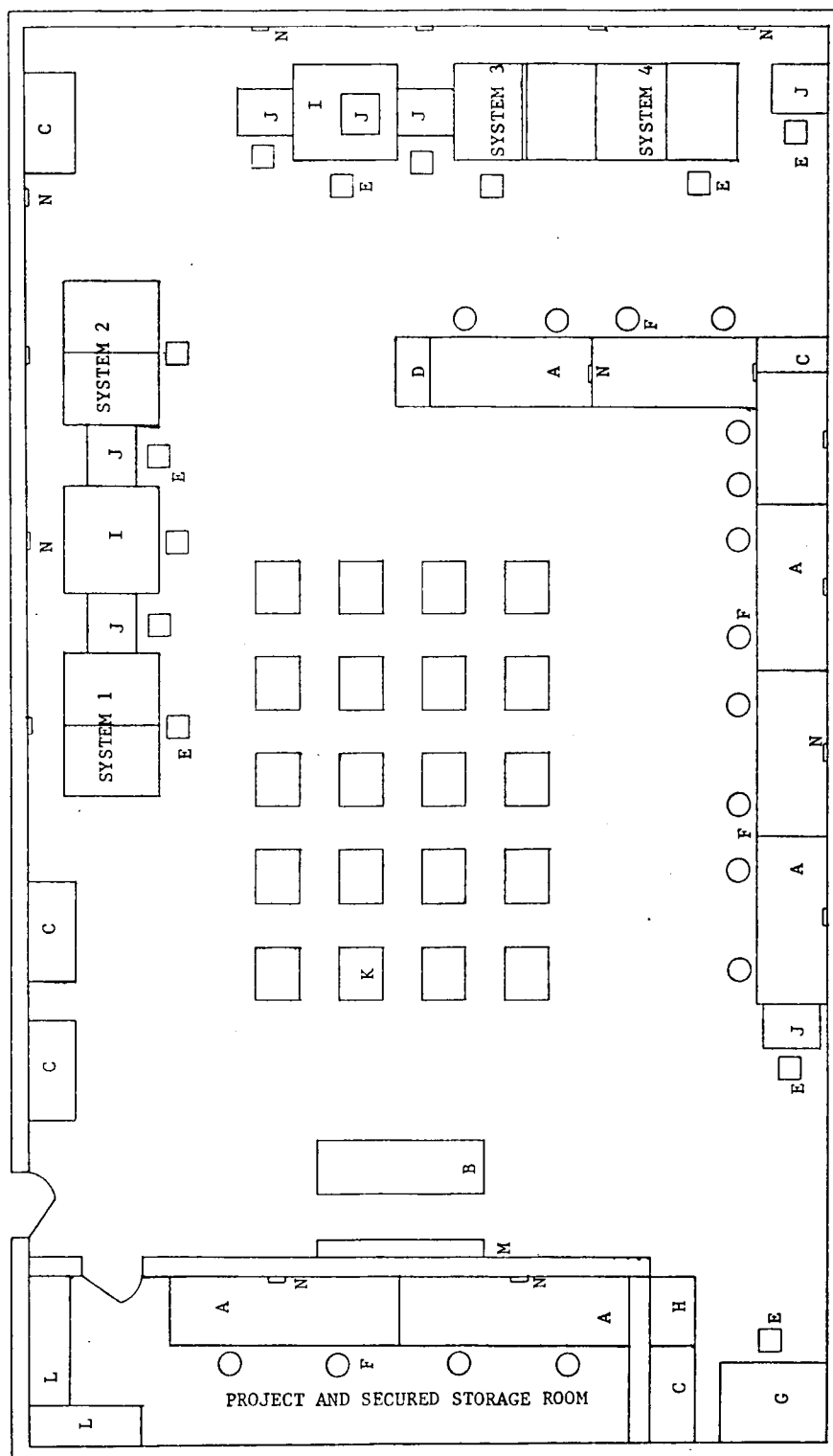


Figure 5. Mini/Microcomputer Laboratory.

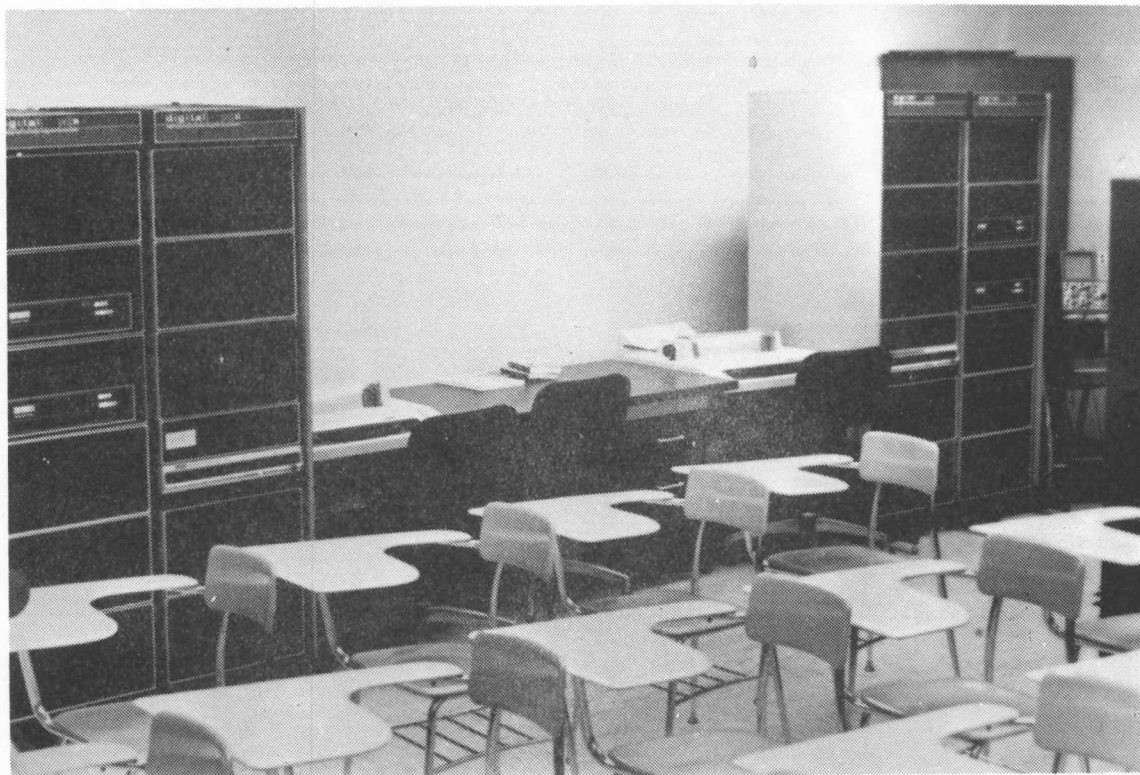


Figure 6. Minicomputer Systems 1 and 2 (PDP 11/05's).



Figure 7. Minicomputer System 3 (PDP 11/40).

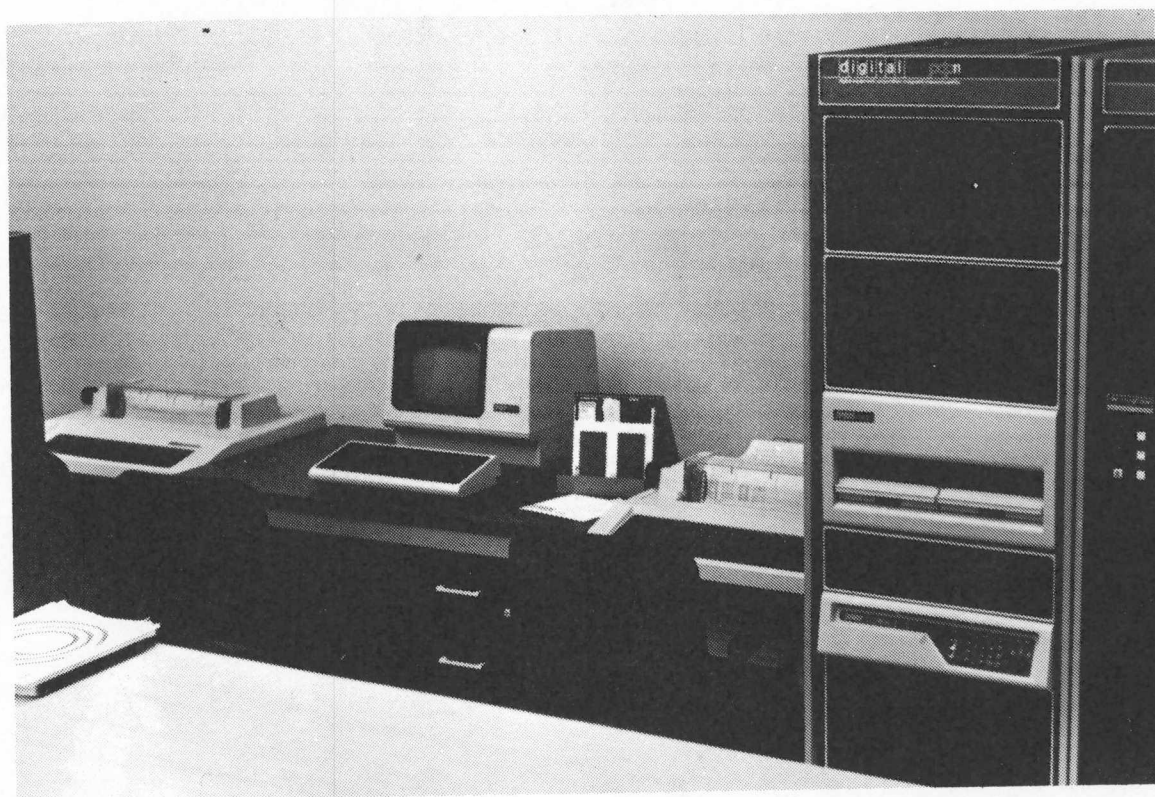


Figure 8. Minicomputer System 4 (PDP 11/04).



Figure 9. Advanced Terminals. VT100 on the left and LA120 on the right are included in the laboratory as well as the more common LA36.

inventory includes devices commonly found in industry such as disks, both hard disk and floppy disk, state-of-the-art terminals, shown in Figure 9, and processors, Figure 10, which are conducive to student activities and possessive of ample computational power. Spare modules and sub-assemblies were chosen based on equipment types and DEC recommendations.

Basic concepts in digital principles are effectively demonstrated through the use of specially modified digital trainers, Figure 11. Students gain practical experience in using standard digital IC's and referencing data books for necessary information. The microprocessor trainers, Figure 12, based on the Intel 8085, also emphasize the utilization of equipment which typifies current industrial standards. Peripheral maintenance skills are further developed through maintenance of the school's terminals (Fig. 13).

Program Administration

At present, this author is the principle instructor of the Mini/Microcomputer Technology program as well as the program director. In addition to years of experience with computers in both the industrial and educational environment, he has received high-level training at DEC's training centers. Competent part-time instructors are employed when needed. The program's advisory committee listed in Appendix G has been useful in maintaining the highly technical and up-to-date nature of the program.

To facilitate the learning process, extensive visual materials are used. Figure 14 shows the concurrent display of an A/V tape with an instructor developed overhead. Use of the LCS board enables effective graphical illustrations of technical concepts. A/V tapes are also provided for student tutorial and self-paced learning, as shown in Figure 15.

Figure 10. Component Modification. Some components have been modified to enhance instructional effectiveness. The panel above the 11/40 processor displays processor states as well as allowing for control and display of the microprogram.

Figure 11. Digital Trainer. The digital trainers allow students to use standard IC's. The units were modified to include eight inputs and eight outputs, two clock frequencies ranges, and breadboard pad for large IC's and interface connections.



Figure 10.

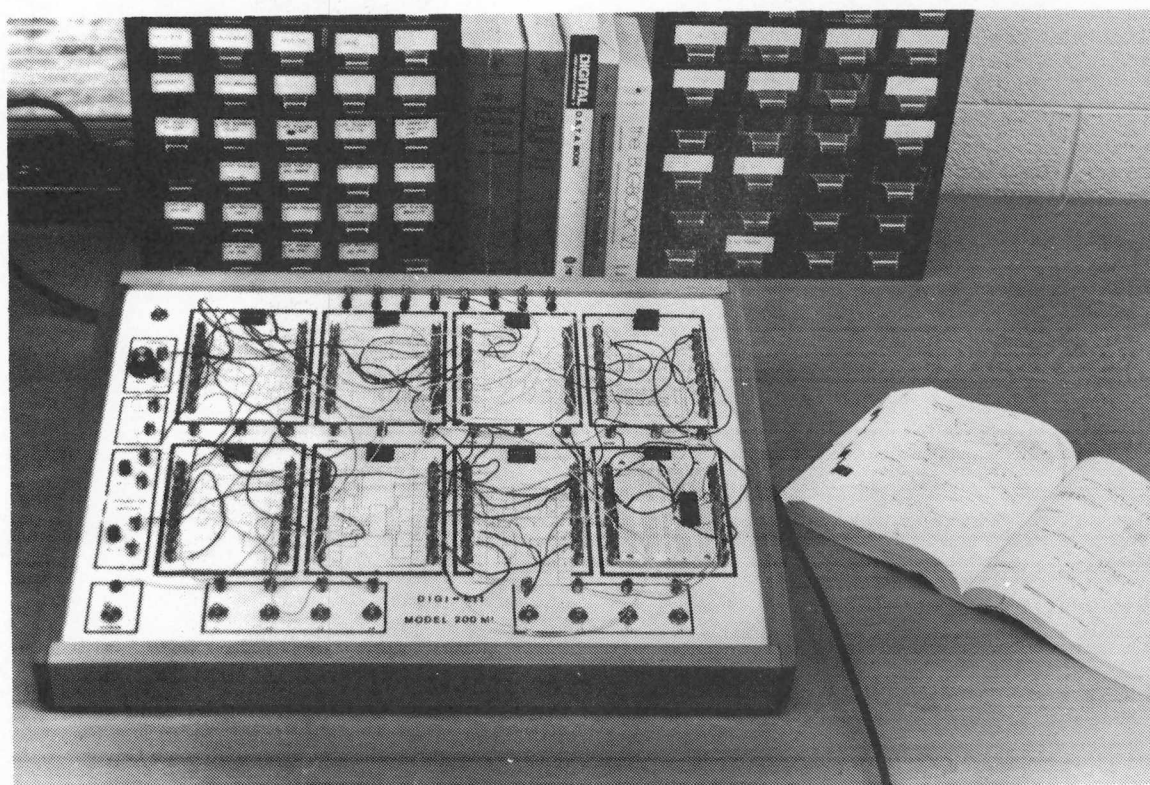


Figure 11.

Figure 12. Microprocessor Trainer. The microprocessor trainers are 8085 based and are conducive to hands-on usage and experimentation. A large breadboarding area provides for interfacing.

Figure 13. Terminal Maintenance. Students gain practical experience in terminal maintenance by repairing the school's academic and administrative terminals. Terminal down-time is also reduced as well as repair costs.

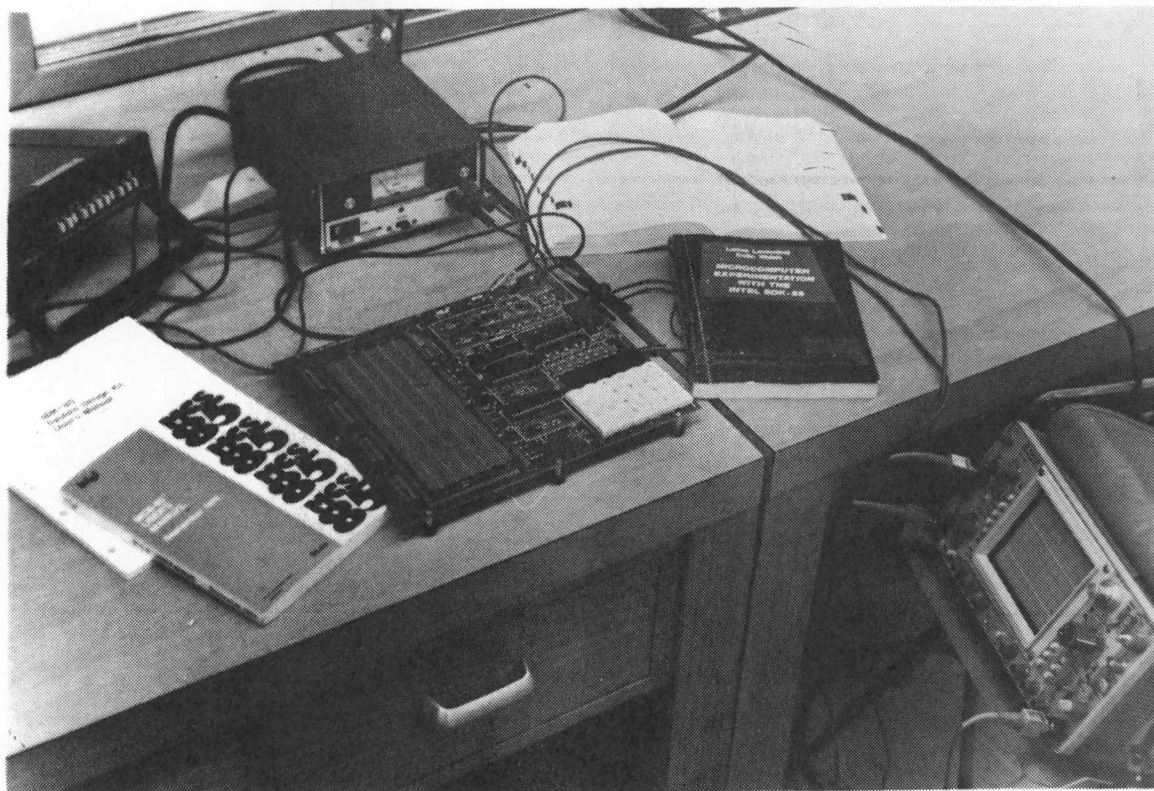


Figure 12.

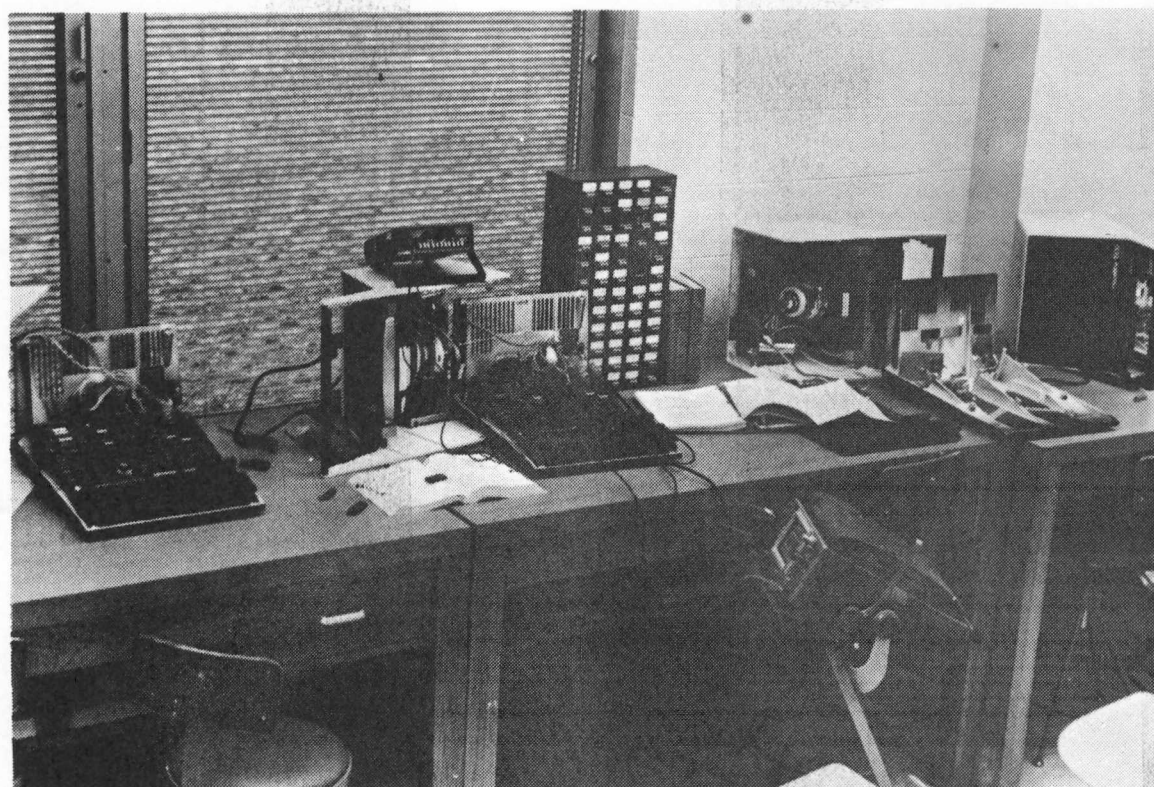


Figure 13.

Figure 14. Visual Display. Detailed visuals greatly enhance instructional effectiveness. Displayed to the left on the LCS board is a pictorial analysis of an instruction cycle while the block diagram on the 11/40 processor on the right illustrates the hardware implementation and data flow during the cycle.

Figure 15. Self-study. A student uses self-paced A/V tapes to deepen her understanding of lecture material. A/V tapes also allow students having difficulty grasping certain principles to review the material at a pace more suitable to their learning characteristics while avoiding disruptive questions and dialog during class.

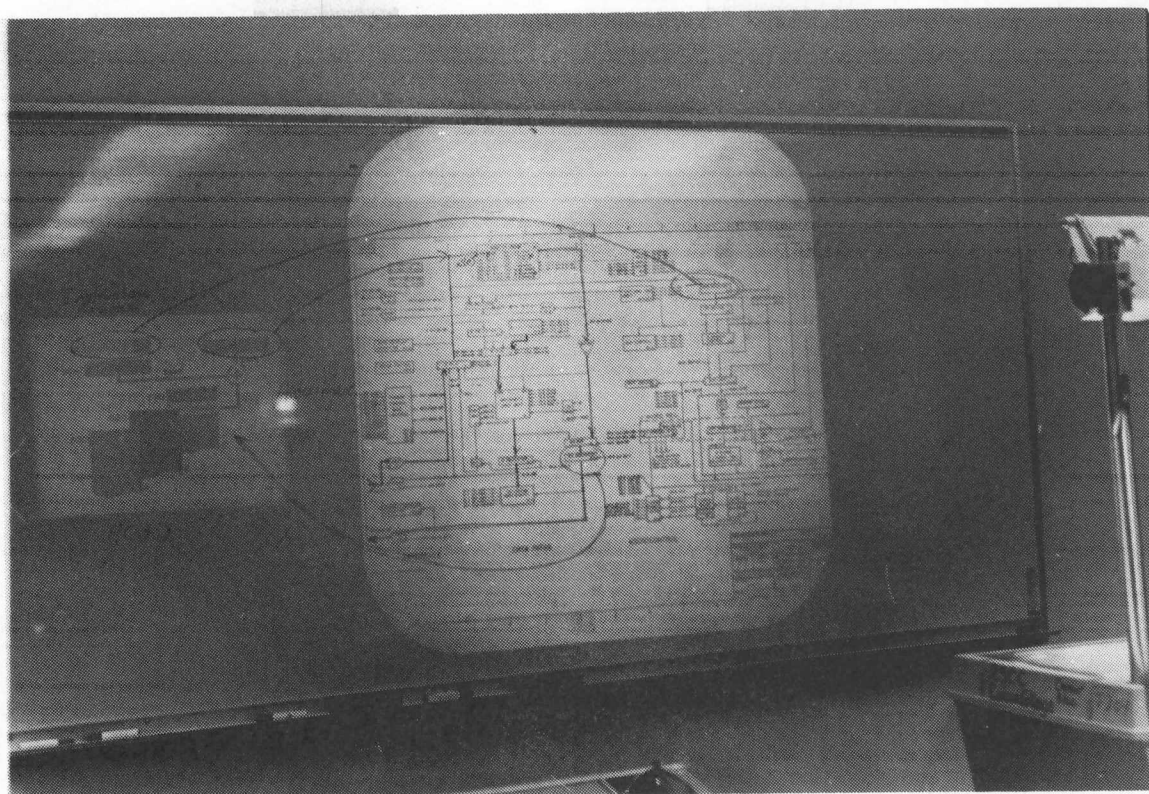


Figure 14.



Figure 15.

Graduate placement efforts consist of letters directed to personnel officers announcing the class graduation, arrangement of on-campus interview sessions, and distribution of student resumes, the development of which is required. Student recruitment activities which have been most productive involve the relationships established with high school counselors and talks to groups of high school students. Posters, Figure 16, have generated a number of responses as have newspaper articles, TV and radio shows, and personal contacts. Inquiries generally receive responses such as the letter in Appendix H. Students have received valuable work experience during vacation periods at DEC, IBM, and ORTEC. A year-round position with IBM is in the process of being established.

Results and Future Considerations

The true effectiveness of any training program is determined by the proficiency demonstrated by the graduates in the industrial environment. Success of the Mini/Microcomputer Technology program at Roane State is clearly shown by the performance of the first graduating class, all of whom secured stable and economically substantial positions in computer related environments. A majority of the graduates were hired by DEC and, by demonstrating well developed skills and a high-level of understanding of computer technology, are moving into positions of increasing responsibility and salary. Their performance is detailed in letters written by their supervisors and included in Appendix H.

A good example of a graduate of Roane State's program is Ronald Haynes, a Knoxville native. Following graduation from Doyle High School in 1978, Ron entered the Mini/Microcomputer Technology program as a

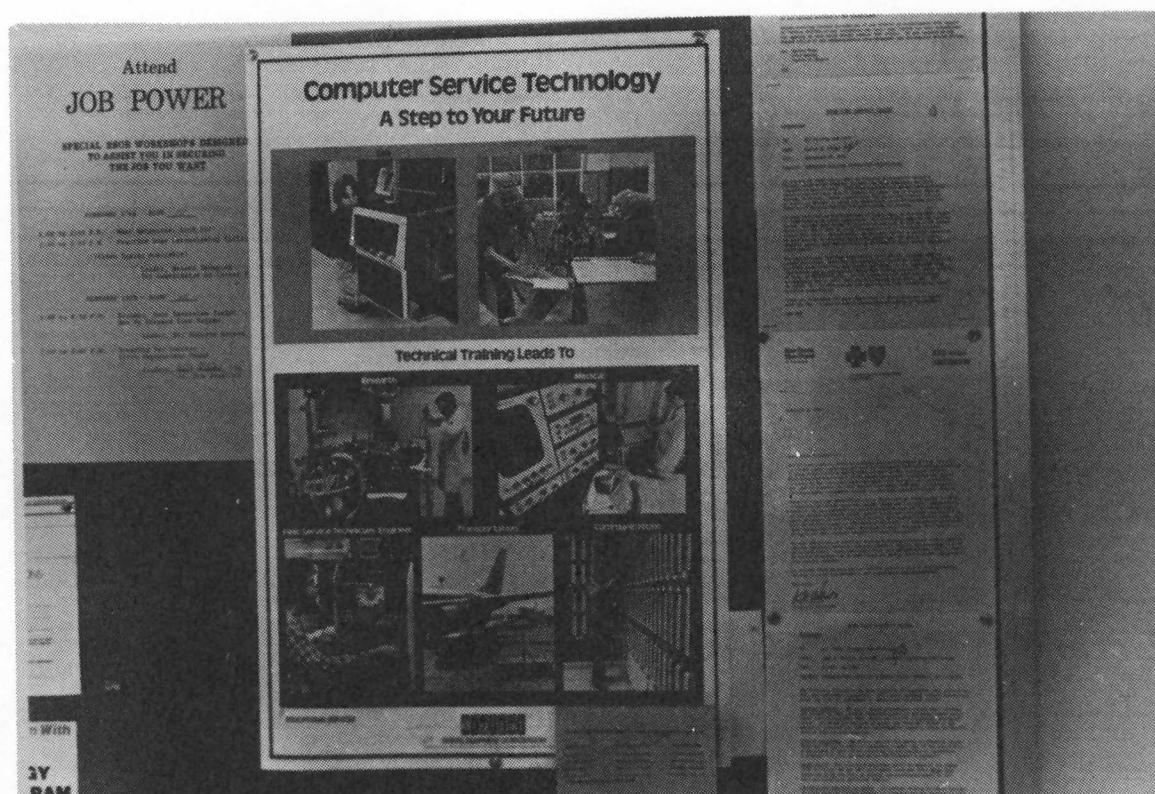


Figure 16. Recruitment Poster. Posters facilitate student recruitment by illustrating program facilities and career opportunities.

member of its first class and proceeded to pursue the training required for competency in minicomputer service. After completion of the degree requirements in the spring of 1980, Ron secured a position with Digital Equipment Corporation in Lynchburg, Virginia, following a brief period of employment with Computer Concepts in Knoxville. While at DEC, Ron demonstrated a high degree of proficiency and responsibility and was soon promoted to the position of remote technician working out of Roanoke, Virginia. He responds to service calls from his residence and performs maintenance and repair procedures with no direct supervision.

At present, Ron is preparing to accept a new position in Blacksburg with the responsibility of satisfying the service requirements of Virginia Polytechnical Institute. This institution maintains a large quantity of computer equipment, soon to be supplemented with the delivery of a number of VAX's, 32-bit, virtual memory computers. With the additional computers, VPI's service contract will be in the neighborhood of \$20,000 per month. To perform the duties involved in such a contract is a challenging assignment even for an experienced technician; an overwhelming display of confidence in a new technician with less than one year's experience.

Another important aspect of this example is that the graduate's duties will involve maintenance and troubleshooting activities on the VAX, a computer much more advanced and complex than those utilized and studied at Roane State. The comprehensive background in computer principles and concepts, which the student developed during the program allow him to extend his skill level to new heights as required.

The institution is currently developing two areas of the curriculum as a result of increasing importance in the computer industry and subsequent need for technically trained personnel in these areas. As previously described, the acquisition of additional funds through ISEP will enable the implementation of a microcomputer development laboratory into the program. The facilities included will allow for the study and development of microprocessor based systems using modern development tools such as the logic analyzer, and the in-circuit emulator.

Another important area in the computer field is that of data communications. A study is currently underway by a project group composed of students and faculty which is investigating the feasibility of the installation of a satellite communication antenna at Roane State. Preliminary discussions of a joint venture with a West Coast two-year institution, also offering a computer technology program, to establish a satellite data link have begun. A major grant from NSF will be necessary and will be sought.

Summary

There is little doubt that post-secondary educational systems must respond to the manpower needs of the computer industry. Programs must be developed which will provide students with the technical skills and knowledge necessary for competent performance in industry. Educators should approach the design and development of the computer technology program with methodical and analytical discipline. The guidelines presented in this manual, proven effective by the Mini/Microcomputer Technology program at Roane State Community College, should be used to establish new programs or enhance existing ones.

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APPENDIXES

APPENDIX A

SUGGESTED TECHNICAL JOURNALS AND PERIODICALS

ACM Communications: Association for Computing Machiners, 113 Avenue of the Americas, New York, New York, 10036.

Application Notes; ASEE, Computers in Education Division, P.O. Box 308, West Long Beach, New Jersey, 07764.

BYTE: Byte Publications, Inc., 70 Main Street, Peterborough, New Hampshire, 03458.

Computer: Institute of Electrical and Electronics Engineers, Inc., Computer Society, 5855 Naples Plaza, Suite 301, Long BEach, California, 90803.

Computer Design: Computer Design Publishing Corporation, 11 Goldsmith Street, Littleton, Massachusetts, 01460.

Computer Journal: British Computer Society, 29 Portland Plaza, London W1, England.

Computer Products: Gordon Publications Inc., 20 Community Place, Morristown, New Jersey, 07960.

Computerworld: Computerworld, Inc., 797 Washington Street, Newton, Massachusetts, 02160.

Computing Newsletter for Community Colleges: Center for Cybernetic Systems Synergism, P.O. Box 7345, Colorado Springs, Colorado, 80933.

Creative Computing: Burchenal Green, P.O. Box 789-M, Morristown, New Jersey, 07412.

Datamation: Technical Publishing Company, 1801 La Cienega Boulevard, Los Angeles, California, 90035.

Digital Design: Benwell Publishing Corporation, 1050 Commonwealth Avenue, Boston, Massachusetts, 02215.

IBM Systems Journal: IBM Corporation, Armonk, New York, 10504.

IEEE Transactions on Computers: IEEE, 345 East 47th Street, New York, New York, 10017.

Interface Age: Wolfe and Jones, 13913 Artesia Boulevard, Cerritos, California, 90701.

International Journal of Mini and Microcomputers: Acta Press, Box 2481,
Anaheim, California, 92804.

Mini-Micro Computer Report: News Services Inc., 7620 Little River
Turnpike, Annadale, Virginia, 22003.

Mini-Micro Systems: Cahners Publishing Company, 270 St. Paul Street,
Denver, Colorado, 80206.

Minicomputer News: Benwill Publishing Corporation, 1050 Commonwealth
Avenue, Boston, Massachusetts, 02215.

Small Systems World: Hunter Publishing Company, 53 West Jackson
Boulevard, Chicago, Illinois, 60604.

APPENDIX B

DIGITAL EQUIPMENT CORPORATION PROGRAM SUPPORT

The development and implementation of this program is in conjunction with Digital Equipment Corporation(DEC), the sales leader in the minicomputer market. DEC is sponsoring the establishment of minicomputer service technology programs at selected colleges such as Roane State in areas where the potential DEC sales growth and projected customer-service needs are the greatest. As outlined in Description of Tasks and Parameters of the College/DEC MTP Relationship, December 30, 1976, DEC will provide:

- a. Generic and product specific curriculum materials in the form of (1) hardcopies of various curriculum materials (study guides, instructor guides, handouts, etc.) that are applicable to the college's curriculum, and (2) appropriate audio/visual courses.
- b. Faculty training at DEC's Educational Services Training Centers in all areas of computer service technology including both hardware and software courses.
- c. Minicomputer systems and supplies at reduced cost.
- d. Field service work experience for second-year students.
- e. Recruiting interviews on a regular and timely basis for positions in local, district, and regional offices as field service technicians. Open communication will be maintained between DEC personnel groups and RSCC faculty concerning student progress and employment openings.
- f. Talks and advice to RSCC students by the local DEC office concerning career opportunities in the computer industry.
- g. One to three months faculty internship with the local Field Service Office.
- h. Advice to RSCC faculty as to state-of-the-art developments in minicomputer technology as well as content and relevancy of the MCT curriculum.

- i. Assistance to RSCC in developing a public relations program in order to attract technically oriented students with particular attention to minority and female students.
- j. Release of RSCC from copyright restrictions on company materials as required for support of the MCT program.

APPENDIX C

CATEGORICAL LISTING OF COMPUTER TECHNOLOGY TEXTS

Note: The following listing contains texts which have been favorably reviewed and should be used as a starting point from which to begin text selection. It should not be interpreted, however, that unlisted books are unsuitable.

Digital Circuits

Digital Circuits and Systems
Costellucis; Reston, 1981

Digital Computer Fundamentals, Fourth Edition
Bartee; McGraw-Hill, 1981

Digital Principles and Applications, Third Edition
Malvion and Leach; McGraw-Hill, 1981

Digital Integrated Electronics
Taub and Schilling
McGraw-Hill

Digital Systems: Hardware Organization and Design
Hill and Peatman; Wiley

Computer Logic Design
Mano; Prentice-Hall, 1972

Introduction to Digital Techniques
Porat and Barna; Wiley, 1979

Digital Computer Circuits and Concepts, Third Edition
Deem, Muchow, Zeppa; Reston, 1980

Introduction to Digital Computer Technology
Nashelsky; Wiley, 1977

Digital Technology
Williams; SRA, 1977

Digital Electronics: Logic and Systems
Kershaw; Daxbury, 1976

Digital Logic Fundamentals
Floyd; Merrill, 1977

Minicomputers

Minicomputer Systems: Organization and Programming
Eckhouse and Morris; Prentice-Hall

Minicomputers: Structure and Programming
T. G. Lewis; Hayden, 1977

Computer Organization and Architecture
Hayes; McGraw-Hill, 1979

Minicomputer Systems: Structure, Implementation, and Applications
Weitzman; Prentice-Hall, 1981

Computer Organization and Assembly Language Programming
Peterson; Academic Press, 1981

PDP-11 Assembler Language Programming and Machine Organization
Singer; John Wiley and Sons, 1980

Minicomputers: Theory and Operation
Eadie; Reston, 1979

Minicomputers: Hardware, Software, and Selection
Pooch and Chattergy; West, 1979

Microprocessors

Microprocessing Fundamentals
Ramirez and Weiss; McGraw-Hill, 1979

Microprocessors/Microcomputers: An Introduction
Givone and Roesser; McGraw-Hill, 1980

Microprocessors and Microcomputers: Hardware and Software
Tocci and Laskowski; Prentice-Hall, 1979

Microprocessors and Programmed Logic
Short; Prentice-Hall, 1981

Microprocessors: Theory and Applications
Streitmatter and Fiore; Reston, 1979

Microprocessors and Digital Systems
Hall; McGraw-Hill, 1980

Microprocessor Technology
Kershaw; Breton, 1981

Introduction to Microcomputers and Microprocessors
Barna and Porat; John Wiley and Sons, 1976

Integrated Circuits

Introduction to Op Amps: Theory and Application
Wait, Huelsman, Korn; McGraw-Hill, 1977

Integrated Circuits and Semiconductor Devices: Theory and Application,
Second Edition
Deboo and Burrous; McGraw-Hill, 1977

Handbook of Integrated Circuits: for Engineers and Technicians
Lenk; Reston, 1978

Integrated Circuits: Theory and Applications
Wojslaw; Reston, 1978

A User's Handbook of Integrated Circuits
Hnatek; Wiley-Interscience, 1973

Integrated Circuits for Electronics Technicians
Pasahow; McGraw-Hill, 1979

Manual for Integrated Circuit Users
Lenk; Reston, 1973

Data Communications

Telecommunications and the Computer, Second Edition
Martin; Prentice-Hall, 1976

Technical Aspects of Data Communication
McNamara; Digital, 1978

Introduction to Teleprocessing
Martin; Prentice-Hall, 1972

Pulse and Switching

Pulse and Switching Circuit Action
Veatch; McGraw-Hill, 1971

Solid State Pulse Circuits, Second Edition
Bell; Reston, 1981

Basic Pulse Circuits
NYIT; McGraw-Hill, 1978

Fundamentals of Pulse and Digital Circuits, Second Edition
Tocci; Merrill, 1977

APPENDIX D

MCT COURSE SYLLABI

MCT 1100	Introduction to Minicomputers
MCT 1210	Machine/Assembly Language Programming
MCT 1810	Pulse and Switching Circuits
MCT 2000	Computer Service Internship
MCT 2210	Operating Systems
MCT 2310	Digital Circuits
MCT 2350/55	Computer Architecture/Lab
MCT 2410/15	Peripherals I/Lab
MCT 2420/25	Peripherals II/Lab
MCT 2610	Computer System Maintenance/Troubleshooting
MCT 2700	Integrated Circuits
MCT 2850	Microprocessors

MCT 1100
Introduction to Minicomputers

TEXT: Introduction to Minicomputers: Student Workbook Sets by Digital Equipment Corporation.

INSTRUCTOR: D. G. Sweet, Room T-201F

COURSE OBJECTIVES:

1. To introduce the student to the basic organization and operation of a digital computer.
2. To present the fundamentals of computer logic hardware and software, movement of information; identification of major hardware components and their interaction; and concepts of programming and problem solving.
3. To familiarize the student with the basic structure and applications of computer systems.
4. To give the student an understanding of the scope and purpose of the Mini/Microcomputer Service Technology Program.
5. To present a clear picture of the career opportunities and job descriptions available within the computer industry.

COURSE REQUIREMENTS:

The course will be divided into thirteen units, the completion of each to be followed by a unit test. Exercises will be assigned from each unit workbook to be completed at home. There will be a comprehensive final exam given at the end of the quarter.

The final grade will be computed as follows:

Unit Tests	70%
Final Exam	30%

TEACHING MATERIALS:

The course will be presented in a mixed-media format of audio filmstrips, unit workbooks, handout materials, demonstrations and classroom lectures. Guest speakers will also be used to present information concerning the computer industry.

COURSE OUTLINE:

<u>Unit</u>	<u>Topic</u>
1	System Overview a. Types of computers b. Major components c. Capabilities and limitations
2	Terms and conventions a. Units of information b. Units of storage c. Units of time

<u>Unit</u>	<u>Topic</u>
3	Number Systems and Codes a. Binary and octal numbering systems b. Conversions c. Character codes
4	Problem Solving
5	Computer Arithmetic a. Octal and binary addition b. Octal and binary subtraction c. Signed binary numbers
6	Instruction Sets a. Instruction types b. Addressing c. Instruction Sets d. Simple programming
7	Logic and Hardware Basics a. Basic logic gates b. Truth tables c. Logic symbols d. Registers and flip-flops
8	Main Memory a. Functional description (core and semiconductor) b. Interleaving c. ROM d. Cache memory e. Bubble memory
9	Central Processor a. Major registers and functions b. Typical instruction cycles c. Use of console
10	Peripheral devices a. Machine-oriented I/O devices b. People-oriented I/O devices c. Auxiliary storage devices
11	Bus Structures a. Typical bus configurations b. Serial vs. parallel transfers c. Major functions of interfaces
12	General Software a. Assembly language b. Machine language c. High-level languages

MCT 1210
MACHINE/ASSEMBLY LANGUAGE PROGRAMMING

Reference Resources:

1. PDP-11/04/05/10/35/40/45 Processor Handbook
2. PDP-11 Peripherals Handbook
3. PDP-11 Paper Tape Software Handbook
4. Introduction to Minicomputers (A/V Tapes)
5. Introduction to the PDP-11 (A/V Tapes)
6. PDP-11 Programming Card

Instructor: D. G. Sweet, T-201F, 354-3000 ext. 294

Prerequisites:

The student should have a working knowledge of basic computer operation, number systems, computer arithmetic, logic operations, and programming techniques either from MCT 1100 (Introduction to Minicomputers) or from previous experience. Students should see the instructor concerning the latter before registering.

Course Objectives: The student will learn to

1. Describe the general architecture of a PDP-11, including the Unibus, main memory, and the CPU;
2. Describe the action of any instruction or addressing mode;
3. Translate assembly language instructions into machine code;
4. Write assembly language programs to manipulate data in memory, to cause I/O data transfers, and to make use of traps and trap vectors;
5. Use the front panel to load, examine, and run a program;
6. Describe the basic operation of the assembler and use the software to write, edit, run, and debug an assembly language program.

Course Requirements:

Each student is expected to obtain the reference resources as needed. References 3, 4, and 5 are available for use in the computer lab only. There will be programming assignments made at the start of the course with due dates. These are to be completed outside of class in the lab. A sign-up sheet will be posted for each computer. No student should use any of the computer systems unless his/her name is on the sheet. Late programming assignments will be deducted a letter grade (10 points) per day late. Numerous unannounced quizzes will be given as will homework assignments which, unless otherwise specified, will be due the following class period. The grading will be as follows:

Homework Exercises	20%
Quizzes	30%
Lab problems	50%

Course Outline:

<u>TOPIC</u>	<u>REFERENCE</u>
I. Introduction, course overview	1: Chap. 1; 5: System Overview
II. Review Areas	
A. Number Systems	4: Number Systems
B. Computer Arithmetic	4: Computer Arithmetic
C. Logic Operations	4: Logic and Hardware Basics
III. System Architecture	
A. Basic Organization	1: Chap. 7; 2: Chap. 1
B. Unibus	1: 2.1; 2: Chap. 5; 5: Unibus
C. Memory	1: 2.3; 5: Memory and Addressing
D. CPU	1: 2.2; 5: Processor Organization
E. Console Operation	1: 7.4; 5: Console
IV. Addressing Modes, Instruction Formats	1: Chap. 3; 5: Addressing Modes
V. Instruction Set	1: Chap. 4; 2: Chap. 2; 5: Instruction Set
VI. Assembler - Operation and Directives	3: Chap. 2
V. Programming Techniques	2: Chap. 2
A. Stack Operations	1: 5.1
B. Subroutines	1: 5.2, 5.6
C. I/O Programming	2: 5.5; 3: Chap. 7; 5: I/O Programming
D. Interrupts	1: 5.3; 2: 5.6
E. Traps	1: 5.7
F. Position Independent Code (PIC)	1: 5.5; 3: Chap. 7

MCT 1810
Pulse and Switching Circuits

TEXT: Solid State Pulse Circuits by Bell; Reston, 2nd Edition

ADDITIONAL REFERENCES:

Fundamentals of Pulse and Digital Circuits by Tocci; Merrill
Pulse and Switching Circuits by Veatch; McGraw-Hill
Designing with TTL Integrated Circuits by Texas Instruments,
Inc.; McGraw-Hill

INSTRUCTOR: D. G. Sweet

PREREQUISITES:

EET 1310 (Electronics I) or working knowledge of basic transistor theory and circuit theory (AC and DC).

OBJECTIVES:

1. To gain an understanding of the characteristics of pulse waveforms and the passive circuits which shape or delay the waveforms;
2. To become familiar with steady-state switching characteristics of solid state devices;
3. To understand the operation of discrete switching circuits such as clippers, clampers, and inverters;
4. To gain a working knowledge of IC pulse generation circuits such as multivibrators, Schmitt triggers, one-shots, and timers.

COURSE REQUIREMENTS:

Most lecture material will be taken from the required text with some additional material in the form of lectures and/or handouts from other sources. Numerous short quizzes will be given; missed quizzes cannot be made up since the lowest two grades will be dropped. Homework assignments will be taken up and graded according to problems attempted and selected answers. Problems should be worked on plain or ruled 8½" by 11" paper (no spiral paper) on the front side only.

GRADING:

Quizzes	70%
Final	20%
Homework	10%

COURSE OUTLINE:

<u>Topic</u>	<u>Reference</u>
I. Waveform Analysis	Chapter 1
II. Waveshaping	
a. RC circuits	Chapter 2
b. Integrating/Differentiating Circuits	Handouts
c. Delay lines	
III. Solid State Switching Theory	
a. Diode switching	Chapter 3
b. Transistor Switching	Chapter 4, Handouts
1. Bipolar	
2. JFET	
3. MOSFET	
IV. Logic Circuits	
a. Transistor Inverter	Chapter 5
b. Diode Gates	Chapter 10
c. Logic Types	Chapter 10, Handouts
1. DTL	T.I.: Chapter 3
2. RTL	
3. TTL	
4. ECL	
5. CMOS	
V. The Schmitt Trigger and Comparator	Chapter 6
a. Basic operation	
b. IC Schmitt Trigger	
c. IC Voltage Comparator	
VI. Multivibrators	Chapter 8, 9
a. Monostable	
b. Astable	
c. Bistable	
d. 555 Timer	
VII. Sampling Circuits	Chapter 11

MCT 2000
Computer Service Internship

OBJECTIVES

The summer work experience program is a joint effort of both the Mini/Micro-computer Technology Department and area companies involved in computer service and/or usage. It provides the student with the means for gaining practical experience in an actual industrial environment. The student will be able to:

- 1) Observe experienced computer technicians in the servicing and maintenance of minicomputer systems.
- 2) Apply lab skills and classroom theory from completed EET and MCT courses to practical and realistic industrial environment.
- 3) Acquire further technical skills through hands-on experience in an industrial environment.

PREREQUISITES

Students planning on completing their internship requirement during the summer quarter should inform the program coordinator of their intention four to six weeks prior to the start of summer quarter. To be eligible for internship, the student must have completed the following courses with a grade of C or better.

MCT 1810	Pulse and Switching Circuits
MCT 2310	Digital Circuits
MCT 1210	Machine/Assembly Language Programming

REQUIREMENTS

The student will receive 1 hour credit for each 30 hours of work experience. The minimum requirement for the MCT curriculum is 2 hours; however, the student may receive up to 6 hours credit depending on the number of work hours. Each student is required to:

- 1) Meet with the internship coordinator at the end of Spring Quarter to discuss particular job placements and requirements.
 - 2) Maintain a weekly log of work experience activities with particular attention to the following areas:
 - a) utilization or observation of direct applications, of classroom theory and lab skills;
 - b) observation of new technical procedures or theory related to the design or maintenance of digital systems; and
 - c) discussion of new job skills or technical knowledge acquired during the internship period.
- This information should be assimilated and submitted as a weekly report to the program director at the end of the summer.

- 3) Meet with the internship director no later than the first week of fall quarter at which time the student will discuss the internship and submit the following:
 - a) a weekly report for each week of work experience
 - b) an analysis and personal evaluation of job functions of the person(s) with whom the student is most closely associated. If the student has the opportunity to work in more than one functional area, he should analyze each individually as well as the interrelationship between them

The student's final grade will be based on the reports submitted, the oral discussion of work experience activities, and periodic evaluations of the student's performance by the student's supervisor at the work location.

MCT 2210
Operating Systems

INSTRUCTOR: David G. Sweet
T-201F, Office hours posted

REQUIRED TEXTS: PDP11 Software Handbook; Digital Equipment Corporation
Introduction to RT-11; Digital Equipment Corporation

ADDITIONAL LIBRARY RESOURCES:

Minicomputer Systems: Organization and Programming by Eckhouse; Prentice-Hall
Fundamentals of Operating Systems by Lister; Springer-Verlag

COURSE OBJECTIVES:

1. To become familiar with the general characteristics of an operating system and the basic types of operating systems and processing methods.
2. To be able to describe the major components of an operating system and the functional relationship between them as well as the hardware/software interaction.
3. To develop an understanding of program development in terms of the software tools involved.
4. To be able to install, checkout, and maintain an operating system and distinguish between software and hardware faults.
5. To become familiar with the operational characteristics of several popular operating systems currently being distributed.

COURSE REQUIREMENTS:

Each student is expected to utilize listed resources as necessary. Additional handouts will be distributed to support certain topics, and students will be held responsible for the material contained within.

Detailed discussion in the classroom as well as frequent quizzes make it imperative that students make sincere efforts to attend each class meeting. The instructor should be contacted when circumstances necessitate an absence.

The classroom and text information will be supported by hands on usage of the RT-11 Operating System in the Minicomputer Technology Lab. Students will work in pairs and will check out an RK05 disk cartridge for which they will be responsible. It will also be necessary for each student to purchase a floppy disk for use during the quarter. Lab assignments will be made during the quarter together with due dates. Late assignments will be penalized.

Grading will be based on the following percentages:

Quizzes	50%
Final Exam	25%
Lab Assignments	25%

COURSE OUTLINE:

<u>TOPIC</u>	<u>REFERENCES</u>
I. Overview of System Software	Introduction to Minicomputers: Operating Systems
A. Components	Software Handbook, pp. 14-19
1. Operating System	
2. Language Processor	
3. Application Programs	
B. Processing Methods	
1. Single-Job	
2. Real-Time	
3. Foreground/Background	
4. Multiprogramming	
5. Timesharing	
6. Batch	
C. Operating System Components	
1. Executive	
2. Resource Manager	
3. Memory Manager	
4. File Manager	
5. Device Handlers	
6. System Utilities	
II. Executive	Handout
A. Structure	
1. Resident portion	
2. Transient portion	
B. Functional Operation of Resident Monitor	
1. Recognizing events	
2. Maintaining descriptor list	
3. Scheduling	
4. Dispatching	
C. Transient Monitor Operation	
1. User interface	
2. Command interpreter	
III. Resource Management	Handout
A. Efficiency vs. Service	
B. Jobs	
1. Types	
2. Job descriptors	
3. Queues	

III. Resource Management (continued)

- C. Scheduling Concepts
 - 1. Scheduling algorithms
 - 2. Schedulers
 - 3. Dynamic Scheduling
- D. Scheduling in Various Types of Systems
 - 1. Real Time System
 - 2. Batch System
 - 3. Timesharing System

IV. Memory Management

Handout

- A. Basic Concepts
- B. Unmapped Memory Systems
 - 1. Program Segmentation
 - 2. Swapping
 - 3. Overlays
 - 4. Partitioning
 - a) Static
 - b) Dynamic
- C. Virtual (Mapped) Memory Systems
 - 1. Levels of Storage
 - 2. Mapping
 - 3. Segmentation
 - 4. Paging
- D. Memory Protection
 - 1. Partitioned System
 - 2. Virtual Memory

V. File Management

Introduction to Minicomputers:
File Organization

Software Handbook, pp. 20-25,
29-38, 224-275

Handout

- A. Units of Data
- B. Types of Files
 - 1. Master file
 - 2. Transaction file
 - 3. Report file
- C. File Structures
 - 1. Linked
 - 2. Contiguous
 - 3. Mapped
- D. File Organization Methods
 - 1. Sequential
 - 2. Relative
 - 3. Indexed

- V. File Management (continued)
 - E. File Access Methods
 - 1. Sequential
 - 2. Random
 - 3. Record's file address
 - F. Directories
 - 1. User File Directory (UFD)
 - 2. Master File Directory (MFD)
 - G. File Names, Types, and Versions
 - H. File Protection
 - I. Data Base Management

- VI. Device Management
 - A. Device Characteristics
 - 1. Types of devices
 - a) File structured
 - b) Block-replaceable
 - 2. Access Methods
 - a) Sequential
 - b) Direct
 - B. Device Handlers
 - 1. Functions
 - 2. Device descriptor
 - 3. I/O request queue
 - 4. Errors and retries
 - C. Hardware/Software Interface
 - 1. Hardware buffering
 - 2. Device naming
 - 3. Device assignment
 - 4. Device allocation
 - 5. Spooling

- VII. System Utilities
 - A. Overview
 - B. File Transfer
 - C. File Conversion
 - D. File Comparison
 - E. Dumps
 - F. Sorts

Software Handbook, pp. 25-29
Handout

Software Handbook, pp. 38-42,
72-73, 93-94, 303
Handout

VII. System Utilities (continued)

G. System Accounting

H. Formatting

I. Program Cross-Reference

J. Debugging

K. Editors

L. Patching

M. Libraries

VIII. Program Development

A. Languages

1. Assembler
2. High-level

B. Language Processors

1. Assemblers
2. Compilers
3. Interpreters

C. Subroutines

D. Relocation

E. Linking and Loading

F. Debugging

Introduction to Minicomputers:
Programming Languages

Software Handbook, pp. 121-125,
127, 138-149, 164-166

IX. System Management

A. System Installation

1. System generation
2. Initialization

B. Batch Control

C. Interactive System Management

1. Single user
2. Timesharing

D. System Maintenance

Handout

- X. Popular Operating Systems
 - A. RT-11 (DEC)
 - B. RSTS (DEC)
 - C. RDOS, AOS (Data General)

MCT 2310
Digital Circuits

TEXT: Digital Logic Fundamentals, Thomas Floyd, Merrill

ADDITIONAL REFERENCES:

Introduction to Minicomputers, Digital Equipment Corporation

INSTRUCTOR: D. G. Sweet, T-201F
Office hours to be posted

COURSE OBJECTIVES:

1. To become familiar with basic digital principles such as number systems and codes, computer arithmetic, Boolean Algebra, and basic logic gates.
2. To become proficient in the evaluation, minimization, and implementation of logic expressions and combinational logic networks.
3. To develop a working knowledge of more complex digital circuits such as clocks, registers, and counters.
4. To develop a practical understanding of the basic functional elements of a computer or other complex digital systems such as memories and arithmetic logic units.

COURSE REQUIREMENTS:

The student will be expected to complete and turn in homework assignments. Short quizzes will be given regularly and make class attendance imperative. Make-up quizzes will not be given for any reason. There will be at least one project assignment which is to be completed in lab. A comprehensive final exam will be given the last day of class. Problem areas should be discussed with the instructor so that they will not progress and the student fall behind.

GRADING:

Quizzes	60%
Final	30%
Homework	10%

PREREQUISITE:

MCT 1100 Introduction to Minicomputers or a basic knowledge of number systems and logic gates.

COURSE OUTLINE:

<u>Topic</u>	<u>Reference</u>
I. Digital Logic Concepts	Chapter 1
II. Number Systems	Chapter 2
a. Binary	
b. Octal	
c. Hexadecimal	
d. Conversions	
e. Arithmetic operations	
III. Digital Codes and Operations	Chapter 3
a. Number codes	
b. Alphanumeric codes	
c. Error detection/correction	
d. Data formats	
IV. Logic Gates	Chapter 4
V. Boolean Algebra	Chapter 5
a. Logic functions	
b. Rules and Laws	
c. Simplification	
1. Algebraic	
2. Karnaugh mapping	
VI. Combinational Logic	Chapter 6, 7
a. Implementing logic equations	
b. Pulsed operation	
c. Complex functions	
VII. Flip-Flops	Chapter 8
a. RS F/F	
b. JK F/F	
c. D F/F	
VIII. Sequential Logic	Chapter 9, 10
a. Counters	
b. Registers	
IX. Memories	Chapter 11 Handouts
a. Core	
b. Semiconductor	
c. RAM/ROM	
X. Arithmetic Logic	Chapter 12

MCT 2350
Computer Architecture

INSTRUCTOR: David G. Sweet
T-201F, Office hours posted

REQUIRED TEXTS:

KD11-A (PDP 11/40) Processor Maintenance Manual; DEC
PDP 11/40 Engineering Drawings; DEC
MF11-UP Core Memory System Maintenance Manual; DEC

ADDITIONAL RESOURCES:

PDP 11/40 Processor Handbook; DEC
PDP 11 Peripherals Handbook (1976); DEC
Digital Computer Fundamentals, by Bartee; McGraw-Hill
Computer Organization and Programming, by Gear; McGraw-Hill
Introduction to Digital Computer Technology, by Nashelsky; Wiley

COURSE OBJECTIVES:

1. To develop an understanding of the functional design of a digital computer, in particular the basic logic elements and the inter-relationships between them.
2. To become familiar with the design and operation of bus structures and the characteristics of the information found on the bus.
3. To learn the function of timing and control in the computer and the circuits which are involved.
4. To understand the concepts of microprogramming and the correlation of the hardware and software elements of the computer.
5. To become familiar with the principles and concepts of core and semiconductor memory and the logic elements contained within.
6. To become familiar with the detailed logic structure of a computer through analysis of a typical processor.
7. To develop efficient skills in troubleshooting faults occurring in the processor through the use of diagnostic tools and enacting the appropriate repair procedures.

COURSE REQUIREMENTS:

Each student is expected to utilize listed resources as necessary. Additional handouts will be distributed to support certain topics, and students will be held responsible for the material contained within.

Detailed discussion in the classroom as well as frequent quizzes make it imperative that students make sincere efforts to attend each class meeting. The instructor should be contacted when circumstances necessitate an absence. Office hours are posted and students having difficulty in a subject area should feel free to discuss the problems with the instructor.

The classroom and text material will be reinforced and practical skills developed by hands-on usage of the computer system in the laboratory. One system will be investigated in detail while the memory system on several computers will be analyzed. Lab assignments will be made during the quarter corresponding to the current subject area.

Grading will be based on the following percentages:

Quizzes	70%
Final Exam	30%

COURSE OUTLINE:

- I. Basic Processor Organization
 - A. Basic Block Diagram
 - B. Word Formats
 - C. Instruction Cycles
 1. Fetch
 2. Execute
 3. Interrupt
- II. Processor Control
 - A. Conventional Implementation
 - B. Microprogrammed Control
 1. Microinstructions
 2. Microprogram sequencing
- III. Bus Structures
 - A. Multibus Systems
 - B. Unibus
 1. Line characteristics
 2. Unibus signals
 3. Data transfer operations
 - a. DATI, DATIP
 - b. DATO, DATOB
 4. Priority transfer
 - a. Interrupt
 - b. DMA

- IV. Programming (PDP-11)
 - A. Addressing Modes
 - B. Basic Instruction Set
 - C. Traps and Interrupts
 - 1. Interrupt service routines
 - 2. Trap catchers
- V. Processor Analysis: PDP 11/40, KD11-A
 - A. Block Diagram Analysis
 - 1. Data paths
 - 2. Microcontrol
 - 3. Timing logic
 - B. Microprogram Flow Diagrams
 - 1. Microstate signals
 - 2. Microprogram examples
 - C. Module Logic Analysis
 - 1. M7231; Data Paths
 - 2. M7232; U Word
 - 3. M7233; IR Decode
 - 4. M7234; Timing
 - 5. M7235; Status
 - D. Processor Options
- VI. Fault Analysis
 - A. Problem Isolation
 - B. Scope Loops
 - C. Examples
- VII. Memory
 - A. Core Memory
 - 1. Theory of Operation
 - 2. Functional organization
 - 3. Detailed analysis: MF11-UP, 16k Core Memory System
 - B. Semiconductor Memory
 - 1. Theory of operation
 - 2. Functional organization
 - 3. MS11-J, 16k MOS Memory
- VIII. Comparative Analysis of Popular Processors
 - A. HP
 - B. Data General
 - C. TI

MCT 2355
COMPUTER ARCHITECTURE
LAB ASSIGNMENTS

<u>Lab #</u>	<u>Title</u>	<u>Due Date</u>
Processor		
1	Basic Processor Design	
2	KD11-A Module Familiarization	
3	Microprogramming	
4	Signal Sampling/Processor	
5	Microstate Signals	
6	Processor Troubleshooting Problem I	
7	Processor Troubleshooting Problem II	
Memory		
8	MF11-UP Module Familiarization	
9	Signal Sampling/Memory	
10	Memory Troubleshooting Problem	

MCT 2410
Peripherals I

INSTRUCTOR: David G. Sweet
T-201F, Office hours posted

REQUIRED TEXTS:

Hazeltine 1500 Maintenance Manual; Hazeltine Corporation
LA36 DECwriter II Maintenance Manual; Digital Equipment Corporation
LS36 DECwriter II Engineering Drawings; Digital Equipment Corporation
DL11-W Serial Line Unit/Real-Time Clock Option Maintenance Manual; DEC
DL11-W Engineering Drawings; Digital Equipment Corporation

ADDITIONAL RESOURCES:

PDP-11 Programming Reference Card; Digital Equipment Corporation
Technical Aspects of Data Communication; McNamara

COURSE OBJECTIVES:

1. To become familiar with the principles and concepts of asynchronous communication.
2. To develop an understanding of the principles of operation and the hardware structure of representative types of terminal equipment.
3. To be able to outline in block diagram the functional organization of each device studied.
4. To become proficient in the use of system diagnostics, manuals, print sets, and test equipment to check the operation of each device.
5. To know and be able to perform the normal types of maintenance routines required for each device.
6. To be able to isolate malfunctions within each device and perform the necessary procedures to repair or replace the faulty component.

COURSE REQUIREMENTS:

Each student is expected to obtain and utilize listed resources. Additional handouts will be distributed to support certain topics, and students will be held responsible for the material contained within. Detailed discussion in the classroom together with frequent quizzes make it imperative that students make sincere efforts to attend each class meeting. The instructor should be contacted when circumstances make it necessary to miss class.

The lecture and text material will be supported by hands-on usage of representative computer devices. Students will be performing test and repair procedures on devices such as the H1500 Video Terminal, LA36 Hardcopy Terminal, and the DL11-W Line Interface in the Minicomputer Technology Lab.

Grading will be based on the following percentages:

Quizzes	30%
Final	20%
Lab	50%

COURSE OUTLINE:

<u>Topic</u>	<u>References</u>
I. Terminal Concepts	Handouts
A. Fundamentals of Input/Output	
B. Terminal Types and Functions	
C. Basic Operational Organization	
II. Asynchronous Data Communication	Handouts
A. Basic Concepts of Serial I/O	McNamara: pp. 1-16
B. Data Formats	
C. Buffering	
D. The UART	
III. Data I/O Interfaces	Handouts
A. 20 mA Current Loop	McNamara: pp. 17-28
B. RS-232C	pp. 43-72
IV. Hazeltine 1500 Video Terminal	H1500 Maintenance Manual
A. General Description	
B. Theory of Operation	
1. Data transfers	
2. TV processing	
3. Firmware	
4. Microprocessor control	
C. Checkout Procedures	
D. Troubleshooting	
1. Power supply	
2. Logic board	
3. Monitor board and chassis	

- V. DEC LA36 DECwriter II Hardcopy Terminal
 - A. Functional Description
 - B. Theory of Operation
 - 1. Firmware
 - 2. Control Logic
 - 3. Data Interface
 - 4. Carriage Servosystem
 - 5. Printer
 - C. Adjustment Procedures
 - D. Troubleshooting
 - 1. Logic assembly
 - 2. Mechanical assemblies
 - VI. Computer I/O Interfaces
 - A. Functional Organization
 - B. DL11 Asynchronous Line Interface
 - C. DZ11 Line Multiplexer
 - VII. Diagnostic Programming
 - A. Test Loops (self-written)
 - B. System Diagnostics
- LA36 Maintenance Manual
- DL11 Maintenance Manual
Handouts

MCT 2415
Peripherals I Lab

<u>Experiment Number</u>	<u>Title</u>	<u>Due Date</u>
1	Asynchronous Line Communication--the UART	
2	H1500 Functional Organization	
3	H1500 Checkout and Repair: Power Supply	
4	H1500 Checkout and Repair: Logic and Monitor Assemblies	
5	LA36 Functional Organization	
6	LA36 Alignment	
7	LA36 Data Transfers	
8	LA36 Troubleshooting	
9	DL11/DZ11 Operational Characteristics	
10	Diagnostics	

MCT 2420
Peripherals II

INSTRUCTOR: David G. Sweet
T-201F, Office hours posted

REQUIRED TEXTS:

RK05 Disk Drive Maintenance Manual; DEC
RK05 Engineering Drawings; DEC
RK11 Moving Head Disk Drive Controller Manual; DEC
RK11 Engineering Drawings; DEC
TE16/TE10W/TE10N DEC Magtape Transport, Maintenance Manual; DEC
TE10W Engineering Drawings; DEC

ADDITIONAL RESOURCES:

PDP-11 Programming Card
PDP-11 Peripherals Handbook
Disk Principles: A/V Course Tapes and Workbooks; DEC
Tape Concepts: A/V Course Tapes and Workbooks; DEC

COURSE OBJECTIVES:

1. To develop an understanding of the principles and concepts involved in recording on magnetic mass storage devices such as disks and magtape units.
2. To be able to outline the functional organization of tape and disk units.
3. To learn the interface structure of these devices and to control of operation and data flow performed by the interfaces.
4. To become familiar with the electromechanical devices involved in the operation and control of tape transports and disk drives.
5. To develop a general understanding of the function and operation of subassemblies and logic modules through analysis of laboratory systems.
6. To utilize this knowledge to become skillful in effectively maintaining and troubleshooting these types of subsystems.
7. To be able to perform necessary alignment and adjustment procedures to insure proper operation of the devices.

COURSE REQUIREMENTS:

Each student is expected to utilize listed resources as necessary. Additional handouts will be distributed to support certain topics, and students will be held responsible for the material contained within.

Detailed discussion in the classroom as well as frequent quizzes make it imperative that students make sincere efforts to attend each class meeting. The instructor should be contacted when circumstances necessitate an absence. Office hours are posted and students having difficulty in a subject area should feel free to discuss the problems with the instructor.

The principles and concepts of classroom subject areas will be developed and reinforced through the hands-on utilization of industry standard mass-storage units such as cartridge disk drives, a magtape transport, and their associated controllers and interfaces. Maintenance procedures will be performed on these devices. Lab assignments will be made during the quarter corresponding to the current subject area.

Grading will be based on the following percentages:

Quizzes	70%
Final Exam	30%

COURSE OUTLINE:

<u>Topic</u>	<u>References</u>
I. Disk Principles	Disk Principles: A/V Course
A. Types of Disks	Handouts
1. Removable	
2. Non-Removable	
B. Head Positioners	
1. Tyeps	
2. Servo Systems	
3. Detection Techniques	
C. Read/Write Heads	
1. Head Support	
2. Head Mobility	
D. Formatting and Operation	
E. General Care	

- D. Maintenance
 - 1. Preventive Maintenance
 - 2. Alignments and Adjustments
 - 3. Corrective Maintenance

VI. Other Mass Storage Devices

- A. Disks
- B. Tape
- C. Solid State

- D. Maintenance
 - 1. Preventive Maintenance
 - 2. Alignments and Adjustments
 - 3. Corrective Maintenance

VI. Other Mass Storage Devices

- A. Disks
- B. Tape
- C. Solid State

MCT 2425
PERIPHERALS II
LAB ASSIGNMENTS

<u>Lab #</u>	<u>Title</u>	<u>Due Date</u>
Disks		
1	Identification of Disk Types	
2	RK05 Disk Drive Familiarization	
3	Maintenance Programming	
4	RK05 Alignments and Adjustments	
5	RK11 Familiarization	
6	Disk Drive/Controller Troubleshooting Problems	
MagTape		
7	TE10W Transport Familiarization	
8	TE10W Alignments and Adjustments	
9	Signal Sampling/Transport	
10	MagTape Troubleshooting Problem	

MCT 2700 INTEGRATED CIRCUITS

INSTRUCTOR: David G. Sweet
T-201F, office hours posted

REQUIRED TEXTS: Handbook of Integrated Circuits: For Engineers and Technicians
by Lenk; Reston

ADDITIONAL LIBRARY RESOURCES:

Integrated Circuits and Semiconductor Devices by Deboo/Burrous; McGraw-Hill
A User's Handbook of Integrated Circuits by Hnatek; Wiley Interscience
Designing with TTL Integrated Circuits by Texas Instruments Inc.; McGraw-Hill

COURSE OBJECTIVES:

1. To learn practical circuit design techniques using integrated circuits.
2. To gain an understanding of integrated circuit design and fabrication techniques.
3. To become familiar with practical aspects of linear and digital IC devices and typical device applications.
4. To develop an understanding of the operational characteristics of linear and digital IC's as presented on device data sheets in terms of their effect on circuit design and performance.
5. To become familiar with the latest developments in IC technologies together with the devices currently being produced with utilized these technologies.

COURSE REQUIREMENTS:

Each student is expected to utilize listed resources as necessary. Additional handouts will be distributed to support certain topics, and students will be held responsible for the material contained within.

Detailed discussion in the classroom as well as frequent quizzes make it imperative that students make sincere attempts to attend each class meeting. The instructor should be contacted when circumstances necessitate an absence. Grading will be based on the following percentages:

Quizzes 75%
Final Exam 25%

COURSE OUTLINE:

<u>Topic</u>	<u>Reference</u>
I. Introduction	
II. Semiconductor Technology	Lenk: pp. 3-13 Hnatek: pp. 1-73 Handout
A. Basic Types of Semiconductors	
B. Design Considerations	
C. Production Techniques	
III. Practical Considerations for Integrated Circuits	
A. Packaging and Mounting IC's	Lenk: pp. 22-38
B. Temperature and Power Dissipation	Lenk: pp. 16, 43-50
C. Power Supplies	Lenk: pp. 51-60
IV. Linear Integrated Circuits	
A. Operational Amplifiers	
1. Theory of Operation	Handout
a) Differential amplifiers	Deboo & Burrous: pp. 88-94
b) Basic circuit analysis	
2. Op-amp Configurations	Handout
a) Inverting, non-inverting amplifier	Lenk: pp. 62-72
b) Voltage follower	
c) Summing amplifier	
d) Integrating amplifier	
e) Differentiating amplifier	
3. Op-amp specifications and terminology	Handout
a) open-loop, closed-loop gain	Lenk: pp. 91-106
b) Frequency response	
c) Frequency compensation	
d) Common-mode rejection	
e) Slow rate, rise time	
f) Recovery from saturation	
g) Offset voltage and current	
h) Input/output impedance	
i) Bias current	
j) Noise	

<u>Topic</u>	<u>Reference</u>
4. Linear Applications	Handout
a) Basic system design	Lenk: pp. 151-174
b) Unity gain with fast response	
c) Active filters	
d) Instrumentation amplifiers	
e) Other linear applications	
5. Non-linear Applications	
a) Peak detectors	
b) Oscillators	
c) Linear staircase and ramp generator	
d) Other non-linear applications	
6. Linear IC Packages	Lenk: pp. 189-318
a) Voltage regulators	Hnatek: pp. 330-360
b) Phase-locked loops	Deboo & Burrous: pp. 95-107
c) Dual differential comparater	
d) High frequency amplifiers	
e) Audio amplifiers	
f) Balanced modulators	
V. Digital Integrated Circuits	
A. Early Types	Deboo & Burrous: pp. 192-196
1. DCTL	
2. RTL	
3. DTL	
B. TTL Logic	Handout
	TI: pp. 23-82
C. ECL	
D. I ² L	Deboo & Burrous: pp. 200-204
E. MOS Technology	Hnatek: pp. 161-220
1. PMOS, NMOS	
2. CMOS	
3. Other MOS technologies	
F. Interfacing Logic Types	Lenk: pp. 357-388

<u>Topic</u>	<u>Reference</u>
VI. Semiconductor Memories	Handout
A. ROM	
B. RAM	
C. High Density Technologies	
1. Charge-coupled devices (CCD)	
2. Magnetic bubble memory	
3. Other technologies	
VII. Display Fundamentals	Handout
VIII. LSI and VLSI Circuits	Handout
A. Microprocessors	
B. Support Devices	
C. Microcomputers	

MCT 2850
MICROPROCESSORS

Text:

Lecture-Microprocessor Theory and Applications, by Streitmatter and Fiore; Weston

Lab - "Microcomputer Experimentation with the Intel SDK-85";
Prentice Hall, Inc.

Additional Reference:

"MCS-85 User's Manual"; Intel, Inc.

Instructor: Ken W. Renner

Work: EG&G ORTEC 482-4411 EXT 262 (Oak Ridge)

Home: 693-3891 (Knoxville) 6:30 - 11:30 PM

Prerequisites: Consent of Instructor

Course Objectives:

1. To gain an understanding of the basic architecture of microprocessors, in particular the Intel 8085.
2. To become familiar with instruction sets for various microprocessors.
3. To understand the operation of microprocessors as they relate to engineering systems design.
4. To become familiar with memory and microprocessor support chips.

Course Requirements:

Lecture material will be taken from the required text with additional material in the form of lectures and/or hand-outs and examples from other sources. Emphasis will be placed on "hands-on" experience in the lab. Each student will be responsible for completing an individual project using the SDK-85. Homework assignments will be due one week after the assignment. No late homework will be accepted since the lowest two grades will be dropped.

Grading:

Project	30%
Lab	30%
Homework	20%
Final	20%

Course Outline:

<u>Day</u>	<u>Topic</u>	<u>Chapter*</u>
March 31	Introduction to μ P's Hexadecimal Math	1,2
April 7	Intel 8085 Architecture and Instruction Set	4
April 14	Introduction to Software	5
April 21	Microprogramming Examples Assembly Level Programming	9
April 28	Digital Concepts for μ P Addr. and Data Bus Control	3 6
May 5	Input/Output	7
May 12	Memory μ P Support Chips	8
May 19	Microcomputer Applications	
May 26	Comparison of Popular μ P's	
June 2	Final Exam--Project Due	

* Chapter numbers refer to the lecture text-Microprocessor Theory and Applications.

APPENDIX E

MCT LABORATORY EXPERIMENT EXAMPLES

- MCT 2355 Computer Architecture
 - Laboratory 2: Module Familiarization
 - Laboratory 4: Signal Sampling
- MCT 2425 Peripherals II
 - Laboratory 3: Maintenance Programming
- MCT 2210 Operating Systems
 - Laboratory 2: Generating a Unique Monitor

MCT 2355
COMPUTER ARCHITECTURE
PROCESSOR

Laboratory 2

Module Familiarization

Equipment: None Required

System: 11/40

References: KD11-A Engineering Drawings
KD11-A Maintenance Manual

Objectives:

1. To become familiar with the modules contained in the KD11-A processor and the backplane configuration.
2. To locate specific devices on a module.

Procedure:

Part I

1. Identify all modules in the KD11-A processor and describe their functional components. Include module numbers in your listing.
2. Physically locate each of the modules in the processor.
3. Using the module utilization diagram, write in the module # and functional name for each module.

Part II

1. Under supervision of a lab assistant, remove the M7231 module. (Slide the board out about 2 inches, then remove the cable before removing the module completely.)
NOTE: Always make sure that power is off before removing or inserting any type of board into the backplane.
2. Locate on the board and label on the component drawing the following elements:
 - a. ALU
 - b. BA Register
 - c. B Register
 - d. D Register
 - e. B Mux
 - f. BA Mux

Be sure to include all devices which comprise each element.

3. Replace the module. Reconnect the cable making sure that the cable shielding is toward the board. Use adequate pressure but do not force the board into its backplane slot.

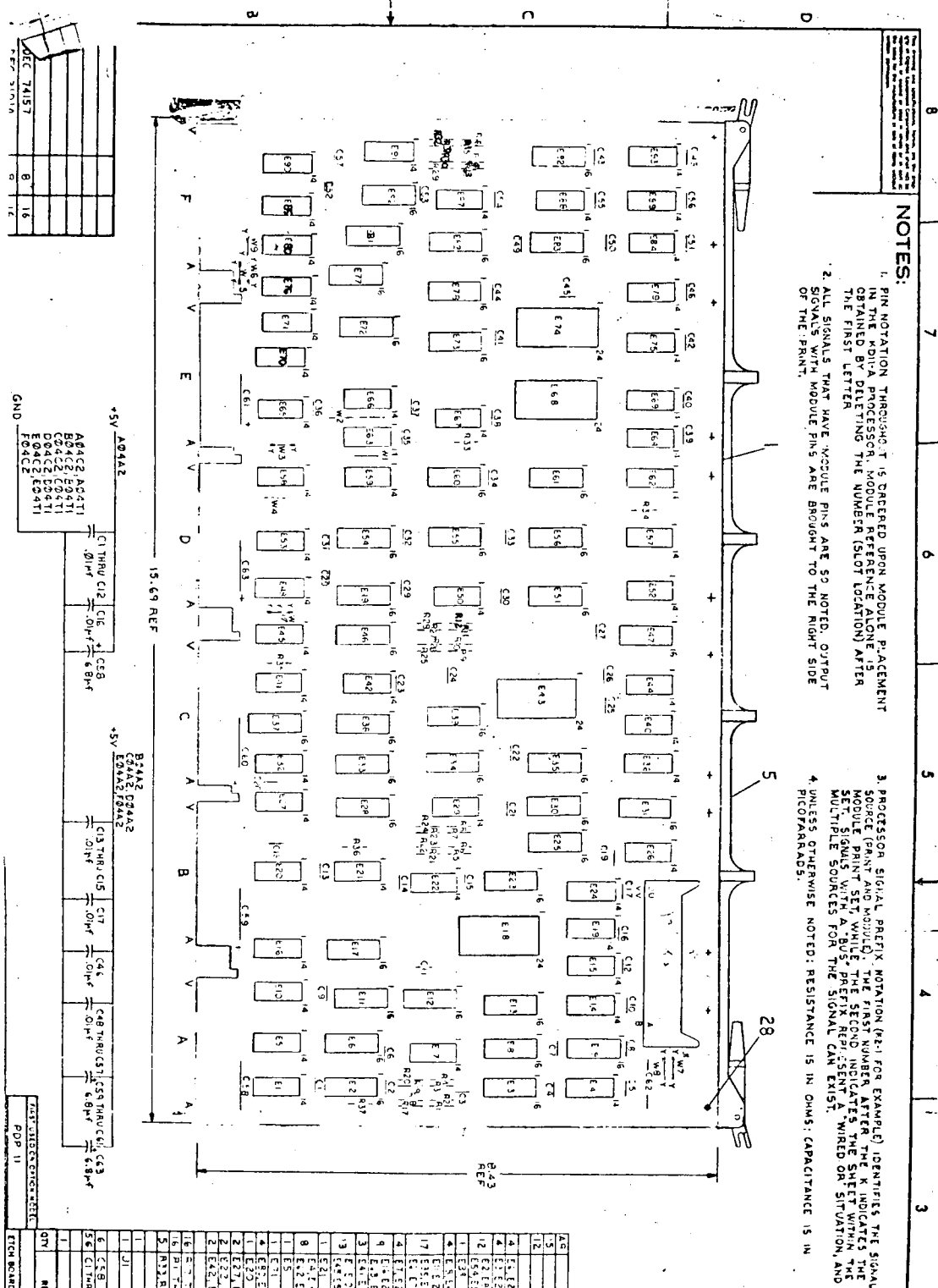
Questions:

1. Where is the KM11 Maintenance Module placed when in use.
2. Where does the cable you removed from the M7231 module go. What signals are on the lines.
3. How many slots are in the KD11-A backplane? How are backplane units connected.
4. How is the Unibus terminated. Why must this be done.

MODULE #	1	2	3	4	5	6	7	8	9
A									
DESCRIPTION									
B									
C									
D									
E									
F									

VIEW FROM WIRING SIDE

8
7
6
5
4
3
2
1



MCT 2355
COMPUTER ARCHITECTURE
PROCESSOR

Laboratory 4: Signal Sampling

Equipment: Oscilloscope
 Probes (3)

System: 11/40

References: 11/40 Engineering Drawings
 Oscilloscope Manual (if needed)

Objectives:

1. To become familiar with the backplane pin layout in order to locate selected signals
2. To be able to use the P MATCH signal to relate instruction execution and signal generation to the microprogram
3. To learn how to sample any two signals using an oscilloscope and determine the time relationship between them
4. To examine selected signals present during the execution of an instruction

Procedure:

PART I

1. Put the Sync probe on PIN E04E2 (P MATCH L) K1-9
2. Put the Scope Channel 1 probe on Pin C06B1 (BUT 37H), K5-3
3. Deposit the following program in memory:

(500)	062702	Add #307, R2
(502)	000307	307
(504)	000775	BR.-3
4. Start the program
5. Put the uaddress 04 (Flows 1) in the switch register and observe the pulse train (6-8 pulses).

The short time period is the execution time of the BRANCH instruction and the long time period is the execution of the ADD instruction.

 - a) Press A Trig View on the scope and observe both waveforms simultaneously. Draw the two signals indicating pulse width and amplitude.

Maintain A Trig in an appropriate position on the screen to us as a reference

- b) Observing the pulse train for the instructions, determine the execution time for both the ADD and BRANCH instructions. Draw a graph to illustrate.

Note: The foregoing procedure can be used to measure the time fram for any instruction.

- c) Decrease the time base (two BUT37 pulses displayed) and observe the position of BUT37 relative to the P MATCH signal. Graph the two signals on the same time axis to indicate relative timing.
6. Put 05 (Flows 2) in the Switch Register and again observe the Relative position of BUT37 to P MATCH. Graph the two signals.
 7. Put 340 (Flows 7) in the Switch Register and record the results. This time observe at least four BUT37 pulses.

Note: You should observe from steps 5 and 6 that the actual ubranch testing for BUT27 (as well as for all BUT's) occurs effectively after the uinstruction in which it is included and often appears simultaneously with the next uinstruction. This should emphasize the fact that the BUT affects the uaddress of the second u instruction following the BUT u word.

PART II

1. Connect the sync probe to PIN E04E2 (P Match), K1-9
2. Place the scope channel 1 probe on PIN A07D1 (BUS MSYN), K404
3. Place the scope channel 2 probe on PIN A07D2 (BUS SSYN), K4-6
4. Start the program from PART I
5. Put 016 in the Switch Register. With the scope in dual trace mode and with A Trig View on, observe and record the MSYN and SSYN signals (on the same time axis) and their relationship to the trigger (P Match) signal

Note: The foregoing procedure can be used to sample any two signals and determine the time relationship between them.

PART III

1. Using the maintenance display and single clocking, step through the microinstructions included in the program of PART I.
2. Record the microstates and displayed data on a uflow worksheet. Be sure to indicate the occurrence of MSYN and SSYN.
3. Verify microstates using the flows. Add to the worksheet the occurrence of DATI and CLKOFF.

PART IV

1. Use the program in PART I and the method in PART II, to determine and record the timing relationship of the following signals for the ADD instruction.

Channel 1 (ref): K5-3, BUT37 C06B1

Channel 2: K4-2, CLK IR D07C1
 K4-2, CLK D E07N2
 K4-4, BUS MSYN A07D1
 K4-6, BUS SSYN A07D2
 K1-2, SDM1 A04V2
 K1-2, SDM0 A04MI

2. Since the BUT37 occurs twice during program execution, choose a trigger signal (microstate) which will identify the ADD instruction.
3. Graph all seven signals on the same sheet and indicate with vertical divisions the microstates which are involved in the execution of the ADD instruction.

Note the relative timing of the signals involved.

Questions:

1. a) From the results of Steps 5 and 6, PART I, determine the execution time of uinstruction 04.
b) Compare this time to the clock pulse indicated for the uinstruction.
2. In Step 7, PART I, the P MATCH pulses occur during (the execution of) which instruction?
Why?
3. a) In PART II, how many bus cycles occur during the execution of the program.
b) Refer to the uinstruction flows and determine after which uinstruction the bus cycles occur.
c) What is the approximate time required for a memory read cycle?
4. Compare the number of bus cycles indicated by the worksheet to the number observed in PART II. Explain the discrepancies noted.

MCT 2420
PERIPHERALS II

Laboratory 3: Maintenance Programming

Equipment: RK05 Utility Cartridge

System: Any system with RK05 Disk Drive

References: PDP-11 Peripherals Handbook
RK05 Maintenance Manual
PDP-11 Programming Card

Objectives:

1. To learn to write code to direct a peripheral device to perform specified operations necessary for certain maintenance procedures.
2. To gain a better insight into the details of I/O programming for disk systems.

Theory:

In general, peripheral devices may be tested either on-line or off-line. For the RK05 Disk Drive, off-line testing may be done by using an RK05 Exerciser or by making a number of jumper connections in the logic assembly. Of course, one of these methods must be used if the processor is not operational. However, since an Exerciser is often not available and changing jumpers for each directive is somewhat troublesome, many technicians prefer on-line testing using simple routines to directly control drive operations for troubleshooting or for making critical adjustments. Factory diagnostics may also be used on-line when checking over-all disk system operation.

In order to write the programs for this laboratory, reference must be made to the Peripherals Handbook to determine which device registers must be utilized to accomplish the specified operations as well as the data which must be entered into these registers. This general procedure may be extended to any peripheral device. The programs developed will be needed for later laboratory exercises and will probably be useful in the field.

Procedure:

Part I

1. Write and code a program which will cause the heads to perform an oscillating seek (heads continuously seek a specified cylinder address and then return to cylinder zero). The cylinder seek range should be specified through the Switch Register. Allowance should be made so that a restore operation (RTZ) can also be specified.

2. Obtain a utility cartridge from a lab assistant. Extend the drive forward and remove the top cover. With system power on, insert the cartridge into the drive and press the LOAD switch. If the heads do not load properly, notify a lab assistant immediately.
3. Enter the program into the computer. Test the program by performing the following oscillating seeks:
 - a) 4 cylinder
 - b) 64 cylinder
 - c) 202 cylinder
 - d) Restore (RTZ)Note the differences between the seek times for various seek distances.

Part II

1. Write and code a program which will cause the heads to perform a direct cylinder seek. The desired cylinder address should be specified through the Switch Register.
2. Using the same utility cartridge, test the program by seeking the following cylinder addresses:
 - a) 5
 - b) 85
 - c) 105
 - d) 202Verify the seek operation by reading the cylinder address using the vernier scale on the carriage assembly. (See p. 5-22, RK05 Maintenance Manual.)

Questions:

1. Having noted the time required for seek operations, especially for the longer seeks, discuss the considerations which should be made in the software for an RK05 device handler to reduce data transfer time.
2. What areas might be suspect as faulty if the heads do not seek to the proper address?

MCT 2210
OPERATING SYSTEMS

LAB II: Generating a Unique Monitor

I. Introduction

Most users can use the RT-11 system components as distributed and should do so unless unique requirements dictate that a tailored operating system be generated. However, for a knowledgeable user, the system generation procedure allows for the specification of parameters so that the operating system conforms more precisely to the needs of the user and the structure of the hardware system.

The RT-11 system generation procedure enables you to customize the monitor and the device handlers. Options available fall basically into two categories: 1) which services to include in the monitor and 2) which peripherals to support in the resulting system. The dialog also allows you to specify peculiarities of the hardware configuration on which the resulting system runs.

II. The SYSGEN Process

The system generation process consists of three basic steps: the planning necessary to determine the desired configuration; execution of the SYSGEN program and command files; and the actual assembling and linking of the system using the SYSGEN program output.

A. Planning

Prior to running the SYSGEN program you must have some preliminary information:

1. A list of the peripheral devices on the target hardware system
2. The CSR and vector addresses for the peripheral interfaces
3. A list of the monitor services required

You should also have read the SYSGEN dialog given in the handout and understand the questions as well as the implications of the responses.

B. Execution of SYSGEN Program

Your responses to the SYSGEN program allow it to construct five output files. The first two are the conditional files that are assembled with the standard monitor components to generate the customized system. The last three are indirect command files which are used to assemble and link the desired system. Due to this file creation, there must be sufficient room on your disk (roughly 2000 blocks)

C. Assembly and Linking of the System

Once you generate the conditional and command files using SYSGEN, you must then use these files to assemble and link the new monitor and device handlers. The system source files needed are on you disk.

III. Procedure

The system generated will be a single job monitor configured to run on the 11/40 system.

A. Planning

The planning phase will be covered in class, and the particular responses listed in the handout.

B. Run SYSGEN

1. Mount your disk in drive 2 and boot from RK1: (leave both drives unprotected) set DATE
2. Type `.R SYSTEM` (you may elect not to run the long form of the dialog since you already have a copy of it)
3. Respond to the questions with the appropriate pre-determined answers
4. After SYSGEN finishes, copy the conditional files SYCND.MAC and SYSTBL.MAC from RK1: to RK2:

C. Assemble and Link Your System

1. Type `.@SYSBLD` (This is a command file which assembles and links the monitor. It takes a long time to execute.)
2. The system will type out each command as it executes it. (See handout)
3. Get a brief directory of your disk. Note the new .SYG files

D. Restructure your Disk

1. Rename all SYG files to SYS
2. Delete: a) all .MAC files except DEMO\$\$
b) all .OBJ files
c) all files starting with SYS (e.g.: SYSGEN, SYSMAC, etc.)
d) all .COM files with today's date
3. Squeeze your disk
4. Boot your disk
When the new SJ monitor comes up it should indicate that it is a generated version with "(S)". You have now created your own operating system

APPENDIX F

MCT LABORATORY SYSTEMS

- I. Systems 1 and 2: General Studies
 - A. PDP 11/05 Processor with 16kw Core Memory
 - B. PC-11 Paper Tape Reader/Punch
 - C. RK11 Dual Cartridge Disk Drive (RK05F, RK05J) and Controller
 - D. LA36 Writer Terminal (hardcopy)

- II. System 3: Hardware Studies
 - A. PDP 11/40 Processor with 32kw Core Memory
 - B. PC-11 Paper Tape Reader/Punch
 - C. RK11 Dual Cartridge Disk Drive (RK05J) and Controller
 - D. RX01 Floppy Disk System
 - E. TME11 Magnetic Tape Drive (9 track) and Controller
 - F. LA36 DEC Writer II Terminal
 - G. RT11 Operating System

- III. System 4: Software Studies
 - A. PDP 11/04 Processor with 32kw MOS Memory
 - B. RX02 Dual Floppy Disk Drive and Controller
 - C. LA120 Terminal
 - D. LA36 Terminals (2)
 - E. VT100 Video Terminal
 - F. RT11 Operating System

*NOTE: DEC equipment is utilized primarily because of the multi-faceted contribution program established between RSCC and DEC. The equipment was purchased far below list price.

APPENDIX G

MCT ADVISORY COMMITTEE
1980/81

Mr. Bob Spence
Manager
Minicomputer Technology Program
Educational Services
Digital Equipment Corporation

Mr. Mich Gorka
Regional Training Representative
Minicomputer Technology Program
Educational Services
Digital Equipment Corporation

Mr. Wally Novak
Branch Manager
Field Service
Digital Equipment Corporation

Mr. Lew Hall
Manager
Field Engineering Division
IBM

Mr. Ken Renner
Development Engineer
Fast Circuits Group
EG & G ORTEC

Mr. Phil Cole
Customer Service
Physical Sciences Group
EG & G ORTEC

Dr. R. E. Bodenheimer
Professor
Electrical Engineering Department
The University of Tennessee

APPENDIX H

LETTERS

Placement Letter

Recruitment Letter

Graduate Evaluation Letter



ROANE STATE COMMUNITY COLLEGE
HARRIMAN, TN 37748 (615) 354-3000

Digital Equipment Corporation
9041 Executive Park Drive
Knoxville, Tennessee 37923

Dear Personnel Director:

Roane State Community College is proud to announce the forthcoming graduation of the first class of students to complete the requirements for the Associate of Science Degree in Mini/Microcomputer Technology (ASMCT). The MCT program at Roane State, already recognized as one of the finest computer technology programs in the country, is based on an effective combination of classroom theory and hands-on training utilizing the extensive mini-computer facilities within the program. These facilities include fully operational PDP-11 minicomputer systems comprised of a variety of peripheral devices and options such as hard and floppy disks, magtape, paper tape, hardcopy and video terminals, real time operating systems with Basic and Macro, and various communications options.

In addition to basic electronics, integrated circuits, pulse and switching circuits, and digital logic, the curriculum contains courses in computer architecture, peripheral devices, operating systems, programming languages, interfacing design, and microprocessors. Design considerations, operational characteristics, and troubleshooting techniques are the major areas focussed upon. Each student has also completed a period of practical work experience with one of several local computer based companies. Mathematics, humanities and social science round out the curriculum.

It is the desire of Roane State to facilitate the recruitment process for your company and to assist the graduating student in securing a challenging position in the fast-paced computer industry. To this end, we have set aside two days, May 20 and 21, when these students will be available on campus for interview sessions with company representatives. If you feel that there might be a position within your company for a person trained in the aforementioned technical areas, please contact the school at 354-3000, ext. 294, so that we may schedule the interviews.

We will be glad to provide any data concerning the students or the program which would be of interest to you prior to the interviews. Also, if an interview session is not possible or practical at this time, please let us know in what manner we can be of assistance in this extremely important area.

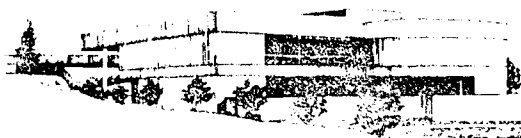
Thank you for your time and cooperation.

Yours truly,

A handwritten signature in cursive script, reading "David G. Sweet".

David G. Sweet, Director
Mini/Microcomputer Technology

DGS:MLB



**ROANE STATE
COMMUNITY
COLLEGE** HARRIMAN,
TN 37748
(615) 354-3000

September 6, 1978

Darryl Robertson
104 North Kingston Avenue
Rockwood, Tennessee 37854

Dear Darryl:

It has been brought to my attention that you have expressed an interest in our new Mini/Microcomputer Service Technology program. We at Roane State are very proud of this program and the fact that we were chosen by the world's leader in minicomputers, Digital Equipment Corporation, as a school to which they will provide support and assistance. The computer industry has recognized an urgent need for well-trained computer technicians, a need which can no longer be satisfied with in-house training programs. This demand for computer technicians, especially in the computer service area, is certainly to be expected when you consider the explosive and apparently limitless growth of the computer industry.

If you feel that you would like to be a part of this ever-expanding industry, abounding in opportunity, it is important for you to take a close look at our Mini/Microcomputer Service Technology program. We will start you off with very basic courses in computers and electronics, assuming little or no background in these areas, and take you through seven quarters of carefully designed curriculum with much time being spent actually working on computer processors, video terminals, line printers, disk drives, and other components found in modern computer systems. No other school in the southeast can offer such high level technical training.

Other additional features of the program include field service work experience for second-year students, talks by industry representatives on career opportunities, a placement program for recruitment of graduates and an advisory committee comprised of personnel from the computer industry to ensure that the program maintains an awareness of the developments in computers and incorporates them into the curriculum.

If this brief description of our new program has stirred any interest or brought to mind some questions, whether you are looking for a full degree program or just a few courses to upgrade your technical abilities, please contact the Career Education Division at Roane State. I will be more than happy to send you additional information or set up a time when I may talk to you personally. I look forward to hearing from you.

Yours truly,

David G. Sweet
Mini/Microcomputer Technology

DAS:MLB

digital

30 October 80

Roane State Community College
Harriman, TN 37784

Dear Mr. Sweet:

My letter and those enclosed are intended as a follow-up to employment of four (4) of your graduates. It has been a real pleasure to see these young men come into the business world so well prepared.

As Branch Personnel Manager, I am always concerned when we hire a new graduate, untested and making their first move away from home. Overall this concern has been diminished by the maturity and level of expertise demonstrated by your graduates, and I look forward to meeting your next class.

You are to be commended for your course content, dedication to excellence and being, in my opinion, the leader in Computer Technology instruction.

Sincerely,

DIGITAL EQUIPMENT CORPORATION



William O'Neal
Branch Personnel Manager
Charlotte District

WO/jmh

Enclosures

DIGITAL EQUIPMENT CORPORATION, SUITE 80, 5445 SEVENTY-SEVEN CENTER DRIVE
CHARLOTTE, NORTH CAROLINA 28210
704-525-7150



30 October 80

Roane State Community College
Harriman, TN 37748

Dear David:

I would like to take this opportunity to comment on the Mini/Microcomputer Technology program at Roane State Community College.

David Myers, a May graduate, started work for me July of this year. After working with him for three months, and observing his work, I have been very pleased with his performance. Specifically, I would like to comment on the following items:

- Knowledge of basic electronics, digital logic and circuitry based on the curriculum at Roane State is very in depth and state of the art.
- Comprehension of system concepts and interfacing is very extensive.
- Understanding of programming languages and software is well above average.
- Hands on experience from the summer work period obviously reinforced classroom material presenting a well rounded program.

The list could become quite lengthy, but the above items are of utmost importance to technical competence, as well as, customer satisfaction.

I realize these comments are related specifically to David's performance, but that could only result from the program you have at Roane State. The curriculum has obviously been well planned to help meet the ever increasing needs of the computer industry.

I wish you continued success and look forward to seeing additional graduates. If I may ever be of assistance to you, please do not hesitate to call.

DIGITAL EQUIPMENT CORPORATION, SUITE 80, 5445 SEVENTY-SEVEN CENTER DRIVE
CHARLOTTE, NORTH CAROLINA 28210
704-525-7150

Roane State
30 Oct 80
-2-

Sincerely,

DIGITAL EQUIPMENT CORPORATION

A handwritten signature in cursive script that reads "Bill Thompson".

Bill Thompson
Field Service Unit Manager
Charlotte District

BT/jmh

DIGITAL EQUIPMENT CORPORATION

digital

October 22, 1980

Dear Mr. Sweet:

In May I had the pleasure of interviewing your minicomputer tech graduates for a position with Digital Equipment.

I was amazed with their technical knowledge and understanding of computer systems. Listed below are some items that impressed me.

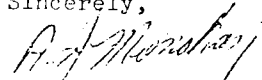
1. They were well educated in the field of electronics.
2. They understood computer systems.
3. They had a basic software knowledge.
4. Your course design covers our industry and equipment well.
5. They came to the interview with all material needed for a well rounded interview.

May I say thank you for the fine job you are doing in educating people for the computer industry, and for the employee's we have hired from your school. As you know, we hired four of the five graduates and they are all working with minimal training on Digital's part.

John Carow is working in Richmond for me and doing an outstanding job. I sent him to a couple of specialized courses at our training center and since his return he has been handling all his assigned accounts without any problems.

Again I say thank you for your graduates.

Sincerely,



A. J. Monahan
Field Service Unit Manager

AJM/dt

DIGITAL EQUIPMENT CORPORATION, 2720 ENTERPRISE PKWY, SUITE 210, RICHMOND, VIRGINIA 23229
804-747-1300

VITA

David Gordon Sweet was born in Charlotte, North Carolina, on May 25, 1951. After one year of elementary school, he moved to Atlanta, Georgia, where he completed his elementary and high school education, graduating from Sandy Springs High School in 1969. The following September he entered the University of Tennessee from where, after interim studies at Georgia Institute of Technology and Southern Technology Institute, he received a Bachelor of Science Degree in Electrical Engineering in March 1974.

From May 1974 to February 1975, Mr. Sweet was employed by Texas Instruments Incorporated, Dallas, Texas, in the capacity of process engineer, Semiconductor Division. In March 1975 he accepted a teaching assistantship at the University of Tennessee and began study toward a Master's Degree. He then served as a research assistant from September 1975 to August 1975 at which time he became employed as a faculty member at Roane State Community College. Mr. Sweet currently maintains the position of Assistant Professor and Director of the Mini/Microcomputer Technology Program.

He resides in West Knoxville with his two children.