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ABSTRACT

This guide describes Energy Conservation-and-Use Technology (ECUT), identifies job categories for technicians working in the field, and assists planners, administrators, faculty, and industrial and community educators in establishing and conducting relevant training programs. Section 1 defines the ECU technicians, provides a job description, and describes ECUT job performance requirements. A model ECUT curriculum plan is provied in section 2. Content is analyzed and course descriptions are presented. Other topics covered are content and format of instructional materials and adaptation for use in cooperative and continuing education. Program planning and development is the focus of section 3. These considerations are explored: establishment of advisory committee, needs determination, faculty selection, library, equipment, student selection and services, and laboratory facilities. Section 4 overviews program implementation and evaluation. Appendixes, amounting to almost three-fourths of the guide, include types of equipment with which ECU technicians work, ECUT curriculum (semester system), 23 ECUT course outlines (with descriptions and module titles and time required), survey-of-needs questionnaire, library references and periodicals, and equipment list for ECUT curriculum by course. (YLB)

CURRICULUM FOR ENERGY-CONSERVATION-AND-USE TECHNICIANS

Program Planning Guide

Contract No. 300780551
Project No. 498AH80027

Daniel M. Hull
Project Director

TECHNICAL EDUCATION RESEARCH CENTER – SOUTHWEST/
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OFFICE OF VOCATIONAL AND ADULT EDUCATION

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CORD

CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

FOREWORD

A careful examination of the aggregate technology associated with current and future energy production, utilization, and conservation leads to the following conclusions:

- Energy-related technical occupations require knowledge and experience in using complex equipment incorporating two or more fields of technical expertise.
- The technical aspects (principles and equipment) of energy occupations are changing dramatically and will continue to change over the next several decades.

A technically broad-based, interdisciplinary curriculum has been developed and tested for use by two-year postsecondary institutions to prepare technicians for work in energy-related fields. To support the curriculum, 124 instructional modules have been developed for 16 of the courses. These modules are also useful for retraining employed technicians and for energy-awareness courses at high schools and in community education.

The purpose of this Guide is to describe Energy Conservation-and-Use Technology, identify job categories for technicians working in the field, and to assist planners, administrators, faculty, and industrial and community educators in establishing and conducting relevant training programs.

The Guide provides a model curriculum plan and suggests methods for adapting the modular materials to curricula tailored to specific localities or employer needs. Also included is information about educational facilities, equipment, staffing, and instructional materials needed for training technicians in this field.

Funds for this project were provided under contract from the United States Department of Education, Office of Vocational and Adult Education, Division of National Vocational Programs; Curriculum and Instruction Branch.

ACKNOWLEDGMENTS

The staff of the Center for Occupational Research and Development wishes specifically to acknowledge the valuable contributions made to this project by the National Project Advisory Committee. This group, listed in Appendix A, consisted of educators and employers of technicians working in utility companies, research and development establishments, processing plants, and equipment manufacturing plants, and as operators of hotel, motel, apartment, school, and hospital facilities. This group provided guidance and encouragement to the project and specific job/task information used in the curriculum design.

Also, a special thanks is due to the four field-test sites that implemented and evaluated this new curriculum and displayed patience and consideration with CORD's project staff.

- Horry-Georgetown Technical College, South Carolina
  Mr. Wade Harper - ECUT Coordinator
- Marshalltown Community College, Iowa
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- Red Wing Area Vocational Technical Institute, Minnesota
  Ms. Pat Enz - ECUT Coordinator
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I. ENERGY TECHNOLOGY

In the recent decade of the 1970s, alarming shortages and escalating costs of energy emerged as a problem of national concern. Consumers asked "How can I keep utility bills down?" Business and industry speculated on the availability and cost of future energy resources. Research establishments laid plans to develop alternatives to petroleum as a fuel. Electric power plants began converting buildings and equipment to take advantage of other fuels.

In this setting, energy technology has evolved to what it is today — a very broad, technical discipline encompassing the production, conservation and utilization of energy, and research and development related to these areas. With the evolution of energy technology there has evolved also a need for technicians with employable skills and knowledge in the energy-related technologies. For the purpose of this Guide, these technicians will be designated Energy Conservation-and-Use Technicians, or ECUTs.

DEFINITION OF ENERGY CONSERVATION-AND-USE TECHNICIAN

Prior to considering an Energy Conservation-and-Use Technician curriculum, it is necessary to define the technician. The first step in this definition is to identify fields in which such a technician might be employed, e.g.:

- Energy-related research and development.
- Energy production (electric power plants, solar collections, etc.).
- Energy use (factories, buildings, equipment, etc.).
- Energy conservation (audits, construction techniques, retrofits, etc.).

Similarly, functions performed by such a technician should be identified, e.g.:

- Provide direct support to engineers/scientists.
- Operate and/or maintain mechanical, electrical/electronic, electromechanical or more complex equipment or systems.
- Perform building "operating engineer services (operations and maintenance of building HVAC, electrical, and mechanical systems.
- Perform systems operational tests and analyses.
- Perform energy-use audits.
- Perform energy conservation technical services: construction, retrofits,

load balancing, etc.

• Install and monitor equipment.

Based on the criteria noted above, a very general definition of an Energy Conservation-and-Use Technician can be formulated:

> A systems-oriented worker who possesses a combination of skills and abilities and can apply this interdisciplinary capability in jobs to develop, construct, test, operate, maintain, and/or install modern equipment used in homes, businesses, institutions, factories, and other installations. Typically, this equipment consists of systems utilizing combinations of mechanical, electrical, thermal, fluid, and/or optical components, and frequently these systems are controlled by electronic computers or microprocessors.

The energy technician can apply these skills in a variety of tasks to develop, construct, test, install, operate, and maintain today's modern equipment in the energy and energy-related technologies. The equipment used on today's industry, business, and home has become more complex. Such equipment may consist of systems and subsystems of mechanical, electrical, thermal, hydraulic, and optical components. Moreover, these systems are controlled frequently by electronic computers and microprocessors. In addition to the technical specialists who are currently practicing in our country's workforce, a growing need exists for systems-oriented technicians who are capable of understanding the diversity of components that exist in modern equipment and the interrelationship between these components.

The equipment associated specifically with energy-related technologies — those technologies dedicated to the production, utilization, and conservation of energy — is typical of today's modern, complex equipment. Such equipment may contain electric motors, heaters, lamps, electronic controls, mechanical drives and linkages, thermal systems for cooling and drying, lubricants, optical or microwave systems and communication links, pneumatic and hydraulic drives, pneumatic controls and, in some instances, even nuclear radioactive samples and counters. If energy technicians are to work effectively with modern equipment of this type, they must have an understanding of the underlying technical disciplines — mechanical, electrical, thermal, hydraulic, and optical — and their interrelationships.

JOB DESCRIPTIONS

Because the ECUT can work for such a wide variety of employers, the job definition in the previous section is very general and not particularly useful. A degree of specificity can be made, however, if job descriptions are presented according to each of the four major areas of energy use and conservation.

A. Energy-Related Research and Development

1. Employers: Research and development organizations within institutions, private industry, government, and the military.
2. Job Description: Under the direction of an engineer, physicist, chemist, or metallurgist, the technician will design, construct, and operate breadboards or laboratory experiments involving complex physical phenomena and equipment, perform tests and measurements on system performance, document results in reports and/or laboratory notebooks, and perform periodic maintenance and repair of equipment. Test data frequently will be acquired and reduced via interfaces with laboratory microcomputers. The technician will frequently supervise other workers.

B. Energy Production

1. Employers: Power plants, solar energy equipment manufacturers, installers and users; process plants that use high-temperature heat, steam or hot water.
2. Job Description: Develops, installs, operates, maintains, modifies, and repairs systems and devices used for the conversion of fuels and other resources into useful energy. Systems may be furnaces or plants to produce hot water, steam, mechanical motion, or electrical power. Typical systems, which include furnaces, electrical power plants, and solar heating systems, may be controlled manually, by semiautomated control panel, or computer. The technician will frequently supervise other workers.

C. Energy Use

1. Employers: Production line equipment maintenance; building and/or plant equipment maintenance; maintenance departments of hospitals, apartments, hotels/motels, office buildings, schools, churches, shopping centers and restaurants.

2. Job Description: Installs, operates, maintains, repairs, and modifies complex electromechanical, thermal, fluid, and optical systems used in production lines and for climate control and hot-water supply in hospitals, apartments, hotels/motels, office buildings, schools, churches, shopping centers, and restaurants. This type of equipment may be automatically controlled with microcomputers. The technician will frequently supervise other workers.

D. Energy Conservation

1. Employers: Consulting engineers, energy audit firms, residential and commercial energy audit departments of public utility companies, municipal governments, architects, builders, and HVAC equipment manufacturers' representatives and sales outlets.

2. Job Description: The ECUT typically would work on a team led by an engineer, performing the following activities: determine specifications for new-building construction, modifications, and retrofits (equipment, structures, and installation); use instruments and procedures, and perform calculations, to measure energy use and efficiency of components and systems (which may provide support to the building or activities within it); perform audits of energy use and management, including economic cost-versus-benefits analyses; through written document or oral presentations, recommend building retrofits and/or changes in equipment to achieve energy savings. The technician will frequently supervise other workers.

Some of the jobs for Energy Conservation-and-Use Technicians may be identified with employers under the following job titles:

- Technician
- System Technician
- Instrumentation and Control Technician
- Electromechanical Technician
- Plant Operator
- Control Room Operator
- Operating Engineer
- Building Maintenance Technician
- Energy Conservation Technician
- Energy Management Technician
- Production Equipment Technician
- Building Operating Equipment Technician
- Energy Audit Technician
- Laboratory Technician

NATIONAL WORKFORCE REQUIREMENTS

The need for ECUTs is rapidly expanding. Dr. Moore of the Baylor University Hankamer School of Business conducted a national assessment of employer needs for Energy Conservation-and-Use Technicians. Nine hundred eighty-six employers throughout the nation were surveyed as to future needs for technicians in energy-related fields. These employers can be grouped into the following nine categories: 1) research and development organizations, 2) utilities companies, 3) manufacturing plants, 4) processing plants, 5) hotels/motels/apartments, 6) office and business building managers, 7) schools/hospitals, 8) architectural and construction firms, and 9) consulting engineers.

The survey provided data relative to needs within their total workforce for employees engaged in "planned energy use and/or applying energy conservation methods" in specified areas such as heating, cooling, and lighting. The results of Moore's survey showed average annual need for new "energy technicians" for the decade to be 7,352, with the total need for the same ten-year period being 73,520.

ECUT JOB PERFORMANCE REQUIREMENTS

Because of the breadth of jobs available to ECUTs, a single list of tasks and required knowledge for successful job performance is almost limitless, and impossible to describe succinctly. However, to assist in designing the model curricula, an inquiry on job tasks was made to selected employers serving on the National Advisory Committee. Nine members provided sufficient information to form a collective profile of tasks:

- Sandia Corporation (Energy R & D)
- Dallas Power and Light (Energy Conservation)
- Holiday Inns of America (Energy Use)
- Cities Service Corporation (Energy Production)
- Los Alamos National Laboratory (Energy R & D)
- Scott and White Memorial Hospital (Energy Use)
- Trammel Crow Office Building Management (Energy Use)
- Vought Corporation (Energy Conservation)
- ASHRAE Education Committee Representative

The useful data obtained from the inquiry pertained to the types of equipment with which ECUTs would work and the nature (or scope) of work they would perform.

Equipment

The graph shown in Figure 1 represents the equipment or subject areas that were considered important by employers of energy technicians. A listing of important equipment within each category is shown in Appendix B. The percentages assigned to each category in the graph represent the average of the items of equipment identified by each employer compared to the total number of equipment items in that category. The nearly uniform distribution through the nine categories indicates the breadth of technical competencies required for ECUTs.

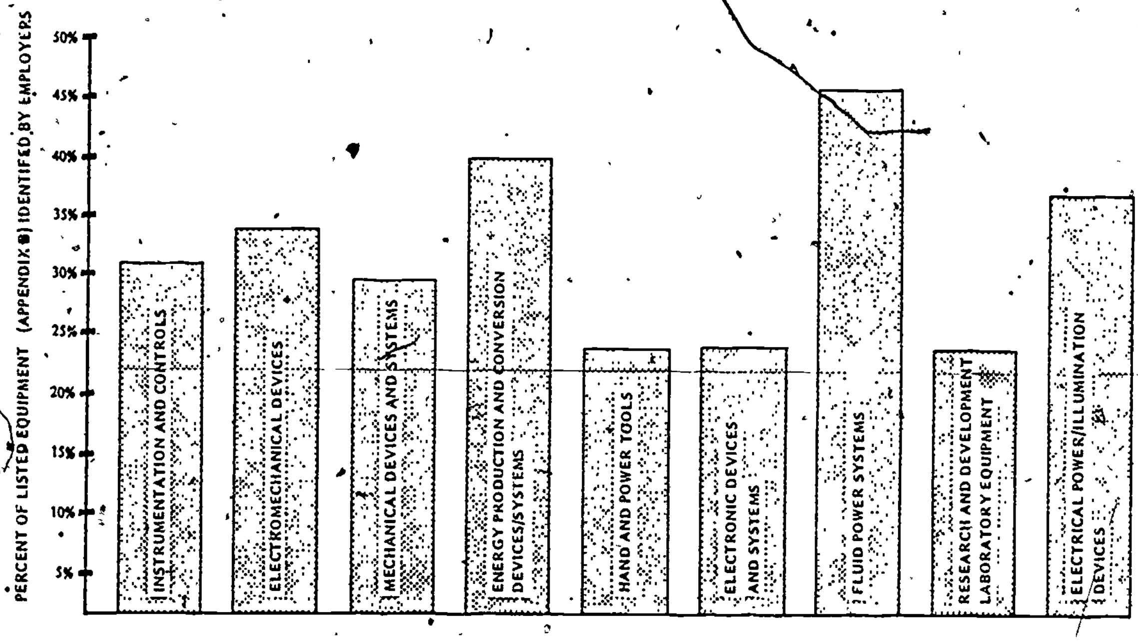

Figure 1. ECUTs work with equipment in these technical categories.

Tasks

Employers were asked how frequently ECUTs work with the equipment listed in Appendix B. They weighted their responses accordingly: never -

0; infrequently (once per month or less) - 1; occasionally (once per week) - 2; frequently (daily) - 3 points. The graph shown in Figure 2 illustrates the specific tasks or job skills that are required for ECUTs to perform on various types of equipment.

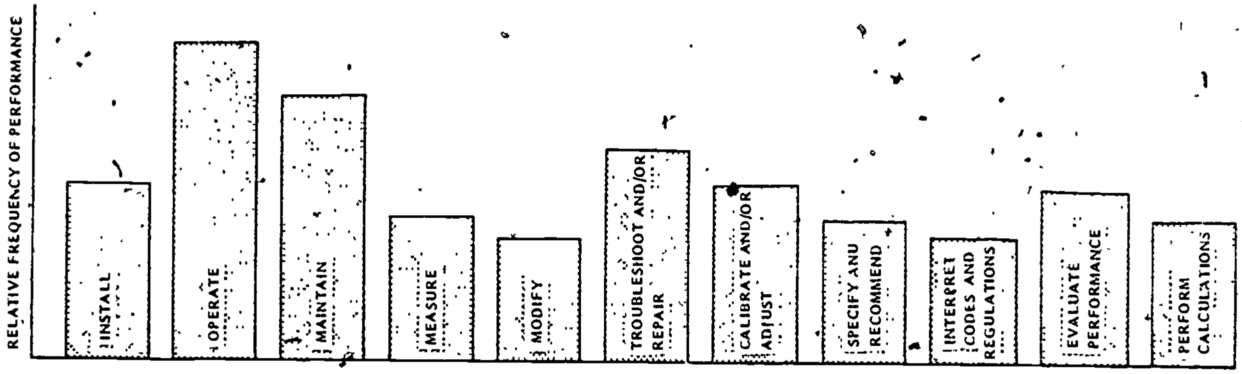

Figure 2.
What types of tasks do ECUTs perform?

Communications Skills

Not included in either of these two graphs are the communications job skills emphasized by employers, such as:

Verbal --The ECUT must be able to communicate not only with other technical persons, but also nontechnical persons such as business persons, operators, and maintenance mechanics, and the general public.

Written - ECUTs must be able to write letters, specifications, and reports, and maintain laboratory notebooks. They must also be able to make simple equipment and fabrication sketches and schematics, and be able to read and interpret complex schematics, blueprints, and instruction manuals.

The curriculum described in the following section reflects the need to provide a broad, interdisciplinary technical core with not only sufficient specialization for immediate job entry skills, but also a base to learn, after employment, new principles and skills as the technology changes.

II. CURRICULUM

The ECUT curriculum represents a major innovation in technician curriculum design for the 1980s. It reflects the need for technicians to have an interdisciplinary technical base (electrical, mechanical, thermal, and fluidal principles) and the recent desire and willingness by employers to provide additional specialization or retraining for their employees as the need arises.

ANALYZING THE CONTENT

A technically broad-based curriculum such as the ECUT contains four types of courses, which can be grouped accordingly:

Support courses
Principles courses
Devices courses
Systems courses

These groupings are shown graphically in Figure 3.

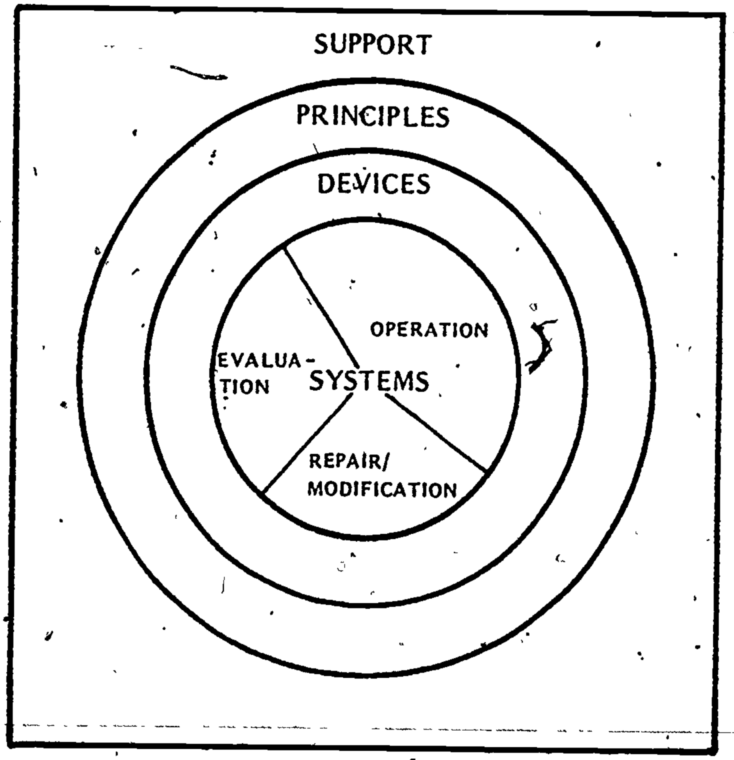

Figure 3.

To understand the interrelationship of these four types of courses in such a "systems-oriented" curriculum, one should examine the technical content and/or courses required for job performance in each of the four categories of ECUTs described in Chapter I. Diagrams showing these relationships for four example job requirements are presented in Figures 4 through 7.

As an example, study the sequence of content in Figure 4. The major job

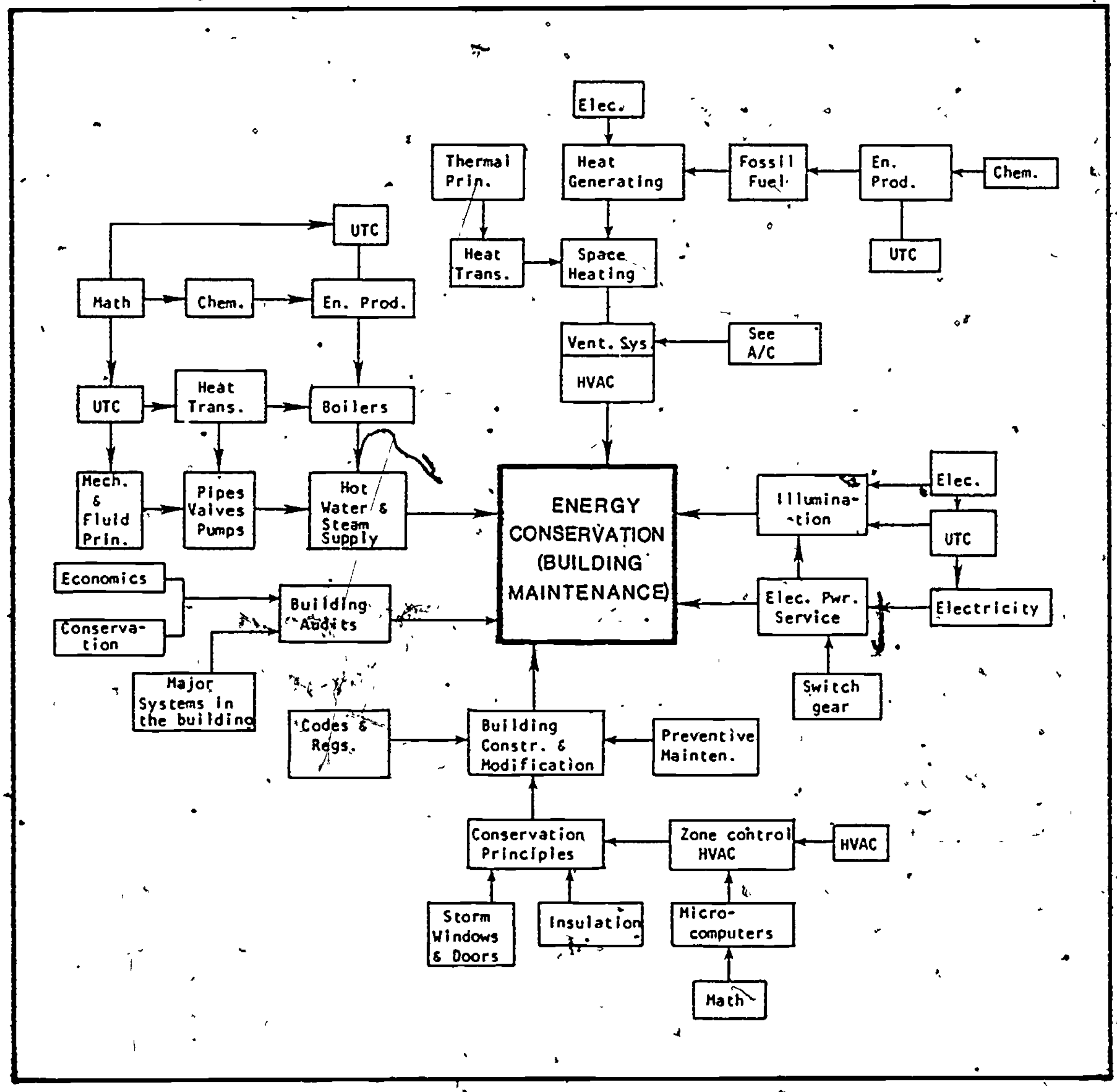

Figure 4. Technical content/course for Energy Conservation (Building Maintenance) Technician job requirements.

requirement is energy conservation related to building maintenance (shown in the bold block). One system included in building maintenance might be the hot water and steam supply system (located left of center). To understand, operate, and maintain this system requires knowledge and skills of devices such as boilers, pipes, valves, and pumps. An understanding of these devices requires knowledge of principles of heat transfer, mechanics and fluids, energy production systems, and unified technical concepts (physics). These principles can only be learned if one possesses skills in support courses such as chemistry and math. Careful study of each diagram (Figures 4-7) should aid in understanding more clearly why the various courses are included in the ECUT curriculum.

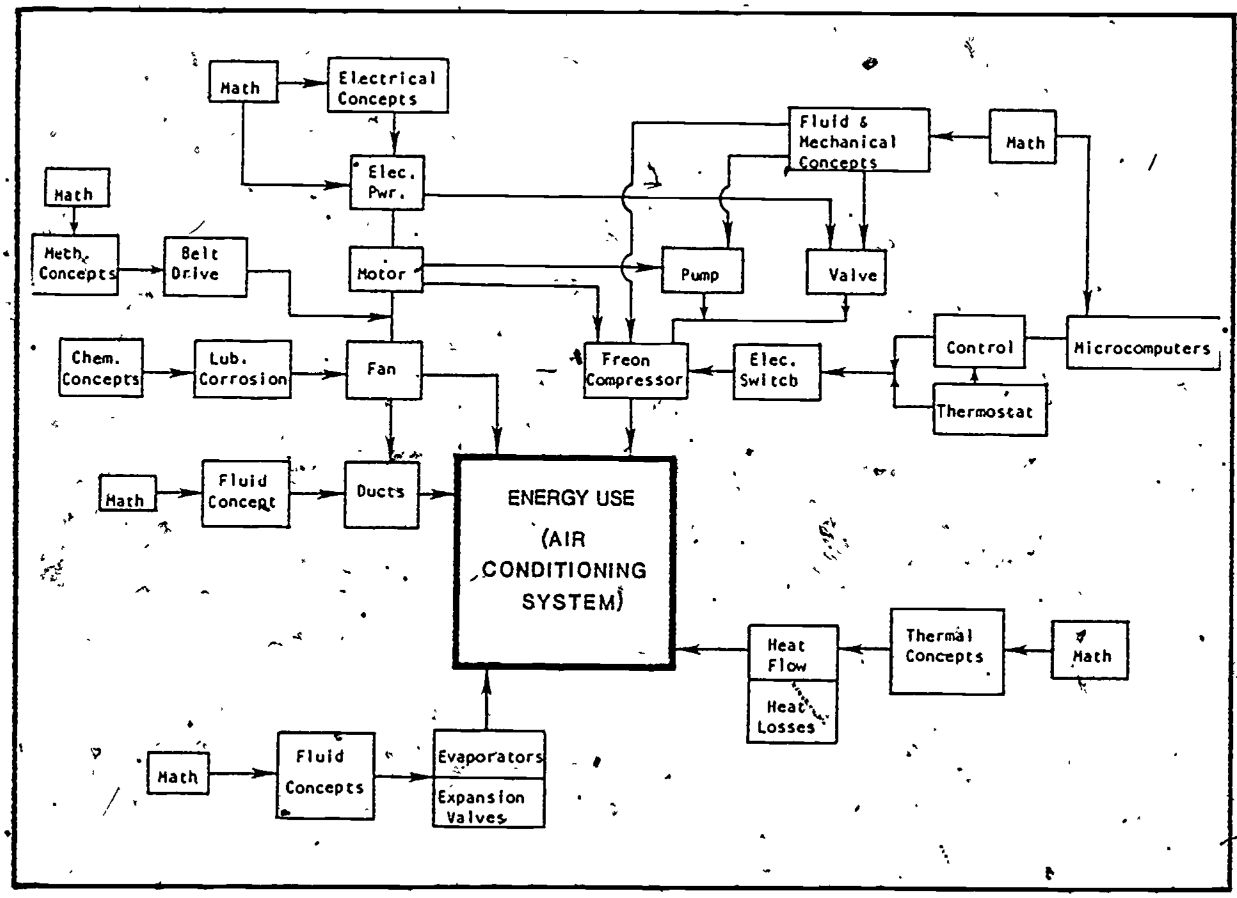

Figure 5. Technical content/courses for Energy Use (Air Conditioning System) Technician job requirements.

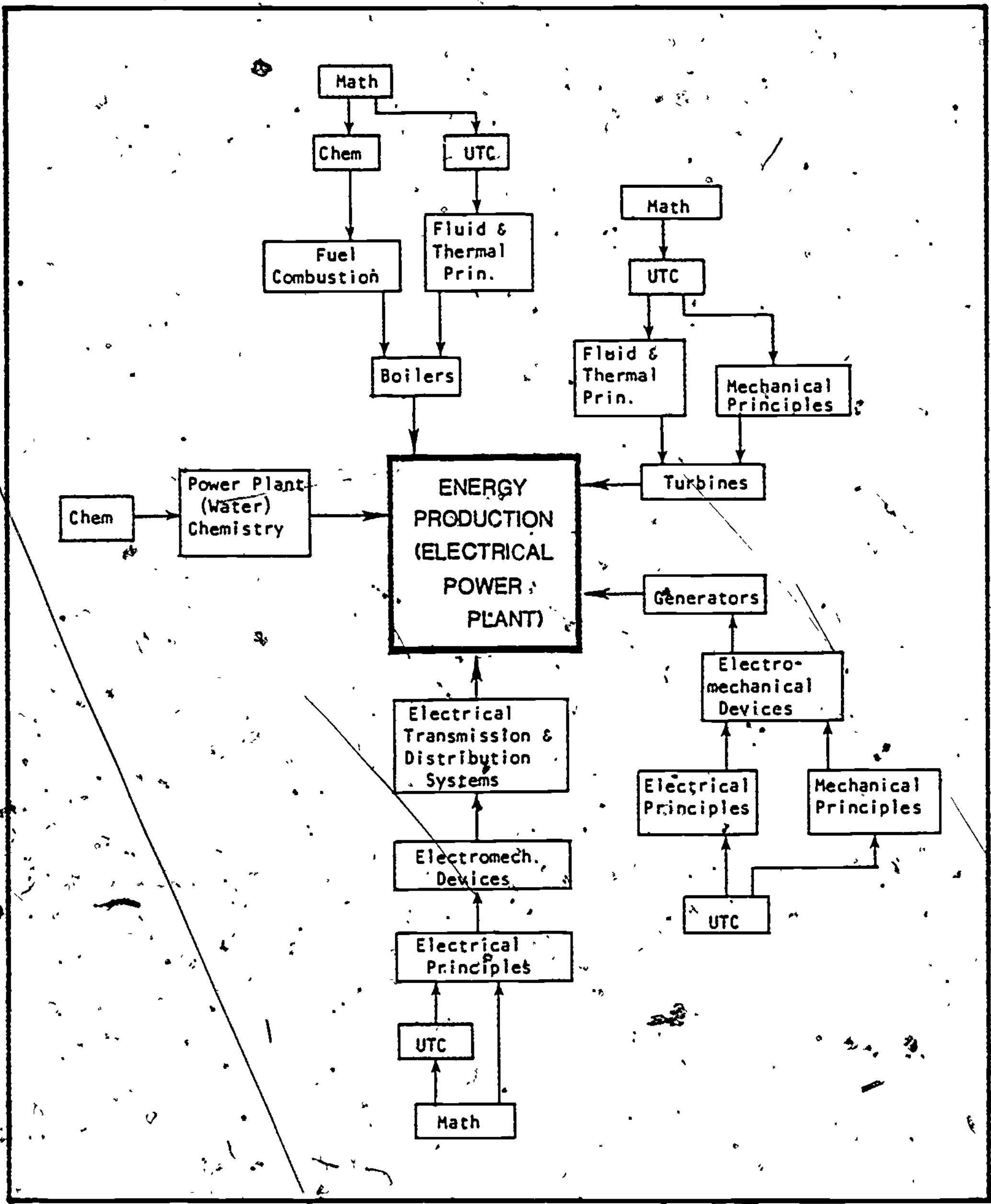

Figure 6. Technical content/courses for Energy Production (Electrical Power Plant) Technician job requirements.

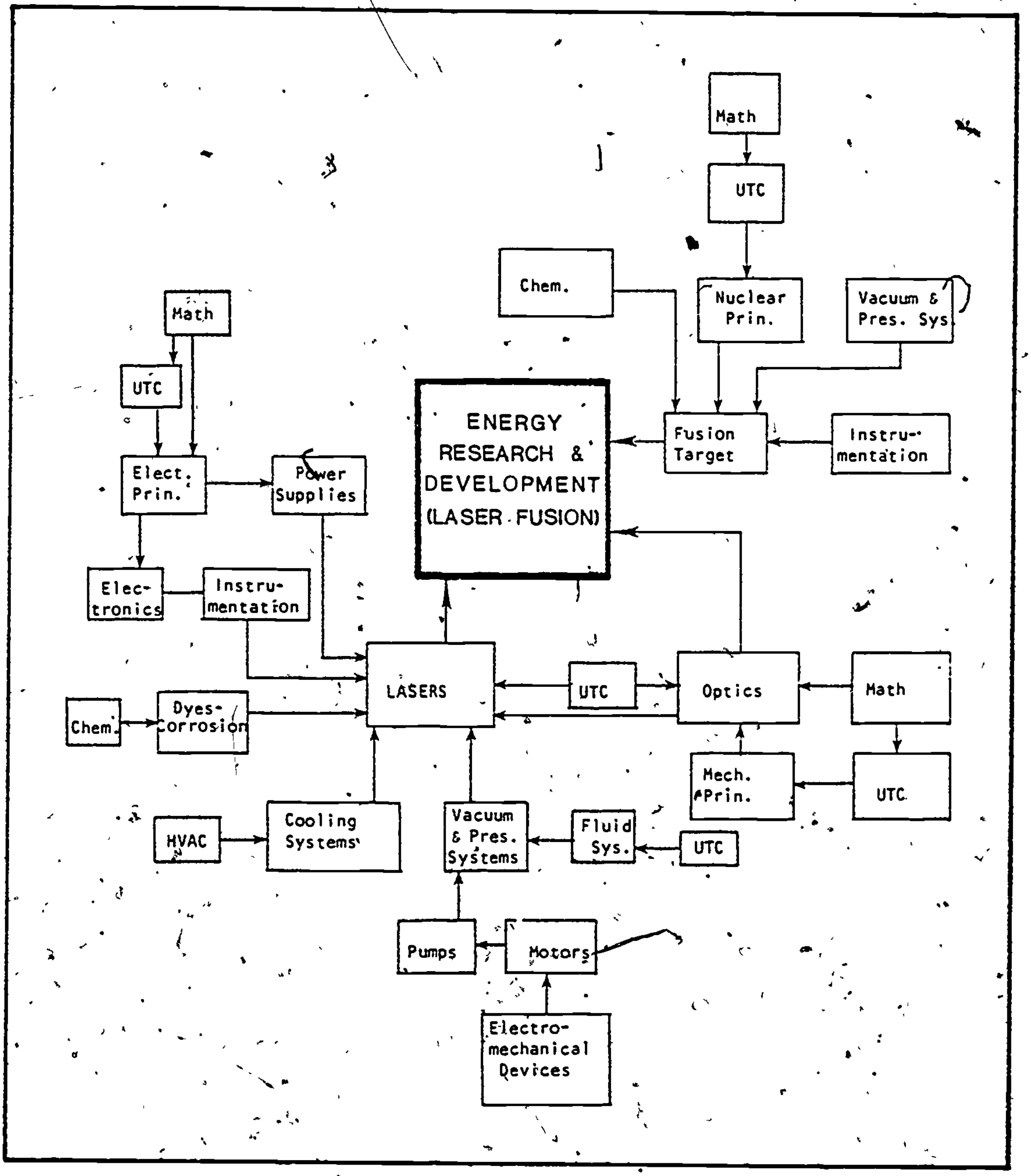

Figure 7. Technical content/courses for Energy Research and Development (Laser Fusion) Technician job requirements.

Figure 8 graphically illustrates the role of each course in the ECUT curriculum, according to the four major groupings.

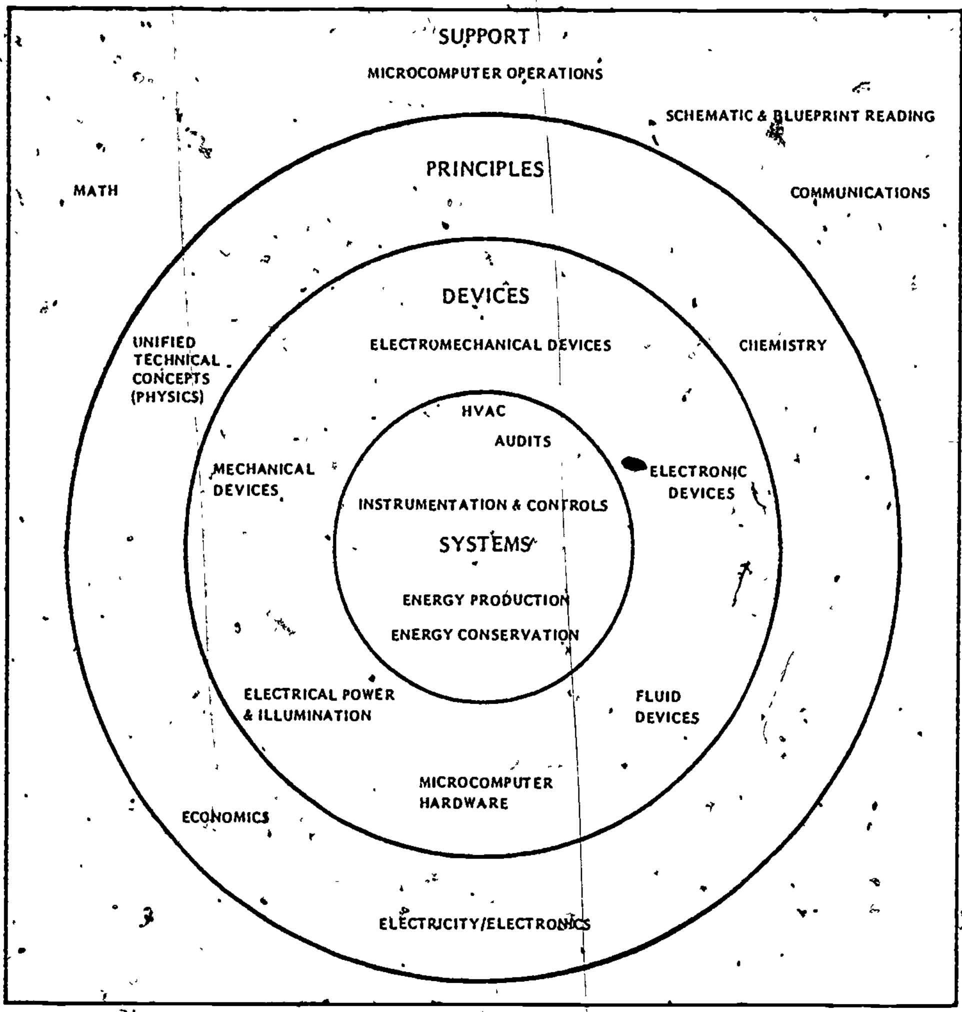

Figure 8. Four major groupings of courses in the ECUT curriculum.

CURRICULUM STRUCTURE

The curriculum shown on the following page is a recommended course sequence based on the quarter system. A comparable program for the semester system may be found in Appendix C. Course descriptions for this curriculum are provided on pages 17-21.

ENERGY CONSERVATION-AND-USE TECHNICIAN
RECOMMENDED CURRICULUM
QUARTER SYSTEM

	Lec.	Lab.	Contact Hours
First Quarter			
Chemistry for Energy Technology I	3	3	6
*Fundamentals of Energy Technology	3	0	3
Technical Math I	3	0	3
Microcomputer Operations	3	3	6
Technical Communications	4	0	4
	16	6	22
Second Quarter			
Unified Technical Concepts I (Physics)	3	6	9
Chemistry for Energy Technology II	3	3	6
*Energy Economics	3	0	3
Technical Math II	3	0	3
Schematic and Blueprint Reading	1	3	4
	13	12	25
Third Quarter			
Unified Technical Concepts II (Physics)	3	6	9
*Energy Production Systems	3	0	3
Mechanical Devices and Systems	3	3	6
Fundamentals of Electricity and Electronics	3	3	6
	12	12	24
Fourth Quarter			
Unified Technical Concepts III (Physics)	3	6	9
Electromechanical Devices	3	3	6
Electronic Devices and Systems	4	4	8
Elective	3	0	3
	13	13	26
Fifth Quarter			
Electrical Power and Illumination Systems	3	3	6
Microcomputer Hardware	3	3	6
Heating, Ventilating and Air Conditioning	4	4	8
*Energy Conservation	3	3	6
	13	13	26
Sixth Quarter			
Fluid Power Systems	3	3	6
*Energy Audits	2	4	6
Instrumentation and Controls	3	3	6
*Codes and Regulations	3	3	6
	11	13	24

*Technical specialty courses

The Energy Conservation-and-Use Technician curriculum is a broad-based, technical curriculum organized around core courses and technical specialty courses. The core area comprises 82% of the total curriculum and contains both technical support courses and courses that develop the systems-oriented interdisciplinary skills. The specialty area contains courses that are related specifically to the needs of an energy technician. Technical specialty courses are marked with an asterisk.

Figure 9 is a graphical representation of the student contact hours for core and specialty courses in the ECUT curriculum. Only 18% of the curriculum (on a contact hour basis) is devoted to technical specialty courses. The technical core, representing 82% of the curriculum, can provide the base for numerous other modern technician programs in fields such as electromechanical, laser/electro-optics, computers, biomedical equipment, instrumentation/control, etc.

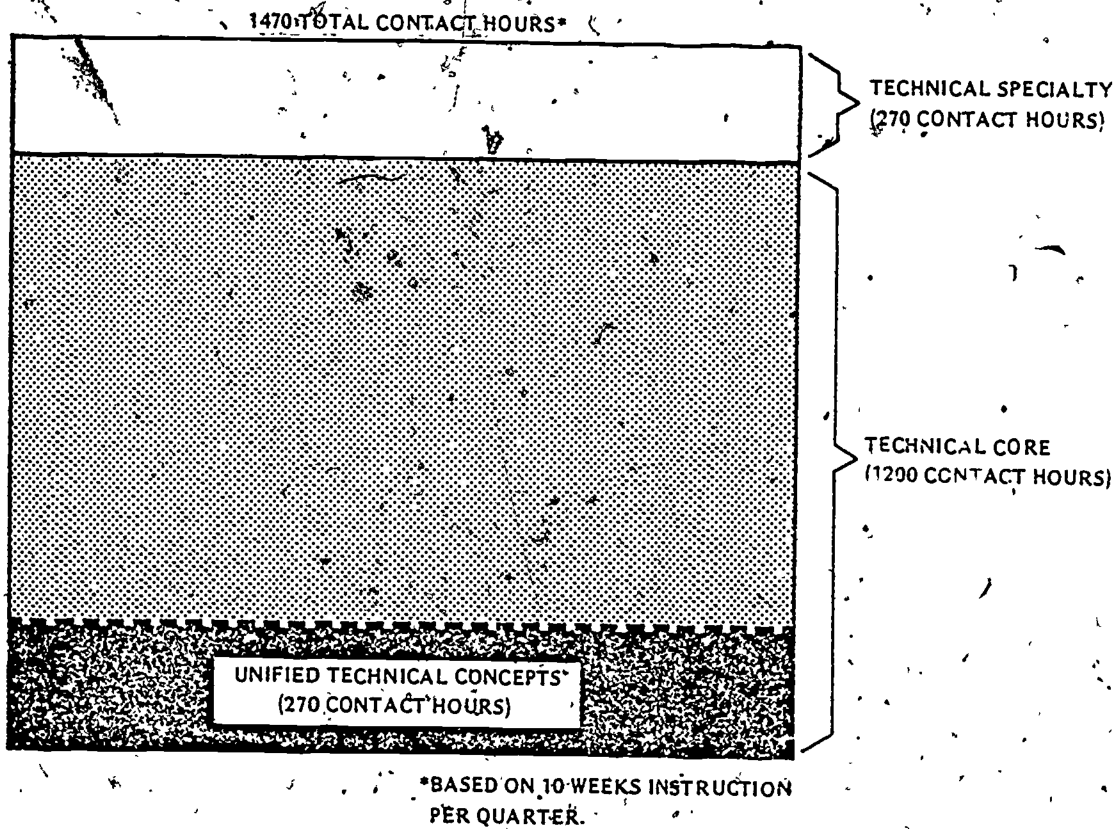

Figure 9. Division of core and specialty contact hours in two-year Energy Technician curriculum.

This type of curriculum implementation offers many flexibilities to schools in program implementation and in utilization of instructors and laboratories, which may result in opportunities for savings in operating costs.

Unified Technical Concepts

Also noted in Figure 9 is the large percentage (18%) of the curriculum allotted to Unified Technical Concepts (Physics).

Technical education has for many years been characterized by a process of teaching technical principles by practical applications. To retain this extremely effective process while, at the same time, introducing a broader range of technology, the ECUT curriculum adopted the Unified Technical Concepts method of physics instruction. In this system basic concepts are selected that have applications in several fields of technology. Instead of a vertical structure in which the traditional fields of physics (electricity, heat, mechanics, fluids, etc.) are studied as separate phenomena, the unified concepts system selects single concepts that cut squarely across these traditional groupings. With this system it is possible to utilize practical industrial applications to teach principles such as: force, rate, resistance to flow, time constants, energy converters, force transformers, etc. Interesting applications from modern commercial equipment provide the laboratory experiences for the unified concepts, instead of the technical "apparatus" of the traditional physics laboratory.

Mathematics, long a stumbling block for many students, is given valuable reinforcement when the same mathematics form is repeated many times in problems dealing with mechanical, electrical, pneumatic, and thermal examples of a single concept.

COURSE DESCRIPTIONS

Each course in the curriculum is described to indicate both its content and relevance to the overall program.

First Quarter

<u>Chemistry for Energy Technology I</u>. A course designed with a special emphasis on all aspects of chemistry as it relates to the work of an energy technician. Topics covered include safety, structure of matter, chemical equations and calculations, refrigeration, gases, air pollution, and solutions.

<u>Fundamentals of Energy Technology</u>. A course designed to give the student an overview of the field of energy conservation and use and to provide descriptions of job functions typical to energy technicians. Topics covered include sources of energy, uses of energy, energy analysis, and energy and the environment. The course material is organized to show the compatability of the total curriculum and the purpose of the approach chosen.

Technical Math I. A course designed to provide students with the math background necessary for energy conservation tasks. Topics include formula interpretation, metric system, logarithms and exponents, angles and triangles, vectors and scalars, reading and drawing graphs, dimensional analysis, and precision and accuracy.

Microcomputer Operations. This course covers the operation and programming of microcomputers. The first part of the course concentrates on general concepts such as computer codes, binary arithmetic and the major parts of most computers. The small microcomputer systems are studied and applied to typical energy-related data-gathering and control problems. In the third part of the course, a larger, disk-based system is used. Its operation and the kinds of software it uses are studied and applied to energy conservation. Finally, students learn the elements of BASIC programming.

Technical Communications. The ability to write and speak well is important not only for the transfer of information; writing capabilities, as well as speaking expertise, often have an effect on the employees' advancement. This course, Technical Communications, shows the technician how to develop ideas in a clear, organized fashion. The exercises included in each module will help the student to put new skills into practice.

Second Quarter

Unified Technical Concepts I. UTC provides the specialization and, at the same time, develops a broad, diversified system of orientation for technicians. It teaches physical concepts such as force, resistance, and power and relates them to the technology through practical applications in the four principal energy forms (mechanical, fluidal, electrical, and thermal). This modularized approach relies heavily upon analogies and applied relationships of basic concepts by putting traditional physics and engineering into "work clothes."

Chemistry for Energy Technology II. This course is a continuation of Chemistry for Energy Technology I, covering corrosion, metals, plastics, ceramics, lubricants, adhesives, thermochemistry, fuels, and nuclear chemistry. These topics are discussed in relationship to the work performed by energy technicians.

Energy Economics. Energy Economics is a course designed to familiarize the student with the energy-conserving and cost-saving measures that are available, as well as the analysis techniques that are necessary for accurate evaluation of energy projects.

Technical Math II. Technical Math II is intended to provide the student with the math background necessary for the performance of energy conservation tasks. Subjects covered range from plane geometry to trigonometric functions.

Schematic and Blueprint Reading. Schematic and Blueprint Reading should be designed to familiarize the student with the standard symbols and techniques used in schematics of electrical, mechanical, hydraulic and pneumatic systems, and structural blueprints. Devices and systems discussed in other courses in the Energy Conservation-and-Use Technician curriculum are used as examples. The laboratory should stress the identification of parts and the relationships of the schematic or blueprint to the system it describes.

Third Quarter

Unified Technical Concepts II. A continuation of Unified Technical Concepts. Concepts discussed include power, potential and kinetic energy, energy converters, and vibrations and waves.

Energy Production Systems. Energy Production Systems is an in-depth technical study of processes and equipment used to convert energy resources (such as geothermal and the sun) and fuels (such as coal and natural gas) into useful energy forms, such as electricity, heat and motion, or light. This course will enable the Energy Conservation-and-Use Technician to select optimum energy sources and equipment for maximum economy, availability, efficiency, and/or environmental quality.

Mechanical Devices and Systems. Mechanical Devices and Systems is an in-depth study of the principles, concepts, and applications of various mechanisms that may be encountered in industrial application of energy use and conservation. The mechanical components and systems are divided into eight modules of instruction, covering operational procedures, uses, maintenance, troubleshooting, and repair and replacement procedures. The procedure or application portion of the modules will emphasize practical maintenance and installation of equipment and selection and specification of proper replacement components from manufacturers' catalogs.

Fundamentals of Electricity and Electronics. A course designed to provide the student with basic knowledge and skills in d.c. and a.c electrical circuits to include circuit analysis, recognition and use of electrical components and electrical measurement instruments. Topics presented include voltage, resistance, current, power, Ohm's law, inductors, capacitors, series and parallel circuits, and magnetic circuits and devices.

Fourth Quarter

Unified Technical Concepts III. A continuation of UTC I and II. Concepts covered include force transformers, transducers, time constants, and radiation.

Electromechanical Devices. Electromechanical Devices is designed to provide the student with a working knowledge of control elements in electrical circuits, transformers, motors, and generators. Topics presented include switches, circuit breakers, relays, fuses, transformers, d.c. and a.c. motors, and generators.

Electronic Devices and Systems. A course designed to provide the student with a working knowledge of modern electronic devices and the circuits in which they are employed. Electronic troubleshooting techniques are stressed throughout the course. Topics presented include rectifiers, transistors, SCRs and triacs, vacuum and gaseous tubes, filters, amplifier circuits, operational amplifiers, noise reduction, digital circuits, and display devices.

Fifth Quarter

Electrical Power and Illumination Systems. This course is designed to provide the student with a practical knowledge of electrical power, distribution systems, and illumination systems. In addition, the students also practice electrical measurement, wiring methods, illumination measurement and circuit control - and are provided with an overview of the parts of the electrical distribution system.

Microcomputer Hardware. This course begins with an introduction to integrated circuit logic and a discussion of common electrical and logical digital interfacing techniques. Specific techniques for getting both digital and analog data into and out of microcomputers are surveyed. Applications of these techniques to actual control problems are illustrated. Finally, data communication ideas and microcomputer troubleshooting techniques are covered.

Heating, Ventilating, and Air Conditioning. This course is designed to develop an understanding of air conditioning and heating systems and their characteristics, applications, and limitations. The intent of this course is to present the basics of such systems and factors affecting the selection and efficient operation of both commercial and residential heating and air conditioning equipment.

Energy Conservation. Energy Conservation is designed to give the student technical knowledge and specific skills required to perform conservation measures relative to the most common energy uses. The student will learn and utilize the basic principles of energy conservation and efficiency.

Sixth Quarter

Fluid Power Systems. Fluid Power Systems is designed to give the student an overview of fluid power technology and a working knowledge of each of the components used in fluid power circuits. Hydraulic and pneumatic systems will be discussed, with emphasis placed on troubleshooting and maintenance procedures involved in each. Topics presented include fundamentals of fluid dynamics, conventional fluid circuits, and fluid power components.

Energy Audits. This course provides an overview of the purpose, objectives, and mechanics of the energy audit process. Full background and procedural instructions precede case studies and laboratory practice in auditing. Finally, audit analyses are undertaken, with students recommending remedial actions based on analyses of their practice audits.

Instrumentation and Controls. Instrumentation and Controls is designed to provide the student with practical knowledge and skills in the specification, use, and calibration of measuring devices and the principles and applications of automatic control processes. The course stresses the integration of knowledge gained in previous courses through the detailed examination of control systems for electrical power production, heating, air conditioning, and manufacturing.

Codes and Regulations. This course should be designed to provide the technician with a basic understanding of the labyrinth of codes and regulations imposed upon each area of responsibility. The subject matter not only should familiarize the student with many national codes, but also should instruct the student in how state and local codes can be found and used.

Detailed course outlines, including prerequisites, are found in Appendix D.

INSTRUCTIONAL MATERIALS

The basis of a sound instructional program is well prepared materials. If properly reviewed by educators and employers, tested and revised, such materials, will best serve the instructional program, the students and, ultimately, the employers. The best materials also meet stringent content requirements for flexibility, relevance, currency, validity, and accuracy.

Material Content and Format

As noted earlier, energy technology encompasses a variety of technical job opportunities with equally great variations in knowledge-and-skills requirements. A curriculum that offers a two-year program must be flexible enough to be adapted to specific employer needs on a local basis. Modular materials allow pinpoint selection of appropriate instructional units; for example, the energy auditor, whose major involvement is with instruments with only an incidental involvement in production, should be allowed to select those instructional units applicable to that limited involvement. The flexibility of brief, single-subject, self-contained modules allows a curriculum — whether a seminar, short course, course option, or full course — to be custom designed to meet specific needs.

The curriculum material is passed through a variety of critical reviews to ensure its relevancy. Determination of local instructional needs — by a local or regional needs assessment and task inventory — makes possible the selection of material relevant to local, current needs.

Historically, technical instructional materials have evolved slowly. Too often, materials became available at about the same time that they became obsolete. To eliminate this problem, the materials described in this Guide are being offered within months following their initial preparation by authors and reviewers involved in the production process.

Further, through continuing efforts of the National Advisory Committee for Energy Technician Training, technological advances as well as national employment opportunities are reviewed, and relevant data is passed on to institutions and organizations using the material.

The materials are updated as necessary to ensure currency. The most effective manner of ensuring currency, however, is for users of the materials to utilize their local industrial advisory committees (IAC) to keep the local programs up to the minute on technological changes, variations, and workforce requirement fluctuations.

From the educator's standpoint, educational materials must assume a valid educational format. In this case, the materials are presented in a strictly cognitive form; that is, behavioral objectives are stated in measurable terms (perform, calibrate, draw, list, measure), and each module and its procedures emphasize manipulative skills, founded on valid, relevant theory and practice.

Thus, each module, as well as the entire curriculum for energy technicians, consists of valid, current, relevant, and flexible materials.

Module Elements

Instructional modules developed specifically for this energy technician curriculum contain these basic elements:

Introduction: Identifies topic (and often includes rationale for studying the material).

Module Prerequisites: Identifies knowledge and skills students should possess before studying the module.

Objectives: Clearly identifies what the student is expected to know and do upon completion of module. Objectives are stated in terms of action-oriented behaviors, including such terms as "operate," "measure," "calculate," "identify," and "define," instead of words with many interpretations, such as "know," "understand," "learn," and "appreciate."

Subject Matter: Presents background, theory, and techniques supporting the objectives. (Subject Matter is written with the technical student in mind.)

Exercises: Provides practical problems to which student can apply new knowledge from module study.

Laboratory Materials: Identifies equipment required to complete laboratory procedures.

Laboratory Procedures: Presents experiments or "hands-on" activities, including step-by-step instructions. (Experiments are designed to reinforce student learning.)

Data Tables: Included in most first-year or basic-course modules, the data tables help students learn how to collect and organize data.

Reference Materials: Presents suggestions for supplementary reading.

Test: Measures each student's achievement against objectives stated at the beginning of the module.

Modules average approximately 35 typewritten pages, including illustrations. (Illustrations normally are line drawings that are easily understood and can be reproduced on copy machines for overhead projection.) New modules can be added easily, or existing ones modified, for self-paced instruction or short courses.

COOPERATIVE EDUCATION

This technology is adaptable to a cooperative arrangement — a plan that offers important advantages to students, to the school, and to employers of technicians. A cooperative education program provides an opportunity for a student to learn through coordinated study and employment experience. Students alternate periods of attendance at the institution where they study their technical program with periods of supervised employment in business or industry, which provides both training and work experience. The employment constitutes an essential element in their education. The students' employment should be closely related to the field of study in which they are engaged.

When students test their knowledge of theory in a work situation, study becomes more meaningful. Co-op students learn not only the essentials of the technology but also the importance of reliability, cooperation, and judgment as an employed worker in a chosen occupational field.

Co-op students' career choices are stimulated and strengthened by work experiences. A satisfactory work experience provided in a co-op program assists in stimulating the students' interest and effectiveness in the institutional phase of the program, making it more meaningful. The experience in a co-op program also assists students in knowing if they have made the proper occupational choice prior to completing their educational program and entering employment.

A class of students in cooperative technical programs usually spends the first semester or the first two quarters in school; then time is divided so that half of the students have a semester or quarter of employment experience while the other half continue to study. During the next semester or quarter, the half who have worked return to their formal studies at school while the other half are employed. They usually alternate again so that each student has two semesters or at least two quarters of work experience in the program. The students' technical program is lengthened beyond the curriculum outlined in this Guide by an amount of time equal to the total length of the employment experience.

Specific employment is obtained, as circumstances permit, by the educational institution with the cooperation of the student. The institution regards the work-experience program as an integral part of the technician program as a whole. It is not regarded primarily as an opportunity for earning, although each student while working is paid at the prevailing wage scale for the job performed. Work reports by both the student and the employer are submitted to the school work program coordinator.

The cooperative work-experience program is an opportunity for the students to gain directly related experience, which makes them more valuable as employees. As a result of the work experience in particular establishments, many students are offered permanent positions upon completion of schooling. Cooperating establishments agree, however, not to make offers of employment that become effective before a trainee completes the program.

Cooperative programs provide opportunities for the educational institution to maintain close contact with employers in their various programs. This contact becomes a two-way channel of communication, which helps the educational institution keep its knowledge of specific employer needs in each technical field up to date. At the same time, it keeps employers acquainted with and involved in the institution's programs.

CONTINUING EDUCATION.

Many of the ECUT curriculum courses are suitable for use in continuing education to retrain existing employees in this technology. The modular materials have many advantageous characteristics that make them suitable for the distribution of energy information.

Energy topics that are applicable to continuing education are listed below. Modules from the following specific course titles are included.

- Energy Awareness — One or more courses that are introductory or fundamental in nature that would familiarize the student with energy and its parameters.

  Fundamentals of Energy Technology
  Energy Production Systems

- Energy Conservation — One or more courses ranging from general information on insulation and passive solar heating to more technical topics such as illuminating systems for homes and offices, and heating, ventilating and air conditioning systems. Local interest would determine the content and degree of specificity.

  Fundamentals of Energy Technology
  Energy Production Systems
  Energy Economics
  Energy Conservation
  Energy Audits

- Energy Economics — One or more courses that would provide the student with the tools to make sound financial decisions involving energy such as cost-versus-benefit analysis and life-cycle costing. Energy audits should also be taught with complexity determined by the audience.

- Technical Specialties — These courses would have as their main objective the training and/or retraining of the existing workforce on energy management and could include such topics as alternate energy sources, conservation in energy systems (mechanical, electrical, and fluidal), and planning for the energy future. Nearly all of the technical course materials in the curriculum (including UTC physics) have been found useful for these types of course offerings.

III. PROGRAM PLANNING AND DEVELOPMENT

Planning should begin with establishment of an advisory committee and a determination of needs, followed by an evaluation of local potential for meeting such needs. Considerations should include:

- Faculty.
- Student Selection and Services.
- Facilities.
- Equipment.
- Library.

The extent and implications of each of these considerations are explored in the following sections.

ADVISORY COMMITTEE

The success of this program depends, to a great extent, on the formal and informal support of an advisory committee. This committee should be appointed by the chief administrative officer of the institution and should be comprised of local (or regional) employers of Energy Conservation-and-Use Technicians representing each of the four major areas — energy-related research and development, energy production, energy use, and energy conservation. These members serve without compensation. The committee normally consists of about ten members, who should serve from two to three years with staggered terms.

The selection of industrial members of an advisory committee should be based upon the recommendation of one of the company's executives. This provides one assurance that the company recognizes and is committed to support the program. Industrial members should preferably be the company's first-line technical supervisors. The supporting companies should be kept informed of the committee's progress, and they should be publicly thanked for their efforts on behalf of the institution.

The local advisory committee should assist in studies to determine and define the following: the need for the technical assistant program; the knowledge and skills technicians will require; employment opportunities; available student enrollment; curriculum content; faculty qualifications; laboratory facilities and equipment; resources both within and outside of the institution; and cost and financing of the program. If the survey indicates that a program should be initiated and will be supported, the committee's help in planning and implementing it is invaluable.

Upon implementation, the committee provides continuing liaison between the institution and employers. Frequently, the committee helps administrators obtain local funds and state and federal support for the program. The committee also aids in placement of graduates of the program and in evaluating the performance of the graduates on the job. Such evaluations often indicate minor modifications that more closely align the program with employment requirements and opportunities.

The advisory committee should understand that the program is not intended to make individual students proficient in all duties that they might be asked to perform. Proficiency in work comes only with practice and experience. It is impossible to accurately predict the rate of change within various work situations. Employers should expect to provide reasonable on-the-job orientation to acquaint the new employee with operational procedures of the facility.

The committee should meet as regularly as needed and should keep formal minutes of its proceedings (which could become, in compilation, an annual report of the proceedings). For further elaboration on the role and responsibilities of the advisory committee in technical education programs, refer to Riendeau's Advisory Committees for Occupational Education: A Guide to Organization and Operation.*

This Guide, designed primarily for planning and development of full-time programs in post high school institutions, can be used by the administrator of the institution and an advisory committee as a starting point for development of their own program. It can and should be modified where necessary and adapted to meet local needs and institutional criteria.

NEEDS DETERMINATION

By using accumulated data and a local industrial advisory committee, a program planner may develop a preliminary local or regional needs determination. The needs survey should take a form other than an informal question or two to associates of committee members. It is suggested that a needs assess-

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*Riendeau, Albert J. Advisory Committee for Occupational Education: A Guide to Organization and Operation. New York: McGraw-Hill, 1977.

ment instrument (similar to the one shown in Appendix E) include questions documenting: number of existing employees; number of existing vacancies; number of expected vacancies; and type of work to be performed. A follow-up survey to determine specific knowledge and skills needed by an entry-level employee should be sent to those companies hiring Energy Conservation-and-Use Technicians. This survey does not need to be elaborate and can consist of a checklist of performance objectives derived from the national task inventory.

When the survey instruments are returned to the school, they should be compiled for use in a localized task inventory for the occupation. A review of the task inventory by the advisory committee is essential at this point. Resurveying at periodic intervals and changing course content accordingly keeps the training program up-to-date and ensures that trainees have a better chance for employment. In today's world of specialized skills and employment, the old concept of curriculum by guess or by past procedure is a disservice to the student and to the training institution.

FACULTY SELECTION

The effectiveness of the program and the curriculum depends largely upon the competence and enthusiasm of the teaching staff. With a qualified and interested faculty, a needed educational program may flourish. Qualified faculty members may exist at the institution or within the industry or organization planning the program, or it may be necessary to recruit a faculty from outside sources. In any event, faculty consideration includes these recommended items:

- Numerical Requirements — The number of faculty members needed is based upon the duties assigned each member, number of students in the program (first- and/or second-year) and number of courses scheduled for instruction. The typical teaching load is 18 to 24 class/lab hours per week, with the department head assigned not more than 12 hours to allow time for administrative duties.
- Competency — The department head should have a strong academic grounding in two of the four energy areas and have a thorough understanding of the interdisciplinary nature of energy education. Experience in industry (e.g., two years or more in an energy-related field) is also important.
- Availability — Qualified personnel must be available within a suitable

time frame. (Assistance in identifying faculty requirements and in locating qualified personnel may be obtained from the local industrial advisory committee.)

- Affordability — The salary structure is a prime consideration. Instructors with experience in industry command salaries competitive with industry.

Technical programs are designed to produce supportive employees who increase the effectiveness of the total workforce. This principle should be applied to increase the effectiveness of the teaching staff.

Adequate time should be set aside to allow new staff personnel to review the curriculum materials, to visit — if possible — a successful program and its faculty, and to engage in a brief teacher training or familiarization program. The latter program should be designed to ensure that the teacher has an adequate overview of the curriculum materials and a general appreciation of the modular concept. Also, if possible, the teacher should be afforded an opportunity for dialog with developers of the material, thereby resolving any variances between intended meaning and interpretation.

Staff assistants may be used in stock control to set out the proper equipment for laboratory classes, to keep equipment operating properly, to assist in the development of teaching materials, to supervise laboratories, and to do a limited amount of routine paper grading and project checking.

By adjusting the size of the supportive staff to the demands of enrollment, a school may partially solve the problem of staffing instructors when it is necessary to teach a number of different courses in one term. Supportive staff members may be recruited from the student body or from graduates of the program.

New approaches to the organization of faculty should be considered. Team teaching is one such approach. In this sense, team teaching is the organization of a technical staff into a coordinated teaching unit. Teaching assignments are made on the basis of the individual member's special training and talents. Team planning allows for concurrent courses to be closely coordinated by team members to best utilize the student's time while the student is moved smoothly to progressively higher levels. The interdisciplinary nature of the ECUT curriculum especially lends itself to team teaching.

A weekly departmental staff meeting to encourage and sustain team teaching efforts is recommended. At these meetings, team members can assess and evaluate progress and plan on the basis of this evaluation and on current developments. This is especially important when a new course or a new technique is involved.

In addition to coordinating concurrent courses, staff meetings provide for free exchange of ideas on teaching techniques discovered to be useful and on recently developed laboratory projects that seem to be particularly successful.

To help keep a staff effective, an institution should encourage all staff members to update their knowledge of current industrial practice. Their knowledge of teachnig techniques and innovations in education must continue to grow and expand. Membership in professional and educational associations should be encouraged, together with active participation in professional association work at local, state, regional, and national levels. Through such organizations, faculty can keep up with new literature in the field and maintain closer liaison with employers.

Close contact with employers will also ensure success of the program through the following areas:

- Employment of graduates.
- Opportunities for cooperative programs.
- Assistance in organizing and presenting short courses and conferences.
- Donations of equipment and scholarships.
- A viable industrial advisory committee.

LIBRARY

In each module, a list of reference materials is included. For the convenience of each institutional or industrial program developed, a suggested list of references and periodicals is presented in Appendix F.

Dynamic developments, causing rapid changes in technological science and practice, make it imperative that a student learn to use a library. Instruction for technology students should include assignments that require them to use the library so that they may form the habit of using the library as a tool in learning. This knowledge helps students to develop professional attitudes and further teaches them to depend upon libraries to keep abreast of new developments.

Reference materials and related media materials for teaching the technology should be reviewed continuously and revised or replaced, keeping in mind 1) the rapid development of new knowledge, techniques, and procedures in the field, 2) the results of research in methodology of teaching in the field of energy technology, and 3) the dynamics of change within the structure and philosophy of the energy industry. It is mandatory that instructors constantly seek and review new references and related media materials as they become available and adopt those that are an improvement over those suggested in this Guide or those currently in use.

Instructors of all courses should inform their students that library use is an important part of the program. Planned assignments that require the use of a library to research additional facts and new techniques on pertinent subjects enable students to understand the resources available and their relation to technology. Open-book examinations that require use of a library provide excellent objective experiences. Under the incentive of such examination and the pressure of time, students obtain clear understandings of their own competencies in library use.

The growth and success of a graduate technician depend largely on an ability to keep up with changes in the field.

Library content may be classified as basic encyclopedic and reference index material, reference books pertinent to all areas of energy technology, relevant periodicals and journals, and audiovisual aids.

Therfore, a central library, under the direction of a professional librarian, is important to the success of a technology 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, thereby stimulating interest in related literature; however, a central library ensures acquisition and cataloging according to accepted library practices and provides systematic card files, which facilitate the location of reference materials. It also provides a controlled and orderly system for lending books to students, typical of a system they might encounter as employed technicians. Provisions for lending materials for out-of-library use should be systematic and efficient. Suitable study space should be provided to students for use of references.

A limited library incorporating books referenced in the curriculum material, supplemented by appropriate specifications and relevant trade journals, should be maintained in the instructional area.

EQUIPMENT

Proper training of technicians for industry entails hands-on experience with industrial-type equipment, insofar as is practical. A list of generic supplies and equipment necessary for a viable program is found in Appendix G. This list incorporates specific items called out in each module in the laboratory procedures.

Not included in the list are such items as audiovisual aids and models. Such materials are available commercially from industry public relations offices. Also, used equipment and materials can provide excellent teaching aids. In industry-sponsored training programs, such equipment may be obtained from stock; institutions may need to look to industry — especially their industrial advisory committees — for contributions of used equipment.

STUDENT SELECTION AND SERVICES

The preparation of functionally competent Energy Conservation-and-Use Technicians makes three major demands upon the training program: 1) the training should equip graduates to take an entry job in which they will be productive; 2) it should enable graduates to advance to positions of increasing responsibility after a reasonable amount of experience; and 3) it should provide a comprehensive foundation to support further study.

Students entering the program should have certain capabilities, including comprehension and knowledge of underlying subject areas and related skills and adequate study habits and language competencies.

The program described in this Guide is designed for the typical average student (high school graduate or equivalent with one year of math and one basic science course); however, ability levels of those who enter the program generally vary greatly. Many students, whose intelligence and interest make them capable of mastering the curriculum required in the program, have underdeveloped scholastic skills. If applicants for admission to the program do not have the necessary scholastic background and skills, they should be given an opportunity to enter an organized program for the development of prerequisite skills before entering the technical program. This would ensure them a good probability of successfully completing the technical program. The institution should provide developmental programs to give students this opportunity.

Personal interviews with prospective students for the purpose of effective guidance and counseling are essential. Students should be given interest and aptitude tests by the guidance and counseling departments of the institution to assist them in selecting educational and occupational objectives consistent with their interests and abilities. This will assist them in determining their career objectives and selecting the programs appropriate to their interests.

Students should be given a thorough orientation program upon entry to the institution. This program should include an orientation to the facilities available on the campus, including the student lounges, dining areas, bookstores, and recreational facilities. In particular, they should be given a comprehensive tour of the library to familiarize them with its various facilities and procedures and rules governing its use.

Students should be provided information regarding student membership in technical and professional organizations, local, state-wide, and national, and encouraged to join such organizations. Membership in professional organizations provides students with an opportunity to receive excellent material on a regular basis at a substantial reduction in cost, to associate with other people in the field at meetings, and to develop a habit of regularly reading journal articles to keep their technical knowledge in the field current.

Graduates of the program should be aided in every way in finding suitable employment. Placement of graduates is an important and multifaceted responsibility involving the placement department, the department head and instructors, and either directly or indirectly, the advisory committee. However, the primary placement responsibility in new and changing technologies should rest upon the department faculty. They should send out announcements of upcoming graduates to the respondents of the needs survey and to committee members. Outstanding and successfully placed graduates and their employers are the most effective advertisers of the program.

The institution should conduct periodic follow-up studies of graduates to improve curriculum and teaching techniques, evaluate training effectivensss, maintain good employer-employee relationships, and provide a continuing evaluation of the total program.

LABORATORY FACILITIES

Laboratory experiences are central in any technical study dealing with industrial materials and processes. All technical courses in the ECUT curriculum require laboratories except for two: Energy Economics and Energy Production Systems.

Schools with ongoing programs in Electronics, Instrumentation, Microcomputer Operations, and HVAC should normally have adequate laboratory facilities and equipment for ECUT courses. Some courses such as Energy Audits and Codes and Regulations will require field trips to actual equipment installations. Chemistry courses in the ECUT curriculum can be accommodated in a conventional chemistry laboratory.

Special attention should be given to the laboratory facilities and equipment for the Unified Technical Concepts (UTC) courses. The UTC courses differ significantly from traditional courses in physics. If they are to accomplish their purpose, which is to provide a broad technical base for the energy curriculum, the laboratories must be planned accordingly.

Ninety-five application modules in the five categories listed below have been chosen for the ECUT curriculum. Laboratory equipment must be provided for these modules as follows:

Electricity/Electronics	29 modules
Mechanics Dynamics	18 modules
Fluids	21 modules
Heat	15 modules
Light	12 modules

The unified concepts in the order of presentation are: Force, Work, Rate, Resistance, Power, Vibrations and Waves, Potential and Kinetic Energy, Energy Convertors, Force Transformers, Transducers, Time Constants, and Radiation and Optics.

It is essential for the success of the unified technical concepts system of instruction that the courses (and consequently the laboratories) be organized around the concepts and not around the traditional categories of physics (Heat, Electricity, Mechanics, etc.). This makes it mandatory that equipment for all five of the applications areas (Electricity, Mechanics, Fluids, etc.) be scheduled and prepared for each course. Furthermore, many of the applications modules do not use "apparatus" that can be purchased as units, stored, and taken "off the shelf" when needed. Instead, this instructional equipment must be constructed, preferably by technical specialists, and made semipermanent laboratory fixtures.

Developing a viable UTC laboratory facility will ultimately require the cooperation of teaching specialists from several areas. The hypothetical arrangement shown in Figure 10 illustrates what might be an ideal configuration of facilities for the development of a UTC laboratory. The plan shown is conceptual only and does not represent the relative space requirements for the indicated activities. It does represent what might be termed an optimum arrangement for providing close working relationships between an instructional staff responsible for the core program of technical concepts and the technical specialists who teach in discrete technologies. Equally significant in this plan, the specialized laboratories are adjacent to the technical concept laboratories to facilitate the use of equipment and tools in developing instructional units.

Two highly significant advantages accrue from the arrangement shown in Figure 10. First and foremost, provision is made for teachers of the technologies and teachers of the unified concepts to share office space, classrooms, and laboratories. This kind of interrelationship is absolutely essential. Second, the immediate accessibility of laboratories (technology to concepts) makes it possible to develop teaching applications that are of maximum utility. Demonstration units and laboratory projects can be readily moved from the specialty labs to the concept labs.

In order to understand the true significance of these two features, it is only necessary to study the effect that isolation of technical specialties has had in the past. The semiautonomous nature of specialized technologies has, more often than not, resulted in a distressing lack of respect for support courses in physics, on the part of both technology teachers and students in the technologies. Physics instruction, often just as "departmentalized" as the technologies, became sterile, highly generalized, and altogether uninteresting. Technical students seldom found any relationship between physics "courses" and technical courses.

The unified technical concepts system has potential to provide a highly flexible technical core for a number of technologies in addition to the ECUT curriculum. Modular course design adds immeasurably to this potential. A substantial investment in laboratory facilities for this system would appear to be justified by the evidence at hand that most, if not all, industrial technologies are becoming broader in scope, more and more sophisticated, and more systems-oriented.

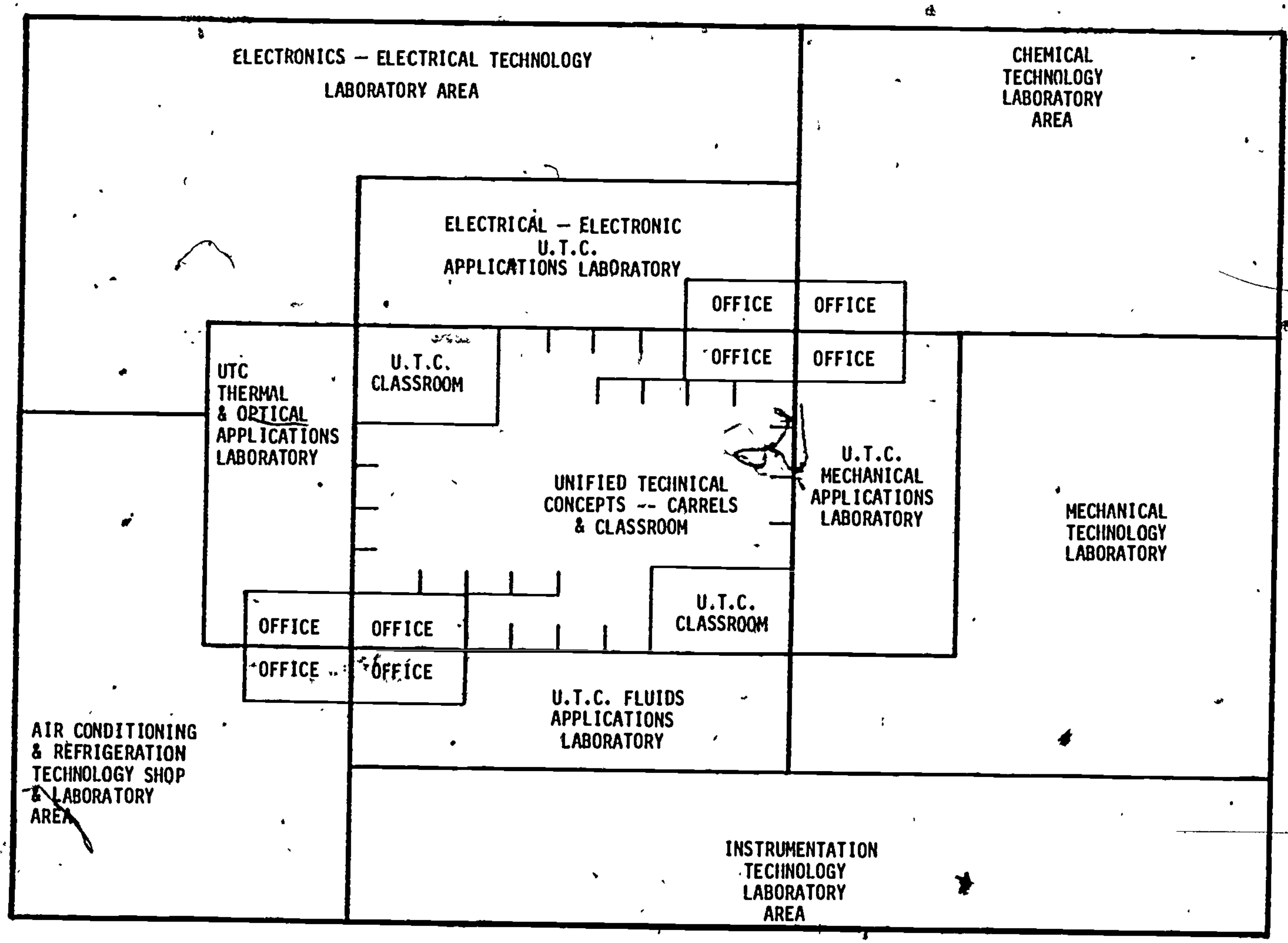

Figure 10. UTC facility concept.

IV. PROGRAM IMPLEMENTATION AND EVALUATION

The level of effort involved in implementing a new program of instruction may vary from one setting to another, but the essential elements of implementation are the same.

IMPLEMENTATION

Implementation includes:

Identification of needs.

Determination of curriculum requirements.

Preparation and presentation of program proposal, obtaining approval.

Selection and preparation of staff.

Acquisition of facilities and equipment.

Enlistment of students.

<u>Local/Regional Needs Assessment/Analysis</u>

Determination of needs consists of three steps:

<u>Identification of employers</u>:
(both present and potential).

<u>Identification of jobs</u>:
Task inventory.
Entry-level requirements.
Employment projections.

<u>Analysis of Needs</u>:
Benefits versus expenditures.

A listing of employers should be available to interested schools. Local identification of such employers can be achieved readily with the counsel of a well chosen industrial advisory committee, many of whom will be employers (or representatives of employing organizations) of energy technicians.

With the assistance of the committee and local employers, the several aspects of job identification can be successfully completed in a relatively brief period of time. Usually, this step can be carried out by mail, utilizing properly prepared survey instruments.

Any new program should be self-justifying. The benefits should justify the cost. Factors entering into this analysis include:

Quantity of job opportunities.
Quality of job opportunities.

Projected job opportunities.
Capability of instruction to offer program:
- Budget.
- Facilities.
- Faculty.
- Administrative fervor.
  (Without an administrative commitment, no program is apt to evolve, even though all other elements are present.)

The industrial advisory committee's expertise should be utilized in this analysis of needs. Each member should be given an opportunity to review and evaluate the cumulative results of the needs survey and the school representative's assessment of the institution's capabilities. The advisory committee members may be able to suggest or propose ways of overcoming certain weaknesses or shortcomings.

Curriculum Requirements Determination

Because curricula must be responsive (in technical education) to the real needs of technological industry, any determination of curriculum requirements must come after a realistic assessment and analysis of industrial workforce needs. The modular curriculum suggested in this Guide for training Energy Conservation-and-Use Technicians can be adopted wholly or in part to meet the real needs of industry. The materials to be used should be selected with care and, preferably, with the consultation of committee members to ensure compatability with industrial needs.

Personnel familiar with the material's content and sequencing, and experienced in the matching of the curriculum to needs, should be utilized in developing the program. Members of the industrial advisory committee, with knowledge of workforce training needs, should assist in the review and selection process.

Once program implementation reaches this development point, a formal proposal — in most institutions — must be prepared and presented to appropriate administrators, boards, and agencies.

Program Proposal Preparation

Three criteria should be satisfied in presenting a successful proposal for a new technical education program.

Need (for program). This criterion should have been established by the needs assessment and analysis. All data, both supportive and detractive, should be included, along with letters or directly-quoted comments and opinions of industrial advisory committee members.

Capability (of institution to provide program). This criterion includes: 1) fair and comprehensive evaluation of a schools' interest in the program (top executives and/or administrative support and faculty enthusiasm), 2) its budgetary potential (requires a good estimate of program's cost and enrollment potential), and 3) its available facilities.

Cost effectiveness. There are two approaches to this determination: 1) immediate effectiveness — whenever possible, a program should be self-sustaining. Thus, it is important to establish program cost versus direct economic return. All the inputs to making this determination, including a realistic projection of enrollment in the program, should be incorporated into this proposal; 2) long-term effectiveness — total effect of the program on school resources should be weighed against benefits to society. In many instances, these determinants must be stated in intangible terms. Even so, they should be presented fairly and as accurately as possible.

Proposal Format

The format of the proposal varies extensively from school to school; however, as a general rule, any proposal should be as straightforward, concise, and simply stated as its preparer can make it. The following elements are meant only to imply a possible outline:

Preface. What the document is, who prepared it, for whom it was prepared. No more than one page.

The Need. Reflecting all items discussed earlier.

The Curriculum.

The Plan. Organizational approach; facilities utilization; human and financial resources.

The Cost.

The Benefits.

The Recommendations. Based on reasonably drawn conclusions.

Letters/Documents of Support.

Evaluation of Existing Compatible Programs.

Once a program has received formal approval, instructional preparation becomes an immediate consideration.

EVALUATION

Human endeavor is subject to continual evaluation, generally informal, but evaluation nonetheless. It is this ongoing monitor-review activity that guides any individual or corporate activity to ultimate success — success that can be assessed only in retrospect. An educational program — human endeavor of a corporate nature — should also be evaluated progressively (as well as on the basis of its end product) to ensure its constancy toward the development of a successful end product.

Curriculum Acceptance

While a major evaluation factor is adequate enrollment, other criteria provide significant, if not major, evaluation tools:

Drawing power and holding power of program.
Does program attract and hold qualified students in a manner comparable with similar technical programs?

Student enthusiasm and morale.
Is there an observable exprit de corps within the classes or groups of students enrolled in the program?

Enrollment figures (compared with similar technical programs or with enrollment goals or limitations) answer the first question. The second may require a more comprehensive evaluation. For example, student response to a program may be evaluated subjectively by adjudging such factors as:

Interest/disinterest in classroom activities, laboratory procedures, and homework or outside study (based on attentiveness and actions).

Enthusiasm/indifference as related to the total program (based on attendance).

Test scores on materials that judge students' progress in assimilating skills and knowledge essential for technical employment.

More commonly, however, evaluation tools are employed to reflect the students' responses more directly. This objective evaluation procedure (from the faculty's standpoint), which employs one or more questionnaires, seeks responses in the following areas:

Teacher effectiveness (including lab instructors).

Materials applicability (including understandability and program content relevance).

Facilities and equipment adequacy.

Student self-evaluation (including attitude, progress, and continued interest).

Graduate Performance

The ultimate evaluation of a technical education program stems from the success of its graduates:

Do their skills and knowledge meet entry-level requirements?

Are they successful in the job market?

Does their on-the-job performance satisfy employer expectations?

Are they promotable?

These questions may be asked of both the graduates and their employers. (Placement records may be more indicative of a hungry job market than a successful training program; therefore, evaluation should go beyond this initial transition from student to employee.)

Graduated students, along with their employers, should also be asked to reflect upon or review the training program periodically. This means of relating program content to occupational needs should prove especially valuable in incorporating new or updated technological developments into the program.

APPENDIX A

PROJECT ADVISORY COMMITTEE

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PROJECT ADVISORY COMMITTEE

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Southern States Energy Board
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Asnuntuck Community College
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Mr. Gene Hildman, Chief Engineer
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Mr. John David Lawrence, President
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Mr. Bill Matheny
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Texas Instruments
Dallas, Texas

Mr. Charles Maybeck
Chairman of Energy Programs
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Daytona Beach, Florida

Mr. Ernest Mayeux, General Manager
Dallas Downtown Office Building
Trammel Crow Company
Dallas, Texas

Ms. Ivonna McCabe
Director of Energy Technology
Tacoma Community College
Tacoma, Washington

Dr. Faye McQuiston, Chairman
ASHRAE Education Committee
Professor of Mechanical Engineering
Oklahoma State University
Stillwater, Oklahoma

Dr. George Mehallis
Executive Director
Technical Education
Broward Community College
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Dr. Raymond E. Morrison
Training Program Supervisor
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Mr. Tom Reid
Vice President & Director
Horry Campus
Horry-Georgetown Technical College
Conway, South Carolina

Mr. Bill Robinson
Staff Engineer, Energy Conservation
Holiday Inns, Inc.
Memphis, Tennessee

Dr. Richard Rounds, Director
Day Division
Albuquerque Technical Vocational Institute
Albuquerque, New Mexico

Mr. Jerry Schmehl, Consultant
Division of Technical Vocational Education
Minnesota State Department of Education
Saint Paul, Minnesota

Mr. Martin Schwartz
Director of Research
Camden County College
Blackwood, New Jersey

Mr. Milton R. Simonds
Energy Coordinator
FMC Corporation
Philadelphia, Pennsylvania

Dr. Wilson Sorenson, President
Utah Technical College at Provo
Provo, Utah

Mr. John J. Talbert
American Institute of Plant Engineers
E-Systems
Dallas, Texas

Mr. Rulon Wells
Associate Dean
Utah Technical College at Provo
Provo, Utah

APPENDIX B

TYPES OF EQUIPMENT, BY CATEGORY, WITH WHICH ECUTs WORK

APPENDIX B

TYPES OF EQUIPMENT, BY CATEGORY, WITH WHICH ECUTs WORK

INSTRUMENTATION AND CONTROLS

Rotameters
Differential Pressure Devices
Pitot Tubes
Turbine Meters
Anemometers
Open Channel Wires
Magnetic Flowmeters
Liquid-in-Glass Thermometers
Liquid-Filled Dial Thermometers
Bimetallic Thermometers
Crayon Temperature Indicators
Liquid Temperature Indicators
Pellet Temperature Indicators
Resistance Temperature Indicators
Microcomputers
Thermocouples
Optical Pyrometers
Total Radiation Pyrometers
Manometers
Limp Diaphragm Gages
Bourdon and Bellows Gages
Sight Gages
Bubble Tubes
Float/Buoyancy Meters
Capacitance Level Gages
Direct Current Meters
Alternating Current Meters
Multimeters
Gas Analyzers
Servos
Solenoids

ELECTROMECHANICAL DEVICES

Motor Speed Controllers
Motor Starters
Autotransformers
Servos
Motors, A.C., D.C,
Generators, A.C., D.C.
Relays
Buzzers
Vibrators
Horns
Brushes
Contacts
Starting Capacitors

ELECTROMECHANICAL DEVICES, continued.

Meter Movements/Meters
Servomechanisms
Switches
Fuses

MECHANICAL DEVICES AND SYSTEMS

Belts
Sheaves
Chains
Sprockets
Gears
Transmissions
Speed Reducers
Shafts
Couplings and Joints
Bearings
Seals
Gaskets
O-Rings
Clutches
Linkages
Cams and Cam Followers
Fans and Blowers
Valves
Packing

THERMAL ENERGY PRODUCTION AND CONVERSION DEVICES/SYSTEMS

Boilers
Superheaters
Turbines
Solar Hot Water
Solar Hot Air
Heat Pumps
Waste Heat Recovery Systems
HVAC Systems
Lighting/Illumination
Heat Exchangers

HAND AND POWER TOOLS

Conventional Hand Tools:
- Hammers
- Pliers
- Screwdrivers
- Common Wrenches
- Torque Wrenches

Hand Power Tools:
- Drills
- Sanders
- Grinders
- Saws

Bench & Floor Power Tools:
- Drill Presses
- Bench Grinders/Polishers
- Mills
- Lathes
- Surfacers/Planers
- Vises
- Saws

Metal Working Tools:
- Hand Breaks
- Hand Shears
- Notchers

Precision Measuring Devices:
- Levels
- Squares
- Rules
- Micrometers
- Radius Gages
- Other Dial Type Gages

Drawing Tools:
- T-Squares
- Triangles
- Compasses
- Dividers
- Templates
- Curves
- Marking Instruments
- Lettering Devices

ELECTRONIC DEVICES AND SYSTEMS

Resistors
Potentiometers
Capacitors
Inductors
Transformers
Chokes
Rectifiers
Diodes

ELECTRONIC DEVICES AND SYSTEMS, continued:

Transistors
SCRs
Triacs
Vacuum Tubes
Gaseous Tubes
Gates
Inverters
LEDs
CRTs
Oscilloscopes
Vacuum Tube Multimeters
Logic Analyzer
Transistor Digital Multimeters
Oscillators
Frequency Counters
Volt-Ohmmeter
Amp Probe
Bridges
Photovoltaic Cells
Photoconductive Cells
Batteries

FLUID POWER SYSTEMS

Pressure Measuring Devices
Pumps
Compressors
Motors (Fluid)
Cylinders
Limited Action Rotary Devices
Hoses
Pipes and Tubing
Connectors
Fittings
Valves
Valve Actuators
Accumulators
Reservoirs
Auxiliary Tanks
Separators
Filters
Strainers
Lubricators
Regulators
Oil Heaters
Dryers

RESEARCH AND DEVELOPMENT LABORATORY EQUIPMENT

Hot Cells
Fuel Cells
Glove Boxes
Master-Slave Manipulators
Intruder Sensor Systems
Detection Systems
Vertical Axis Turbines
Vacuum Recovery Systems
Purification Systems
Spectroscopy Systems
Photovoltaic Generators
Pressure Systems
Computers
Minicomputers
Microprocessors
Graphic Display Devices
Assay Instrumentation
Pulsed Neutron Generators
Solar Tracing and Collection Systems
Seismic Sensors
Seismometers
Ion Implantation Devices
Waste Vitrification Furnaces
Magma Effects Simulation Furnaces
Thermoelectric Generators
Cryogenic Systems
Superconducting Magnets
Silicon Solar Cells
Electro-Optic Fibers and Couplers
Explosives & Explosive Devices

ELECTRICAL POWER AND ILLUMINATION DEVICES

Wiring/Cables
Switching Gears
Fuse Boxes/Fuses
Circuit Breaker Boxes/Circuit Breakers
Conduit
Lamp Fixtures
Ballasts/Starters
Lamps/Incandescent
Lamps/Fluorescent
Lamps/Gas Discharge
Solid State Dimmers
Timers
Connectors
Convenience Outlets
Transformers

APPENDIX C

ECUT CURRICULUM BASED ON SEMESTER SYSTEM

ENERGY CONSERVATION-AND-USE TECHNICIAN
RECOMMENDED CURRICULUM
SEMESTER SYSTEM

First Semester	Lec.	Lab.	Contact Hours
Unified Technical Concepts I (Physics)	3	6	9
Chemistry for Energy Technology I	2	2	5
Technical Math I	2	0	2
Fundamentals of Energy Technology	2	0	2
Microcomputer Operations	3	3	6
	12	11	23

Second Semester	Lec.	Lab.	Contact Hours
Unified Technical Concepts II (Physics)	3	6	9
Chemistry for Energy Technology II	2	2	5
Technical Math II	2	0	2
Energy Production Systems	2	0	2
Fundamentals of Electricity and Electromechanical Devices	3	4	7
	12	12	25

Third Semester	Lec.	Lab.	Contact Hours
Mechanical and Fluid Systems	3	4	7
Electrical Power and Illumination Systems	2	2	4
Electronic Devices and Systems	3	3	6
Schematic and Blueprint Reading	1	2	3
Energy Conservation	2	2	4
	11	13	24

Fourth Semester	Lec.	Lab.	Contact Hours
Codes and Regulations	2	2	4
Heating, Ventilating and Air-Conditioning	3	3	6
Technical Communications	3	0	3
Instrumentation and Controls	3	3	6
Energy Economics and Audits	3	3	6
	14	11	25

RELATIONSHIP BETWEEN SEMESTER COURSES AND QUARTER COURSES

ENERGY CONSERVATION-AND-USE TECHNOLOGY CURRICULUM

Quarter System

Course	Contact Hrs/Wk	Wks of Instr	Total Contact Hrs per Course	Total Contact Hrs per Cluster
Unif. Tech. Con. I	9	10	90	
Unif. Tech. Con. II	9	10	90	
Unif. Tech. Con. III	9	10	90	270
Chem. for Energy Technology I	6	10	60	
Chem. for Energy Technology II	6	10	60	120
Fund. of Engy. Tech.	3	10	30	30
Tech. Math I	3	10	30	
Tech. Math II	3	10	30	60
Microcomp. Opr.	6	10	60	
Microcomp. Hdwe.	6	10	60	
Instrum. & Ctrl.	6	10	60	180
Energy Economics	3	10	30	
Energy Audits	6	10	60	90
Fund. of Electricity & Electronics	6	10	60	
Electromech. Dev.	6	10	60	120
Engy. Prod. Systems	3	10	30	30
Mech. Dev. & Syst.	6	10	60	
Fluid Systems	6	10	60	120
Electronic Dev. & Systems	8	10	80	80
El. Pwr. & Illum. Systems	6	10	60	60
Schem. & B.P. Rdg.	4	10	40	40
Engy. Consv.	6	10	60	60
HVAC	8	10	80	80
Tech. Comm.	4	10	40	40
Codes & Regs.	6	10	60	60
TOTAL CONTACT HOURS				1440

Semester System

Course	Contact Hrs/Wk	Wks of Instr	Total Contact Hrs per Course	Total Contact Hrs per Cluster
Unif. Tech. Con. I	9	15	135	
Unif. Tech. Con. II	9	15	135	270
Chem. for Energy Technology I	4	15	60	
Chem. for Energy Technology II	4	15	60	120
Fund. of Engy. Tech.	2	15	30	30
Tech. Math I	2	15	30	
Tech. Math II	2	15	30	60
Microcomp. Opr. (½ Microcomp. Hdwe.)	6	15	90	
Instrum. & Ctrl. (½ Microcomp. Hdwe.)	6	15	90	180
Engy. Econ. & Audits	6	15	90	90
Fund. of Electricity & Electromech. Dev.	7	15	105	105
Engy. Prod. Systems	2	15	30	30
Mech. & Fluid Syst.	7	15	105	105
Electronic Dev. & Systems	6	15	90	90
El. Pwr. & Illum. Systems	4	15	60	60
Schem. & B.P. Rdg.	3	15	45	45
Engy. Consv.	4	15	60	60
HVAC	6	15	90	90
Tech. Comm.	3	15	45	45
Codes & Regs.	4	15	60	60
TOTAL CONTACT HOURS				1440

APPENDIX D

ECUT COURSE OUTLINES

COURSE OUTLINES

CHEMISTRY FOR ENERGY TECHNOLOGY I

COURSE DESCRIPTION

Chemistry for Energy Technology I is a course designed with a special emphasis on all aspects of chemistry as it relates to the work of an energy technician. It is an energy-specific chemistry course designed for the student interested in pursuing a career in the energy field. The basic chemistry information and techniques presented in the 5 modules of this course have been deemed necessary for the applications that will be encountered by the energy technician.

PREREQUISITES

None.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	CH-01 Safety in Chemical Operations	3	3
II.	CH-02 Structure of Matter	6	6
III.	CH-03 Chemical Equations and Calculations	7	7
IV.	CH-04 Refrigeration, Gases, and Air Pollution	7	7
V.	CH-05 Solutions	7	7

COURSE OUTLINE

I. Safety In Chemical Operations
   A. Laboratory Safety Rules
   B. Personal Protective Equipment
   C. Fire Safety and Explosions
      1. Fire Prevention
      2. Fire Fighting
   D. Chemical Toxicity
      1. Physiological Effects of Chemicals
      2. Dangers of Acids
      3. Vapor Poisoning
      4. Merck Index
   E. Electrical Hazards
   F. Special Hazards
   G. Radiation Hazards
   H. Laboratory First Aid
      1. Chemical Burns
      2. Wounds and Fractures
      3. Shock
      4. Poisons (Swallowed)
      5. Poisons (Inhaled)
      6. Heat Stroke/Heat Exhaustion

II. Structure of Matter
   A. States of Matter
      1. Chemical and Physical Changes
      2. Classification of Matter
   B. Atomic Structure
      1. The Atom
      2. Composition of the Atom
      3. Symbols
      4. Naming of Compounds
      5. Formula Writing
   C. Chemical Bonding
      1. Ionic Bonding
      2. Covalent Bonding
      3. Hydrogen Bonding
      4. Metallic Bonding

III. Chemical Equations and Calculations
   A. Chemical Calculations
      1. Scientific Notation
      2. Significant Figures
      3. Metric System
      4. Problem Solving
   B. Chemical Equations
      1. Atomic Weight
      2. Isotopes
      3. Molecular Weights
      4. The Mole
      5. Writing and Balancing Equations
      6. Types of Chemical Reactions
      7. Calculations Based Upon Chemical Equations
   C. Gravimetric Analysis

IV. Refrigeration, Gases, and Air Pollution
   A. Refrigeration
   B. Characteristics of Gas
      1. Pressure
      2. Pressure-Volume Relationship
      3. Volume-Temperature Relationship
      4. Standard Temperature and Pressure
      5. Pressure-Temperature Relationship
      6. The Combined Formula
      7. Ideal-Gas Law
      8. Dalton's Law of Partial Pressure
      9. Graham's Law of Gaseous Diffusion
      10. Kinetic Theory of Gases
      11. Deviations from the Gas Laws
   C. Air Pollution
      1. Sources of Air Pollution
      2. Particulates
      3. Smog
      4. Sulfur Oxides
      5. Nitrogen Oxides

6. Hydrocarbons
7. Ozone
8. Sampling of Pollutants

V. Solutions
   A. The Liquid State
      1. Evaporation and Condensation
      2. Vapor Pressure
      3. Distillation
      4. Viscosity
   B. Dispersions
      1. Suspensions
      2. Colloids
      3. Solutions
   C. Solution Types and Characteristics
      1. Importance of Solutions
      2. Solution Process
      3. Unsaturated and Saturated Solutions
      4. Solubility
      5. Effect of Temperature on Solubility
      6. Effect of Pressure on Solubility
      7. Rate of Solution
      8. Supersaturated Solutions
      9. Concentration of Solutions
      10. Molar Concentration
      11. Normal Concentration
      12. Density
      13. Dilutions
   D. Acid, Bases, and Salts
      1. Titrimetric Analysis
      2. Measurement of pH
      3. Salts

FUNDAMENTALS OF ENERGY TECHNOLOGY

COURSE DESCRIPTION

Fundamentals of Energy Technology is designed to give the student an overview of the field of energy conservation and use and to provide descriptions of job functions typical to energy technicians. The course material is organized to show the compatibility of the total curriculum and the purpose of the approach chosen.

PREREQUISITES

None.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	EF-01 Energy Technology	3	0
II.	EF-02 Sources of Energy: I	5	0
III.	EF-03 Sources of Energy: II	5	0
IV.	EF-04 Uses of Energy	5	0
V.	EF-05 Energy Analysis	5	0
VI.	EF-06 Energy and the Environment	5	0
VII.	EF-07 Energy Resource Guide	2	0

COURSE OUTLINE

I. Energy Technology
   A. What is Energy
   B. When Did the Crisis Start?
   C. What is the History of Energy?
   D. What are the Factors Affecting Demand for Energy?
      1. Per Capita Energy Consumption
      2. Population
      3. World Distribution of Energy Sources
      4. How Does Energy Relate to the United States Economy?
      5. What Factors Must be Considered When Choosing Energy Sources?
      6. Fossil Fuels
         Petroleum, coal, tar sands, oil shale, natural gas
      7. Nuclear
      8. Geothermal
      9. Solar
      10. Hydropower
      11. Tidal Power
   E. Who Will Make the Decisions About Energy?

II. Sources of Energy I
   A. Sources of Energy: I
   B. Wood

C. Coal
   1. The Nature and Distribution of Coal
   2. Development of Coal
D. Petroleum
   1. The Nature and Distribution of Petroleum
   2. The Development of Petroleum
E. Natural Gas
   1. The Nature and Distribution of Natural Gas
   2. The Development of Natural Gas
F. Oil Shale
G. Tar Sands

III. Sources of Energy II
A. Sources of Energy: II
B. Nuclear Energy
   1. Nuclear Fission
   2. Fission Reactions
   3. Breeder Reactors
   4. Nuclear Fusion
C. Solar Energy
   1. Direct Solar
   2. Solar Technology
   3. Ocean Thermal
   4. Wind
D. Geothermal Energy
   1. Nature and Distribution of Geothermal Sources
   2. Development of Geothermal Energy
E. Hydropower
   1. Natural Water Courses
   2. Tides
F. New Sources
   1. Synthetic Fuels
   2. Biomass

IV. Uses of Energy
A. Uses of Energy
B. Energy Consumption and Distribution
C. Heating and Cooling
   1. Heating and Cooling Systems
      Single zone system, multizone system, terminal reheat system, variable air volume system, constant volume system, induction system, dual duct system, fan coil system, self-contained systems
   2. Applications
      Selection of heating/cooling system, selection of thermostat setting, consideration of efficiency, insulation, other considerations
D. Illumination
   1. Illumination Systems
   2. Applications
      Selection of light sources, reduction of intensity, control of lighting, use of natural lighting

E. Transportation
   1. Transportation Systems
   2. Applications
      Increased engine efficiency, increased load factors, mass transit, personal conservation
F. Industrial Power
   1. Industrial Power Systems
   2. Applications
      New industrial systems, recycling, increased energy efficiency of electrical generation, consideration of load factors, utilization of control systems
G. Communications

V. Energy Analysis
   A. Measurement of Energy
      1. Energy Units
      2. Power Units
   B. Energy Conservation
      1. Energy Systems
      2. Principles of Conservation
   C. Energy Audits
      1. Audit Methods
      2. Economic Analysis

VI. Energy and the Environment
   A. The Environment
   B. Effects of Energy Use on the Environment
      1. Effects of Energy Use on the Air
         Carbon monoxide, particulates, sulfur oxides, hydrocarbons, nitrogen oxides, carbon dioxide,
      2. Effects of Energy Use on Water
         Thermal pollution, direct water pollution, disturbance of natural ecosystems
      3. Effects of Energy Use on Land
         Mining, pipelines, solar collectors
   C. Pollution Control
      1. Reclamation
      2. Devices and Equipment
         Emission controls for automobiles, sulfur oxide controls for power plants, cooling towers
   D. Wastes
      1. Wastewater
      2. Solid Wastes
      3. Nuclear Wastes

VII. Energy Resource Guide
   A. Energy Conservation-and-Use Technician (ECUT)
      1. Other Job Titles
      2. The ECUT Curriculum
   B. Classroom Projects
      1. Field Trips
      2. Guest Speakers
      3. Energy Management Game

4. Demonstration

C. Films

1. Coal
2. Petroleum
3. Natural Gas
4. Nuclear
5. Solar
6. Geothermal
7. Oil Shale
8. Tar Sands
9. Miscellaneous Energy Subject
10. General Energy Subjects

D. Publications

1. Coal
2. Petroleum
3. Natural Gas
4. Nuclear
5. Solar
6. Geothermal
7. Miscellaneous Energy Subjects
8. General Energy Subjects

E. Glossary

TECHNICAL MATH I

COURSE DESCRIPTION

Technical Math I is designed to provide students with the math background necessary for energy conservation tasks. Topics include formula interpretation, metric system, logarithm and exponents, angles and triangles, vectors and scalars, reading and drawing graphs, dimensional analysis and decision and accuracy.

PREREQUISITES

The student should have completed one year of high school math.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contract Hours/Week	
		Class	Laboratory
I.	S-1 Formula Interpretation	4	0
II.	S-2 Dimensional Analysis	3	0
III.	S-3 International System of Units	4	0
IV.	S-4 Angles and Triangles	4	0
V.	S-5 Vectors and Scalars	4	0
VI.	S-6 Reading and Drawing Graphs	3	0
VII.	S-7 Logarithms and Exponents	5	0
VIII.	S-8 Precision, Accuracy, and Measurement	3	0

COURSE OUTLINE

I. Formula Interpretation
   A. Solving Formulas and Equations
   B. Application of Formulas to Physical Problems

II. Dimensional Analysis
   A. Systems of Units
      1. Fundamental Units
      2. Derived Units
   B. Dimensionless Quantities
   C. Checking an Equation Dimensionally
   D. Conversion Between Units

III. International System of Units
   A. Origin of the International System of Units
   B. Units in the SI System
   C. Other Units Used with SI Units
   D. SI Units In Unified Technical Concepts
   E. Definitions of SI Units
      1. Base Units
      2. Supplementary Units

IV. Angles and Triangles
   A. Angles (The Subject of Trigonometry)
      1. Units of Angular Measure
      2. Measurement of Angles

B. Triangles
    1. Similar Triangles
    2. Right Triangles
C. Trigonometric Ratios — Sine, Cosine, and Tangent
D. Vectors

V. Vectors and Scalars
    A. Vectors
    B. Adding Vectors by the Graphic (Polygon) Method
    C. Graphical Components

VI. Reading and Drawing Graphs
    A. Basic Steps for Graphing Experimental Data
    B. Summary

VII. Logarithms and Exponents
    A. Addition, Subtraction, Multiplication, and Division of Numbers Expressed in Powers of Ten
    B. Logarithms
    C. Finding the Antilogarithm
    D. Interpolation
    E. ~~Evaluating Formulas Containing Logarithms~~
    F. Natural Logarithms
    G. Applications of Natural Logarithms

VIII. Precision, Accuracy, and Measurement
    A. Counting and Measurement
    B. Accuracy and Precision in Measurement
    C. Specifying Errors in Measurement
    D. The Reading of Scales

MICROCOMPUTER OPERATIONS

COURSE DESCRIPTION

This course covers the operation and programming of microcomputers used by energy conservation technicians. The first part of the course concentrates on general concepts such as computer codes, binary arithmetic and the major parts of most computers. Then small microcomputer systems are studied and applied to typical energy-related data-gathering and control problems. In the third part of the course, a larger, disk-based system is used. Its operation and the kinds of software it uses are first studied and applied to energy conservation problems. Finally, students learn the elements of BASIC programming.

PREREQUISITES

The student must be able to calculate the value of integer exponentials like 2^5 and use a voltmeter to measure voltages.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	MO-01 Computer Codes	4	4
II.	MO-02 Microcomputer Architecture	4	4
III.	MO-03 Microcomputer Applications	4	4
IV.	MO-04 Disk-Based Operating Systems	4	4
V.	MO-05 Energy Applications of Microcomputers	4	4
VI.	MO-06 Introduction to BASIC	5	5
VII.	MO-07 BASIC Programming	5	5

COURSE OUTLINE

I. Computer Codes
   A. Electrical Codes
      1. Digital Codes
      2. Analog Codes
   B. Logical Codes
      1. Bytes, Words and Superwords
      2. Numerical Codes
         Binary, octal, radix indication, hexadecimal
   C. Base Conversion
      1. Binary/Octal Conversion
      2. Binary/Hexadecimal Conversion
      3. Hexadecimal/Octal Conversion
      4. Binary/Decimal Conversion
      5. Binary Arithmetic
      6. Large Binary Numbers
   D. Other Logic Codes
      1. BCD Numbers
      2. Alphanumeric Codes
      3. Operation Codes

II. Microcomputer Architecture
    A. The Microcomputer as a Control Device
        1. Digital Interfaces
        2. Analog Interfaces
    B. Computer Components
        1. Addresses
        2. Kim — A Specific Example
        3. The Bus
    C. CPU Architecture
        1. The Accumulator
        2. The Program Counter
        3. The Index Register
        4. Examining CPU Registers
        5. Assembly & Machine Code
        6. A Simple Program
        7. Branching & Immediate Data
        8. Other Instructions

III. Microcomputer Applicatons
    A. Control Applications
        1. System Elements
        2. Control Theory
        3. The Solar — Heated House
    B. Data Logging
        1. Logger Components
        2. Site Evaluation
        3. Larger Systems

IV. Disk-Based Operating Systems
    A. Disk Systems
    B. File Manipulation
        1. Files
        2. Creating and Storing Files
        3. Mistakes
        4. File Control
        5. Copying Files
        6. Rename and Erase
    C. The Editor
    D. Program Assembly
    E. ASM DIAG
    F. Load DIAG
    G. DIAG
    H. BASIC

V. Energy Applications of Microcomputers
    A. Energy Conservation Programs
    B. Solar
        1. The Collection System
        2. Heat Loads
        3. Economic Factors
    C. Load Shedding

VI. Introduction to BASIC
  A. BASIC Graphics
    1. Core Graphics
       Screen control, turtle commands
    2. Additional Graphics Commands
       Pen control, other turtle moves
  B. Computational Commands
    1. The LET Instruction
       Arithmetic expressions, parentheses, precedence rules
    2. Printing
  C. Programming Mode
    1. Line Numbers
    2. Input
    3. Scientific Notation
  D. Looping
    1. The GOTO Command
    2. Loops
  E. Disk Control

VII. BASIC Programming
  A. Conditional Statements
  B. Parts of the IF Instruction
  C. Indexing
  D. Dimensions
  E. Functions
    1. Format of Functions
    2. Other Functions
  F. Subroutines

TECHNICAL COMMUNICATIONS

COURSE DESCRIPTION

Technical Communications should provide the student with working knowledge of and firsthand experience in the use of communication techniques, procedures, forms and formats employed in industry and business. Technical presentations follow a unique style and depend heavily upon precise graphics. Technicians learn accepted methods of describing devices and processes, and of making oral and written technical presentations. Also, proper use of written manuals, guides, specifications and vendor instructions are reviewed.

PREREQUISITES

None.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week Class	Laboratory
I.	TC-01 Introducing Technical Communications	4	0
II.	TC-02 Conducting and Reporting Research	5	0
III.	TC-03 Writing Outlines and Abstracts	5	0
IV.	TC-04 Writing Definitions	5	0
V.	TC-05 Describing Mechanisms	5	0
VI.	TC-06 Describing a Process	5	0
VII.	TC-07 Performing Oral and Visual Presentations	5	0
VIII.	TC-08 Putting Skills Into Practice: Formal Report and Presentation	6	0

COURSE OUTLINE

I. Introducing Technical Communications
  A. Purpose of Course
  B. Definition of Technical Writing
  C. Basic Principles of Technical Writing
  D. Style
    1. Audience Adaptation
    2. Scientific Attitude
    3. Mechanics
  E. Introduction to Oral Communications

II. Conducting and Reporting Research
  A. Conducting and Reporting Research
  B. Completing Preliminary Steps
  C. Assembling a List of Sources
    1. Searching Subject Heading Indexes
    2. Using the Card Catalog
    3. Consulting Specialized Guides
    4. Locating Bibliographies
    5. Using Indexes and Abstract Services
    6. Utilizing Encyclopedias
    7. Using Dictionaries

8. Utilizing Handbooks
9. Using Yearbooks
10. Employing Information Centers
D. Utilizing the Best Tool
E. Using Research Results
1. Taking Notes
2. Assembling an Annotated Bibliography
3. Reporting Orally
4. Distinguishing Between Formal and Informal Reports
F. Summarizing: Conducting and Reporting Research

III. Writing Outlines and Abstracts
A. Planning and Summarizing
B. Outlines
1. No Point — No Plan
2. Outlining Effectively
3. Steps in Outlining
4. Rules for Formal Outlines
C. Abstracts and Introductory Summaries
1. Types of Abstracts
2. Suggestions for Writing Abstracts
D. Summary

IV. Writing Definitions
A. What Should be Defined
1. Familiar Words for Unfamiliar Things
2. Unfamiliar Words for Familiar Things
3. Unfamiliar Words for Unfamiliar Things
B. How Definitions are Constructed
1. Informal
2. Formal
Class, Distinguishing Characteristic, Summary of Formal Usage, Additional Suggestions for Formal Usage
3. Amplified Definitions
C. Where Definitions Should be Placed

V. Describing Mechanisms
A. Describing Mechanisms
B. Components of the Description of a Mechanism
1. Some Potential Problems
2. Specifications

VI. Describing a Process
A. Describing a Process
B. Problems Encountered in Describing a Process
C. Types of Processes
D. Instructions in a Process

VII. Performing Oral and Visual Presentations
A. Oral and Visual Aspects of Technical Communication
B. Oral Presentations and Activities

1. Oral Reports and Presentations
2. Leading Conferences and Group Discussions
3. Interviews and Other Person-to-Person Transactions

C. Visual Illustrations
1. What Illustrations Can Do
2. Types of Illustrations
Tables, figures

VIII. Putting Skills Into Practice: Formal Report and Presentation

A. Selecting the Topic
1. Analyzing the Audience
2. Developing a Plan

B. Writing A Rough Draft
1. Making an Outline
2. Assembling the Rough Draft
Prefatory pages, body of the report, appendix

C. Polishing the Final Copy

D. Presenting the Report Orally

E. Final Revisions

UNIFIED TECHNICAL CONCEPTS I, II, III (PHYSICS)

COURSE DESCRIPTION

Unified Technical Concepts is designed to teach the basic principles of physics as they apply to mechanical, fluid, electrical and thermal systems. Practical applications and hands-on laboratory work are stressed throughout the course. Concepts presented include: Force, Work, Rate, Resistance, Power, Potential and Kinetic Energy, Force Transformers, Energy Converters, Transducers, Vibrations and Waves, Time Constants, and Radiation.

Quarter System

The number of UTC application modules recommended for the Energy Conservation-and-Use Technician curriculum is listed in the table below by concept module number and quarter. Concepts are listed in the order recommended to meet prerequisites for other courses in the ECUT curriculum.

Quarter	Concept Number	Essential Application Modules	Optional Application Modules	Total
Second (UTC I)	1-0	8	2	10
	2-0	4	0	4
	3-0	6	0	6
	5-0	7	5	12
Quarter Totals		25	7	32
Third (UTC II)	6-0	4	2	6
	11-0	4	5	9
	7-0	3	3	6
	9-0	3	10	13
Quarter Totals		14	20	34
Fourth (UTC III)	8-0	3	2	5
	10-0	6	2	8
	12-0	2	2	4
	13-0	5	7	12
Quarter Totals		16	13	29
Total		55	40	95

Semester System

The number of UTC application modules recommended for Energy Conservation-and-Use Technician curriculum is listed in the table below by concept module number and semester. Concepts are listed in the order recommended to meet prerequisites for other courses in the ECUT curriculum.

Semester	Concept Number	Essential Application Modules	Optional Application Modules	Total
First (UTC I)	1-0	8	2	10
	2-0	4	0	4
	3-0	6	0	6
	5-0	7	5	12
	6-0	4	2	6
	11-0	4	5	9
Semester Totals		33	14	47
Second (UTC II)	7-0	3	3	6
	9-0	3	10	13
	8-0	3	2	5
	10-0	6	2	8
	12-0	2	2	4
	13-0	5	7	12
Semester Totals		22	26	48
Total		55	40	95

Module Selection

Unified Technical Concepts is a flexible physics instructional system consisting of 193 modules designed to meet the needs of a number of technologies. The CORD staff has determined that the following modules are best suited for use in the Energy Conservation-and-Use Technician curriculum. Those application modules preceded by an asterisk are considered essential. Other application modules listed are optional. CORD recommends that UTC courses for Energy Technicians include the 55 "essential" application modules and a selection of additional "optional" modules chosen to meet the needs, schedules and budgets of individual schools.

PREREQUISITES

Technical Math I or one year of high school algebra.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

1-0 Force

*1M2 Addition of Mechancial Forces
*1M3 Addition of Torques
1M6 Tension in Wires and Cables
*1F1 Atmospheric Pressure
*1F2 Density, Buoyancy and Specific Gravity
1F4 Manometers
*1E3 Electric Forces and Fields
*1E4 Magnetic Forces and Fields
*1T1 Thermometers
*1T2 Temperature Difference and Heat Flow

2-0 Work

*2M2 Work Done by a Winch
*2F1 Work Done by a Water Pump
*2T1 Heat Energy Required for a Temperature Increase
*2T4 Fundamentals of Air Conditioning

3-0 Rate

*3M2 Velocity at Constant Acceleration
*3M3 Displacement at Constant Acceleration
*3M5 Rotational Motion
*3E1 Electric Current
*3E2 Frequency
*3T2 Rate of Heat Conduction

5-0 Resistance

*5M2 Effect of Lubricants
5M3 Rolling Friction
*5F2 Viscosity
*5F3 Fluid Resistance in Pipes
5F4 Valves and Regulators
*5E1 Ohm's Law
*5E2 Series and Parallel Resistors
5E4 Conductors, Semiconductors and Insulators
5E5 Resistance of Wires
*5E6 Resistance of Semiconductor Junctions
5E8 Volt-Ohm-Milliammeter
*5T2 Heat Flow Through Insulation

6-0 Power

*6M2 Prony Brake
*6F1 Hydraulic Power

*6E1 Electrical Power Measurement
6E3 Efficiency of Electric Motors and Generators
6E4 Electrical Power Consumption
*6T1 Heat Exchangers

7-0 Potential and Kinetic Energy

7M3 Rotational Kinetic Energy of a Flywheel
*7F2 Venturi Meters
7F3 Pitot Tubes
*7E2 Energy Stored in a Capacitor
*7E3 Energy Stored in an Inductor
7E4 Series and Parallel Capacitors

8-0 Force Transformers

8M1 Levers
*8M3 Drive Systems
8M4 Gear Trains
*8F1 Hydraulic Press
*8E1 Electric Transformers

9-0 Energy Convertors

9F1 Turbines
9F2 Fluid Pumps
9F3 Wind Power
9F4 Fans and Blowers
9F5 Vacuum Pumps
*9E1 Electric Generators
9E2 Alternators
*9E3 Electric Motors
9E4 Solenoids and Relays
*9E5 Photovoltaic Materials
9T1 Boilers
9T2 Thermoelectric Generators
9T3 Solar Collectors

10-0 Transducers

*10M1 Strain Gages
10M2 Accelerometers
*10F1 Bourdon Tubes
10F5 Vacuum Gages
*10E1 Meter Movements
*10T2 Bimetallic Strips
*10T3 Temperature Measuring Devices
*10T5 Thermistors

11-0 Vibrations and Waves

11M3 Vibration Isolation
*11M4 Resonance
*11F1 Cavity Vibrations and Standing Waves
11F5 Pressure Measurements of Sound Waves

*11E1 Alternating Voltage and Current
11E2 Phase Relationships in AC Circuits
11E3 Oscilloscopes
*11E4 Rectifiers
11E5 Electronic Filtering in DC Power Supplies

12-0 Time Constants

12F1 Rate of Emptying Tanks
*12E1 RC Circuits
12T1 Response Time of Thermocouples
*12T2 Time Constants of Heating and Cooling

13-0 Radiation

*13L1 Inverse Square Law — Spreading of Light
*13L2 The Optical Spectrum
*13L3 Light Sources
13L4 Lasers
13L5 Stroboscopes — Light Pulses
13L6 Optical Filters — Absorption of Light
13L7 Specular and Diffuse Reflection of Light
13L8 Image Formation with Mirrors
13L9 Prisms — Refraction and Dispersion of Light
13L10 Lenses — Focusing and Spreading of Light
*13L16 Infrared Radiation Thermometers
*13L17 Illumination

CHEMISTRY FOR ENERGY TECHNOLOGY II

COURSE DESCRIPTION

Chemistry for Energy Technology II is a course designed with a special emphasis on all aspects of chemistry as it relates to the work of an energy technician. It is an energy-specific chemistry course designed for the student interested in pursuing a career in the energy field. The basic chemistry information and techniques presented in the 6 modules of this course have been deemed necessary for the applications that will be encountered by the energy technician.

PREREQUISTIES

Chemistry for Energy Technology I.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
VI.	CH-06 Corrosion and Electrochemistry	5	5
VII.	CH-07 Metals and Ceramics	5	5
VIII.	CH-08 Thermodynamics and Thermochemistry	5	5
IX.	CH-09 Fuels	5	5
X.	CH-10 Plastics, Adhesives and Lubricants	5	5
XI.	CH-11 Nuclear Chemistry	5	5

COURSE OUTLINE

VI. Corrosion and Electrochemistry
- A. Corrosion
- B. Electrochemistry
  1. Electrode Potentials
  2. Electrolysis
  3. Electrolytic Refining (Metals)
  4. Law of Electrolysis
  5. Electrochemical Machining
  6. Voltaic Cells
- C. Electrochemical Corrosion
  1. Boiler Corrosion
  2. Boiler Water Treatment
- D. Protection of Metals from Corrosion

VII. Metals and Ceramics
- A. Solids
  1. Bonding
  2. Melting Point
  3. Sublimation
- B. Properties of Metals
  1. Thermal Properties
  2. Electrical Conductivity

3. Mechanical Properties and Testing

C. Alloys

1. Classifications
2. Types of Steel

   Pig iron, cast iron, wrought iron, powdered iron, carbon steel, alloy steels, high-alloy steel, tool steel

3. Examples of Other Alloys

D. Ceramics

VIII. Thermodynamics and Thermochemistry

A. Thermodynamics

1. Heat
2. Specific Heat
3. Refrigeration Units
4. Changes of State
5. Solar Energy Storage
6. Heat Transfer
7. Heat Pipe

B. Thermochemistry

1. Relationship Between Matter and Energy
2. Calorimetry

IX. Fuels

A. Characteristics of Fuels

1. Solid Fuels
2. Gaseous Fuels
3. Liquid Fuels

B. Organic Chemistry

1. Classification of Organic Compounds
2. Alkane Series
3. Nomenclature
4. Alkene Series
5. Alkyne Series
6. Cycloalkanes
7. Aromatic Hydrocarbons
8. Nomenclature of Aromatic Compounds
9. Substituted Hydrocarbons

C. Gasoline Production

D. Alternate Energy Sources

1. Methanol
2. Ethanol
3. Hydrogen
4. Biomass
5. Geothermal
6. Solar Energy

E. Summary

X. Plastics, Adhesives, and Lubricants

A. Plastics

1. Polymer Additives
2. Processing of Plastics
3. Properties of Major Plastics

B. Analysis and Testing of Plastics

C. Adhesives

D. Lubrication

XI. Nuclear Chemistry
   A. Nuclear Chemistry
      1. Nuclear Radiation
      2. Radioactive Decay Series
      3. Half-Life
      4. Detection of Radioactivity
   B. Nuclear Reactions
      1. Nuclear Fission
      2. Nuclear Fusion
      3. Nuclear Reactors
      4. Breeder Reactors
   C. Radioisotopes

ENERGY ECONOMICS

COURSE DESCRIPTION

Energy Economics develops the techniques necessary to evaluate the economic impact and advantages of energy production. Is is a course designed to familiarize the student with the energy-conserving and cost-saving measures that are avaliable, as well as the analysis techniques that are necessary for accurate evaluation of energy projects. The conceptual format enables the student to apply the appropriate tools to a diversity of energy-related decisions. The course concludes with financial analysis of alternate energy applications.

PREREQUISITES

The student should have a good understanding of basic algebraic functions.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	EE-01 Fundamentals of Energy Cost Analysis	6	0
II.	EE-02 Financial Parameters of Energy Economics	6	0
III.	EE-03 Financial Techniques of Energy Economics	6	0
IV.	EE-04 Economics of Energy Alternatives	6	0
V.	EE-05 Economic Analysis and Energy Conservation Projects	6	0

COURSE OUTLINE

I. Fundamentals of Energy Cost Analysis
   - A. Business Firms and Energy Conservation
     1. Profit, Revenue, and Cost
     2. Measurement of Energy Conservation
     3. Individuals and Non-Profit Organizations
   - B. Types of Costs
   - C. Economic Efficiency
   - D. Determinants of Price
     1. Supply
     2. Market Supply
     3. Demand
     4. Market Demand
     5. Market Price
     6. Additional Factors that Influence Price
   - E. Marginal Analysis
     1. Marginal Cost and Marginal Cost Savings
     2. How To Use Marginal Analysis

II. Financial Parameters of Energy Economics
   - A. Principal and Interest
   - B. Time Value of Money

C. Future Value of a Fixed Amount
   1. Compounding Process
   2. Future Value of $1
   3. Future Value of Amounts Greater Than $1
   4. How to Read the Future Value of $1 Table
   5. Observations Concerning the Future Value of a Fixed Amount
   6. Cost Escalation
   7. Conclusion
D. Present Value of A Fixed Amount
   1. Derivation of a Formula for Present Value
   2. How to Read the Present Value of $1 Table
   3. Present Value of Amounts Greater Than $1
   4. Observations Concerning the Present Value of a Fixed Amount
E. Shorter Time Periods

III. Financial Techniques of Energy Economics
A. Cost of An Annuity
   1. Accumulation of An Annuity
   2. Sum of An Annuity of $1 Formula
   3. The Sum (Future Value) of An Annuity of $1 Table
   4. Sum of An Annuity of More Than $1 Per Year
B. Present Value of An Annuity
   1. Calculation of the Present Value of An Annuity
   2. Present Value of An Annuity of $1
   3. The Present Value of An Annuity of $1 Table
   4. Present Value of Annuities Larger Than $1
C. Analysis of Energy Projects, Using Present Value of an Annuity
D. Present Value of An Irregular Flow of Cost Savings
   1. Cost Escalation and Present Value
   2. Conclusion

IV. Economics of Energy Alternatives
A. Finances of An Investment
B. Taxes
   1. Corporations and Taxes
   2. Tax Credits
C. Life on An Investment
D. Life-Cycle Costing

V. Energy Analysis
A. Replacement Projects and Original Projects
B. Mutually-Exclusive Projects
C. Net Cost Savings Per Year
D. Payback Period
E. Capital Recovery Factor
F. Benefit-Cost Analysis
G. Net Present Value Method
   1. Definition of Net Present Value
   2. Calculation of Net Present Value
   3. Usefulness of the Net Present Value (NPV) Method
   4. Shortcomings of the NPV Method
H. Internal Rate of Return (IRR) Method
   1. Definition of Internal Rate of Return
   2. Calculation of the Internal Rate of Return (IRR)

3. IRR and An Irregular Flow of Cost Savings
4. Use of IRR and Evaluation of Mutually-Exclusive Projects

I. Comparison of Methods for Evaluating Energy Projects

TECHNICAL MATH II

COURSE DESCRIPTION

Technical Math II is intended to provide the student with the math background necessary for the performance of energy conservation tasks. Subjects covered range from plane geometry to trigonometric functions.

PREREQUISITES

None.

RECOMMENDED TEXT

Elementary Technical Math with Calculus, from MacMillan Publishing Co.

COURSE OUTLINE

- I. Geometry
  - A. Plane Figures
    - 1. Lines
    - 2. Angles
    - 3. Polygons
  - B. Measurement of Plane Figures
    - 1. Perimeter
    - 2. Area
  - C. Right Angles
    - 1. Pythagorean theorum
    - 2. Triangles
  - D. Circles
    - 1. Terms
    - 2. Measurements
      - Circumference, Area
  - E. Solids
    - 1. Polyhedrons
      - Volume, lateral area
    - 2. Cylinders
      - Volume, lateral area
    - 3. Pyramids
      - Volume, lateral area
    - 4. Cones
      - Volume, lateral area
    - 5. Spheres
      - Surface area, volume
- II. Logarithms
  - A. Logarithms and Antilogarithms
  - B. Common Logs
  - C. Natural Logs
  - D. Exponential Equations and Power of Numbers
- III. Trigonometry
  - A. Ratios
    - 1. Angles
      - Types, measurement
    - 2. Trigonometric Functions

B. Trigonometric Tables

C. Right Triangles
   1. Trigonometric Functions
   2. Logarithms of Functions

D. Functions of Angles
   1. Finding angle on coordinate system
      First quadrant, second quadrant, third quadrant, fourth quadrant
   2. Finding angle given function

E. Radian Measure

F. Vectors
   1. Calculation
   2. Representation
   3. Multiple vectors

G. Graphs
   1. Sine curve
      Cycle, frequency, period
   2. Cosine curves

SCHEMATIC AND BLUEPRINT READING

COURSE DESCRIPTION

Schematic and Blueprint Reading should be designed to familiarize the student with the standard symbols and techniques used in schematics of electrical, mechanical, hydraulic and pneumatic systems and structural blueprints. Devices and systems discussed in other courses in the Energy Conservation-and-Use Technician curriculum are used as examples. The laboratory should stress the identification of parts and the relationships of the schematic or blueprint to the system it describes.

PREREQUISITES

None.

RECOMMENDED TEXT

Blueprint Reading for Commercial Construction, from Van Nostrand Reinhold Company.

COURSE OUTLINE

I. Electronic Schematics
   A. Standard Symbols in Schematics
   B. Reading Electrical Schematics
   C. Circuit Layout and Component Identification
   D. Schematics for Electronic Instrumentation
   E. Residential Electrical Circuits
   F. Electrical Power Distribution Systems

II. Mechanical Schematics
   A. Schematics of Mechanical Parts
   B. Dimensions and Tolerances
   C. Orthographic Projections
   D. Standard Symbols in Hydraulics and Pneumatics

III. Blueprints
   A. Frame Construction
   B. Heating, Ventilating and Air-Conditioning
   C. Plumbing
   D. Structural Steel
   E. Concrete and Masonry

ENERGY PRODUCTION SYSTEMS

COURSE DESCRIPTION

Energy Production Systems is an in-depth technical study of the processes and equipment used to convert fuels, such as coal and natural gas, and energy resources, such as sunlight, into useful energy forms: electricity, heat, or motion. This course will enable energy technicians to select optimum energy sources and equipment for maximum economy, availability, efficiency, and/or environmental quality. The first four modules of the course emphasize fuels and energy sources, examine their properties, and describe how they are used to produce steam and hot water. These modules extend information as far as the boiler in the system. The final three modules emphasize how energy is used: to produce motion, to drive a turbine, or to produce electricity. Thus, steam that is produced by the combustion of a fuel, as described in Module EP-01 or EP-02, is used in processes that are described in later modules.

PREREQUISITES

The student should have completed the Fundamentals of Energy Technology course.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

	Contact Hours/Week Class	Laboratory
I. EP-01 Generation of Steam and Hot Water Using Solid Fuels	4	0
II. EP-02 Generation of Steam and Hot Water Using Liquid and Gaseous Fuels	4	0
III. EP-03 Generation of Steam, Hot Water and Hot Air Using Solar Collectors	4	0
IV. EP-04 Generation of Steam and Hot Water Using Nuclear and Experimental Power Sources	4	0
V. EP-05 Combustion Engines	5	0
VI. EP-06 Turbines	5	0
VII. EP-07 Production of Electricity	4	0

COURSE OUTLINE

I. Generation of Steam and Hot Water Using Solid Fuels
   A. Types and Properties of Solid Fuels
      1. Coal
      2. Other Solid Fuels
   B. Handling of Solid Fuels
      1. Transportation
      2. Unloading
      3. Storage
      4. Sizing
   C. Combustion of Solid Fuels
      1. Stages of Combustion
      2. Chemical Reactions in Combustion

D. Burning of Solid Fuels
   1. Stokers
   2. Pulverized Coal Systems
   3. Cyclone Furnaces
   4. Fluidized Beds
   5. Excess Air
   6. Boilers
   7. Removal of Ash
E. Economic and Environmental Aspects of Solid Fuel Systems
   1. Economic Considerations
   2. Environmental Considerations

II. Generation of Steam and Hot Water Using Liquid and Gaseous Fuels
A. Types and Properties of Liquid and Gaseous Fuels
   1. Liquid and Gaseous Fossil Fuels
      Fuel oil, natural gas, liquefied petroleum gas, manufactured gas, shale oil
   2. Liquid and Gaseous Fuels Derived from Coal
      Manufactures gases, coal gasification, coal liquefaction
   3. Gaseous and Liquid Fuel from Biomass
      Gaseous products, liquid products
B. Fuel Handling
   1. Transportation
   2. Storage
   3. Preparation for Burning
   4. Waste Disposal
C. Combustion Systems for Liquid and Gaseous Fuels
   1. Burners
   2. The Complete Combustion System
D. Relative Advantages of Liquid and Gaseous Fuels
   1. Economics
   2. Environmental Considerations
   3. Summary of Advantages and Uses

III. Generation of Steam, Hot Water, and Hot Air Using Solar Collectors
A. Solar Radiation
   1. Solar Constant (Insolation)
   2. Factors Affecting Incident Solar Radiation
      Absorption in the atmosphere, solar altitude
   3. Absorption by Various Materials
B. Efficiency of Conversion of Solar Energy to Useful Heat
C. Hot Water Systems
   1. Flat-Plate Collectors
   2. Concentrating Collectors
   3. Effect of Adjusting Orientation of Collector for Maximum Collection Efficiency
   4. Total System Configuration
      Storage devices, control considerations, comparison of efficiency for various configurations
D. Hot Air Systems
   1. Passive Systems
   2. Collectors
   3. Storage
   4. Comparison to Water-Based Systems

E. Solar Furnaces for Steam Generation
   1. Axial Tower
   2. Parabolic Collectors
   3. Location
   4. Reduction of Heat Loss
   5. Maintenance
F. Factors Affecting System Operation
   1. Architectural Factors
   2. System Size
   3. Economic Factors

IV. Generation of Steam and Hot Water, Using Nuclear and Experimental Power Sources
   A. Nuclear Reactors (Fission)
      1. Light Water Reactors
         Reactor design, boiling water reactors, pressurized water reactors, status of light water reactors, the nuclear fuel cycle, safety of nuclear reactors
      2. Heavy Water Reactors
      3. Gas Cooled Reactors
      4. Breeder Reactors
   B. Nuclear Fusion
      1. Magnetic Confinement Fusion
      2. Inertial Confinement Fusion
      3. Fusion Reactors
      4. Projected Technology
   C. Geothermal Energy Supply
      1. Geothermal Energy Resources
      2. Present Geothermal Technology
   D. Ocean Thermal Energy
      1. Principles
      2. Basic Plant Design
      3. Present Technology

V. Combustion Engines
   A. Classification of Engines
      1. Place of Combustion
         Internal combustion engines, external combustion engines
      2. Means of Energy Conversion
         Reciprocating engine, rotary engine
      3. Type of Mechanical Cycle
         Two-stroke cycle, four-stroke cycle
      4. Type of Cooling System
         Water cooling systems, air colling systems
      5. Arrangement of Cylinders
         In-line cylinder configuration, V-type cylinder configuration, opposed cylinder configuration, radial cylinder configuration
   B. Components of an Internal Combustion Engine
      1. Cylinder block
      2. Cylinder head
      3. Manifolds
      4. Valve Train

Camshaft, tappet (valve lifter), push rod, rocker arm assembly, valve springs, valves

5. Piston and Connecting Rod Assembly
   Piston, connecting rod, bearings,
6. Crankshaft Assembly
   Crankshaft, flywheel

C. Engine Lubrication Systems
   1. Splash System
   2. Barrel-Type Pump System
   3. Oil Slinger System
   4. Pressure-Feed System
      Oil pan, oil pump, oil filter

D. Fuel Systems
   1. Fuel Injection
      Types of injection systems, nozzles
   2. Carburetion
      Fuel pump, fuel filter, air cleaner, carburetor, fuel tank, fuel lines
   3. Efficiency of Fuel System

E. Electrical System
   1. Battery
   2. Ignition/Starting Switch
   3. Ignition System
      Coil, distributor, spark plugs, repair and timing of the ignition system
   4. Starting System
      Solenoid, starter motor
   5. Charging System
      Alternator/generator, voltage regulator, ammeter

VI. Turbines

A. Steam Turbines
   1. The Simple Steam Turbine
   2. Impulse Turbines
      Single-stage impulse turbine, velocity-stage impulse turbine, pressure-stage impulse turbine, combination pressure- and velocity-stage turbine
   3. Reaction Turbines
   4. Steam Turbine Design Features
      Nozzles, rotor, casing, blade seals, shaft seals, bearings, steam chest, extraction ports, turning gear, steam flow paths
   5. Steam Turbine Systems and Applications
      Condensing turbines, noncondensing turbines, mixed pressure turbines, extraction turbine, reheat turbines

B. Gas Turbines
   1. Gas Turbine Design Features
      Air intake system, compressor, combustor, turbine, exhaust system
   2. Gas Turbine Characteristics and Applications

C. Hydraulic Turbines
   1. Hydraulic Impulse Turbine
   2. Hydraulic Reaction Turbines

3. Wind Turbines

VII. Production of Electricity

A. Electrical Power Plants Using Steam Turbines and Combustion Engines

1. Steam Turbine Plants

Steam cycles and efficiency, system configuration, generation of three-phase A.C. power, comparison of plant costs

2. Hydroelectric Plants
3. Internal Combustion Engine Plants
4. Generation of Direct Current Power

B. Batteries

1. Principles of Electrochemical Energy Generation
2. Conventional Batteries
3. Developmental and Experimental Batteries

C. Fuel Cells

D. Photovoltaic Generation of Electricity

1. Principles of Operation
2. Photovoltaic Cells
3. Application of Photovoltaic Electric Generation

MECHANICAL DEVICES AND SYSTEMS

COURSE DESCRIPTION

Mechanical Devices and Systems is an in-depth study of the principles, concepts and applications of various mechanisms that may be encountered in industrial applications of energy use and conservation. The mechanical components and systems are divided into eight modules of instruction, covering operational principles, uses, maintenance, troubleshooting, and repair and replacement procedures. The procedure or application portion of the modules will emphasize practical maintenance and installation of equipment and selection and specification of proper replacement components from manufacturers catalogs.

PREREQUSITES

The student should have completed the following Unified Technical Modules: Concept Modules 1-0, "Force," 2-0, "Work," 6-0, "Power," and 8-0, "Force Transformers"; and Application Module 8M3, "Drive Systems." One year of high school algebra also must have been completed.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week Class	Student Contact Hours/Week Laboratory
I.	MS-01 Belt Drives	3	3
II.	MS-02 Chain Drives	3	3
III.	MS-03 Gear Drives	4	4
IV.	MS-04 Drive Train Components I	4	4
V.	MS-05 Drive Train Components II	4	4
VI.	MS-06 Linkages	4	4
VII.	MS-07 Fans and Blowers	4	4
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COURSE OUTLINE

I. Belt Drives
- A. Mechanical Drives
- B. The Belt Drive
- C. Types of Belts
- D. Flat Belts
  1. Length Measurement and Calculation
  2. Belt-Speed Calculation
  3. The Positive-Drive Belt
- E. Maintenance of Flat Belts
  1. Splicing of Flat Belts
  2. Troubleshooting of Flat Belts
- F. V-Belts
  1. Design Variations
  2. Variable-Speed Belt Drives

3. Forms of Belt Drives
4. V-Belt Sizes and Matching Numbers
5. Pulley Size

G. Maintenance of V-Belt Drives
1. Sheave Alignment in V-Belt Drives
2. V-Belt Installation
3. Belt Tension
4. Troubleshooting of V-Belts
5. V-Belt Drive Selection

II. Chain Drives
A. Characteristics of Chain Drives
B. Types of Chains
C. Chain Length
D. Sprockets
1. Types of Sprockets
2. Sprocket Speed
3. Sprocket Position
4. Idler Sprockets
5. Selection of Chain Drives

E. Maintenance
1. Alignment
2. Chain Installation
3. Chain Tension and Sag
4. Lubrication
5. Sprocket Inspection

F. Troubleshooting of Chain Belts
G. Chain Storage

III. Gear Drives
A. Mechanical Basics
B. Gear Basics
C. Terminology
D. Types of Gears
1. Parallel-Axes Gears
2. Intersecting-Axes Gears
3. Non-Intersecting, Nonparallel-Axes Gears
4. Moving-Axes Gears

E. Gear Trains
F. Maintenance
1. Lubrication
2. Adjustment
3. Inspection and Troubleshooting

G. Selection of Gear Drives

IV. Drive Train Components I
A. Shafts
1. Shaft Spacing
2. Bossed and Turned-Down Shafting
3. Flexible Shafts
4. Shaft Expansion
5. Alignment
6. Metalizing of Shafts

7. Bent Shafts
8. Shaft Selection
9. Shaft Keys and Keyseats

B. Bearings

C. Plain Bearings
1. Mounted Plain Bearings
2. Lubrication

D. Antifriction Bearings
1. Radial Bearings
2. Thrust Bearings
3. Combination Bearings
4. Mounted Bearings
5. Shaft Alignment
6. Belt Tension
7. Shock Loads
8. Bearing Installation
9. Vibration
10. Current Through Bearings
11. Lubricants
    Lubrication systems
12. Troubleshooting
13. Selection of Antifriction Bearings

V. Drive Train Components II

A. Seals
1. Static Seals — Gaskets and O-Rings
2. Dynamic Seals
3. Mechanical Seals

B. Couplings
1. Definitions
2. Rigid Couplings
3. Flexible Couplings.
4. Universal Joints
5. Selection of Couplings

C. Clutches
1. Definitions
2. Friction Clutches
3. Magnetic Clutches
4. Jaw Clutches
5. Dry Fluid Clutches
6. Hydraulic Clutches

VI. Linkages

A. Terms and Definitions

B. Types of Linkages

C. Cams
1. Terms and Definitions
2. Types of Cams
3. Types of Followers

VII. Fans and Blowers

A. The Two Fan and Blower Types
1. Axial-Flow Fans and Blowers
2. Centrifugal Fans and Blowers

3. Materials of Construction
4. Accessories

B. Energy Conservation
1. The Economizer Cycle
2. The Heat Wheel and Other Heat Exchangers
3. Controllable-Pitch Fans and Speed Controls
4. Dampers
5. Air Curtains for Energy Conservation
6. The Heat Recovery Air Curtain

C. Testing and Air Flow Measurements

D. Anemometers

E. Maintenance

F. Fan Selection

G. General Information and Terms
1. Pressure Increases
2. Fan Laws
3. Fan Wheel Diameter
4. Pressure and Pressure Difference
5. Air Horsepower
6. Air Density
7. Efficiency

VIII. Valves

A. Components and Operating Principles

B. Uses of Valves

C. Valve Types

D. Materials for Valves

E. Valve Codes and Markings

F. Valve Actuators

G. When Automatic Controllers are Used

H. Valve Maintenance

FUNDAMENTALS OF ELECTRICITY AND ELECTRONICS

COURSE DESCRIPTION

Fundamentals of Electricity and Electronics is designed to provide the student with basic knowledge and skills in dc and ac electrical circuits to include circuit analysis, recognition and use of electrical components and electrical measurement instruments. Topics presented include voltage, resistance, current, power, Ohm's law, inductors, capacitors, series and parallel circuits and magnetic circuits and devices.

PREREQUISITES

Unified Technical Concepts I.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	FE-01 Basics of Electricity and Magnetism	3	3
II.	FE-02 Electricity in Motion	5	5
III.	FE-03 Direct Current Through Series and Parallel Resistors	6	6
IV.	FE-04 AC Circuit Analysis	6	6
V.	FE-05 Reactance and Impedance	6	6
VI.	FE-06 Magnetic Circuits and Devices	4	4

COURSE OUTLINE

I. Basics of Electricity and Magnetism
   A. Electricity
      1. The Direction of Electric Force
      2. The Size of Electric Force
   B. Magnetism
      1. Natural or Permanent Magnets
      2. Magnetic Field Around a Wire
   C. Summary

II. Electricity in Motion
   A. Electric Current
   B. Electromotive Force
   C. Production of Electron Flow
      1. The Generator
      2. The Battery
      3. Thermoelectric Pumps
      4. Photoelectric Pumps
      5. Piezoelectric Pumps
   D. Resistance
      1. Kind of Material
      2. Length of Material
      3. Cross-Sectional Area
      4. Temperature

E. Resistance of Wires
F. Types of Resistors
   1. Variable Resistors
   2. Special Resistors
G. OHM's Law

III. Direct Current Through Series and Parallel Resistors
   A. Kirchhoff's Voltage Law
   B. Kirchhoff's Current Law
   C. Series Parallel Circuits
   D. Mesh Current Analysis
   E. Superposition Analysis
   F. Substitution Analysis
   G. Wheatstone Bridge

IV. AC Circuit Analysis
   A. Definition of Alternating Current
      1. Frequency
      2. Generation of A.C.
   B. Practical A.C. Generators
      1. Armature Coil Size
      2. Field Magnet
      3. Rotation of Field Coils
      4. Three-Phase A.C.
      5. Phase Between Voltage and Current
      6. Adding Two A.C. Currents or Voltages
   C. Power in A.C. Circuits
   D. Alternating Current Values
      1. Maximum Or Peak
      2. Instantaneous
      3. Average
      4. Effective or RMS Value
   E. Rectifiers and Power Supplies
      1. A.C. Source
      2. Transformer
      3. Rectifier
      4. Half-Wave Rectifier
      5. Full-Wave Rectifier
      6. Filter
      7. Voltage Divider
      8. Voltage Regulator

V. Reactance and Impedance
   A. Impedance
   B. Inductors
      1. Induced Current
      2. Mutual Induced Current
      3. Self-Induced Current
   C. Inductance
      1. Factors Affecting Inductance
         Number of turns, type of care, spacing between windings, diameter of coil, coil diameter/length ratio
      2. Phase Relationship in an Inductor

D. Inductive Reactance
   1. Inductors Connected in Series
   2. Inductors Connected in Parallel
E. Typical Inductors
   1. Power-Frequency Inductors
   2. Audio-Frequency Inductors
   3. Radio-Frequency Inductors
F. Testing Inductors
G. Capacitors
   1. Factors Affecting Capacitance
      The Area of the plates, the distance between the plates, types of dielectric
   2. Phase Relationships in A Capacitor
   3. Capacitive Reactance
   4. Capacitors Connected in Series
   5. Capacitors Connected in Parallel
H. Types of Capacitors
I. Testing Capacitors
J. Impedance in an RL and RC Circuit
   1. Vector Concepts
   2. RL and RC Circuits
K. Power Factor
L. Time Constants
M. Universal Time Constant Chart

VI. Magnetic Circuits and Devices
A. The Laws of Magnetism
B. Electromagnetism
C. Magnetic Terms and Magnetic Circuits
   1. Magnetomotive Force
   2. Magnetic Flux
   3. Reluctance and Permeability
   4. Classification of Magnetic Substances
   5. The B-H Curve
   6. Hysteresis
D. Magnetic Devices
   1. Relays
   2. Relay Coils and Cores
   3. Relay Contacts
   4. Relay Circuits
   5. Transformers
   6. Transformation Ratio
E. Input/Output Voltage Phase
   1. Transformers Used as Impedance Matching Devices
   2. Transformer Losses and Efficiency
   3. Types of Transformers
   4. The Power Transformer
      The Audio Transformer, the radio-frequency transformer
F. Motor Action

ELECTROMECHANICAL DEVICES

COURSE DESCRIPTION

Electromechanical Devices is designed to provide the student with a working knowledge of control elements in electrical circuits, transformers, motors and generators. Topics presented include switches, circuit breakers, relays, fuses, transformers, d.c. and a.c. motors and generators.

PREREQUISITES

The student should have completed a course in d.c. and a.c. circuit analyses.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week Class	Laboratory
I.	EM-01 Electromechanical Devices - An Introduction	3	3
II.	EM-02 Control Elements in Electrical Circuits	4	4
III.	EM-03 Transformers	4	4
IV.	EM-04 Generators and Alternators	4	4
V.	EM-05 D.C. Motors and Controls	5	5
VI.	EM-06 A.C. Motors and Controls	5	5
VII.	EM-07 Synchromechanisms	5	5

COURSE OUTLINE

I. Electromechanical Devices - An Introduction
   A. Magnetic Forces and Fields
   B. The Origin of Magnetism
   C. Magnetic Fields of Electric Currents
   D. Forces on Charged Particles Moving Through Magnetic Fields
   E. Generator Action
   F. Motor Action
   G. Transformers

II. Control Elements in Electrical Circuits
   A. Switches
   B. Testing and Maintenance of Switches
   C. Relays
   D. Testing and Maintenance of Relays
   E. Relay Circuits
   F. Fuses
   G. Checking and Replacing Fuses
   H. Circuit Breakers
   I. Checking Circuit Breakers

III. Transformers
- A. The Basic Transformer
- B. Power Losses in Transformers
- C. Power Transformers
- D. Autotransformers
- E. Other Transformers
- F. Troubleshooting Transformers

IV. Generators and Alternators
- A. The Simple D.C. Generator
- B. Construction of D.C. Generators
- C. Field Coil Connections in D.C. Generators
- D. Operation of D.C. Generators
- E. The Alternator
- F. Automobile Alternators
- G. Large Alternators
- H. Operation of Alternators
- I. Maintenance

V. D.C. Motors and Controls
- A. The Simple D.C. Motor
- B. Construction of D.C. Motors
- C. D.C. Motor Controls
- D. Motor Efficiency
- E. Motor Maintenance and Troubleshooting

VI. A.C. Motors and Controls
- A. Three-Phase A.C. Motors
  1. Rotating Magnetic Fields
  2. Synchronous Motors
  3. Induction Motors
  4. Power Factor in A.C. Motors
- B. Synchronous Motors
  1. Rotor Construction
  2. Field Excitation and Power Factor
  3. Starting Synchronous Motors
  4. Applications of Synchronous Motors
- C. Three-Phase Induction Motors
  1. Rotor Construction
  2. Starting Three-Phase Induction Motors
  3. Applications of Three-Phase Induction Motors
  4. Wound Rotor Motors
- D. Single-Phase Induction Motors
  1. Capacitor-Start Motors
  2. Permanent-Capacitor Motors
  3. Repulsion-Induction Motors
  4. Shaded-Pole Motors
  5. Speed Control of Single-Phase Induction Motors
- E. Universal Motors

VII. Synchromechanisms
- A. The Synchro Transmitter
- B. The Synchro Receiver

C. Differential Synchro Transmitters and Receivers
D. The Synchro Control Transformer
E. Classification of Synchromechanisms
F. Applications of Synchromechanisms

ELECTRONIC DEVICES AND SYSTEMS

COURSE DESCRIPTION

Electronic Devices and Systems is designed to provide the student with a working knowledge of modern electronic devices and the circuits in which they are employed. Electronic troubleshooting techniques are stressed throughout the course. Topics presented include rectifiers, transistors, SCR's and triacs, vacuum and gaseous tubes, filters, amplifier circuits, operational amplifiers, noise reduction, digital circuits and display devices.

PREREQUISITES

The student should have completed one year of algebra and should also be familiar with the concepts of direct current and alternating current electronics.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

	Student Contact Hours/Week	
	Class	Laboratory
I. ED-01 Concepts and Applications of Input and Output	5	5
II. ED-02 Vacuum Tubes	5	5
III. ED-03 Solid State Devices	6	6
IV. ED-04 Integrated Circuits	6	6
V. ED-05 Indicators and Displays	6	6
VI. ED-06 Digital Techniques	6	6
VII. ED-07 Analog and Digital Systems	6	6

COURSE OUTLINE

I. Concepts and Applications of Input and Output
   A. Applications of Stages and Systems
   B. Oscillators and Wave Generators
      1. Oscillators
      2. Wave Generators
         Astable, monostable, bistable
      3. Ramp Generators
      4. Waveshaping
      5. Integrator
      6. Differentiator
      7. Clippers
      8. Slicers
      9. Rectification and Filtering
      10. Regulators
      11. Indicators and Displays
         Incandescent lamps, neon lamps, light-emitting devices

12. Thyristors
    Bidirectional triode thyristor
13. Digital Techniques
    Decision-making stages, memory

C. Summary

II. Vacuum Tubes
  A. Vacuum Tube Amplifiers
    1. Operation
    2. Cathode Bias
    3. Class of Operation
    4. Distortion
    5. Amplifier Configurations
       Common cathode, common grid, common plate
    6. Stage Coupling
       Capacitive coupling, transformer coupling, direct current coupling
    7. Miscellaneous Tube Circuits
       Laser amplifiers, traveling-wave tube amplifier, klystron amplifier
  B. Summary

III. Solid State Devices
  A. Bipolar Devices
    1. Semiconductor Materials
    2. Conduction of Atoms
       P-type atoms, n-type atoms, combined atoms, formation of the 4-3 combination (p-type material), formation of 4-5 combination (n-type material), conduction of P- and N-type materials
    3. Formation of the P-N Junction
    4. Diodes
       Rectifiers, one-way switches, regulators, voltage-variable capacitors
    5. Diode Testing
    6. Bipolar Transistors
    7. Bipolar Transistor Testing
    8. Identification of NPN or PNP Transistors
  B. Field-Effect Devices
    1. Junction FETs
    2. Insulated Gate FETs
       Depletion mode, enhancement IGFET
    3. Configurations
    4. FET Safety Precautions

IV. Integrated Circuits
  A. The Impact of Integrated Circuits
    1. Advantages
    2. Disadvantages
  B. Types of IC's
    1. Bipolar IC's
    2. MOS IC's

3. Other Style IC's
   Thick film, hybrid IC's
C. Applications of Analog ICs
   1. Operational Amplifier
   2. Power Supply Requirements
   3. Chip Use
   4. Practical Operational Amplifier Uses

V. Indicators and Displays
   A. Incandescent Lamps
   B. Neon Lamps
   C. Light-Emitting Diodes (LEDs)
      1. LED Uses
      2. On-Off LED
      3. Segment Display LEDs
      4. Special Application LEDs
   D. Liquid Crystal Displays (LCDs)

VI. Digital Techniques
   A. Primary Binary Logic Devices
   B. Basic Logic Functions
      1. Decision-Making
         AND gate, OR gate
   C. Gate Application
      1. Memory
         The latch flip-flop, the latch application, the D flip-flop, D flip-flop application, JK flip-flop, JK flip-flop application

VII. Analog and Digital Systems
   A. Analog Systems
      1. Power Supplies
      2. Audio Systems
         Direct current coupling, capacitor and transformer coupling
      3. Silicon Controlled Rectifiers — D.C. Control Systems
      4. Triacs-A.C. Control Systems
      5. Temperature Monitoring Systems
      6. Humidity Controller
      7. Light-Sensing System
   B. Digital Systems
      1. Binary Counters
      2. Shift Register

ELECTRICAL POWER AND ILLUMINATION SYSTEMS

COURSE DESCRIPTION

Electrical Power and Illumination Systems is designed to provide the student with practical knowledge of electrical distribution systems and contains a section with specific emphasis on illumination systems. Topics presented include three-phase electrical systems, generating stations, high-voltage transmission and distribution systems, industrial and residential power distribution, wiring and electrical codes, illumination measurements, and indoor and outdoor lighting systems.

PREREQUISITES

The student should have mastered basic physics and d.c. and a.c. circuit analysis. The student should have also taken or be taking, Electromechanical Devices.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	PI-01 Efficiencies of Electrical Power Distribution Systems	4	4
II.	PI-02 Electrical Power Transmission and Distribution	4	4
III.	PI-03 Industrial Electrical Distribution	4	4
IV.	PI-04 Residential Electrical Distribution	4	4
V.	PI-05 Electrical Energy Management	4	4
VI.	PI-06 Fundamentals of Illumination	4	4
VII.	PI-07 Light Sources	3	3
VIII.	PI-08 Efficiency in Illumination Systems	3	3

COURSE OUTLINE

I. Efficiencies of Electrical Power Distribution Systems
   A. A.C. Power Systems
      1. Transmission and Distribution of Electrical Power
      2. Energy Losses in Electrical Power Systems
      3. Voltage Control In Electrical Power Systems
   B. Review of A.C. Circuit Analysis
      1. A.C. Circuit Elements
      2. Series Circuits
      3. Parallel Circuit
   C. Power Factor and System Efficiency
      1. Power in A.C. Circuits
      2. Power Factor
      3. Improving Power Factor with Shunt Capacitors
      4. Improving Power Factor with Series Capacitors
   D. Three-Phase Power
   E. Summary

II. Electrical Power Transmission and Distribution
- A. Typical Transmission and Distribution System
- B. Transmission Lines
  1. Poles and Towers
  2. Cables
  3. Lightning Arresters
- C. Substations
- D. System Components
  1. Transformers
  2. Voltage Regulators
  3. Circuit Breakers
  4. Disconnect Switches
  5. Instrumentation
  6. Power Factor Correction
  7. Protective Relaying
- E. A Typical Substation
- F. Symmary

III. Industrial Electrial Distribution
- A. Primary Substations
  1. Primary Substation Design
  2. Increasing Reliability of Primary Substations
- B. Secondary Substations
  1. Secondary Substation Design
  2. Secondary Substation Connections
- C. Distribution Voltages
- D. System Grounding
- E. Circuit Protection Devices
  1. Circuit Breakers
  2. Relays
  3. Overcurrent Protection
- F. Summary

IV. Residential Electrical Distrubution
- A. Codes and Testing Laboratories
  1. National Electric Code
  2. Underwriters Laboratory
- B. Circuit Devices
  1. Switches
  2. Outlets
  3. Circuit Protection
- C. Wires
  1. Wire Sizes
  2. Insulation Types
  3. Cables
  4. Selection of Proper Wire Sizes
- D. Boxes and Conduit
  1. Types of Conduit.
  2. Sizing Conduit and Boxes
- E. Wiring Practices
  1. Color Codes
  2. Gounding

3. Splices and Connections
4. Circuit Connections
F. Summary

V. Electrical Energy Management
A. Economics of Electrical Power Production
1. Variations in Demand
2. Cost of Meeting Peak Demands
3. Inefficiencies of Minimum Demands
4. Inefficiencies of Poor Power Factors
5. Who Pays the Price?
B. Industrial Electrical Loads
1. Lighting Loads
2. Heating Loads
3. Motor Loads
C. Reduction of Energy Waste
1. Energy Awareness
2. Equipment and Facility Modification
3. Maintenance Programs
4. Power Factor Correction
5. Alternate Energy Sources
D. Electrical Load Characteristics
1. Diversity
2. Demand
3. Load Factor
4. Power Factor
E. Utility Rate Schedules
1. Demand Charge
2. Energy Charge
3. Load Factor Discount
4. Power Factor Provisions
5. Fuel Clause
6. Time-Of-Day Metering
F. Electrical Load Management
1. Electrical Energy Audits
2. Timed Load Control
3. Load Shedding and Restoring
4. Ideal Rate Method
5. Instantaneous Rate Method
6. True Forecast Method
G. Summary

VI. Fundamentals of Illumination
A. The Nature of Light
1. Definition of Light
2. Generation of Light
3. Characteristics of Light Behavior
4. The Inverse Square Law
B. Light and Color
1. Human Eye Response
2. Nature of Color Vision
3. Additive Color Mixture

4. Subtractive Color Mixture

C. The Visual Process
   1. The Human Eye
   2. Adaptation
   3. Visual Capacity
   4. Visual Acuity
   5. Aging and Abnormal Eyes
   6. The Visual Environment
D. Units of Light Measurement
   1. Luminous Intensity
   2. Luminous Energy
   3. Illumination
   4. Brightness
E. Measurement Techniques
   1. Measurement Illumination
   2. Measurement of Candlepower
   3. Measurement of Reflectance
F. Quantity of Illumination
   1. The Visual Task
   2. Visual Performance
G. Quality of Illumination
   1. Brightness Distribution
   2. Atmosphere
H. Summary

VII. Light Sources

A. Characteristics of Light Sources
   1. Spectral Energy Distribution
   2. Efficacy
   3. Lumen Depreciation
   4. Mortality
   5. Incandescent Lamps
   6. Lamp Construction
   7. Spectral Energy Distribution
   8. Lamp Characteristics
B. Fluorescent Lamps
   1. Lamp Construction
   2. Electrical Characteristics
   3. Spectral Energy Distribution
   4. Lamp Characteristics
C. High-Intensity Discharge (HID) Lamps
   1. Mercury-Vapor Lamp Construction
   2. Metal Halide Lamp Construction
   3. Spectral Energy Distribution
   4. HID Lamp Characteristics
D. High-Pressure Sodium Lamps
   1. Lamp Construction
   2. Spectral Energy Distribution
   3. Lamp Characteristics
E. Low-Pressure Sodium Lamps
   1. Lamp Construction
   2. Spectral Energy Distribution

3. Lamp Characteristics
F. Comparison of Lamps
G. Light Control
H. Summary

VIII. Efficiency in Illumination Systems
A. Energy and Illumination
1. Energy Requirements for Illumination
2. Cost of Lighting
B. Improved Utilization of Illumination Energy
1. Energy Efficiency in Lighting Design
2. Efficiency and Use of Light Sources
3. Efficiency of Luminaries
4. Thermal-Controlled Fluorescent Luminaries
5. Turning Lights Off
6. Use of Daylight
7. Equipment Maintenance
C. Cost of Illumination
1. Incandescent Versus Fluorescent for Residential Lighting
2. Pay-Back Costing
3. Lifetime Costing
D. Summary

MICROCOMPUTER HARDWARE

COURSE DESCRIPTION

This course provides an introduction to hardware associated with microcomputers used in energy-conservation applications. It concentrates on interfacing and on input/output electronics. Design of microcomputers is covered only to the point of enabling student to pinpoint problems and specify systems appropriate for various applications.

The course begins with an introduction to integrated circuit logic and a discussion of common electrical and logical digital interfacing techniques. Specific techniques for getting both digital and analog data into and out of microcomputers are surveyed. Applications of these techniques to actual control problems are illustrated. Finally, data communication ideas and microcomputer troubleshooting techniques are covered.

PREREQUISITES

The student should have completed the course in Microcomputer Operations and have the ability to use d.c. instruments and to breadboard integrated circuits (IC).

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	MH-01 Digital Components	4	4
II.	MH-02 Semi-Conductor Logic Families	4	4
III.	MH-03 Input/Output Devices and Techniques	4	4
IV.	MH-04 Analog/Digital Conversion	4	4
V.	MH-05 Data Communication	4	4
VI.	MH-06 Bus Systems	5	5
VII.	MH-07 Troubleshooting Microcomputer Components	5	5

COURSE OUTLINE

I. Digital Components
   A. Changes and the Computer's Components
   B. Digital Signals
      1. Gates
         The AND gate, the NAND gate, the NOR gate
      2. Exclusive and Non-Exclusive OR Gates
      3. Addition/Subtraction Circuitry
      4. Decoders
      5. Multiplexers
      6. Flip-Flops
         The set-reset flip-flop, the trigger flip-flop, the master-slave flip-flop, the steerable flip-flop (J-K), D-type flip-flops, register, counters, buffers,

II. Semi-Conductor Logic Families
   A. Atomic Makeup of Silicon Crystals
   B. Diodes
   C. Transistors
      1. TTL Logic Devices
      2. Emitter-Coupled Logic (ECL)
      3. Integrated Injection Logic (IIL or I^2L)
   D. MOS Technologies
      1. PMOS
      2. NMOS
      3. CMOS

III. Input/Output Devices and Techniques
   A. Input/Output Devices and Techniques
      1. Parallel/Serial Transmission
      2. Synchronous/Asynchronous Communication
         Regular sampling, asynchronous communication, synchronous communication
      3. Interrupts
      4. I/O Busing
      5. I/O Hardware
      6. Switches
      7. Display
      8. I/O Coding
      9. I/O Storage Devices
   B. Future Developments

IV. Analog/Digital Conversion
   A. Mechanical Conversion Devices
   B. Electrical Conversion Techniques
      1. Digital-to Analog Computer
      2. Analog-to-Digital Conversion
      3. Resolution
      4. Counter-comparator
      5. Successive Approximation
      6. Simultaneous Conversion
      7. Microprocessor-Controlled Conversions

V. Data Communication
   A. Channels
   B. Bandwidths

VI. Bus Systems
   A. Characteristics of a Bus
      1. Signals
         Address lines, data lines, control lines
      2. Motherboard
      3. Comparision of Busing Systems
   B. Timing and Synchronization
   C. Bus Interfacing
      1. Bus Connectors
      2. Physical Dimensions

3. Types of Interfacing Bus Systems
4. Documentation

VII. Troubleshooting Microcomputer Components
A. Introduction to Troubleshooting Equipment
B. Logic Probes and Pulsers
1. Current Tracer
2. Logic Clips and Comparators
3. Oscilloscopes
4. Logic Analyzers
5. Troubleshooting Techniques
6. Using A Logic Analyzer
7. Handling Integrated Circuits

HEATING, VENTILATING AND AIR-CONDITIONING

COURSE DESCRIPTION

This course is designed to give the student an overview of heating, ventilating and air-conditioning systems and a working knowledge of each component and subsystem. Emphasis is placed on proper operation and maintenance to achieve maximum system performance.

PREREQUISITES

The student should have completed Unified Technical Concepts, I, II, and III; Mechanical Devices and Systems; and Electromechanical Devices.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	HC-01 Basic Refrigeration Cycle	5	5
II.	HC-02 System Types	5	5
III.	HC-03 Refrigeration Equipment	5	5
IV.	HC-04 Residential Heating Equipment	5	5
V.	HC-05 Boilers for Heating Applications	5	5
VI.	HC-06 Piping	5	5
VII.	HC-07 Air-Handling Equipment	5	5
VIII.	HC-08 Psychrometrics	5	5

COURSE OUTLINE

I. Basic Refrigeration Cycle
   A. Principles of Refrigeration
   B. Basic Refrigeration Components
      1. Compressor
      2. Condenser
      3. Metering Device
      4. Evaporator
   C. Basic Refrigeration System
   D. Pressure-Enthalpy Diagram
   E. Refrigerant Properties
      1. Pressure (psia)
      2. Enthalpy (Btu/lb)
      3. Temperature (°F)
      4. Specific Volume (ft^3/lb)
      5. Entropy (Btu/lb/°F)
      6. Percent Vapor
   F. Refrigeration Cycle
      1. Condensation Line
      2. Evaporation Line
      3. Expansion Line
      4. Compression Line
      5. Ideal Saturated Cycle

6. Actual Operating Cycle
G. Refrigeration System Analysis
H. Basic Refrigeration Measurements
1. Gage Manifold
2. Use of the Gage Manifold
3. Temperature Measurements

II. System Types
A. All-Air Systems
1. Single-Zone Systems
2. Reheat Systems
3. Variable-Volume Systems
4. Dual Duct Systems
5. Multi-Zone Systems
B. Air-and-Water Systems
C. All-Water Systems
D. Unitary Systems
1. Single-Package Units
2. Split Systems
3. Through-the-Wall Systems
4. Room Air Conditioners
5. Heat Pumps

III. Refrigeration Equipment
A. Compressors
1. Drives
2. Capacity Control
B. Heat Rejection Equipment
1. Air-Cooled Condensers
2. Water-Cooled Condensers
3. Cooling Towers
4. Evaporative Condensers
C. Evaporators
1. Direct Expansion Coils
2. Water Chillers
D. Metering Devices
1. Automatic Expansion Valve
2. Thermostatic Expansion Valve
3. High Pressure Float
4. Low Side Float
E. Accessories
1. Oil Separator
2. Mufflers
3. Heat Exchangers
4. Strainer-Drier
5. Sight Glass
F. Controls
1. Temperature Controls
2. Pressure Controls
3. System Control
G. System Configurations

H. Absorption Chillers
1. Evaporator
2. Absorber
3. Generator
4. Condenser
5. Heat Exchanger and Eductor

IV. Residential Heating Equipment
A. Warm Air Furnaces
1. Upflow Forced Warm Air Furnace
2. Basement Forced Warm Air Furnace
3. Downflow Forced Warm Air Furnace
4. Horizontal Forced Warm Air Furnace
B. Electric Furnaces
1. Heating Element
2. Limit Controls
C. Oil-Fired Furnaces
1. Combustion Chamber
2. Heat Exchanger
3. Atomizing Oil Burner
Fan and combustion air adjustment, oil pump, oil nozzle, ignition system, flame detector
D. Gas-Fired Furnaces
1. Heat Exchanger
2. Main Gas Burners
3. Pilot Burners
4. Thermocouple
5. Gas Valve

V. Boilers for Heating Applications
A. Boiler Types
1. Fire-Tube Boilers
2. Water-Tube Boilers
3. Cast Iron Boilers
B. Scotch Marine Boilers
1. Pressure Vessel
2. Headers and Smoke Boxes
3. Insulation and Jacketing
4. Water Controls
5. Combustion Control
C. Burners
1. Combustion Air
Natural draft, induced draft, forced draft
2. Mechanical Atomizing Oil Burners
3. Air or Steam Atomizing Oil Burners
4. Horizontal Rotary Oil Burners
5. Gas Burners
D. Fuel Train Controls
1. Pilot Gas Control
2. UL Gas Control
3. FM Gas Control
4. FIA Gas Control
5. Oil Control

E. Flame Safeguard Systems
   1. Infrared Flame Detection
   2. Ultraviolet Flame Detection
   3. Flame Rectification
F. Combustion Control
   1. Turn On
   2. Turn Off
   3. Firing Rate Control
      On-off, on-off, low-fire start, high-low, modulating

VI. Piping
   A. General Piping Design
      1. Pipe Types and Applications
      2. Pipe Supports
      3. Valve Types and Applications
      4. Pressure Losses in Valves and Fittings
   B. Water Piping
      1. System Types
      2. Pump Connections
      3. Pipe and Pump Sizing
   C. Refrigerant Piping
      1. Functions of Piping
      2. Hot Gas Pipe
      3. Liquid Line
      4. Suction Line
      5. Multiple Compressor Connections
      6. Refrigerant Pipe Sizing
   D. Steam Piping
      1. Piping Connections
      2. Steam Traps
      3. System Types
   E. Soldering Copper Tubing
   F. Brazing Copper Tubing
   G. Summary

VII. Air-Handling Equipment
   A. Basic Airflow Principles
   B. Friction Losses in Ducts
      1. Air Friction Charts
      2. Duct Fittings
   C. Duct Design
      1. Air Velocity
      2. Velocity Reduction Method
      3. Equal Friction Method
      4. Static Regain Method
   D. Air Outlets
      1. Airflow Patterns
      2. Outlet Types
   E. Fans and Blowers
      1. Centrifugal Blowers
      2. Propeller Fans

F. System Applications
   1. Single Zone Constant Volume
   2. Single Zone Variable Volume
   3. Multi-zone Constant Volume
   4. Dual Duct
   5. Return Air Systems
G. Summary

VIII. Psychrometrics
A. Definition of Terms
B. Elements of the Psychrometric Chart
   1. Dry-Bulb Temperature Lines
   2. Specific Humidity Lines
   3. Saturation Line
   4. Relative Humidity Lines
   5. Wet-Bulb Temperature Lines
   6. Specific Volume Lines
   7. Enthalpy Scale
   8. Enthalpy Deviation Lines
   9. Sensible Heat Factor Scale
   10. The Completed Chart
C. Psychrometric Processes
   1. Heating and Cooling for Comfort
   2. Calculations
   3. Air Mixtures
D. Plotting a Process on the Psychrometric Chart
E. Summary

ENERGY CONSERVATION

COURSE DESCRIPTION

Energy Conservation is designed to give the student technical knowledge and specific skills required to perform conservation measures relative to the most common energy uses. The student will learn and utilize the basic principles of energy conservation and efficiency.

PREREQUISITES

Unified Technical Concepts, Energy Technology, Energy Production Systems

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

	Student Contact Hours/Week Class	Laboratory
I. EC-01 Energy Conservation — An Introduction	3	3
II. EC-02 Conservation Principles and Efficiency Measurements — Space Heating	4	4
III. EC-03 Conservation Principles and Efficiency Measurements — Space Cooling	5	5
IV. EC-04 Conservation Principles and Efficiency Measurements — Hot Water and Steam Supply Systems	4	4
V. EC-05 Conservation Principles and Efficiency Measurements — Illumination	4	4
VI. EC-06 Conservation Principles and Efficiency Measurements — Electric Motors	5	5
VII. EC-07 Conservation Principles and Efficiency Measurements — Building Construction	5	5

COURSE OUTLINE

I. Energy Conservation — An Introduction
- A. Availability of Energy Supplies
  1. Necessity of Energy Conservation
  2. Patterns of Energy Conservation
     Laws and regulations, environmental effects, costs of energy conservation
  3. Estimation of Fuel Consumption
- B. Conservation in Energy-Using Equipment
  1. Heating, Cooling, and Ventilating Systems
  2. Hot Water and Steam Systems
  3. Lighting Systems
  4. Industrial Equipment
- C. Conservation in Building Construction and Use
  1. Sealing of Heat Leaks
  2. Building Construction
  3. Heating and Cooling Equipment Operation
- D. Conservation in Transportation
  1. Choice of Car and Equipment
  2. Maintenance
  3. Driving Habits

II. Conservation Principles and Efficiency Measurements — Space Heating
  A. Central Building Control
  B. Structure of Heating Systems
  C. The Energy Survey
  D. Improved Furnace Operation
    1. Improvement of Combustion Efficiency
       Reduction of heat losses, proper sizing of heating systems, flue gas damper, estimate of savings from furnace improvement
    2. Control of Outdoor Air
       Reduce minimum outdoor air, low leakage dampers, reduction of ventilation during unoccupied periods, control of exhaust air, estimate of savings from outside air control
  E. Improved Heating Coil Operation
    1. Reset of Hot Deck Temperature
    2. Zone Optimization
    3. Estimate of savings from Improved Heating Coil Operation
  F. Control of Fan Operation
    1. Duty Cycling of Fans
    2. Equipment Scheduling
  G. Individual Room Control
    1. Lowering Thermostat Setpoint
    2. Reducing Temperature During Occupied Periods
    3. Separating Heating and Cooling Setpoints
    4. Converting from Constant-Air-Volume to Variable-Air-Volume
    5. Estimating Savings From Individual Room Control

III. Conservation Principles and Efficiency Measurements — Space Cooling
  A. Fundamental Considerations of Space Cooling
    1. Humidity
       Dew point, hygrometer, psychrometric chart
    2. Total Heat Content
    3. Refrigerants
    4. Coefficient of Performance
    5. Cooling Effect Measurements
  B. Structure of Cooling Systems
  C. Energy Survey for Cooling
  D. Methods of Conserving Energy
    1. Control of the Chiller Operation
       Reduction of the compressor head, isolation of off-line chillers, chiller sequencing and control, spot cooling
    2. Reduction of Building Heat Load

Reduction of solar heat gain through windows, reduction of heat gain through the roof, reduction of internal heat load

3. Use of Outddor Air for Cooling
4. Control of the Cooling Coils
   Reset of cold deck temperature (or enthalpy), zone optimization, savings from improved cooling coil operation
5. Control of the Fans
   Duty-cycling of fans, equipment scheduling, savings from fan control
6. Individual Room Control
   Raising the cooling thermostat setpoint, separating heating and cooling setpoints, conversion from constant-air-volume to variable-air-volume

IV. Conservation Principles and Efficiency Measurements — Hot Water and Steam Supply Systems
   A. Hot Water and Steam Supply Systems
      1. Hot Water Systems
      2. Steam Systems
   B. Types of Heat Loss
      1. Conduction
      2. Convection
      3. Radiation
   C. Pressure and Flow Measurement
   D. Energy Survey for Steam and Hot Water Supply Systems
   E. Methods of Reducing Energy Consumption in Hot Water and Steam Supply Systems
      1. Reducing the Consumption of Hot Water or Steam
      2. Reducing Losses in the System
      3. Increasing the Efficiency of the System
   F. Measurement Devices

V. Conservation Principles and Efficiency Measurements — Illumination
   A. Consequences of Overillumination
   B. Light Sources
      1. Incandescent Lamps
      2. Fluorescent Lamps
      3. Mercury Arc Lamps
      4. Sodium Vapor Lamps
   C. Efficiencies of Lamps
   D. Energy Survey for Illumination
   E. Energy Conservation Methods for Illumination
      1. Reducing Illumination Levels
      2. Improving Lighting Facilities
      3. Changing Lamp Type
      4. Changing Lighting Patterns
      5. Using Waste Heat From Lighting
   F. Measurements of Illumination

VI. Conservation Principles and Efficiency Measurements — Electric Motors
   A. An Introduction to Conservation of Electrical Power
   B. Power Consumption
      1. Actual Power
      2. Apparent Power
      3. Reactive Power
      4. Power Factor
      5. Effects of Low Power
      6. Measurement of Power
      7. Correction of Low Power Factor
         Capacitor banks, switched capacitors, synchronous motors
      8. Energy Survey for Electric Motors and Electric Power Usage
   C. Conservation Improvements — Electric Motors
      1. Improvement of Operation
         Regular inspection and maintenance, Control of peak demand by rescheduling, selection of continuous production processes
      2. Improvement of Equipment
         Changing oversized motors, installing higher voltage systems, replacing worn or inefficient motors, improving heat removal
   D. Electrical Power Management
      1. De-Energizing Equipment
      2. Reducing Peak Loads
      3. Improving Power Factor

VII. Conservation Principles and Efficiency Measurements — Building Construction
   A. Energy Conservation in Building Construction
   B. Heat Exchange Between a Building and Its Surroundings
   C. Energy Survey for Building Construction
   D. Design Considerations for Reduction of Energy Loss for New Buildings
      1. Choice of Site and Orientation of Building
      2. Choice of Materials
      3. Adequate Insulation
      4. Inclusion of a Vapor Barrier
      5. Ventilation
      6. Earth-Sheltered Design
      7. Choice of Windows
      8. Proper Sizing of Heating System
      9. Recovery of Waste Heat
      10. Flue Dampers
      11. Automated Control of Heating and Cooling
      12. Color of Roof
      13. Thermal Storage
      14. Utilization of Solar Energy
      15. Heat Pumps
      16. Reduction of Energy Loss — Retrofit in Existing Buildings

17. Caulking and Weatherstripping
18. Adding Storm Doors
19. Adding a Vestibule
20. Adding a Windbreak
21. Adding Storm Windows or Additional Glazing
22. Adding Insulation
23. Adding Automatic Controls
24. Adding Awnings and Other Shading Devices
25. Adding Flue Dampers
26. Resizing the Heating System
27. Maintaining Heating Systems
28. Adding Solar Energy Equipment

E. Specific Techniques for Energy Conservation in Existing Buildings
1. Window Loss
   Combination storm windows; single-pane storm windows, plastic sheets, draperies, blinds, and shades
2. Heat Loss Through Walls and Ceilings
   Insulating with batts or blankets, insulating with rigid board, insulating with loose fill, insulating with foam, adding more insulation
3. Infiltration
   Caulking, weatherstripping, installing storm doors,

F. Advanced Techniques to Measure Energy Loss From Buildings
1. Infrared Scanning Devices
2. Blower Doors

FLUID POWER SYSTEMS

COURSE DESCRIPTION

Fluid Power Systems is designed to give the student an overview of fluid power technology and a working knowledge of each of the components used in fluid power circuits. Hydraulic and pneumatic systems will be discussed with emphasis placed on troubleshooting and maintenance procedures involved in each. Topics presented will include fundamentals of fluid dynamics; conventional fluid circuits and fluid power components.

PREREQUISITES

The student should have completed one semester of algebra and one semester of technical physics.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

	Student Contact Hours/Week	
	Class	Laboratory
I. FL-01 Introduction and Fundamental of Fluid Power	3	3
II. FL-02 Fluid Power Properties and Characteristics	3	3
III. FL-03 Fluid Storage, Conditioning, and Maintenance	4	4
IV. FL-04 Pumps and Compressors	4	4
V. FL-05 Actuators and Fluid Motors	4	4
VI. FL-06 Fluid Distribution and Control Devices	4	4
VII. FL-07 Fluid Circuits	4	4
VIII. FL-08 Troubleshooting Fluid Circuits	4	4

COURSE OUTLINE

I. Introduction and Fundamentals of Fluid Power
  A. Introduction to Fluid Power
    1. Background and Applications of Fluid Power
    2. Advantages and Disadvantages of Fluid Power
    3. Advantages
    4. Disadvantages
  B. Basic Fluid Power Systems
    1. Hydraulic Systems
    2. Pneumatic Systems
  C. Review of Physics Fundamentals
    1. Forms of Energy
    2. Force and Pressure
    3. Work Done By A Fluid
    4. Power In Fluid Power Systems
  D. Basic Principles of Fluid Behavior
    1. The Continuity Equation
    2. Bernoulli's Theorem

3. Torricelli's Theorem
4. Gas Laws

E. Basic Fluid Circuits and Symbols
1. Hydraulic Circuit
2. Pneumatic Circuit

F. Summary

II. Fluid Power Properties and Characteristics

A. Properties of Hydraulic Fluids
1. Viscosity
2. Viscosity Index
3. Lubricating Ability
4. Rust and Corrosion Prevention
5. Oxidation Stability
6. Demulsibility
7. Resistance to Foaming
8. Flash and Fire Points
9. Specific Gravity

B. Types of Hydraulic Fluids
1. Water
2. Petroleum Oils
3. Water-Oil Emulsions
4. Water-Glycol Fluids
5. Synthetic Fluids

C. Maintenance of Hydraulic Oils

D. Replacing Hydraulic Oil

E. Properties of Pneumatic Fluids

F. Summary

III. Fluid Storage, Conditioning, and Maintenance

A. Reservoirs and Tanks
1. Hydraulic Reservoirs
2. Pneumatic Tanks

B. Temperature Control
1. Cooling in Hydraulic Systems
2. Cooling in Pneumatic Systems

C. Filters and Strainers
1. Types of Hydraulic Filters
2. Location of Hydraulic Filters
3. Pneumatic Filters
4. Air Pressure Regulators
5. Air-Line Lubricators
6. FRL Units

D. Sealing Devices
1. Compression Packings
2. O-Rings
3. V-Rings
4. Piston Cup Packings
5. Piston Rings
6. Wiper Rings
7. Seal Materials

E. Summary

IV. Pumps and Compressors
   A. Theory of Pumps
      1. Positive-Displacement Pumps
      2. Characteristics of Positive-Displacement Liquid Pumps
      3. Nonpositive-Displacement Pumps
   B. Hydraulic Pumps
      1. Vane Pumps
      2. Piston Pumps
      3. Selection of Hydraulic Pumps
      4. Pump Maintenance
   C. Pressure Boosters
   D. Air Compressors
      1. Reciprocating Compressors
      2. Rotary Compressors
      3. Compressor Maintenance
   E. Vacuum Pumps
   F. Summary

V. Actuators and Fluid Motors
   A. Fluid Power Actuators
      1. Construction of Hydraulic Cylinders
      2. Cylinder Operating Characteristics
      3. Construction of Air Cylinders
      4. Mounting and Application of Cylinders
      5. Special Cylinder Types
      6. Rotary Actuators
      7. Causes of Cylinder Failure
      8. Cylinder Maintenance
   B. Fluid Motors
      1. Hydraulic Motor Types
      2. Hydraulic Motor Performance
      3. Air Motors
   C. Summary

VI. Fluid Distribution and Control Devices
   A. Accumulators
      1. Accumulator Types
      2. Accumulator Applications
      3. Accumulator Maintenance
   B. Pressure Intensifiers
   C. Fluid Conductors and Connectors
      1. Rigid Pipes
      2. Semirigid Tubing
      3. Flexible Hoses
      4. Plastic Tubing
   C. Fluid Control Devices
      1. Directional Control Valves
      2. Servo Valves
      3. Pressure Control Valves
      4. Flow Control Valves
      5. Other Control Devices
   D. Summary

VII. Fluid Circuits
- A. Fluid Power Symbols
- B. Basic Hydraulic Circuits
  1. Cylinder Circuits
  2. Motor Circuits
  3. Speed Control
- C. Basic Pneumatic Circuits
  1. Cylinder Circuits
  2. Motor Circuits
  3. Speed Control
  4. Multi-Pressure Circuits
- D. Synchronous Motion
  1. Hydraulic Cylinders In Series
  2. Fluid Motors as Synchronizers
  3. Air Cylinders
  4. Hydraulic Motors
- E. Actuator Speed
  1. Pneumatic Circuits
  2. Hydraulic Circuits
- F. Energy Efficiency in Hydraulic Circuits
  1. Pump Unloading
  2. Double-Pump Hydraulic Systems
  3. Use of Accumulators to Improve System Efficiency
  4. Use of Accumulators in High-Low Circuits
- G. Summary

VIII. Troubleshooting Fluid Circuits
- A. Maintenance and Troubleshooting in Fluid Power Systems
  1. Causes of Failure

     Dirt, heat, misapplication, improper fluids or poor fluid maintenance, faulty installation, poor maintenance, improperly designed circuits
  2. Symptoms of Failure
- B. Troubleshooting Hydraulic Circuits
  1. Measuring Equipment
  2. Troubleshooting Procedures
- C. Troubleshooting Pneumatic Circuits
- D. Safety Considerations
  1. Safety Circuits
  2. Safety Procedures and Regulations
- E. Summary

ENERGY AUDITS

COURSE DESCRIPTION

This course provides an overview of the purpose, objectives and mechanics of the energy audit process. Full background and procedural instructions precede case studies and laboratory practice in auditing. Finally, audit analyses are undertaken, with student recommending remedial actions based on analyses of his or her practice audits.

PREREQUISITES

Energy Conservation

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	EA-01 Total Energy Management	2	4
~~II.~~	~~EA-02 Elements of an Energy Audit~~	~~2~~	~~4~~
III.	EA-03 Energy Audit Procedures and Analyses	2	4
IV.	EA-04 Building Systems	2	4
V.	EA-05 Lighting Systems	2	4
VI.	EA-06 Auditing HVAC Systems — Part I	2	4
VII.	EA-07 Auditing HVAC Systems — Part II	2	4
VIII.	EA-08 Auxiliary Equipment Systems	2	4
IX.	EA-09 Process Energy Systems	2	4
X.	EA-10 Applications of Solar Energy	2	4

COURSE OUTLINE

I. Total Energy Management
  A. Total Energy Management and the Energy Audit
    1. The Energy Audit
    2. Types of Audits
       Walk-through audits, mini-audits, maxi-audits
    3. Other Benefits of Energy Conservation
  B. Basic Concepts of Total Energy Management
    1. Fundamental Building Systems
       Energized systems, non-energized systems, human systems
    2. System Interaction
       End-use restriction, efficiency in operation, system efficiency
  C. Building System Interaction
  D. Energy-Use Characteristics
    1. Schools
    2. Hospitals
    3. Public Buildings
    3. Long-Term Public Care Facilities
    4. Commercial Buildings
    5. Residences

6. Industrial Applications

E. Understanding Energy Billings
   1. Bill Charges
      Energy, customer-related, demand
   2. Load Factor
   3. Low Power Factor Penalty
   4. Time of Day
   5. Ratchet Rate

F. Determining How Much Energy is Used

G. Developing Energy Consumption Data

II. Elements of an Energy Audit
   A. The Energy Audit
   B. Performing the Energy Audit
   C. Energy Auditing Instruments
   D. Infrared Thermography
   E. Energy Saving Potential
      1. Conservation Opportunities While Heating Buildings
      2. Cooling
      3. Lighting
      4. Domestic Hot Water
   F. Calculating Simple Payback
   G. Life-Cycle Costing

III. Energy Audit Procedures and Analyses
   A. The Energy Auditing Process
   B. Types of Energy Audits
      1. Walk-Through Audits
      2. Mini-Audits
      3. Maxi-Audits
      4. Computer Simulation Models
   C. Performing the Energy Audit
   D. Building Profile
      1. General Information
      2. Population Density and Analysis by Department
      3. Construction
      4. Meters
      5. Equipment
      6. Data Collection
   E. Fuel and Utility Bills
   F. Equipment Survey: Connected Load for Each Fuel Type
   G. Building Survey
   H. Auditors, Energy Conservation Programs and Total Energy Management
      1. Maintenance and Operational Changes
      2. Simple Payback
      3. Priority Ranking of Measures
      4. Implementing Energy Measures
      5. Total Energy Management

IV. Building Systems
A. Building Systems: Total Energy Management
    1. The Energy Audit
    2. Conservation Opportunities
B. Infiltration and Exfiltration
    1. Building Exteriors
    2. Stack Effect
    3. Caulking and Weather Stripping
    4. Storm Windows
C. Solar Heat Gain
    1. Orientation
    2. Exterior Shading
    3. Internal Shading
    4. Window Glass Treatments
D. Heat Loss Through Windows
    1. U Value
    2. Mean Radiant Temperature
E. Heat Flow Through Walls, Roof, and Floors
    1. R Value and U Value
    2. Insulation
        Exterior Facing, Interior Facing, Roof Insulation, Floor Insulation
F. Internal Heat Flow
    1. Air Leakage
    2. Conductive Heat Flow
G. Conclusions

V. Lighting Systems
A. Lighting Systems: Modifications and Requirements
B. Lamp Types
    1. Incandescent Lamps
        R-Lamps, PAR lamps, ER lamps
    2. Fluorescent Lamps
    3. High Intensity Discharge (HID) Lamps
        Mercury lamps, metal halide lamps, sodium lamps
C. Energy Conservation Opportunities
    1. Usage Pattern Modifications
        Program consideration, program options
    2. Work Station Modifications
    3. Maintenance Considerations
    4. Illumination Level Modifications
        Reducing lighting levels, lamp modifications, luminaire modifications
    5. Control Modifications
    6. Heat-of-Light Recovery Systems
D. Summary

VI. Auditing HVAC Systems — Part I
- A. HVAC and Building Energy Use
- B. General HVAC Systems Description and Modification Suggestions
  1. Single Zone System
  2. Multi-Zone System
  3. Terminal Reheat System
  4. Variable Air Volume System
  5. Constant Volume System
  6. Induction Systems
  7. Dual Duct Systems
  8. Fan Coil System
- C. Heating and Ventilation
  1. Building Heat Load
  2. Distribution System Loads
     Distribution systems
  3. Primary Energy Conversion Equipment
  4. Heating Equipment: Maintenance Guidelines
     Self-contained systems

VII. Auditing HVAC Systems — Part II
- A. Cooling and Ventilation: Reducing Energy Consumption
  1. Building Cooling Load
  2. Distribution System Loads
  3. Primary Energy Conversion Equipment
- B. Energy Conservation Opportunities

VIII. Auxiliary Equipment Systems
- A. Auxiliary Functions
- B. Domestic Hot Water
- C. General Considerations
  1. Average Use
  2. Average Temperatures
  3. Generation and Storage
  4. Distribution
- D. Energy Conservation Opportunities
  1. Domestic Hot Water Temperatures
  2. Hot Water Consumption
  3. Storage and Distribution Systems Efficiency
     Piping insulation, insulation of hot water storage tanks
  4. Hot Water Generation
- E. Elevators and Escalators
  1. Elevators
  2. Escalators
- F. Kitchens and Cafeterias
- G. Laundries
- H. Computer Facilities
- I. Miscellaneous Equipment

IX. Process Energy Systems
   A. Auditing Process Energy
   B. Baking Ovens
      1. Basic Oven Types
         Convective ovens, radiant ovens,
      2. Modes of Oven Heating.
         Direct-fired, indirect-fired,
         electric, microwave
      3. Operational Control
      4. Heat Balance
   C. Energy Conservation — Evaluation of Scope
      1. Moisture Into the Oven
      2. Combustion Efficiency
      3. Exhaust Heat Loss
      4. Radiation from Oven Casing
      5. Band Heat Losses
      6. Atmospheric Burner Systems
      7. Combustion Air Requirements
   D. Hearth Furnaces — Elements of Furnace Construction
   E. Direct-Fired Heaters
      1. Economy and Efficiency
      2. Industrial Furance Efficiencies
      3. Heat Losses
      4. Furnace Draft and Pressure
      5. Stack Gas Losses
         Preheating cold charge, preheating
         combustion air or fuel, waste-heat
         boilers
      6. Fuel Saving in Open-Hearth Furnaces

X. Applications of Solar Energy
   A. Alternative Resources: Historic and Economic Perspective
   B. Application of Solar Energy
   C. Solar Collectors and Existing Heat Systems
      1. Cooling and Dehumidification
      2. Regenerating Desiccants with Solar Heat
      3. Estimated Costs
   D. Active Solar Systems
      1. The Heating Process
         Hardware, storage, controls,
         antifreeze protection
      2. Air and Liquid Systems
      3. Domestic Hot Water Generation
      4. Space Heating and Cooling
   E. Passive Solar Energy Systems
      1. Requirements and Characteristics
      2. Direct Gain Systems
      3. Indirect Gain Systems
      4. Attached Greenhouse
      5. Roof Ponds
      6. Isolated Gain Systems

INSTRUMENTATION AND CONTROLS

COURSE DESCRIPTION

Instrumentation and Controls is designed to provide the student with practical knowledge and skills in the specification, use and calibration of measuring devices and the principles and applications of automatic control processes. The course stresses the integration of knowledge gained in previous courses through the detailed examination of control systems for electrical power production, heating, air conditioning and manufacturing.

PREREQUISITES

Unified Technical Concepts, Mechanical Devices and Systems, Fluid Power Systems, and Electronic Devices and Systems.

RECOMMENDED TEXT

CORD-developed instructional modules as follows:

		Student Contact Hours/Week	
		Class	Laboratory
I.	IC-01 Principles of Process Control	3	3
II.	IC-02 Instruments for Fluid Measurements — Pressure and Level	4	4
III.	IC-03 Fluid Flow Measurement	4	4
IV.	IC-04 Instruments for Temperature Measurement	4	4
V.	IC-05 Instruments for Mechanical Measurement	4	4
VI.	IC-06 Pneumatic Controls	4	4
VII.	IC-07 Automatic Control Systems	4	4
VIII.	IC-08 Boiler and Other Special Control Systems	3	3

COURSE OUTLINE

I. Principles of Process Control
   A. Instrumentation and Control: The Concept
      1. Open-Loop Control
      2. Closed-Loop Control
      3. Negative Feedback in the Control System
   B. Valve Operation and Fail-Safe Conditions
   C. Controller Action
   D. Valve and Controller Selection
   E. Process Dynamics — Capacity Versus Capacitance
   F. Pressure Control
   G. Dead Time and Lag Time

II. Instruments for Fluid Measurements — Pressure and Level
   A. Control Quality of the System
      1. Measurement Theory
      2. Accuracy
      3. Pressure Measurement
      4. Liquid Manometers
      5. Reference Values for Pressure Measurement

Bourdon tubes and pressure elements, pressure elements, diaphragm, strain gages,

6. Calibration of Pressure Transmitters and Gages

B. Liquid Level Measurements
1. Float-Operated Devices
2. Head-Type (or Pressure) Devices
3. Capacitance Devices
4. Conductance Electrodes
5. Ultrasonic Detectors
6. Radiation Detectors
7. Displacers

III. Fluid Flow Measurement
A. Flow Rate Calculations
B. Velocity of Flowing Fluid
C. Head Flow Measurement
1. Calculation Principles
2. Flow Equations
3. Differential Producers
Orifice plate, venturi tubes, flow nozzle, target meters,
4. Pressure Tap Locations
Vena contracta tap locations, pipe or full flow tap locations, flange tap locations
5. Viscosity Correction
Turbulent and laminar flow
6. Practical Considerations
Applications of head flow meters
D. Non-Head-Type Flow Meters
1. Turbine Flow Meters
2. Magnetic Flow Meters
3. Ultrasonic Flow Meter

IV. Instruments for Temperature Measurement
A. Temperature Scales
B. Temperature Measurement
1. Electrical Temperature Transducers
Thermocouples, thermocouple applications, read-out device (millivolt measurement), thermcouple reference junction compensation, special thermocouple applications
2. Resistance-Temperature Devices (RTD)
3. Optical Temperature Measurement
C. Mechanical Temperature Transducers
1. Filled Thermal Systems
Capillary tubes of the filled system, error and compensation in the system
2. Bimetallic Elements

V. Instruments for Mechanical Measurement
   A. Control Practices
   B. Transducers and Transmitters
      1. Motion Detectors — Linear
         Linear potentiometer — A linear motion to electrical transducers, linear motion variable inductor, linear variable differential transformer (LVDT), variable capacitance for linear movement
      2. Motion Detectors — Rotary
         Rotary potentiometers, rotary variable differential transformer (RVDT), synchro systems, flyball governor
      3. Velocity Measurement — Rotary
         Tachometers
   C. Force Sensors
      1. Strain Gage
      2. Piezoelectric Crystal
   D. Proximity and Limit Detectors
      1. Contact-Type Proximity Detectors
      2. Noncontact-Type Proximity Detectors
   E. Applications

VI. Pneumatic Controls
   A. Pneumatic Transmitters — Force Balance Type
      1. Flapper Nozzle
         Relay, feedback
      2. Force Balance Differential Pressure Transmitter
   B. Pneumatic Controllers — Force Balance Type
      1. Proportional Control Mode
      2. Proportional Plus Reset Control
      3. Proportional-Plus-Derivative Control
      4. Controller Action
      5. Controller Specifications
   C. Motion Balance Pneumatic Instruments
   D. Signal Transducers
      1. Current-to-Pressure Transducers
      2. Pressure-to-Current Transducers
   E. General Applications of Pneumatic Instruments
      1. Transmission Lag
      2. Volume Boosters
      3. Valve Positioners
   F. Conclusion

VII. Automatic Control Systems
   A. Closed-Loop Controls Vs. Open-Loop Controls
      1. Closed Loop or Automatic Feedback Control and Control Modes
      2. On-Off Control
      3. Proportional Control
         Proportional output and gain

Proportional Control Application
    4. Reset Control
    5. Derivative Control
  B. Process Dynamics and Control Mode Selection
    1. Process Reaction to a Step Change
       process gain, dead time
    2. Transmitter Gain
    3. Loop Gain
  C. Controller Tuning
    1. Controller Tuning by Step Analysis
    2. Control Mode Settings by the Ziegler-Nichols Method
    3. Control Quality Evaluation

VIII. Boiler and Other Special Control Systems
  A. Control Quality
  B. Cascade Control
    1. Need for Cascade Control
    2. Cascade Control Theory
    3. Operation of a Cascade Control System
  C. Ratio Control
  D. Theory And Design of Ratio Control System
  E. Feedforward Control
  F. Boiler Control
    1. Boiler Control Theory
       - Need for special control considerations, combustion air control, drum level and feedwater control, dual fuel control
    2. Water Tube Drum Boiler
    3. Control System for a Drum Boiler
       Air and fuel control, dual fuel control, drum level and feedwater control, feedback trim control of air-Fuel ratio, safety shutdown procedures and conditions

CODES AND REGULATIONS

COURSE DESCRIPTION

This course should be designed to provide the technician with a basic understanding of the labyrinth of codes and regulations imposed upon each area of responsibility. The subject matter should not only familiarize the student with many national codes, but should also instruct the student in how state and local codes can be found and used.

PREREQUISITES

Fundamentals of Electricity and Electronics, Electrical Power and Illumination Systems, and Heating, Ventilation and Air Conditioning.

RECOMMENDED TEXT

Standard Building Codes, Standard Plumbing Codes, Standard Gas Codes, and Standard Mechanical Codes, from Southern Building Code Congress International, Birmlingham, Alabama

COURSE OUTLINE

I. Regulating Agencies
   A. National
   B. State
   C. Local

II. Building Codes
   A. Electrical
   B. HVAC
   C. Plumbing
   D. Structural
      1. Methods
      2. Materials
   E. Health and Safety

III. Industrial Codes
   A. Building Codes
   B. Pollution-Control Standards
   C. Health and Safety

IV. Service Establishment Codes
   A. Restaurants
   B. Hotels-Motels-Apartments
   C. Schools
   D. Hospitals

V. Codes in Research and High Technologies
   A. Laboratory Safety
   B. Radiation Protection
      1. Nuclear
      2. Optical

APPENDIX E

SAMPLE LETTER AND SURVEY INSTRUMENT

SUBJECT: SURVEY OF NEEDS-ENERGY TECHNICIANS

Gentlemen:

A few moments of your time can provide valuable assistance to efforts by Utah Technical College at Provo/Orem in anticipating needs for graduate technicians with employable skills in energy occupations (conversion, utilization and conservation as well as research and development).

Results of data obtained in this survey will be used to determine a realistic pciture of needs in public and private sectors within our service region.

Please take time to complete the attached brief questionnaire and drop it in the return mail. Your response will be confidential, but the collective results of the survey will be available to you if you are interested.

Thank you for your continuing support and your special assistance in this assessment effort.

Sincerely yours,

ABC:pt

Enclosure: "Survey of Needs" questionnaire

SURVEY OF NEEDS

The purpose of this Survey of Needs is to determine future needs for certain kinds of employees with technical training below the bachelor's degree level.

> Modern equipment used in homes, businesses, institutions and factories has become more complex. It typically consists of systems utilizing combinations of mechanical, electrical, thermal, fluid and/or optical components, and frequently these systems are controlled by electronic computers or microprocessors. In addition to the technical specialists who currently are employed, we have been advised that a growing need exists for *systems-oriented technicians** who possess combinations of skills and abilities, and can apply this interdisciplinary training in jobs to develop, construct, test, operate, maintain, install or sell modern equipment. Many of these jobs are related, either directly or indirectly, to our country's increasing emphasis on conservation and more efficient uses of energy.

Please answer these few questions.

1. Name of your organization ______________________________
2. Product or service offered ______________________________
3. Approximate total employment in your organization ______________________________
4. a. Does your organization employ graduates of vocational-technical schools or community colleges to construct, fabricate, operate, maintain, install or sell equipment or systems that involve any <u>two</u> or more of the following technical areas?

   Mechanics. Fluids.
   Electronics. Thermodynamics.
   Optics. Computers. ☐ Yes ☐ No

   b. If your answer is "yes," please estimate the number of these employees you now have: ______________

5. a. Do you plan to hire technicians with interdisciplinary training in the next few years? ☐ Yes ☐ No

   b. If your answer is "yes," then, including attrition and new positions, how many such technical employees do you expect to hire by 1983? __________.

6. Who in your organization could best identify the specific tasks performed by your techical employees?

   Name ______________________________ Title ______________________________
   Address ______________________________
   Telephone ______________________________

*Typically, these employees might be engaged in:

1) Energy use-and-conservation management (or auditing).
2) Power plant or energy conversion equipment operation.
3) Research and development work (supporting an engineer or scientist in laboratory or field investigations of physical and chemical phenomena using sophisticated instrumentation for measuring physical parameters).
4) Maintenance of production equipment, plant equipment, or buildings.
5) Sales, distribution and/or installation of equipment or systems.
6) Other job categories requiring crosstraining in two or more technical specialties.

Thank you for your participation. If you would like to have the analyzed results of this survey, check here ☐.

This form has been completed by

Name ______________________________
Title ______________________________
Telephone ______________________________

Use reverse side for additional comments.

APPENDIX F

LIBRARY REFERENCES AND PERIODICALS

APPENDIX F

LIBRARY REFERENCES AND PERIODICALS

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PERIODICALS

Alternate Sources of Energy Magazine
Route 2, Box 90-A
Milaca, MN 56353

The Builder Magazine
National Association of Home Builders
15th & M Streets, NW
Washington, DC 10005

Changing Times Magazine
The Kiplinger Magazine
Editors Park, MD 10782

DOE News
U.S. Dept. of Energy
Room A-1135
175 W. Jackson Blvd.
Chicago, IL 60604

Earth Shelter Digest and Energy Report
1701 E. Cope
St. Paul, MN 55109

Energy
Business Communications Co, Inc.
P. O. Box 2070 C
Stamford, CT 06906

Energy and Power Journal
National Education Council on Energy & Power
P. O. Box 618
Concord, MA 01742

Energy Conservation Digest
Dulles International Airport
P.O. Box 17346
Washington, DC 20041

Energy Conservation/Education Information Bulletin
~~ERIC/Clearing-house for Science, Mathematics and~~
Environmental Education
The Ohio State University
1200 Chambers Road, 3rd Floor
Columbus, OH 43213

The Energy Consumer
Department of Energy
Office of Consumer Affairs
Washington, DC 10585

Energy Currents
ACCJC (Energy Communications Center)
One DuPont Circle NW
Washington, DC 20036

Energy Insider
U.S. Department of Energy
Room 8F-089
Mail Stop 1E-218
Washington, DC 20585

Energy Management
Industrial Publishing Co.
Division of Pittway Corp.
Cleveland, OH

Energy Report
University of LaVerne
National Energy Research and Information Institute
1950 Third Street
LaVerne, CA 91750

Energy User News
P. O. Box 402
Martinsville, NJ 08836

Energy Users Report
The Bureau of National Affairs, Inc.
1231 25th S. NW
Washington, DC 20037

Farm Energy Magazine
200 W. Towers
1200/35th St.
W. Des Moines, IA 50165

Home Energy Digest/Woodburning Quarterly
8009 34th Ave. South
Minneapolis, MN 55420

Homeowners How-To Magazine
P. O. Box 2841
Boulder, CO 80321

Industrial Heating
National Industrial Publishing Co.
1610 Potomac Ave.
Pittsburgh, PA 15216

In Review, SERI
Solar Energy Research Institute
1617 Cole Blvd.
Golden, CO 80401

New Shelter Magazine
Rodale Press
33 E. Minor St.
Emmaus, PA 18049

Popular Mechanics
P. O. Box 10064
Des Moines, IA 50350

Popular Science
Boulder, CO 80303

Power
1221 Avenue of the America's
New York, NY 10020

Solar Age Magazine
P. O. Box 2927
Clinton, IA 52735

Windows for Energy Efficient Buildings
c/o Steve Selkowitz
Energy Efficient Windows Program
90-3111
Lawrence/Berkeley Laboratories
1 Cyclotron Rd.
Berkeley, CA

APPENDIX G

EQUIPMENT LIST

APPENDIX G

PRELIMINARY LABORATORY EQUIPMENT LIST FOR ECUT CURRICULUM

This list is a compilation of required equipment, supplies and tools by course. Before designing and ordering materials for a course, the instructor should read the laboratory procedures and order equipment compatible with that already in existance at the institution.

CHEMISTRY FOR ENERGY TECHNOLOGY I

Equipment

Balance
Beakers, assorted sizes
Buret holder
Buret, 50 ml
Clay triangles
Crucible holders
Crucible tongs
Crucibles, assorted sizes
Desiccator
Electrical conductance apparatus
Explosion shield
Eyewash fountain
Face shield
Fire extinguisher
Flasks, Erlenmeyer, assorted sizes
Fume hood
Gas cylinder
Gas regulator
Graduated cylinders, assorted sizes
Hot plate
Iron rings (2), small
Meker or Bunsen burner
Oven
Pipette, 10 ml, graduated
Pneumatic trough
Ring stands
Rubber policeman
Safety glasses
Safety shower
Test tube rack
Test tubes, assorted sizes
Thermometer
Tongs
Vacuum filter flask
Vacuum pump
Wash bottle
Waste disposal

Supplies

Acetone
Aluminum foil
Aluminum metal
Asbestos wire gauze

Supplies continued

Barium chloride
Benzene
Carbon tetrachloride
Clamp
Copper metal
Copper sulfate
Cyclohexane
Di-chloroethane
Ethyl acetate
Glass tubing, 5-cm length
Hydrochloric acid
Iron
Kerosene or gasoline
Lead metal
Magnesium
Magnesium sulfate, $MgSO_4 \cdot 7\ H_2O$
Methyl alcohol
Nitric acid
Phenolphthalein indicator
Potassium bromide
Potassium chlorate
Potassium chloride
Potassium nitrate
Rubber stoppers, #4, one-holed
Silver nitrate
Sodium bicarbonate
Sodium chloride
Sodium hydroxide
Sodium phosphate
Stirring rod
Sugar
Sulfuric acid
Tin
Vacuum tubing
Vinegar, white table (approximately 5%)
Weighing paper
Wire gauze
Zinc

CHEMISTRY FOR ENERGY TECHNOLOGY II

Equipment

- Balance
- Beakers, assorted sizes
- Burner
- Calorimeter
- Condenser
- Cylinders, graduated, assorted sizes
- Flasks, distilling, assorted sizes
- Flasks, Erlenmeyer, assorted sizes
- Fractionating column
- Funnels, assorted sizes
- Geiger counter
- Heating mantle
- Hot plate
- Petri disk
- Pipette
- Pipette holder
- Radium dial watch
- Refractometer
- Ring stand
- Separator funnel
- Thermometer
- Vials
- Watch glass
- Water condenser

Supplies

- Agar
- Aluminum foil
- Aluminum sulfate solution
- Ammonium hydroxide
- Aniline hydrochloride, saturated aqueous solution
- Benzoyl peroxide
- Boileezers
- Boric oxide
- Bromie water
- Calcium sulfate
- Carbon tetrachloride
- Castor oil
- Clamp
- Coal, soft
- Copper nitrate, 5% solution
- Copper strips, 2 x ½ inch
- Copper wire
- Dimethyldichlorosilane
- Dropper
- Ether
- Formaldehyde solution 40% (formalin)
- 4-Methyl-M-Pheylene Diisocyanate (tolylene-2,4-diisocyanate)
- Gamma source
- Glass rod
- Glass tubing
- Glycerol

Supplies continued

- Hexamethylene diamine (5% in water)
- Hydrochloric acid
- Iron shot
- Iron (II) sulfate, 0.1 M
- Lead foil
- Lead nitrate, 5% solution
- Lead shot
- Lime water
- Litmus paper
- Lucite or Plexiglas pellets or chips
- Magnesium ribbon
- Magnesium sulfate
- Medicine dropper
- Mercurous nitrate, 5% solution
- Mercury nitrate
- Mortar
- Nails
- Nitric acid
- Oil bath
- pH paper
- Phenolphyhalein indicator 1%
- Phthalic anhydride, powder
- Potassium chloride
- Potassium chromate
- Potassium hexacyanoferrate, $K_3Fe(CN)_6$, 0.1 M
- Potassium hydroxide
- Potassium iodide
- Potassium nitrate
- Potassium thiocyanate
- Radioactive ore
- Radioactive potassium iodide
- Rubber tubing
- Sebacoyl chloride (5% in carbon tetrachloride)
- Silicone oil
- Silver nitrate
- Soap solution
- Sodium bicarbonate
- Sodium carbonate
- Sodium chloride
- Sodium dichromate
- Sodium hydroxide
- Sodium phosphate
- Sodium sulfate
- Stannous octoate
- Stirring rod
- Test tube rack
- Test tubes (10)
- Wood splinters or excelsior
- Zinc nitrate, 5% solution
- Zinc strips, 1 x ½ inch or mossy zinc

ELECTRICAL POWER AND ILLUMINATION SYSTEMS

Equipment

Footcandle meter
Milliammeter, a.c., 0-100 mA
VOM

Supplies

Boxes, for mounting one switch or duplex outlet
Cables, assorted
Capacitors, ranging from 1.0 μf to 5.5 μf, 120 V a.c.
Clamps, cable for boxes

Supplies continued

Inductor, 2-H (Henry), 120 mA (milliampere), maximum current
Nuts, wire
Resistors, assorted
Switches, three-way

Tools

Wire cutters and strippers
Yardstick or tape measure calibrated in feet

ELECTROMECHANICAL DEVICES AND SYSTEMS

Equipment

Alternators, automobile
Ammeters, various a.c. and d.c.
Autotransformer, 0.20 KVA variable, input 120 V a.c., output 133 V a.c., 1.5 A with male quick-disconnect terminals, mounted on open stand
Blender with universal motor, 115 V a.c.
Fan (small) with shaded-pole motor, 115 V a.c., 0.9 A maximum
Generator, 12-volt compound d.c.
Lamps, 6-V with red and green lenses
Mechanical couplings and mounts for connecting electric motor to generator and alternator
Milliammeter, d.c., 0-250 mA
Motors, various a.c. and d.c.
Outlet, 110 V a.c. with connectors compatible with relay
Power supplies, various d.c.
Prony brake
Scale, spring, 0-20 lb
Splash shield for motor
Stroboscope
Synchro-differential transmitter type 23CDX6 or equivalent with mount
Synchro-receiver type 23TR6 or equivalent with mount
Synchro-transmitter type 23TX6 or equivalent with mount
Tachometer
Transformer, power, primary 115/230 V a.c., secondary 12/24 V a.c., secondary current 4/2 A, with male quick-disconnect terminals, mounted on board
Transformer, variable 0-130 V a.c.
Voltmeters, capable of testing a.c., d.c. voltage, ohms in wide ranges

Equipment continued

Wattmeter, a.c., 115 a.c. 1 A; Simpson Model 79
Wattmeter, 0-1500 W

Supplies

Battery, 6 volt
Capacitor, starting, for motor (¼ or 1/3 hp, 115 V a.c.)
Disk dials, 360° to fit synchro motor shafts
Filings, iron
Light dimmer, SCR, 100 W, 115 V a.c., with power cord and receptacle
Magnets, bar
Power cord, a.c. with female quick-disconnect terminals and connecting wires with female quick-disconnect terminals
Power cord, 115 V a.c. with connectors compatible with relay
Relay, 6-V d.c. with DPDT switch and removable dust cover
Resistors, assorted
Rheostat, 500 Ω, 100 W
Rod, hard, steel, ¼" x 4"
Solenoid, with core, 12 V a.c.
Switches, assorted
Washers, iron
Water cooling for prony brake
Wires, connecting
Wires, heavy-duty connecting

ELECTRONIC DEVICES AND SYSTEMS

Equipment

Amplifier, operational, 741 C
Binary counter, 74193 synchronous
Digital trainer with data and logic switches and LED indicators (suggest the Heathkit ETW-3200 digital trainer)
Ohmmeter, d.c.-a.c. with leads
Oscilloscopes, triggered 5 mHz dual trace or 2 oscilloscopes, triggered 5 mHz single trace
Oscilloscope, triggered 10 mHz (dual trace if possible)
Power supplies, various specialized
Signal generator, 0-20,000 Hz (audio)
Sine wave generator (1000 kHz)
Vacuum tube voltmeter, a.c., volt range 1-20 V a.c.
Vacuum tube voltmeter, d.c., volt range 0-1000 V d.c.
Voltmeter, d.c. with leads

Supplies

Breadboard
Capacitors, assorted
Filament transformer, 120 V a.c./12-6 V a.c.
Hookup wire
IC, 7400 TTL NAND gate
J-K Flip flops (2) 7476 dual
LED, Red
Potentiometers, assorted
Resistors, assorted
Vacuum tube 12 AX7

ENERGY CONSERVATION

Equipment

Analyzer, portable, for flue gas temperature and gas composition
Anemometer
Hygrometer
Strip chart recorder

Equipment continued

Thermometer, surface temperature (model HH-2 digital thermocouple meter from Omega Engineering, Inc., or a similar thermometer)

Supplies

Insulation, pipe (Should be at least one inch thick)

FLUID POWER SYSTEMS

Equipment

Accumulator, spring-loaded or gas-loaded
Actuators
Air compressor
Air motor
Air pressure gage
Compressed air flowmeter
Cylinder loading device
Hydrualic circuit tester or appropriate flowmeter, pressure gage, thermometer, and loading valve
Hydraulic cylinder, double-acting
Hydraulic cylinder, spring-acting with spring return
Hydraulic cylinders, various types
Hydraulic flowmeter
Hydraulic fluid flowmeter
Hydraulic power unit with pump, reservoir, filter, adjustable pressure relief valve, pressure gage
Hydraulic pressure gage
Hydraulic reservoir
Loading devices for cylinders
Loading devices for motors
Mechanical load for hydraulic system
Motor, reversible fluid
Muffler
Pneumatic cylinders, various types
Pneumatic flowmeter

Equipment continued

Pneumatic power unit with compressor, intake filter, filter-regulator-lubricator unit with pressure gage
Pressure gages
Pressure intensifier
Stop watch
Sump restrainer
Tachometer or strobe
Valves, air pilot, check, flow, control, hydraulic check, hydraulid directional control, hydraulic pressure relief, needle, pneumatic directional control, sequence, unloading
Wattmeter, electrical

Supplies

Filters, high-pressure line, suction
Pneumatic connecting hoses

HEATING, VENTILATING AND AIR CONDITIONING

Equipment

Butane torch, hand-held
Gas-fired furnace
Gage manifold
General controls adapter No. 103050G
Manometer, water-filled U-tube with valve
Oxyacetylene torch
Refrigeration system with R-12 refrigerant
Thermometer, electronic contact with 3 sensors
Thermometer, mercury
Thermometer, 0-300°F
Voltmeter, d.c.

Supplies

Connectors, tubing
Flame ignitor
Gas supply
Solder and flux, assorted
Tubing, assorted copper

Tools

Hand tools, assorted
Safety goggles
Tubing cutter
Vise

INSTRUMENTATION AND CONTROLS

Equipment

Air supply (100 lb)
Ammeter, 0-50 mA
Control valves, diaphragm-operated by 3 to 25 psig. Valves can be single-seated. air-to-open, or air-to-close, with a 1-inch body and ½-inch trim
Differential pressure transducer, using a variable capacitor as the input transducer (a Rosemont brand)
Differential pressure transmitter, using a LVDT as the input tranducer (a Foxboro brand)
Force balance pneumatic controller, moment balance version, such as Foxboro Model S-8 with field mounted connection block; a Taylor Transcope series, or a Fischer and Porter Model 45
Force balance pneumatic transducer moment balance version such as Foxboro Model 13A d/P cell or a Taylor Model d/P cell
Gages, assorted pressure
Manometer, mercury bell, 30-in laboratory quality with a psig scale and an inches-of-water scale
Manometer or test gage capable of reading 200 inches of water - 2%
Oscilloscope. time-base, capable of frequency and voltage measurement in the audio frequency range and having a sensitivity of 1 mV/cm
Ohmmeter with one ohm resolution onf the R x 10 ohm scale
Potentiometer, 0-5000 ohm wire wound with 1% tolerance
Power supply, 0-100 V variable d.c.
Power supply, 10 V d.c.
Pump - an electrically-operated pump that will deliver 10 to 20 gpm flow against a 20 psig head pressure
Orifice meter run, 2-inch pipe with orifice flange and flange tap locations
Orifice plates, concentric type in the following sizes: 0.500 inches, 0.750 inches, 1.000 inches
Regulators, assorted fixed and variable
RTD with a temperature-resistance calibration curve

Equipment continued

Strip chart recording controllers, with fast (1 inch/minute) and slow (1 inch/hour) chart speeds. Controller should be pneumatic with conventional 3 to 15 psig input and output
Tanks, 10-gallon to use as the reservoir and process. The reservoir should be flat, about 10 to 12 inches high. The cylinder used should be about 8 feet high and 10 to 12 inches in diameter
Test gage, 0-30 psig
Thermometer, glass, capable of temperature measurement in the 0-400°F temperature range with 2" resolution
Transmitter level that has an adjustable range approximately 0-20 to 0-200 inches of water and pneumatic 3 to 15 psig input and output
Valves
Voltmeter with 0.02 mV resolution on a scale that will measure 50 mV full scale

Supplies

Clip leads, 30-inch
Hoses, assorted
Pipes, assorted
Pipe fittings
Resistors, sodium with 1% tolerance with a power rating of 1 watt
Thermocouple lead wire, 4 ft, J type
Tubing fittings
Tubing, polyetheylene, 10 ft of ¼ inch
Wiring, assorted

MECHANICAL DEVICES AND SYSTEMS

Equipment

Axial duct fan (motor drive) in circular duct 10-12" in length
Belt drive, consisting of a motor, sheaves (preferably with at least two grooves) & belts
Drive train assembly of auto, truck or tractor (including rear axle, differential, and drive shaft, and clutch)
Gear box from auto, truck or tractor
Gears, herringbone, rack and pinion, spiral bevel, spur and worm, spur, worm, helical
Gears, miscellaneous, showing excessive wear, tooth breakage, rubbing, etc.
Lab scale or postage scale
Level
Manometers, water, 3/16" bore
Motor, 110 V a.c.
Spring scales, 0 to 48 oz
Static pressure tube
Thermometer, 0-212°F
Toilet flush mechanism
Valves, ball, butterfly, gate, globe, knife gate, needle, pinch, poppet, swing, taper plug
Wattmeter, in-line type for 100 V
Wooden scales, calibrated in 1/32"

Supplies

Couplings, assorted from following group: flange, split-type cuff, compression, jaw, floating, toothed, flexible tire, chain, universal joint, double Hooke-joint, ball joint
Impact tube
Rollers, round plastic ½" dia x 8" length
Sprockets and chain
Valve packing materials - spiral and die-molded ring

Tools

Calipers
Hand tools, assorted, including packing pullers
Vernier gages

MICROCOMPUTER HARDWARE

Equipment

ASKII keyboard or supply board kit
Cassette tape recorder
Logic analyzer
Microcomputer, KIM-1
Oscilloscope
Power supply, assorted specialized
Spaker, 8-ohm speaker
VOM

Supplies

Capacitors, assorted
Fiber optic cable
Integrated circuits, assorted
LED, GaA (900 nm)
Resistors, assorted
Transistors, assorted

MICROCOMPUTER OPERATIONS

Equipment

Breadboarding system (TERC KIM-100)
Cassette tape recorder (Sanyo ST-45)
Cassette tape with cooling curve program
Floppy disk, 8½", containing SOLAR, MANUAL and AUTO
Microcomputer (Commodore KIM-1)
Microcomputer, disk-based with CP/M, BASIC/5, and BASIC-E
Oscilloscope with external triggering
Potentiometers, assorted
Power supplies, various specialized
Speaker, 8 ohm, 2" diameter

Supplies

Capacitors, assorted
Connections to KIM output ports, power and tape recorder
Diodes, assorted
Floppy disk, 8½" blank
Integrated circuits, assorted
Resistors, assorted
Resistors, assorted variable
Switch, 16-pin DIP
Transistor, NPN (2N3392 or equivalent)

UNIFIED TECHNICAL CONCEPTS I, II, AND III

Equipment

Accelerometer
Air conditioning unit
Alternator
Ammeter, d.c., a.c.
Anemometer or pitot tube
Autotransformer, variable
Balance, triple beam, scale
Beakers, assorted sizes
Boyle's Law apparatus, such as Sargeant Welch #1080
Bridge, wheatstone
Bunsen burner
Calorimeter
Cartridge, phonograph
Cell, photovoltaic silicon
Circuit breaker
Coil, automobile ignition
Coil, choke, 500 μH
Coil, 205 μH
Cooler, thermoelectric
Cylinder, nitrogen
Detector, photovoltaic
Dewar flask of liquid nitrogen
Differential gage, pitot tube
Dryer, hair
Fan, electric
Flask, Erlenmeyer, assorted sizes
Flowmeter
Force table and accessories
Gage, commercial bonded strain
Gage, McLeod
Gage, thermocouple vacuum
Generator, small wind-powered electrical
Heating element, electrical
Heating tape
Hot plate
Hydrometer, automobile radiator
Hydrometer, laboratory
Induction coil of Wimshurst-type Electrostatic machine
Laser, helium-neon
Lathe with Norton gear box
Magnets, assorted bar and U
Manometer, vacuum and pressure (mercury tube U-shaped)
Metal base, nonmagnetic
Meter, kilowatthour
Meter, optical oower
Meter, sound level
Microphone
Milliammeter, d.c.
Mirror, concave, 16-inch diameter
Mirror, plane front surface
Motor-generator, demonstration
Motors, 110-V shunt or permanent magnet d.c., variable speed, electric a.c. or d.c.
Movement, 50 μA d.c. meter
Operational amplifier
Optical bench
Oscilloscope
Oscilloscope camera
Photocell, silicon

Equipment continued

Photometer
Pin and cork motor kit
Power meter, laser
Power supplies, d.c. fixed and variable
Power supply, for spectrum tubes
Pressure source, 30 pounds
Propane torch, mounted
Prony brake
Psychrometer, sling
Pump, bicycle
Pump, centrifugal vertical a.c.
Pump, mechanical vacuum
Pump, oil diffusion
Pyrometer
Radiator, automobile or cooling coils from an air conditioner
Recorder, strip chart
Regulators, two-stage, variable pressure
Reel, baitcasting fishing
Ring stand and ring
Rod, fishing
Scales, bathroom, spring, metric for manometer, arms, platform
Signal generator, audio frequency, a.c.
Sockets, miniature screw with leads
Speaker
Spectrometer/prism
Spectroscope, grating
Stand, wooden 12 x 30 inches
Steam engine kit
Stirrer
Stopwatch
Stroboscope or tachometer
Supports, thermometer
Switches, throw, knife, toggle
Telescope kit, refractor
Test tube holder
Thermometers, centigrade and Fahrenheit, oven
Thermocouple or calibrated thermistor (thin-film)
Thistle tube
Timers, laboratory, 555 (integrated circuit)
Tongs, insulated jaws
Transformers, various
Tube, resonance
Tuning forks, 128 Hz, 256 Hz, 512 Hz
Turbine, water with pressure gage and prony brake with scales and revolution counter
Turntable, phonograph
Vacuum pump, hand-operated pressures to 7 inches and 25 inches vacuum
Vacuum system
Venturi tube, glass
Voltmeter, rms
Voltmeter, vacuum tube
VOM
Water pump, d.c.
Wattmeter, a.c.
Weight hanger
Weights, English
Weights, metric
Wheel, bicycle

Unified Technical Concepts, continued.

Supplies

- Battery, auto 12-volt lead-acid
- Battery 1½ volt
- Bearings, assorted
- Bulbs, assorted light
- Candle
- Capacitors, assorted
- Clamp, pinch or hose
- Clip leads
- Clips, battery
- Concrete slab
- Cord, power
- Containers, water
- Cord, a.c. power with clips
- Diodes, assorted, germanium, silicon, zener
- Drycell
- Electrodes, assorted copper or aluminum
- Epoxy
- Ethylene glycol
- Filters, neutral density, infrared
- Glass plates and panes
- Glazing material
- Hoses, connecting
- Iron filings
- Lamp and socket, 12-volt
- Lamps, incandescent, heat
- Leads, test
- Line, nylon fishing
- Lubricants, various
- Mercury
- Meter stick
- Methanol
- Paint, flat black spray
- Plates, aluminum or steel
- Plug, spark
- Potentiometers, assorted
- Pulley
- Rectifier, bridge

Supplies, continued

- Relays, assorted
- Resistors, assorted
- Rods, glass
- Rods, carbon
- Sheave or pulley
- Solder, various types
- Stopcock grease
- Strips, copper, brass, zinc
- Suction cups, rubber
- Tablets, dry fuel
- Transistors, assorted
- Tubes, spectrum: helium, neon, carbon dioxide, water vapor
- Tubing, transparent vinyl plastic, rubber glass wall, copper
- Twine, heavy manila
- Valves, needle, shutoff
- Wire, copper, nichrome, connecting, insulated, nickel, bell
- Wire gauze
- Wire, thermocouple (type J or copper-constantan)
- Wires, flexible braid

Tools

- Calipers, micrometer
- Caliper, vernier
- Crowbar
- Micrometer, metric
- Snips, metal
- Soldering iron
- Steel tape, metric
- Vise