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ABSTRACT

This guide offers information and procedures necessary to train electromechanical engineering technicians. Discussed first are the rationale and objectives of the curriculum. The occupational field of electromechanical engineering technology is described. Next, a curriculum model is set forth that contains information on the standard electromechanical engineering technology curriculum, electives, and related courses. Each course description contains some or all of the following: a discussion of the content of the course, a list of course prerequisites, credit hours to be awarded for completion of the course, a course outline, a list of student competencies addressed in the course, and a list of recommended texts. Course descriptions are provided for 5 courses in the social and related sciences, 6 courses in mathematics and science, and 33 technical courses. Concluding the guide is a section dealing with equipment needed to implement the curriculum. Appendixes to the guide contain guidelines for implementing a problems course, a list of technical organizations and societies and a list of technical publications and periodicals. (MN)

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ELECTROMECHANICAL ENGINEERING TECHNOLOGY CURRICULUM

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high technology advisory council

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July 3, 1984

MEMORANDUM

TO: The People of Georgia

FROM: R. E. Morrison, Jr., Ph.D.
High Technology Coordinator

RE: Preface to the Engineering Technology Curriculum

In the past two years, Georgia has taken the lead in human resource development of engineering technicians for the state's industry. This lead ensures that the industries locating in Georgia, or existing industries planning expansion or re oling will have a readily available supply of highly skilled, educated, and technically adaptable technicians. Over two million Georgians have been trained in the past twenty years in the state's network of thirty technical schools, junior and community colleges.

A quantum step was taken in 1982 when the General Assembly appropriated over $13 million to upgrade the technical school programs to "state-of-the-art" in the electronics, electromechanical and mechanical technologies. In that allocation were directives to develop two year engineering technology programs in the same three fields. These two year programs for a degree of Associate of Applied Technology were begun in September, 1982. The new curriculum, highly qualified technical staff, the latest in instructional equipment and a highly motivated student body are now in place. Our first graduating classes enter the "World of Work" in June 1984. The rhetoric of what should be done is behind us; high technology training for engineering technicians is a fact in Georgia.

New and expanding industries will find a new atmosphere of cooperation where the human resources required to ensure a skilled technician workforce is available. Productive and credentialed employees are available with a positive attitude toward change, adaptability, flexibility and upward mobility.

Each of the three high technology programs is based upon a solid foundation of mathematics, physics and an understanding of the fundamentals basic to the technologies. An understanding of systems, close ties to local business and industry, computer literacy, and characteristics of the high technology programs.

The Georgia "High Technology Advisory Council" was appointed by the Governor as a blue ribbon committee to advise the executive branch of government, the General Assembly, the Board of Education, the Board of Regents and the new Board on Post Secondary Vocational Education regarding high technology and engineering technology education issues. The council is composed of 12 high technology industry representatives in the state and is coordinated by the High Technology Coordinator.

Georgia's commitment to industry, "hi-tech" and quality training is now in place. Contained herein are the coordinated pieces that make up a comprehensive and viable program in the engineering technologies. It is in the basics - this is and will be the difference in Georgia's human resource development product..........the engineering technician.

ELECTROMECHANICAL ENGINEERING TECHNOLOGY CURRICULUM

DEVELOPED BY

THE HIGH TECHNOLOGY CURRICULUM PROJECT

VOCATIONAL AND CAREER DEVELOPMENT DEPARTMENT

GEORGIA STATE UNIVERSITY

ATLANTA, GEORGIA

HARMON R. FOWLER, DEPARTMENT CHAIRMAN

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Education for The Technician: An Introduction

RATIONALE

Relevant education and training to prepare engineering technicians is a critical concern for the productivity needs of this nation. As new and changing technologies and processes for manufacturing, construction, communication, energy, and research and development, occur with great rapidity, the need for engineering assistants who can perform the "nuts-and-bolts" problem-solving tasks associated with current technology has increased significantly. Modern industial and engineering devices that are multisystem in nature require the sort of developmental, maintenance, support, and operational personnel who can change, adjust, and adapt to new situation and utilize increasingly sophisticated hardware with a minimum of retraining. In all, this trend toward innovation as the status-quo has heightened the need for a trained technician who combines theoretical and conceptual knowledge with the manipulative, "hands-on" skill of an artisan or craftsman. It is toward this end that modern technical education must be focused. The remainder of this document offers information and procedures necessary to train engineering technicians who can make a contribution in the emerging technologies.

PURPOSE AND OBJECTIVES

PURPOSE

The purpose of the Engineering Technology Program in Georgia is to produce specialists who possess the broad base of knowledge, skill, and attitude necessary to be productive in modern technical occupations that are characterized by rapid change and highly sophisticated content.

OBJECTIVES

1. To provide basic knowledge, skill, and attitude development based on a systematic analysis of the occupational domain to be served.

2. To produce a technician who is able to deal with the complex systems interactions that characterize modern technological environments.

3. To provide program options that allow in-depth study in specialized areas of the occupational domain beyond the basic skill level.

4. To provide for awarding of credit leading to an associate degree credential, as well as options toward other degree credentials.

5. To provide instruction that maximizes the application of knowledge, skills, and attitudes to real work situations.

6. To provide instruction that prepares the student for the complex problem-solving nature of highly technical occupations.

7. To fully coordinate the high technology program with needs of business and industry through a process of school-community-business inter-cooperation.

8. To provide a system of instruction that is fully responsive to, and perceptive of, the intrinsic nature of change and innovation in highly technical occupations and disciplines.

TECHNICIANS DEFINED

In general the work role of the engineering technician falls between that of the vocational-industrial tradesman and that of the professional engineer. This is a broad range and is ill-defined in practice, having gray areas of work requirements at either end of the continuum and at many points in between. Perhaps the best way to define a technician is by a summary of tasks performed and the accompanying skills required. This must of necessity be done in a broad and generalized fashion with provisions for more specificity left to individial job descriptions. (The basis for this description may be found in a U.S. Office of Education research report entitled Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs.)

It is generally agreed that the engineering technician must have the following kinds of special skills and and abilities:

1. Proficiency in the use of the disciplined and objective scientific method in practical application of the basic principles, concepts, and laws of physics as they comprise the scientific base for the individual's field of technology.

2. Facility with mathematics; ability to use algebra and trignometry as problem-solving tools in the development and definition of, or to quantify, scientific phenomena or principles; and, when needed, an understanding of - though not necessarily facility in - higher mathematics through analytical geometry and some calculus according to requirements of technology.

3. A thorough understanding and facility in the use of materials, processes, apparatus, procedures, equipment, methods, and techniques commonly used in the technology.

4. An extensive knowledge of a field of specialization with an understanding of applications of the underlying physical sciences as they relate to the engineering or industrial processes, or research activities that distinguish the technology of the field. The degree of competency and depth of understanding should be sufficient to enable technicians to establish effective rapport with scientists, managers, and engineers with whom they work and to enable them to perform a variety of detailed scientific or technical work as outlined by general procedures or instructions, but requiring individual initiative, and resourcefulness in the use of techniques, handbook information, and recorded sceintific data.

5. Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas with complete objectivity orally, graphically, and in writing.

Activities Performed

Technicians are expected to perform work tasks and/or support to engineers related to any of a combination of the following kinds of activities:

1. Applies knowledge of science and mathematics extensively in rendering direct technical assistance to physical scientists or engineers engaged in scientific research and experimentation.

2. Designs, develops, or plans modifications of new products, procedures, techniques, processes, or applications under supervision of scientific or engineering personnel in applied research, design, and development.

3. Plans, supervises, or assists in installation and inspection of complex scientific apparatus, equipment, and control systems.

4. Advises regarding operation, maintenance, and repair of complex apparatus and equipment with extensive control systems.

5. Plans production or operations as a member of the management unit responsible for efficient use of manpower, materials, money, and equipment or apparatus in mass production or routine technical service.

6. Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical appartus, equipment, services, and/or products.

7. Assumes responsibility for performance of tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems in the physical sciences and/or for determinations, tests and/or analyses of substances in the physical and other engineering-related sciences; and/or for determinations, tests and/or analyses of substances in the physical and other engineering-related sciences; and prepares appropriate technical reports covering the tests.

8. Prepares or interprets engineering drawings and sketches, or writes detailed scientific specifications or procedures for work related to physical sciences.

9. Selects, compiles, and uses technical information from references such as engineering standards, procedural outlines, and technical digests of research findings.

10. Analyzes and interprets information obtained from precision measuring and recording instruments and/or special procedures and techniques and makes evaluations upon which technical decisions are based.

11. Analyzes and diagnoses technical problems that involve independent decisions and and judgement that require, in addition to technical know-how, substantive experience in the occupational fields.

12. Deals with a variety of technical problems involving many factors and variables that require an understanding of applied scientific and technical understanding - the antithesis of narrow specialization.

It is recognized that no two-year technical training program will be sufficient to prepare engineering technicians for all the problems they will encounter in the workplace. The training should however be sufficient to:

1. Provide occupational skills that are compatible with at least entry-level employment in the chosen field.

2. Provide a broad base of knowledge in science, mathematics, and technical subjects that will allow the technician to progress to higher levels of job competence in an environment characterized by rapid change and innovation.

A DESCRIPTION OF ELECTROMECHANICAL ENGINEERING TECHNOLOGY AND THE RELATED OCCUPATIONAL FIELD

ELECTROMECHANICAL ENGINEERING TECHNOLOGY

What is meant by "Electromechanical Engineering Technology?" Electromechanical in general has to do with systems that involve mechanical and electrical energy. Often, as in motors and generators, there is a transformation between one form of energy and the other. Generators turn mechanical energy into electrical energy and motors accomplish the reverse. The above case is of course extremely simple. The motors and generators often have sophisticated electronic circuits that are used for control functions such as motor speed or generator frequency. Many electromechanical systems also include fluids for the purpose of mechanical energy transmission. Those that use liquids such as oil are called hydraulic while those that use some kind of gas such as air are called pneumatic.

Many EMT systems use microcomputers to implement sophisticated controls and functions. Examples are photocopiers, such as a Xerox machine, and industrial robots. In fact, the industrial robot is perhaps the best example of a complex electromechanical system. Many robots include motors, mechanical linkages, hydraulic and/or pneumatic power transfer components and one or more microprocessors. In addition, these robots normally have various electronic devices such as amplifiers and feedback servos, which are devices that make the robot do as it is told.

Most factories contain numerous electromechanical systems. Some examples are automatic assembly lines, motors, copying machines, air conditoning and ventilating systems and many more.

The above paragraphs describe the kinds of systems found in EMT. So, what is EMT? The key word is technology. Technology means a field of knowledge based in an area where there is a relatively intense concentration of technical skills and knowledge. Technology helps to integrate scientific knowledge within an area, reinforcing innovative activity and mobilizing technical resources. Procedures are involved which couple a high level of research and development (R and D) effort while actively incorporating new concepts and ideas that flow from the R and D. Technology incorporates an advanced level of automation in manufacturing and production control. The field of EMT is very broad and it encompasses a wide variety of many kinds of technical knowledge and skill. Much of the knowledge normally associated with Electronic Engineering Technology is required in EMT.

Modern automated industrial processes invariably involve a large amount of instrumentation. Instruments are required to control and monitor the various stages of complex processes. Instrumentation is one of the areas of elective courses in the EMT program. The others are robotics, electrical technology, and industrial controls.

Robotics deals with the installation, maintenance, repair, and programming of robotic systems, while electrical technology involves power generation and transmission. Industrial control specializes in the kinds of automated equipment found in many factories used to control industrial processes. Included would be microprocessors and programmable controllers.

COMMON EQUIPMENT AND PROCESSES

The graduate of the EMT program will be required to operate a wide variety of test equipment. These are discussed briefly below:

1. Multimeter - The multimeter, often misnamed a voltmeter, is used to measure the electrical parameters of voltage (AC and DC), current (AC and DC), and resistance. The older models are analog in that the value of the paramter is indicated by a pointer moving over a scale. The newer models are digital, which are more accurate, and the value is indicated directly in digital form in a window on the meter.
2. Cathode - Ray Oscilloscope (CRO) - This is an electronic device that has a cathode-ray tube display (similar to a TV face) to display and measure electrical waveforms. The ones that will be used in this program will have the capacity to measure two or more waveforms simultaneously. Very fast waveforms or transients (events that happen only once) can be displayed on the CRO. The faster ones have bandwidths of 100 megahertz (hertz is cycles per second) or more. Such an instrument can display something that lasts 1/100,000,000th of a second. Some CRO's have digital voltmeters built into them and some have the capability of handling many different plug-in modules for specialized applications. The multimeter and CRO are two mainstay instruments used by the graduate of EMT.
3. Function Generator - The function generator is a device used to apply certain special electrical waveforms in a test setup. Among the common waveforms are sine wave, square wave, and triangle wave. The device can put out waveforms at varying frequencies from one per second or less to many millions per second. In addition, many function generators put out a pulse waveform where the on-time (width of pulse) can be varied.
4. Power Supplies - Many different types of power supplies will be used, both AC and DC. These supplies may have closely regulated voltage outputs and have variable current cutoff levels.
5. Logic Analyzer - This is a device specially designed to test digital and microprocessor systems. It can capture and display the very-high-frequency events in sophisticated digital systems to allow effective troubleshooting.
6. Miscellaneous - Other instruments include various gages for measuring fluid pressure, digital logic probes, tachometers, and other similar small instruments.

Some common processes are discussed below:

1. Electrical/Electronic – Many of the processes involved in EMT are electrical or electronic in nature. Examples are signal amplification, filtering, transformation of alternating current (AC) power to direct current (DC) power, computer-controlled functions, power distributions and similar processes.

2. Mechanical – Mechanical processes include utilization of various drive and linkage devices, fluidics, packaging, and other similar mechanical processes.

TYPICAL JOB TITLES

Some of the more common job titles that apply to the field of EMT are discussed in the following paragraphs. You will notice that most have technician somewhere in them. We must differentiate between technician, and engineering technician; the latter being considered at a higher level of knowledge. The engineering technician is considered to have certain design capabilities generally lacking in a "technician". EMT and similar "high technology" graduates are at the engineering technician level. Although their job titles may not reflect this difference, their salaries in all likelihood will.

1. Maintenance Technician – This title could apply to any of the career options in the program. The equipment being maintained could be factory automated control equipment, robot work stations, power transmission and distribution equipment, or various instruments used at the job site. The duties might include some equipment design and specification along with the installation. Preventive maintenance and repair are also probable job duties. Often the maintenance technician works under and closely with an engineer in charge of the technical operations at a given area or the entire factory or job site.

2. Sales and Applications – Often this title will have the term engineer included, such as sales engineer, sales and applications engineer, or merely

applications engineer. As the name implies, sales is a major part of this particular job. The products will be technical in nature and therefore the term technical sales might be more appropriate. The person in one of these jobs will most likely do some design work, at least to the extent of configuring a system to satisfy customer requirements from a large set of candidate components. He or she may very will assist the customer in arriving at product requirements and may help to install and maintain the customer-purchased equipment. The maintenance function would probably not be a part of the job.

3. Field Service Technician - Sometimes this title has engineer substituted for technician or contains both, such as field service engineering technician. The person holding this job title will travel to the customer's location to install, maintain, or repair equipment on site. He or she will probably work for a large company, but not always.

The field service technician will probably travel more than most other technicians and will be on his or her own more often. Since he or she will work closely with customers and be the company's representative, it is important that the field service technician get along well with people. The field service technician can be a specialist in any of the EMT areas, such as electrical technology, robotics technology, instrumentation technology, or industrial control technology.

4. Generic Technician - Any of the four above categories can have a job title with technician as part of the title, such as instrumentation technician, robotics technician, industrial controls technician, or electrical technician. In addition any of the above titles could incldue engineering in it, such as instrumentation engineering technician. The duties of such a technician would still probably involve one or more of the following: maintenance, repair, installation, and operation of the equipment appropriate to the field. There could also be some design work and even some work more characteristic of a field service technician.

5. Miscellaneous Title - Other, less frequently occuring titles include bench technician, calibration technician (more often called instrumentaiton technician) and similar titles. Often companies have their own unique job titles for a technician that are far too numerous to list. The main thing is that the duties for any of the above

have certain similarities such as design, maintenance, installation and repair.

Either of the types of job description as found in the Dictionary of Occupational Titles (DOT), could be applied to the graduates of the EMT program described herein.

The term Electromechanical Engineering is not now widely recognized. Indeed EMT is an emerging discipline that is only at present beginning to attain an identity separate from the traditional electrical/mechanical distinctions.

003.161-010 ELECTRICAL TECHNICIAN (PROFESSIONAL AND KINDRED) ELECTRICAL-LABORATORY TECHNICIAN

Applies electrical theory and related knowledge to test and modify developmental or operational electrical machinery and electrical control equipment and circuitry in industrial or commercial plants and laboratories: Assembles and test experimental motor-control devices, switch panels, transformers, generator windings, solenoids, and electrical equipment and components according to engineering data and knowledge of electrical principles. Modifies electrical prototypes to correct functional deviations under direction of ELECTRICAL ENGINEER (professional and kindred). Diagnoses cause of electrical or mechanical malfunction or failure of operational equipment and performs preventive and corrective maintenance. Develops wiring diagrams, layout drawings, and engineering specifications for system or equipment modificaitons or expansion, and directs personnel performing routine installation and maintenance duties. Plans, directs, and records periodic electrical testing, and recommends or initiates modification or replacement of equipment which failes to meet acceptable operating standards.

710.281-018 ELECTROMECHANICAL TECHNICIAN (INSTRUMENTS AND APPLIANCES)

Fabricates, tests, analyzes, and adjusts precision electromechanical instruments, such as temperature probes, following blueprints and sketches, using handtools, metalworking machines, and measuring and testing instruments: Operates metalworking machines, such as bench lathe, milling machine, punch press, and drill press, to fabricate housings, fittings, jigs and fixtures, and verifies dimensions, using fixtures, binocular microscope, soldering tools, tweezers, and handtools. Installs electrical assemblies and hardware in housing, using handtools and solder equipment. Tests assembles instruments for circuit continuity and operational reliability, using multimeter, oscilloscope, oscillator, vacuum tube voltmeter, and bridge. Analyzes test results and writes report on fabrication techniques used. May calibrate instrument dials according to established standards. May specialize in assembly of prototype instruments and be designated as DEVELOPMENT TECHNICIAN (instruments and applicances), or in assembly of production instruments and be designated as FABRICATION TECHNICIAN (instruments and appliances).

CAREER OPPORTUNITIES

Career opportunities for EMT graduates are numerous and well-paying. According to the Department of Labor, by 1990 more than half of all factory jobs will be associated with robots and other automated factory equipment. A recent study by Georgia Tech for job openings in high-technology industry predicted conservatively that jobs in robotics/automation would grow from 643 jobs per year in the 1980-1985 years to 848 jobs/year in the 1985-1990 years. These jobs represent a mixture of engineering and technician type jobs, with the latter predominating.

There will be a comparable increase in all other areas as predicted by various business magazines and government publications. The drive for increased productivity to be more competitive internationally requires increased automation on the part of industry. Within the next 10 years General Motors predicts that they will install several thousand robots in their factories nationwide.

With the entrance of IBM and Texas Instruments into the robot market, predictions are that by 1990, robot sales will be form $990 million to $2 billion. A Georgia Tech study predicts sales of $385 million by 1985 and $1.4 billion nationwide by 1990. Georgia is expected to pick up about 1% of the above sales.

The availability of powerful inexpensive microcomputers greatly improved the economics of increased automation. With the decrease in the cost of computers have come comparable decreases in the cost of peripheral equipment required to effectively use them. Included are cheaper memory storage, printers, and video stations. Some devices closely related to the computer, such as programmable controllers, have also come down in price during an inflationary period.

All of the above factors enhance the employment opportunities of highly trained people such as those who graduate frm the EMT program.

Numerous career paths are available to EMT graduates. The upwared mobility of technicains, such as those in EMT, has been well demonstrated in the past. It is not at all uncommon for these technicains to be in supervisory positions three or four years after graduation. Included are such positions as foreman, shift supervisor, and lab supervisor. Some move into sales with a sizable increase in salary.

The technician does need to continue his or her education to remain current. He or she should continue to learn through formal or informal means, since technology moves fast, and the stagnant technician quickly becomes obsolete.

TABLE 1. PROJECTED JOB OPENINGS IN GEORGIA FOR HIGH-TECHNOLOGY INDUSTRY

YEARS	RANK	TECHNOLOGY	"Most likely" Average Annual Job Openings
1980-1985	1	Computer/Computer Services	4,872
	2	Communications	1,884
	3	Avionics	800
	4	Robotics/Automation	643
	5	Fiber/Laser Optics	170
	6	Biology	80
	7	Solar Energy	9
1985-1990	1	Computer/Computer Services	5,472
	2	Communications	3,475
	3	Avionics	1,074
	4	Robotics/Automation	848
	5	Fiber/Laser Optics	315
	6	Biology	160
	7	Solar Energy	20
1990-2000	1	Communications	7,220
	2	Computer/Computer Services	6,222
	3	Avionics	1,713
	4	Robotics/Automation	1,244
	5	Fiber/Laser Optics	800
	6	Biology	450
	7	Solar Energy	93

COURSES FUNDAMENTAL TO EMT

This section deals with those courses that are fundamental to all programs EMT. The following paragraphs will discuss the courses and attempt to relate their importance to EMT.

1. Mathematics - The mathematics courses include practical examples which help the student visualize the applicaiton to his or her field. For example, a technician needs to be able to solve the problem of what owuld happen to an object with forces applied to it at two different angles. In trigonometry you will learn that this can be solved by simple calculations using right-angle triangles. The requirements are three five-hour courses in algebra, trigonometry, and calculus with analytical geometry. Practically any technical field is heavily dependent on mathematics. EMT is no exception and in fact, good mathematical ability is probably the best indication of an ability to succeed in EMT. The technical courses in EMT all to a greater or lesser extent require the student to master the above mathematics, to master their theories and be able to apply them successfully.

2. Physics - Here again three five-hour courses are required,. Physics in general is a mathematical but generally simple way of describing our real world. The student of EMT will be introduced to the broad theories of physical reality and the trlationships that are in many cases analogous to the other technologies. The math and physics are part of the broad technical base that graduates of EMT should have. This broad supporting base tends to be much more immutable than some of the specialzed courses peculiar to a particular field.

3. The Humanities or Related Courses - The required humanity courses are English and Compositon, Technical Communications, Economics, and Industrial Relations. These courses will provide the EMT graduate with the required skills to communicate effectively within modern business or industrial settings. The EMT graduate needs not only to be able to communicate in written form, but he or she also needs to understand the nature of a business organization and have the skills to effectively interact with other people.

4. DC Circuits/AC Circuits/Circuit Analysis - These basic courses are fundamental to the understanding

of EMT systems which have so much that is electrical in their character. The theory in these courses provide more of the relatively unchanging basic foundation needed by the EMT graduate.

5. Engineering Graphics - This is required so that the EMT graduate can satisfy the illustrative requirements of technical design. It represents one of the communication tasks of the technician.

6. Computer Fundamentals - This course will enable the EMT student to use a powerful technique for the solution of technical problems. It is taken early (first quarter) and will be useful during the entire program. The EMT student will learn to program a modern microcomputer and this skill will be used and grow more powerful with each course as it is used.

7. Devices Courses - There are three required devices courses: (1) Electronic Devices, (2) Mechanical Devices and Systems, and (3) Electromechanical Devices. These three courses pretty much cover the kinds of devices or components that comprise an EMT system. The first course would deal with such devices as transistors, silicon-controlled rectifiers(SCR's), diodes and similar electronic devices. The second deals with gear systems, pulleys, belts, cogs, and similar mechanical devices. The alst deals with devices such as motors, generators, relays, and solenoids.

8. Electrical Power Distribution - This course deals with the generation of power and the methods of distributing it. Stepup and stepdown ofhigh voltages and the high voltage transmission lines are included in the theory this course. The knowledge and skills that the EMT learns in this course might best be put to use in a public power company such as Georgia Power Company.

9. Instrumentaiton and Controls - Almost any EMT system of any sie will have instrumentaiton and control requiremnts. The ability to adjust and read instruments and then to reach the correct conclusions as to the condition of an EMT system is a required skill of the EMT graduate. He or she, after determining the sytem's condition, must then manipulate the proper controls if needed to bring the system to the correct condition.

INNOVATIONS AND TRENDS

Two areas have shown rapid technology improvements in the last few years, and they are sure to continue for the foreseeable future. These areas are microporcessors and their associated equipment, and robotics.

MICROPROCESSORS

Microprocessors are a product of large-scale integration (LSI) in digital design and came about as a result of the space program. A microprocessor is a computer central processor on a single chip of silicon or germanium. The first microprocessors were of a four-bit (binary term) design and were widely used in hand calcualtors. Subsequently a number of 8-bit microprocessors were produced, resulting in many so-called microcomputers. The popular TRS-80 made by Radio Shack is an example of such a computer. Recently several 16-bit microprocessors have been developed, notable are those of Intel and Zilog that have resulted in microcomputers with the power that once was reserved for what was called a minicomputer. Examples are those of the Digital Equipment Corporation (DEC) and Data General. DEC has made the PDP-11 series for some years, while Data General has produced the Nova.

The new IBM personal computer uses the Intel 8086 16-bit microprocessor and has the power of the above minicomputers at a fraction of the cost. Even more significant is the fact that Motorola is now producing a 16-bit microprocessor with a 32-bit internal architecture which has more power than the Intel 8086. Intel has, however,[7] designed and is nearing production on a full 32-bit microprocessor which will result in a computer with the power of many of the smaller mainframe computers that used to be found only in the larger universities and businesses.

The advances in memory and other associated digital devices have paralleled those of the microprocessor. Memory chips started with numbers of memory bytes on the order of 256. Some memory chips now have over 16,000 bytes on a single chip. (A byte is 8 bits.)

The significance of the above is that cheap and powerful digital computers are available for all forms of automatic control. The digital computer is an ideal control device because of its speed and flexibility. Changes in an automatic control setup can often be effected by software (programming) changes, and software, once generated, can be used over and over. When newer more powerful computers become available, often only minor software changes are required to interface the new equipment to the automatic control setup.

Microcomputers have had an impact on almost the toal spectrum of products in America. They are found in such diverse items as blenders, automobiles, games, and TV's. Factories have them in their products and in their production equipment. This is a trend that is, if anything, increasing in importance.

ROBOTICS

Industrial robots only data back to the early 1960's and found very limited applications until the latter part of the 1970's. Although the term robot, conjures up a humanlike mechanical creature in most people's minds, many industrial robots have little or no anthropomorphic appearance. The Robot Institute of America defines a robot as "a reprogrammable, multifunctional manipulator designed to more material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks."

There are many exciting developments in the field of robotics which are on the near horizon. Several of these will be discussed below:

1. Rudimentary Vision - Vision, which will be provided to the robot through the interaction of a video camera and a computer to analyze the video data, will allow a robot to recognize things and also to determine where things are. Some robots already

have limited vision capability but none can match the performance of a human in picking parts out of a basket containing many different kinds of parts. One thing that is helping to achieve better vision in robots is the more powerful but economical computers which are available.

2. Tactile Sensing - Tactile sensing is the ability to distinguish things through the sense of feel. It is well established that blind people can be more effective in activities that depend on a sense of feel. So, too, the robot may compensate for a lack of vision by improved tactile sensing. Where tactile sensing is used, no ambient light is needed and this would result in some economy. This area is presently showing rapid development.

3. Hand-to-hand Coordination - Some industrial activities require that more than one hand or appendage be used at a time. A robot with more than one hand or the coordination of more than one robot would be required. This capability exists only in a limited sense at a present, but more sophisticated programming is bringing about improvements.

4. Mobility - Some jobs could be better accomplished by a robot that could more effectivley move about within or between work stations. This is presently accomplished by rails but they do not possess the programmabilty and flexibility of the robot.

5. General Purpose Hands - No robot hand has even a small fraction of the capability of a human hand. The robot hand must be changed often in order to accomplish a diveristy of tasks. Research going on is attempting to design robot hands that can be used for a wider variety of tasks.

6. Man-Robot Voice Communication - As robots become more versatile and capable, the ability to communicate by voice with the robot will increase in value. Present-day robots are still too simple for voice communication to have very much payoff, but that promises to change in the near future. The advances in computers are pushing these advances in robots closed. There is a lot of effort being made in industry and at many universities in the field of artificial intelligence which will, in effect, lead to a much more sophisticated robot. The time when voice communications with robots will have a good payout is probably no more than a few years off.

7. Total Self-Diagnostic Fault Training - The increased sophistication and power of the new robots of item 6 above will also make possible this self-fault detection. One can look a little further ahead and also envision self-repair for robots. At any rate self-diagnostics should be available in robots within a few (2-3) years at most. It may very well be able to show an economic payout sooner than some of the other innovations mentioned.

8. Safety - Robots at present can be very dangerous if those who work on them are careless. More inherent safety is desirable and probably will be included in the robot designs of the near future. Safety is almost always of prime concern. The inherent safety mentioned above refers to safety characteristics of the robot whereby it can detect an unsafe situation and compensate for it. It is important to recognie, however, that the use of robots in certain jobs is far better for safety, because of the haards of those jobs.

CURRICULUM MODEL

ELECTROMECHANICAL ENGINEERING TECHNOLOGY
STANDARD CURRICULUM - QUARTER SYSTEM
(SUGGESTED SEQUENCE)

	Class	Lab	Contact Hour	Cr
First Quarter				
D.C. Circuits	4	3	7	5
Computer Fundamentals	3	6	9	5
Algebra	5	0	5	5
Engineering Graphics	1	6	7	3
	13	15	28	18
Second Quarter				
Physics I	4	3	7	5
Trigonometry	5	0	5	5
A.C. Circuits	4	3	7	5
English & Composition	5	0	7	5
	18	6	26	20
Third Quarter				
Electronic Devices	4	3	7	5
Physics II	4	3	7	5
Analytic Geometry and Calculus	5	0	5	5
Circuit Analysis	4	3	7	5
	17	9	26	20
Fourth Quarter				
Technical Communications	4	3	7	5
Digital Electronics	3	3	7	5
Physics II	4	3	7	5
Elective Group I	4	3	7	5
	16	12	28	20
Fifth Quarter				
Electromechanical Devices	4	3	7	5
Elective Group II	4	3	7	5
Elective Group II	4	3	7	5
Digital Applicaitons	4	3	7	5
	16	12	28	20
Sixth Quarter				
Programmable Controllers	4	3	7	5
Elective Group III	4	3	7	5
Elective Group III	4	3	7	5
Elective Group III	4	3	7	5
	16	11	27	20
Seventh Quarter				
Industrial Relations	5	0	5	5
Principles of Economics	5	0	5	5
Elective Group IV	4	3	7	5
EMT Problems (Elective)	0	9	9	3
	14	12	26	18

ELECTROMECHANICAL ELECTIVES

Group I - (Fourth Quarter)
Mechanical Devices & Systems
Fluid Power
Electrical Power & Distribution I

Group II - (Fifth Quarter)
Instrumentation & Controls
Fluid Power
Automatic Motor Controls I
System Drawing
Electrical Power & Distribution II
Feedback & Control Systems

Group III - (Sixth Quarter)
Micro-computer Applications I
Instrumentation & Controls
Thermodynamics
Feedback & Control Systems
Robotics I
Industrial Controls I
AC/DC Machines I
Automatic Motor Controls II

Group IV - (Seventh Quarter)
Industrial Electronics
Industrial Controls II
Programmable Controller Problems
Robotics II
AC/DC Machines II
Thermodynamics
EMT Problems
Plus, any of above not already taken

Group V - (Eighth Quarter) optional
Electronic Instrumentation
COntrol Systems Analysis
Heating & A/C Controls
EMT Problems

Note: Electives from MET or EET may be added to this list by consent of program coordinator.

It is recommended that EMT students have the following courses as a minimum.

Communications & Social Studies	20 hrs.
Mathematics & Science	30 hrs.
Computer & Graphics	8 hrs.
Technical Core	
D.C. Circuits	5 hrs.
A.C. Circuits	5 hrs.
Circuit Analysis	5 hrs.
Electronic Devices	5 hrs.
Digital Electronics	5 hrs.
Mechanical Devices & Systems	5 hrs.
Electromechanical Devices	5 hrs.
Digital Applications	5 hrs.
Instrumentation & Control	5 hrs.
Fluid Power	5 hrs.
Micro-computer Applications I	5 hrs.
Programmable Controller	5 hrs.
	118 hrs.
Electives (4 courses)	18 hrs.
	136 hrs.

RELATED COURSES

COMPUTER FUNDAMENTALS

COURSE DESCRIPTION

This course will provide students with knowledge, skills, and attitudes to use the microcomputer as a tool to solve engineering technology problems typically encountered throughout their programs. Topics taught will include microcomputer architecture, programming concepts, branching, looping, arrays, functions, subroutines, data files, graphics and applications.

PREREQUISITE: Admission to the Program

CREDIT HOURS: 3-6-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Introduction to the Microprocessor A. Hardware B. Terminolgy C. Execution modes D. Programs	3	6
II. Introduction to Concepts of Programming A. Flowcharting B. Variable types C. Operations and formulas D. Simple BASIC programming E. Program comments F. Storage and retrieval of programs	3	6
III. Branching and Looping A. Relational operations B. Logical operations C. Conditional branching D. Multiple branching E. The stop statement F. Loops G. Nested loops	3	6
IV. Arrays A. Lists and tables B. Subscripted variables C. Defining arrays	3	6
V. Functions and Subroutines A. Library functions B. User functions C. Defining	3	6

	Student Contact Hours Class	Laboratory
D. Random numbers		
E. Defining subroutines		
F. Referencing subroutines		
VI. Data Files	3	6
A. Creating sequential data files		
B. Using sequential data files		
VII. Engineering Applications	3	12
A. Electronic technology problems		
B. Electromechanical technology problems		
C. Mechanical technology problems		
VIII. Graphics	3	6
A. Drawing bar charts		
B. Graphing functions		
C. Computer-generated imagery		

STUDENT LABORATORIES

- Execute instructor-supplied simple programs.
- Develop, debug, and execute a simple BASIC program.
- Save, retrieve, and execute a previously developed BASIC program.
- Create a data file, develop a program that will manipulate the file, and produce an acceptable output.
- Given a typical engineering program including all necessary equations and data, develop programs that will solve the problems and produce acceptable output.
- Develop, debug, and execute a program which will produce the answers in tabular form.
- Develop, debug, and execute an interactive program.

STUDENT COMPETENCIES

Upon completion of this course the student will be able to:
- Identify microcomputer hardware and define the associated terms.
- Execute pre-written programs.
- Write, save, retrieve, and execute simple programs in BASIC.
- Write BASIC programs using branching and looping statements
- Write BASIC programs manipulating data using arrays.
- Write BASIC programs using library functions.
- Develop functions and subroutines and incorporate them into BASIC programs.

- Write programs that use and manipulate data files.
- Solve selected technology problems using the microcomputer.
- Define and identfy microcomputer hardware (microcomputer, keyboard, CRT, disk drive, cassette, printer, floppy disk).
- List execution modes (execution, command or immediate, systems, edit).
  (These may differ according to manufacturer.)
- Execute a BASIC program which has been stored on a disk.
- Enter via keyboard and execute a program which has been supplied by the instructor.
- Discriminate between keywords and control words.
- Construct a flowchart which will display the logic of a given program or problem.
- Determine whether or not a line number is necessary in a given expression.
- Construct BASIC statements to compute given formulas.
- Write a simple BASIC program.
- List and give examples of variable types (numeric, string, constant).
- Identify symbols used for arithmetic operations (Addition, subtraction, multiplication, division, and exponentation).
- Outline correct structure for BASIC programs (identification, purpose, process).
- SAVE a BASIC program on tape or floppy disk.
- Retrieve a program which has been stored.
- Write BASIC statements using relational operators (less than,greater than, less than or equal to, greater than or equal to, less than or greater than, equal to).
- Write BASIC statements using logical operator (AND, OR NOT).
- Write BASIC programs using IF-THEN-ELSE statements.
- Demonstrate use of STOP statement to halt program and check progress.
- Identify and code algorithms involving nested loops.
- Generate lists and tables using subscripted variables.
- List examples of subscripted string and numeric variables.
- Define an array using the DIM statement.
- List keywords used as library functions (trig functions ABS, INT, RND, AQR).
- Code a DEF FN statement.
- Code algorithms using GOSUB.
- Code statements using the TAB(N) function.
- Code algorithms which will accumulate.
- Build a data file which contains at least five records.
- Access data files which have been previously created.
- Write, debug, and execute at least one program which solves a problem in the student's major area of interest.
- Plot a given point on the CRT.

RECOMMENDED TEXTS

Bent, Robert J. and Sethares, George C. Basic: An Introduction to Computer Programming. 2nd ed. Monterey, CA: Brooks/ Cole Publishing Co., 1982.

Shelly, Gary and Cashman, Thomas. Introduction to BASIC Programming. Anaheim, CA: Anaheim Publishing Co., 1982.

ECONOMICS

COURSE DESCRIPTION

Basic principles of the American economic system of free enterprise will be covered. An emphasis will be placed not only upon the classic economic principles, but upon understanding these principles as they apply to current economic trends. The role of technical/technologically-oriented industries in the economics of today to be emphasized.

PREREQUISITE: None

CREDIT HOURS: 5-0-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Introduction (Basic Economic Concepts)	1	
II. Economic Forces and Indicators	2	
A. Economics defined		
B. Modern specialization		
C. Increasing production and consumption		
D. Measures of economic activity		
1. gross national product		
2. national income		
3. disposable personal income		
4. industrial production		
5. emploÿment and unemployment		
III. Capital and Labor	3	
A. Tools (Capital)		
1. the importance of saving and investment		
2. the necessity for markets		
B. Large-scale enterprise		
C. Labor		
1. population characteristics		
2. vocational choice		
3. general education		
4. special training		
5. management's role in maintaining labor supply		
IV. Business Enterprise	7	
A. Forms of business enterprise		
1. individual proprietorship		
2. partnership		
3. corporation		
B. Types of corporate securities		

	Student Contact Hours	
	Class	Laboratory
1. common stocks 2. preferred stocks 3. bonds C. Mechanics of financing business D. Plant organization and management		
V. Factors of Industrial Production Cost	10	
A. Buildings and equipment 1. initial cost and financing 2. repair and maintenance costs 3. depreciation and obsolescence costs B. Materials 1. initial cost and inventory value 2. handling and storage costs C. Processing and production 1. methods of cost analysis 2. cost of labor 3. cost of supervision and process control 4. effect of losses in percentage of original product compared to finished product (yield) D. Packaging and shipping E. Overhead costs I. Profitability and business survival		
VI. Price, Competition and Monopoly	5	
A. Function of prices B. Price determination 1. competitive cost of product 3. supply 4. interactions between supply and demand C. Competition, benefits and consequences 1. monopoly and oligopoly 2. forces that modify and reduce competition 3. history of government regulation of competition D. How competitive is our economy?		

	Student Contact Hours Class	Laboratory
VII. Distribution of Income	2	
A. Increasing real income		
B. Marginal productivity		
C. Supply in relation to demand		
D. Incomes resulting from production		
1. wages		
2. interest		
3. rents		
4. profits		
E. Income distribution today		
VIII. Personal Income Management	2	
A. Consumption - the core of economics		
B. Economizing defined		
C. Personal and family budgeting		
D. Analytical buying		
1. applying quality standards		
2. consumer's research and similar aids		
E. The use of credit		
F. Housing - own or rent?		
IX. Insurance, Personal Investments and Social Security	3	
A. Insurance defined		
B. Life insurance		
1. group, industrial, ordinary		
2. type of policies - advantages and disadvantages		
C. Casualty insurance		
D. Investments		
1. savings accounts and government bonds		
2. corporation bonds		
3. corporation stocks		
4. annuities		
5. pension plans		
E. Social Security		
1. old-age survivor's insurance		
2. unemployment compensation		
3. medicare		
X. Money and Banking	3	
A. Function of money		
B. The nation's money supply		

	Student Contact Hours	
	Class	Laboratory
C. Organization and operation of a bank 1. sources of deposits 2. the reserve ratio 3. expansion of bank deposits 4. sources of reserves D. The Federal Reserve System 1. service functions 2. control of money supply E. F.D.I.C.		
XI. Government Expenditures, Federal and Local A. Economic effect B. Functions of government C. Analysis of government spending D. Future outlook E. Financing government spending 1. criteria of sound taxation 2. tax revenues in the U.S. 3. the federal and state personal income taxes 4. the coporate income tax 5. the property tax 6. commodity taxes	3	
XII. Fluctuations in Production, Employment and Income A. Changes in aggregate spending B. Output and employment C. Other factors affecting economic fluctuations 1. cost-price relationships 2. demand for durable goods 3. supply of commodities 4. effects of war 5. inflation and deflation 6. technology and automation D. Government Debt 1. purposes of government 2. how burdensome is the debt 3. problems of debt management	5	
XIII. The United States Economy in Perspective A. Recent economic changes 1. inflation and recession 2. effects of trade imbalance	4	

	Student Contact Hours	
	Class	Laboratory

3. new products and industries
4. increase in governmental controls

B. Present economic problems of U.S. economy
   1. the world market
   2. international cooperation
   3. maintenance of prosperity and progress
   4. economic freedom and security

C. Communism: nature and control by Soviet State

D. Problems common to all systems

E. Special economic problems of the U.S.

STUDENT COMPETENCIES:

At the conclusion of this course, the student will be able to:

- Define what is meant by economics in the traditional sense and state the importance of economics to today's business enterprises.
- Explain the relationship of productivity, balance of trade, and gross national product.
- Explain the roles of capital and labor in the American economic system.
- Contrast individual proprietorships, partnerships, and corporations as methods of business orgranizations.
- Explain how businesses are financed.
- Define and/or explain the importance of the following terms to production cost: capital outlay, materials, direct labor, indirect labor, scrappage and efficiency, materials shipping and handling, overhead, taxation and government regulation.
- Explain how free enterprise is different from monopolistic or socialistic economies.
- Define real income.
- Compute real income given gross income and relevant variables.
- Plan a personal budget.
- Plan a projected program of personal investment, savings, and insurance.
- Explain the meaning of money in economic terms.
- Discuss orally or in writing the effects of government regulation on business and economics.
- List and briefly describe three major problems which affect the American economy today.

RECOMMENDED TEXTS

Amacher. Principles of Economics. (Second Edition). Southwestern Publishing, 1983.

Heilbraner and Thuran. The Economic Problem. Prentice-Hall, 1981.

Olsen and Kennedy. Economics: Principles and Applications (Nineth Edition). Southwestern Publishing, 1978.

Theussen, et al. Engineering Economy. (5th Edition). Prentice-Hall, 1977.

ENGLISH AND COMPOSITION

COURSE DESCRIPTION

This course is designed to enhance the student's skill in writing, grammar usage and composition. Topics for student exercises may be chosen from material discussed or experienced in technical courses. Course material will serve to integrate basic communication skills with studies in technical subject areas. Topics to be covered include grammar, writing skills and composition.

PREREQUISITE: Admission to Program

CREDIT HOURS: 5-0-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Communications and the Technician	5	
A. Why the technician must be proficient		
B. Importance of written communications as an essential skill		
C. Study skills		
1. notetaking skills		
2. following written and oral instructions		
3. test-taking skills		
II. Composition (Emphasis on Student Writing)	47	
A. Diction		
B. Sentence Review		
1. review of basic parts of speech		
2. complete sentences		
3. use and placement of modifiers, phrases, clauses		
4. sentence conciseness		
5. exercises in sentence structure		
C. Grammar usage		
1. capitalization		
2. punctuation		
3. subject-verb agreement		
D. Paragraph construction		
1. topic sentence		
2. development		

3. unity and coherence
4. transistional devices

E. Narration, description, and exposition

F. Theme construction
1. thesis statement
2. transitions
3. conclusions

STUDENT COMPETENCIES

At the conclusion of the course, the student will be able to:

- Explain the need for effective written communication and an appreciation for the writing process.
- Use effective techniques for taking notes, following instructions, and taking tests.
- Analyze the ideas in essays related to technology and society.
- Recognize and articulate multiple points of view.
- Use commonly misused words correctly in basic sentences.
- Punctuate, capitalize, and spell correctly.
- Recognize and write simple, complex, compound, and complex-compound sentence structures.
- Rewrite ambiguous, wordy statements into clear, terse sentences.
- Recognize and write paragraphs using varied organizational techniques (cause and effect, description, definition, and so on).
- Write paragraphs containing well-defined topic sentences and develop each paragraph into a unified whole.
- Use transitional words and paragraphs to achieve coherence and unity in writing.
- Organize thoughts during the pre-writing stage using a written outline.
- Effectively write a unified, well-developed five paragraph theme following standard English grammer usage.

RECOMMENDED TEXTS

Hodges, John C., Whiten, Mary E., Harbrace College Handbook, 9th ed., New York, Harcourt, Brace, Jovanovich, 1982.

Lynch, Robert E. and Thomas, B. Swanzey, eds. The Example of Science: An Anthology for College Composition. Englewood Cliffs, NJ: Prentice-Hall, 1981.

Watkins, Floyd C. and Martin, Edwin T., Practical English Handbook, Boston, Houghton Mifflin.

INDUSTRIAL RELATIONS

COURSE DESCRIPTION

This course includes the study of the basis of human realtions and the organization of individual and group behavior. Leadership, organizational and social environments (including labor unions), career development, communications and group processes as well as selected operating activities are covered. Appropriate case problems are reviewed and discussed. Special emphasis is placed on typical industrial and business relationships in everyday situations.

PREREQUISITE: None

CO-REQUISITE: None

CREDIT HOURS: 5-0-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Fundamentals of Organizational Behavior	4	
A. Working with people		
B. Mainsprings of motivation		
C. Social systems		
D. Morale information and its use		
E. Developing a sound behavioral climate		
II. Leadership and Its Development	6	
A. The leadership role		
B. Effective supervision		
C. Development of participation		
D. Human relations training		
III. Organizational Environment	6	
A. Organizational structures		
B. Organizational dynamics		
C. The individual in the organization		
D. Informal organization		
IV. Career Development in Organizations	6	
A. Understanding career motivation		
B. Making career choices		
C. Attitudes and advancement		
D. Career development and management practices		

	Student Contact Hours	
	Class	Laboratory
V. Social Environment A. Labor unions B. Working with unions C. Employment discrimination D. Managing scientific and professional employees E. Managing employees in international operations	4	
VI. Communications and Group Processes A. Communication with employees B. Communication groups C. Counseling and interviewing D. Group dynamics E. Managing change	10	
VII. Operating Activities A. Appraising and rewarding performance B. Using economic incentive systems C. Integrating work systems with people D. Understanding automation E. Organizational behavior in perspective	4	
VIII. Case Problems in Technical Organizations	10	

STUDENT COMPETENCIES

At the conclusion of the course, the student will be able to:

- List and describe 5 fundamental componenets of a sound organizational environment.
- Explain the critical role of leadership in developing an organizational climate.
- Describe the characteristics of an effective leader.
- List 4 basic types of organizational structures.
- Diagram an organizational structure and label components.
- Develop a personal career objective and explain the rationale for the choice.
- Discuss and evaluate the impact of unionization on the U.S. economy.
- Explain the importance of interpersonal communication in an organization.
- List and describe the various types of communication that are important at work.

- Explain the possible impact of automation on the people in an organization.
- Effectively formulate solutions to organizational problems presented by the instructor.

RECOMMENDED TEXTS

Yoder and Standohar, Personnel Management and Industrial Relations, Englewood Cliffs, NJ, Prentice-Hall, 1982.

Armine et al., Manufacturing Organization and Management, Englewood Cliffs, NJ, Prentice-Hall, 1982.

Everand and Shilt, Business Principles and Management, Southwestern Publishing, 1979.

TECHNICAL COMMUNICATIONS

Technical Communications will provide the student with working knowledge of the use of communication techniques, procedures, and formats used in industry and business. The student will 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 will be reviewed.

PREREQUISITE: English and Composition

CREDIT HOURS: 5-0-5

COURSE OUTLINE	Student Contact Hours Class	Student Contact Hours Laboratory
I. Introducing Technical Communications	3	
A. Purpose of course		
B. Definition of technical writing		
C. Basic principles of technical writing		
D. Style		
1. audience		
2. purpose		
3. scientific attitude		
E. Introduction to oral communication		
II. Conducting Research	6	
A. Completing preliminary steps		
B. Assembling 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. using reference materials		
C. Using research results		
1. taking notes		
2. assembling an annotated bibliography		
III. Planning the report	5	
A. Outlines		
1. outlining effectively		
2. rules for formal outlines		
B. Abstracts and introductory summaries		

	Student Contact Hours	
	Class	Laboratory

1. types of abstracts
2. suggestions for writing abstracts

IV. Writing Definitions
  A. What should be defined
    1. familiar words for unfamiliar things
    2. unfamiliar words for familiar things
  B. How definitions are constructed
    1. informal
    2. formal
      a. class
      b. distinguishing characteristics
      c. summary of formal usage
      d. additional suggestions for formal usage
    3. amplified definitions
  C. Where definitions should be placed

V. Describe Mechanisms
  A. Describing mechanisms
  B. Components of the description of a mechanism
    1. some potential problems
    2. specifications
  C. Describing malfunctions of a mechanism

VI. Describing Processes
  A. Describing a process
  B. Problems encountered in describing a process
  C. Instructions in a process
  D. Describing malfunctions of a process

VII. Putting Skills into Practice: Writing a Formal Technical Report
  A. Writing the rough draft
    1. prefactory pages
    2. body of the report
    3. appendix
  B. Editing the rough draft
  C. Producing the final copy

VIII. Presenting an Oral Technical Report

A. Oral and visual aspects of technical communications
B. Oral presentations and activitfes
   1. oral reports and presentations
   2. leading conferences and group discussions
C. Visual illustrations
   1. what illustrations can do
   2. types of illustrations
D. Presenting the oral report

STUDENT COMPETENCIES

- Explain the importance of technical communications to the engineering technician.
- Use appropriate reference materials in preparing a technical report.
- Write a formal and an informal outline for a technical report.
- Write an abstract for a technical report.
- Write appropriate definitions of technical terminology.
- Precisely describe the characteristics and components of mechanisms.
- Precisely describe the characteristics and componenets of processes.
- Prepare a formal technical report using accepted formats and style.
- Deliver orally an informative persuasive technical presentations using supportive visual aids.

RECOMMENDED TEXTS

Brenner, Ingrid, Mathes, J. C. and Stevenson, Dwight. The Technician As Writer. Indianapolis: Bobbs Merrill, 1980.

Messer, Ronald. Style in Technical Writing. Glenview, Il: Scott-Foresman, 1982.

Sherman, Theodore and Johnson, Simon. Modern Technical Writing, 4th edition. Englewood Cliffs, NJ: Prentice Hall, 1983.

MATHEMATICS AND SCIENCE COURSES

ALGEBRA

COURSE DESCRIPTION

This course is designed to develop and update algebraic skills required for engineering technicians as applied to the solution of practical problems encountered in electrical, mechanical, thermal, hydraulic, pneumatic, and optical technologies. Topics to be covered include functions and graphs, linear equations, determinants, factoring, quadratics, and the solution of right triangles.

PREREQUISITES: Admission to Program

CREDIT HOURS: 5-0-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Fundamental Concepts and Operations A. Numbers and literal symbols B. Fundamental laws of algebra C. The laws of exponents D. Scientific notation E. Exponents and radicals F. Addition and subtraction of algebraic expressions G. Multiplication and division of algebraic expressions H. Equations and formulas	13	
II. Functions and Graphs A. Functions B. Cartesian coordinates C. Graphing functions D. Solving equations graphically	6	
III. Linear Equations and Determinants A. Linear equations B. Graphical solution of systems of two linear equations in two unknowns C. Algebraic solution of systems D. Solution by determinants of systems of two linear equations in two unknowns E. Algebraic solutions of three linear equations in three unknowns	11	

	Student Contact Hours Class	Laboratory
F. Solution by determinants of systems of three linear equations in three unknowns.		
IV. Factoring and Fractions	10	
A. Special products		
B. Factoring		
C. Simplifying fractions		
D. Multiplication and division of fractions		
F. Addition and subtraction of fractions		
V. Quadratic Equations	5	
A. Quadratic equations. Solution by factoring		
B. Completing the square		
C. The quadratic formula		
VI. Variation (optional)		
A. Direct		
B. Inverse		
C. Joint		

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Write concepts mathematically using numbers and symbols.
- Perform mathematical operations using the fundamental laws of algebra and the laws of exponents and radicals.
- Make mathematical computations using scientific notation.
- Perform algebraic operations of addition, subtraction, multiplication, and division on algebraic expressions.
- Perform basic mathematical operations on equations and formulas to solve for any given variable.
- Graph relations and functions with two variables.
- Graphically solve two linear equations with two unknowns.
- Algebraically solve two linear equations with two unknowns.
- Use determinants to solve three linear equations in three unknowns.
- Identify the general form of first, second, and third degree equation products in three unknowns.
- Factor into prime factors algebraic expressions containing common monomial factors.
- Factor the difference of two squares.
- Factor trinomial expressions.
- Factor perfect square trinomials.
- Change a given algebraic fraction into a specified equivalent fraction.

- Perform operations of addition, subtraction, multiplication and division on algebraic fractions.
- Solve equations containing algebraic fractions.
- Solve quadratic equations by factoring.
- Solve quadratic equations by completing the square.
- Solve quadratic equations by use of the quadratic formula.
- Define trigonometric functions using the standard triangle.
- Solve right triangles.

RECOMMENDED TEXTS

Clar and Hart. Mathematics for the Technologies. Englewood Cliff, N.J.: Pretice-Hall, Inc.

Paul and Shaevel. Essentials of Technical Mathematics with Calculus. Englewood Cliffs, NJ.: Prentice-Hall, Inc.

Washington, Allyn J. Basic Technical Mathematics with Calculus. 3rd Edition. Benjamin Cummings.

ANALYTIC GEOMETRY AND CALCULUS

COURSE DESCRIPTION

This course is a survey course designed to develop analytic geometry and calculus skills required for engineering technicians as applied to the solution of practical problems encountered in electrical, mechanical, thermal, hydraulic, pneumatic, and optical technologies. Topics to be covered include analytic geometry, derivatives, integrals, differentiation and integration of polynomial functions and transcendental functions and integration techniques.

PREREQUISITES: Algebra, Trigonometry

CREDIT HOURS: 5-0-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Elements of Analytic Geometry	8	
A. The straight line		
B. The circle		
C. The parabola		
D. The ellipse		
E. The hyperbola		
II. Sequences and Series (optional)		2
A. Finite sequences and series		
B. Infinite sequences and series		
C. Limit of a sequence or series		
III. Derivatives and Applications	15	
A. Limits		
B. The slope of a tangent to a curve		
C. The derivative		
D. Derivatives of polynomials		
E. Derivatives of products and quotients of functions		
F. The derivative of a power of a function		
G. The derivative as a rate of change		
H. Maximum and minimum problems		
I. Implicit differentiation		
IV. Integration and Applications	15	
A. Differentials and inverse differentiation		
B. The indefinite integral		
C. The area under a curve		
D. The definite integral		

	Student Contact Hours Class	Laboratory
E. Finding area by integration		
F. Volume by integration		
G. Applications for the integral		
H. Trapeziodal rule/or rectangula method for approximating areas (optional)		
V. Differentiation of transcendental functions	8	
A. Derivatives of the sine and cosine functions		
B. Derivatives of the other trigonometric functions		
C. Derivatives of the inverse trigonometric functions		
D. Derivatives of the exponential and logarithmic functions		
VI. Integration Techniques (Optional)	4	
A. The genral power formula		
B. The logarithmic and exponential form		
C. Basic trigonometric forms		
D. Integration by parts		
E. Integration by substitution		
F. Use of the tables.		

STUDENT COMPENTENCIES

At the conclusion of this course, the student will be able to:

- Find the straight-line distance between two points on a graph.
- Define and find the slope of a line.
- Write the equation of a straight-line given various properties of the line such as points on the line, slope and/or intercepts.
- Define a circle and write the equation of a circle with the center at (0,0) and with the center at any coordinate (x,y).
- Define and derive the equation of a parabola given appropriate data.
- Define and derive the equation of an ellipse given the appropriate data.
- Define and derive the equation of a hyperbola given the appropriate data.
- Find the sum of a finite arithmetic or geometric series and of other finite series.
- Find the nth term of a sequence.
- Find the sum of an infinite geometric series if one exists.
- Identify convergent and divergent sequences and series.

- Find the limit of an infinite sequence or series if it exists.
- Find the limit of an infinite sequence or series if it exists.
- Determine if a function is continuous.
- Determine the limits of a function if they exist.
- Find the slope of the tangent to a curve.
- Define and find the derivative of a function.
- Derive the derivatives of products and quotients of functions.
- Derive the derivative of a power of a function.
- Use differential calculus to solve problems involving rate of change.
- Use differential calculus to solve maximum and minimum problems.
- Use implicit differentiation to solve applied problems.
- Find the differential of a function.
- Find the antiderivative of a function.
- Define and find the indefinite integral of a function.
- Find the area under a curve.
- Define the definite integral of f (n).
- Find volume by integration.
- Apply integral calculus to solve problems involving moments of inertia, work, average values, etc.
- Compute derivatives of the sine and cosine functions.
- Compute derivatives of the other trigonometric functions.
- Compute derivatives of the inverse trigonometric functions.
- Compute derivatives of the exponential logarithmic functions.
- Integrate functions by use of the general power formula.
- Integrate functions in logarithmic and exponential form.
- Integrate the trigonometric functions.
- Perform integration by parts.
- Perform integration by substitution.
- Perform integration by use of tables.

RECOMMENDED TEXTS

Clar and Hart, Mathematics for the Technologies. Englewood Cliffs, NJ: Prentice-Hall.

Paul and Shaevel, Essential of Technical Mathematics with Calculus. Englewood Cliffs, NJ: Prentice-Hall.

Washington, Allyn J., Basic Technical Mathematics with Calculus. 3rd ed., Benjamin Cummings.

TRIGONOMETRY

COURSE DESCRIPTION

This course is designed to develop trigonometric skills required for engineering technicians as applied to the solution of practical problems encountered in electrical, mechanical, thermal, hydraulic, pneumatic and optical technologies. Topics to be covered include trigonometric functions of angles, vectors, solutions to oblique triangles, graphs of trigonometric functions, j-Operator, identities, inverse functions and logarithms, exponents and radicals and additional solutions to systems and equations.

PREREQUISITE: Algebra

CO-REQUISITE: NONE

CREDIT HOURS: 5-0-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Trigonometric functions of any angle	4	
A. Signs of the trigonometric function		
B. Radian		
C. Applications of the use of radian measure		
II. Vectors and triangles	7	
A. Vectors		
B. Application of vectors		
C. Oblique triangles		
D. The law of sines		
E. The law of cosines		
III. Graphs of the Trigonometric Functions		
A. Graphs of Y=A sin x and Y=A cos x		
B. Graphs of Y=A sin bx and Y=A cos bx		
C. Graphs of Y=A sin (bx+c) and Y=csc x		
D. Graphs of Y=tan x, Y= c[illegible], Y=sec x, Y=csc x		
E. Application of the trigonometric graphs		
F. Composite trigonometric curves		
IV. Exponents and Radicals	7	
A. Positive integers as exponents		

	Student Contact Hours Class	Laboratory
B. Zero and negative integers as exponents		
C. Fractional exponents		
D. Simplest radical form		
E. Addition and subtraction of radicals		
F. Multiplication and division of radicals		
V. The j-Operator	9	
A. Imaginary and complex numbers		
B. Operations with complex numbers		
C. Graphical representation of complex numbers		
D. Polar form of a complex number		
E. Exponential form of a complex number		
F. Products, quotients, powers and roots of complex numbers		
IV. Properties of Trigonometric Functions	4	
A. Fundamental trigonometric identities		
B. Sine and cosine of the sum and difference of two angles		
C. Double-angle formulas		
D. Half-angle formulas		
E. Trigonometric equations		
VII. The Inverse of Trigonometric Functions	2	
A. Inverse trigonometric functions		
B. Principal values		
VIII. Logarithms	5	
A. Exponential and logarithmic functions		
B. Graphs of Y = b and Y = log x		
C. Properties of logarithms		
D. Logarithms to the base 10		
E. Logarithms to the base e		
F. Solutions of the exponential and logarithmic equations		
IX. Additional Solutions to Equations and Systems of Equations	6	
A. Graphical solution of systems of equations		

B. Algebraic solution of systems of equations
C. Equations in the quadratic form
D. Equations with radicals

STUDENT COMPENTENCIES

At the conclusion if this course, the student will be able to:

- Define the six trigonometric functions.
- Determine the sign of the function of an angle.
- Find the value of a given function of an angle.
- Find the value of the angle of the inverse trigonometric function.
- Convert between systems of angular measurement.
- Make trigonometric computations with angles measured in radians.
- Define vector quanities and give examples.
- Graphically represent a vector.
- Graphically add and subtract vectors.
- Use vectors to solve problems by resolving vectors into rectangular components.
- Solve oblique triangles using the laws of sines.
- Solve oblique triangles using the law of cosines.
- Graph the trigonometric functions Y = A sin x and Y = A cos x.
- Graph the trigonometric functions Y =sin (bx + c) and Y = A cos (bx +C).
- Graph the trigonmetric functions Y = A sin bx and Y = A cos bx.
- Determine amplitude, period, and phase of periodic (sinusoidal) motion.
- Graph the trigonometric functions Y = tan x, Y = cot x, Y = sec x, Y = csc x.
- Describe various types of motion in terms of the sine curve.
- Graphically combine two or more trigonometric curves.
- Perform operations involving algebraic expressions containing fractional components.
- Reduce radicals to simplest form.
- Perform operations wtih algebraic expressions containing fractional components.
- Define and describe the complex number system.
- Perform complex numbers graphically.
- Represent complex numbers graphically.
- Write complex numbers in polar form.
- Write complex numbers in exponential form.
- Calculate the product, quotient, powers, and roots of complex numbers.
- Recognize and verify the basic trigonometric identities.
- Prove the validity of trigonometric equations by means of the trigonometric identities.

- Compute the sine and cosine of the sum and difference of two angles.
- Compute the value of the sine and cosine of the double angle.
- Compute the value of the sine and cosine of the half angle.
- Recognize and define inverse trigonometric functions.
- Compute the principal value of a given trigonometric function.
- Recognize and define an equation in exponential form.
- Recognize and define an equation in logarithmic form.
- Graph exponential and logarithmic functions.
- Perform algebraic operations with logarithmic expressions using the properties of a logarithm.
- Write a number as a logarithm to the Base 10.
- Write a number as a logarithm to the Base e.
- Solve exponenetial and logarithmic equations.
- Graphically solve systems of first and second degree equations with two variables.

RECOMMENDED TEXTS

Clar and Hart, Mathematics for the Technologies. Englewood Cliffs, NJ: Prentice-Hall.

Paul and Shaevel, Essentials of Technical Mathematics with Calculus. Englewood Cliffs, NJ: Prentice-Hall.

PHYSICS I

COURSE DESCRIPTION

A practical approach toward the concepts of force, work, rate, and power is presented in Physics I. Students are shown, by classroom demonstration, how these four concepts are applied to the four energy systems - mechanical, fluidal, electrical, and thermal - and then will perform laboratory experiments that relate each concept to the four energy systems.

PREREQUISITE: Admission of Program

CO-REQUISITE: Algebra

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Introduction	5	5
A. Identification of energy systems		
B. Review of simple mathematics		
C. Review of basic concepts of physics		
II. Force	10	10
A. Mechanical systems		
1. linear force		
2. units of mass and force		
3. forcelike quantities		
4. torque		
B. Fluidal systems		
1. pressure		
2. density/pressure relationships		
C. Electrical systems		
1. electromotive force (EMF)		
2. methods of producing an EMF		
D. Thermal systems		
1. temperature difference		
2. temperature scales		
III. Work	10	5
A. Mechanical systems		
1. mechanical work, translational		
2. mechanical work, rotational		
B. Fluidal systems		
1. pressure/volume relationships		

	Student Contact Hours	
	Class	Laboratory
2. energy considerations		
C. Electrical systems		
1. charge movement and EMF		
2. conversion factors for electrical systems		
3. current		
D. Thermal systems		
1. heat flow rate		
2. heat measure		
3. change of state		
IV. Rate	10	5
A. Mechanical system		
1. speed and velocity, linear motion		
2. acceleration, linear		
3. rotational motion, angular velocity		
4. angular acceleration		
B. Fluidal systems		
1. volume flow rate		
2. mass flow rate		
C. Electrical systems		
1. current		
2. AC/DC		
D. Thermal systems		
1. heat energy transfer		
2. heat flow rate		
V. Power	5	5
A. Power equations		
1. power defined		
2. basic equation form		
B. Efficiency		
C. Mechanical systems		
1. translational		
2. rotational		
D. Fluidal systems		
E. Electrical systems		
F. Thermal systems		

STUDENT COMPETENCIES

- Define the following physical quantities and, where applicable, state their units in both SI (International System of Units) and English System of Units:
  - Force
  - Torque
  - Pressure
  - Voltage
  - Temperature Difference
- Given two or more mechanical forces acting along the same line, determine the resultant force.

- Given two of the following quantities in a mechanical rotational system determine the third:
  - Force
  - Lever Arm
  - Torque
- Given two of the following quantities in a fluid system, determine the third:
  - Force
  - Area
  - Pressure
- Given two of the following quantities in a fluid system, determine the third:
  - Pressure
  - Height of fluid
  - Weight density
- Given two or more voltage sources connected in series, determine the resultant voltage.
- Given a temperature in either degrees Celsius or degrees Fahrenheit, determine the equivalent temperature on the other scale.
- Describe how pressure in fluidal systems, voltage in electrical systems, and temperature difference in thermal systems are similar to force and torque in mechanical systems.
- Describe the conditions that must be met for equilibrium in each of the following energy systems:
  - Mechanical
  - Fluidal
  - Electrical
  - Thermal
- Define work and energy in general terms that apply to any energy system, and distinguish work from energy in the following systems:
  - Mechanical translational
  - Mechanical rotational
  - Fluidal
  - Electrical
  - Thermal
- Define the following units of work and energy
  - Foot-Pound
  - Calorie
  - British thermal unit
  - Joule
- Define the following terms and explain their usefulness in determining work done:
  - Radian (mechanical system)
  - Current(electrical system)
  - Specific heat (thermal system)
  - Heat capacity (thermal system)
- Given two of the following quantities in a mechanical translational system, determine the third:
  - Force
  - Displacemnt
  - Work

- Given two of the following quantities in a mechanical rotational system, determine the third:
  - Torque
  - Angular displacement
  - Work
- Given two of the following quantities in a fluidal system, determine the third:
  - Pressure differnece
  - Volume displace
  - Work
- Given two of the following quantities in an electrical system, determine the third:
  - Voltage
  - Charge transferred
  - Work
- Given the temperature difference across a uniform thickness of a substance, the dimensions of the substance, and its thermal conductivity, calculate the heat flow rate through the substance.
- Given two of the following quantities in a thermal system, determine the third:
  - Temperature change of object
  - Heat capacity of object
  - Work (heat energy transferred)
- Define and give examples of:
  - Latent heat
  - Sensible heat
- State the general equation for work, and explain how it applies to each of the following energy systems:
  - Mechanical translational
  - Mechancial rotaitonal
  - Fluidal
  - Electrical
  - Thermal
- Define the following rates and, where applicable, express their basic units both in SI and English systems of units:
  - Speed and velocity
  - Acceleration
  - Angular velocity
  - Angular acceleration
  - Volume flow rate
  - Mass flow rate
  - Electric current
  - Heat flow rate
- In a linear mechanical system, given all the quantities except one in each of the following groups, determine the unknown quantity:
  - Displacement, elasped time, velocity
  - Initial velocity, final velocity, elapsed time, acceleration
  - Mass, force, acceleration

- In a rotational mechanical system, given all the quantities except one in each of the following groups, determine the unknown quantity:
    Angular displacement, elapsed time, angular velocity / Initial angular velocity, final angular velocity, elapsed time, angular accelaration
- In a fluidal system, given all the quantities except one in each of the following groups, determine the unknown quantity:
    Volume of fluid moved, elapsed time volume flow rate / Mass of fluid moved ,elapsed time, mass flow rate
- Given two of the following quantities in an electrical system, determine the third:
    Charge transferred
    Elapsed time
    Current
- Given two of the following quantities in a thermal system, Determine the :
    Heat energy transferred
    Elapsed time
    Heat flow rate
- State the general equation for rate, and explain how it applies to each of the following energy systems:
    Mechancial translational
    Mechanical rotational
    Fluidal
    Electrical
    Thermal
- Define "power" as it applies, in general, to all energy systems; and equations that relate work,elapsed time, force, and rate to power in these energy systems:
    Mechanical system
    Fluidal system
    Electrical system
- List for each energy system the SI and English units used to define power,
- Given any two of the following quantities in any energy system, determine the third:
    Work(or force-like quantity x displacement - like quantity)
    Elapsed time
    Power
- Given any two of the following quantities in any energy system, determine the third:
    Force-like quantity
    Rate
    Power
- Define the following terms:
    Input power
    Output power
    Efficiency

RECOMMENDED TEXTS

Cord, Unified Technical Concepts. Waco, Tx: Center for Occupational Reasearch and Development, 1980.

Dierauf, Edward J.,Jr., and Court, James E. Unified Concepts in Applied Physics. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1979.

PHYSICS II

COURSE DESCRIPTION

The second quarter of Physics builds on the foundation developed in the first quarter by presenting concepts of magnetism, resistance, energy, momentum, force transformers, and energy converters. The course balances theory related to these six concepts with practical hands-on experience in working with associated devices in the four energy systems (mechanical, fluidal, electrical, and thermal).

PREREQUISITE: Physics I

COREQUISITE: Trigonometry

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Magnetism	5	5
A. Magnetic theory		
B. Magnetic fields and flux		
C. Comparison of magnetic and electric circuits		
II. Resistance	10	5
A. Mechanical systems		
1. dry friction		
2. static and kinetic friction		
B. Fluidal systems		
1. fluid resistance in pipes		
2. viscosity		
C. Electrical systems		
1. Ohm's Law		
2. resistivity of conductors		
D. Thermal systems		
1. thermal resistance		
2. insulation		
III. Potential and Kinetic Energy	10	5
A. Mechanical systems		
1. translational		
2. rotational		
B. Fluidal systems		
1. volume/mass conversion		
2. Bernoulli's equation		
C. Electrical systems		
1. charge relationships		

	Student Contact Hours	
	Class	Laboratory
2. capacitors		
D. Thermal systems		
IV. Momentum	5	5
A. Linear momentum		
B. Impulse and momentum change		
C. Angular momentum		
D. Momentum in fluidal systems		
E. Conservation of momentum		
V. Force Transformers	5	5
A. Principles of force transformers		
B. Mechanical systems		
1. the pulley		
2. the lever		
3. the inclined place		
4. the screw		
5. the wheel and the axle		
C. Fluidal systems		
1. the hydraulic lift		
2. mechanical advantage of a hydraulic lift		
D. Electrical systems - electrical transformers		
VI. Energy Converters	5	5
A. General considerations and background		
B. Converters of mechanical input energy		
C. Converters of fluidal input energy		
1. mechanical output energy		
2. electrical output energy		
D. Converters of electrical input energy		
1. mechanical output energy		
2. thermal output energy		
3. optical output energy		
E. Converters of thermal input energy		
1. mechanical output energy		
2. thermal output energy		
3. optical output energy		
F. Converters of optical input energy		
1. electrical output energy		
2. thermal output energy		

STUDENT COMPETENCIES

- Determine the direction and strength of a magnetic field.
- Examine how the concepts of force, parameter, rate, and resistance apply to magnetic circuits.
- List and describe different types of magnetic material.
- Calculate magnetic field strength, or magnetic flux of an area.
- Explain the effects magnetism has in each of the energy systems.
- Describe the effect of magnetic forces exerted on moving charged particles in a magnetic field.
- Compare simple magnetic and electric circuits using the unified concepts.
- Given two of the following quantities in a fluid system determine the third:
  - Pressure
  - Height of fluid
  - Weight density
- Given two or more voltage sources connected in series, determine the resultant voltage.
- Given a temperature in either degrees Celsius or degrees Fahrenheit, determine the equivalent temperature on the other scale.
- Describe how pressure in fluidal systems, voltage in electrical systems, and temperature difference in thermal systems are similar to force and torque in mechanical systems.
- Describe the conditions that must be met for equilibrium in each of the following energy systems:
  - Mechanical
  - Fluidal
  - Electrical
  - Thermal
- Define work and energy in general terms that apply to any energy system, and distinguish work from energy in the following systems:
  - Mechanical translational
  - Mechanical rotational
  - Fluidal
  - Electrical
  - Thermal
- Define the following units of work and energy
  - Foot-Pound
  - Calorie
  - British thermal unit
  - Newton-Meter Joule
- Define the following terms and explain their usefulness in determining work done:
  - Radian (mechanical system)
  - Current (electrical system)

Specific heat(thermal system)
Heat capacity(thermal system)

- Given two of the following quantities in a mechanical translational system, determine the third:
  Force
  Displacement
  Work
- Given two of the following quantities in a mechanical rotational system, determine the third:
  Torque
  Angular displacement
  Work
- Given two of the following quantities in a fluidal system, determine the third:
  Torque
  Angular displacemnt
  Work
- Given two of the following quantities in an electrical system, determine the third:
  Voltage
  Charge transferred
  Work
- Given the temperature difference across a uniform thickness of a substance, the dimensions of the substance, and its thermal conductvity, calculate the heat flow rate through the substance.
- Given two of the following quantities in a thermal system, determine the third:
  Temperature change of object
  Heat capacity of object
  Work (heat energy transferred)
- Define and given examples of:
  Latent heat
  Sensible heat
- State the general equation for work, and explain how it applies to each of the following energy systems:
  Mechanical translational
  Mechanical rotational
  Fluidal
  Electrical
  Thermal
- Define the following rates and , where applicable, express thier basic units both in SI and English systems of units:
  Speed and velocity
  Acceleration
  Angular velocity
  Angular acceleration
  Volume flow rate
  Mass flow rate
  Electric current
  Heat flow rate

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- In a linear mechanical system, given all the quantities except one in each of the following groups, determine the unknown quantity:
  - Displacement, elapsed time, velocity
  - Initial velocity, final velocity, elapsed time, acceleration
  - Mass, force, acceleration
- In a rotational mechanical system, given all the quantities except one in each of the following groups, determine the unknown quantity:
  - Angluar displacement, elapsed time, angular velocity/ Initial angular velocity, final angular velocity, elapsed time, angular acceleration
- In a fluidal system, given all the quantities except one in each of the following groups, determine the unknown quantity:
  - Volume of fluid moved, elapsed time volume flow rate, mass fluid moved, elapsed flow rate
- Given two of the following quantities in an electrical system, determine the third:
  - Charge transferred
  - Elapsed time
  - Current
- Given two of the following quantities in a thermal system, determine the third:
  - Heat energy transferred
  - Elasped time
  - Heat flow rate
- Define resistance in a general way, and state the final form of the energy expended when a forcelike quantity does work to overcome resistance in an energy system.
- Calculate the magnitudes of starting and sliding frictional forces, given the mass or weight of the object, the coefficients of friction, and the angle of incline.
- Given the two of the following quantities in fluidal, electrical, and thermal systems, determine the third:
  - Forcelike quantity
  - Rate
  - Resistance
- Describe the difference between laminar and turbulent flow.
- State the factors contributing to fluid resistance in pipes.
- State the factors contributing to thermal resistance of objects.
- Describe with the use of graphs the definition of resistance as the ration of forcelike quantity to rate in fluidal, electrical, and thermal systems. Include the units of forcelike quantity, rate, and resistance for each system.
- State the fundamental difference between sliding

friction and resistance as it applies to fluidal, electrical and thermal systems.

- Define potential energy, kinetic energy, and conservation of enrgy by using examples from mechanical systems.
- Given any two of the quantities in the following groups, determine the third:

  Mass, velocity, kinetic energy
  Mass, height, potential energy
  Spring constant, spring displacement, potential energy / Moment of inertia, angular velocity, kinetic energy / Capacitance, voltage, potential energy

- Given Bernoulli's equation and the height of liquid in a tank, determine the exit velocity at the bottom of the tank if ther is no fluid friction.
- List and describe the three processes that transfer thermal energy.
- Discuss the conservation of energy as it applies to fluidal, electrical, and thermal systems.
- Define the following terms; state the appropriate units in the mk/s system (SI) and t cg/s system; and give the equation for each:

  Linear momentum
  Angular momentum
  Impulse
  Angular impulse
  Moment of inertia

- Given two of the following quantities, determine the third:

  Mass of an object
  Velocity of the object
  Momentum of the object

- Given all the following quanities, determine the third:

  Moment of inertia of an object
  Angular velocity of the object
  Angular momentum of the object

- Given two of the following quantities except one describing a linear collison, determine the unknown quantity:

  Mass of first object
  Initial velocity of first object
  Final velocity of first object
  Mass of second object
  Initial velocity of second object
  Final velocity of second object

- Explain the following concepts in a short paragraph each:

  Consevation of linear momentum
  Conservation of angular momentum

- Use a given equation to calcuate the force produced on one blade of a reaction turbine, given the velocity of fluid and the mass of fluid per unit time striking the blade.

- Describe specific force transformers in the mechanical translational, mechanical rotational, fluidal, and electrical systems; and discuss their fundamental similarity as transformers of forcelike quantities.
- Define the following terms:
  - Ideal mechanical advantage
  - Actual mechanical advantage
  - Efficiency
- Calculate the ideal mechanical advantage of a specific pulley, lever, screw, wheel and axle, hydraulic press or lift, and electrical transformer.
- Calculate the change in current in an ideal electrical transformer.
- Discuss how the role of resistance in a transformer dissipates energy input and reduces efficience.
- Describe the power input and power output characterisitcs of a transformer that operates continuously.
- Describe energy converters in general terms that apply to all energy-conversion devices.
- Describe the operation of the following energy converters:
  - Vane pump
  - Turbine
  - Electric generator
  - Electric motor
  - Electric heater
  - Internal combustion engine
  - Boiler
  - Solar collector
- Given two of the following quanities, determine the third:
  - Input energy
  - Output energy
  - Efficiency
- Given the efficiency of all the energy converters used in an energy conversion system, determine the overall system efficiency.

RECOMMENDED TEXTS

Cord, Unified Technical Concepts. Waco, TX: Center for Occupational Research and Development, 1980.

Dierauf, Edward J., Jr., and Court, James E. Unified Concepts in Applied Physics. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1979.

PHYSICS III

COURSE DESCRIPTION

This third quarter of Physics will provide the student with practical knowledge of sound scientific principles behind devices and components addressed in four concepts: transducers, energy transfer and storage, vibration and waves, and radiation. Practical hands-on experience with devices common to many technologies is offered in the laboratory.

PREREQUISITE: Trigonometry, Physics II

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Transducers	5	5
A. Basic concepts		
B. Self excited transducers		
C. Externally excited transducers		
II. Energy Transfer and Storage	10	5
A. Basic considerations		
1. thermal cooling		
2. rotational		
B. Mechanical systems		
1. translational		
2. rotational		
C. Fluidal systems		
D. Electrical systems		
E. Thermal systems		
III. Vibrations and Waves	6	15
A. Oscillating systems		
1. simple harmonic motion		
2. oscillating systems with resistance		
3. forced oscillations		
4. resonance		
B. Types of waves		
1. transverse		
2. longitudinal		
C. Wave characteristics		
1. wave velocity		
2. the wave equation		
3. superposition		
4. standing waves		
5. interference		
D. Wave motion as a unifying concept		
1. mechanical systems		

	Student Contact Hours Class	Laboratory
2. fluidal systems		
3. electrical waves		
IV. Radiation	10	10
A. Electromagnetic radiation		
B. Light		
C. Optical instruments		
D. Waves and particles		
E. particle radiation		

STUDENT COMPETENCIES

- In a short paragraph, define a transducer. Include a distinction between those transducers that require external energy sources and those that do not.
- Describe the operation of the following transducers:
  - Strain gage
  - Accelerometer
  - Microphone
  - Turbine flowmeter
  - Barometer
  - Meter movement
  - Thermocouple
  - Thermistor
  - Bimetallic strip
  - Photoconductive cell
  - Photovoltaic cell
- Define the following terms:
  - Steady state
  - Transient
  - Damping
  - Time constant
  - Half-life
  - Decay constant
- Draw and label a graph showing an exponentially-decaying function. Include on the graph the time constants T1/2 and T1/e = = . also write an equation for the function shown on the graph.
- Given the initial temperature of a hot body, the ambient temperature of its surroundings, and the thermal time constant of the system, determine the temperature of the body after a specified time interval.
- Given the number of radioactive atoms in a sample and the decay constant, determine the number of atoms remaining after a specified time interval.
- Given the values of resistance, capacitance, and applied voltage in an RC electrical circuit, determine the time constant for the circuit, the time required for the capacitor voltage to reach 99% of the applied voltage, and the circuit current and capacitor voltage after a

specified time interval.

- Explain how the concept of time constants can be applied to the following energy systems; give a specific example in each case:
  - Mechanical translational
  - Mechanical rotational
  - Fluidal
  - Electrical
  - Thermal
  - Optical
  - Nuclear
- Solve problems involving simple harmonic motion.
- Describe damping phenomena in oscillating systems with resistance.
- Describe systems oscillating under the influence of an energy source.
- Distinguish between longitudinal and transverse waves by giving at least two examples of each types and by drawing and labeling a sketch of each.
- Define the following terms associated with waves and wave motion:
  - Propagating medium
  - Wavelength
  - Frequency
  - Period
  - Displacement
  - Amplitude
  - Phase
  - Standing wave
  - Constructive interference
  - Destructive interference
  - Beats
- Calculate the wavelength of a wave, given its velocity and frequency.
- Interpret the following equation, explaining the significance of each symbol:

  y = A sin 2 (- ft).
- Explain the meaning of the expression, "The current leads the voltage by a given phase angle " by using sine-wave sketches of both current and voltage. Describe the superposition principle.
- Describe wave phenomena in each of the following energy sytems:
  - Mechanical
  - Fluidal
  - Electrical
- Describe in one or two sentences the basic properties of each of the following types of radiation:
  - Sound
  - Light
  - Alpha and beta particles
- Define electromagnetic radiation (radiant energy), and describe a simple experiment that illustrates how electromagnetic radiation can be created.

- List the frequencies in the electromagnetic spectrum from wavelength Em waves of AC power (60 hertz) to gamma rays (10 hertz), including each major part - radio, FM, television, radar, microwave, infrared, visible, ultraviolet, X-ray, and gamma ray.
- Given the equation v + f - relating wave speed, wavelength and frequency - determine the radiation frequency for any part of the electromagentic spectrum.
- Given the equation E = hf or E = h c/e, determine the energy of different waves in Em spectrum.
- Describe qualitatively the nature of an electromagnetic wave in terms of electric and magnetic fields; state what is always required to generate an EM wave; and explain how EM waves are propagated through empty space without benefit of an elastic medium.
- Describe a photon, and explain why both wave and particle-like (photon) phenomena are required to describe interaction of Em radiation with matter. Give examples in which the wave character is most useful in describing Em radiation and in which the photon character is most useful.
- Explain what is meant by the inverse square law and how this law is used to describe the fall-off of EM radiation propagating from a small source.
- Define polarization, and explain what is meant by polarized Em radiation - in particular polarized light.
- Define visible radiation, and determine it's limits numerically in terms of wavelength, frequency, and energy.
- Describe the reflection and refraction of EM radiation - especially light - and set up an experiment to verify the two laws.
- Differentiate between alpha and beta radiation and gamma radiation.
- Briefly explain each of the three parts in the symbol
- Given the appropriate equipment, illustrate and verify the inverse square law of EM radiation in the visible region.
- Given the appropriate equipment, produce and detect polarized light in the microwave region.

RECOMMENDED TEXTS

CORD, Unified Technical Concepts. Waco TX: Center for Occupational Research and Development, 1980.

Dierauf, Edward J., Jr. and Court, James E. Unified Concepts in Applied Physics. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1979.

TECHNICAL COURSES

A-C CIRCUITS

COURSE DESCRIPTION

This course provides the student with the knowledge and skills to analyze basic A-C circuits. The course includes the following main topics: Magnetism, Inductance, Alternating current, Reactance, Impedance, and Admittance.

PREREQUSIITE: DC Circuits, Algebra

CO-REQUISITE: Trigonometry, Phusics I

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Magnetism A. Magnetization curves B. Permability from the BH curve C. Hysteresis D. Eddy current E. Magnetic shielding F. Magnetic circuits	5	3
II. Inductance A. Faraday's law B. Lenz's law C. Counter emf D. Time constant	6	6
III. Alternating Current A. The sine wave B. Peak values C. Instantaneous values of voltage amd current D. The radian E. Rms Values F. Average values	7	6
IV. Reactance A. Inductive reactance B. Capacitive reactance C. Vector algebra	6	6
V. Impedance A. RLC series circuits B. RLC parallel circuits C. Admittance D. Conductance and susceptance E. Power factor	10	6

	Student Contact Hours	
	Class	Laboratory
VI. Impedance networks	3	3
A. Loop equations		

STUDENT LABORATORIES

- Analyze magnetic circuits.
- Operation of an oscilloscope.
- Determine the peak value , RMS value, and peak-to-peak value of a sinewave using an oscilloscope.
- Plot the response curve of a series RL and RC network.
- Plot the response curve of a parallel RC and RL network.
- Analyze A-C circuits using the Thevinin theorem.
- Determine the total current in a series RC, RL and RLC circuit.
- Determine real and apparent power in a series RLC circuit.
- Use loop equations to solve impedance networks.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Operate an oscilloscope.
- Determine peak value, instantaneous value, average value, and RMS value of a sine wave.
- Measure voltage and current in a series RLC circuit and parallel RLC circuit.
- Determine the total impedance and admittance of a series and parallel RLC circuit.
- Use loop equation to solve impedance networks.

RECOMMENDED TEXTS

Boylestad, Robert D. Introductory Circuit Analysis, Fourth Edition, Indianapolis, In: Bobbs Merrill, 1981.

Jackson, Herbert W., Introductory to Electric Circuits, Fifth Edition, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1981.

AC AND DC MACHINES AND APPARATUS I

COURSE DESCRIPTION

AC and DC motors and generators will be covered from their construction and parts to their operating characteristics. Theory of operation, types, efficiency and regulation will be considered as well as their general application. Machines will be run under various loads noting efficiency and power factor.

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Direct-Current Generators	8	6
A. Generator construction, magnetic and electric circuit		
B. Simple DC generator-commutator action		
C. Methods of field excitation, magnetization curve and commutation		
D. Series generator-compound generator		
E. Efficiency and characteristics		
II. DC Motors and Controls	8	6
A. Motor principles and torque development		
B. Generator action and power relationships in a motor		
C. Armature reaction and speed of a DC motor		
D. Controllers, starters, and starting requirements		
E. Ward Leonard system of speed control		
III. AC Generators	8	6
A. Construction, excitation, and regulation		
B. Winding types		
C. Phasor diagrams and efficiency		
D. Operation of generators in parallel synchronizing		
E. Ratings - losses and efficiency, NEC - 445 overcurrent protection		

	Student Contact Hours Class	Laboratory
IV. Poly Phase Induction Motors	8	6

A. Induction motor principles and rotating magnetic devices
B. Rotor and its construction, stator and its construction
C. Principle of operation - speed and slip
D. Torque and starting conditions
E. Squirrel cage - wound rotor and synchronous
F. Starting methods - linestarters
G. Losses, efficiency and ratings

V. Synchronous Motors
A. Construction - operation and starting
B. Excitation and power factor
C. Efficiency and ratings
D. Applications and self-synchronous apparatus

STUDENT LABORATORIES

- Analyze torque versus speed characteristics and calculate efficiency for a DC shunt motor.
- Analyze torque versus speed characteristics and calculate efficiency for a DC compound motor.
- Using separately and self-excited DC shunt generators, study the properties under load and no load conditions. Obtain armature voltage versus armature current load curves.
- Using squirrel cage induction motor, assemble and disassemble, operate under various load conditions. Calculate starting current using name-plate and National Electric Code, article 430-7 (b).
- Using the wound rotor motor examine construction and starting characteristics varying the secondary resistance.
- Using the synchronous motor examine construction, investigate exciting current, synchronous speed and slip in three phases motors.
- Using the three-phase alternator, obtain no-load saturation curve and short circuit characteristics. Learn how to synchronize an alternator to the electric power utility system and observe the effects of improper phase sequence.
- Use the megger meters for insulation testing of motors and generators.
- Use the industrial analyzer for power-factor, wattage, and reactive power (Vars) for measurement.
- Identify all nine leads on a dual-voltage squirrel cage motor, connect to three phase power and run machine.

STUDENT COMPETENCIES

- Identify the types of AC and DC motors.
- Explain the difference in construction and understand the starting and control requirements of the different types.
- Take load readings under varying conditions and draw characteristic curves, calculating: torque vs. speed, speed vs. load, efficiency power factor.
- Utilize the NEC article 430 to determine the proper running and short-circuit protection required for AC and DC motors.
- Calculate the inrush current (accelerating) based on the code letter on the motor nameplate of AC and DC motors.
- Determine circuit requirements based on horse power and voltage and distance between motor and starter.
- Explain required grounding and ground-fault protection.
- Utilize meters, analyzers, meggers, tachometers, etc., to analyze under test the characteristics of motors and plot curves demonstrating various load conditions.
- Explain and measure synchronous speed, slip and factors that control speed.
- Measure slip between no load and full load conditions.
- Explain pull-in and pull-out torque as applied to synchronous motors and field excitation requirements for synchronous motors.
- Explain how synchronous machines are used for power-factor correction including the effects of load and field excitation on power-factor.

RECOMMENDED TEXTS

Kosow, Irving L., Control of Electric Machines, Prentice-Hall.

Lab-Volt Instruction Manuals for System 80550-00.

Lister, Eugene C., Electric Circuits and Machines, Prentice-Hall.

McIntyre, Electric Motor Control Fundamentals, McGraw-Hill.

AC AND DC MACHINES II

COURSE DESCRIPTION

Students will apply control theory to both DC and AC machinery. Learn the general construction and parts of AC and DC machines and their operating characteristics. Also circuit switching and protective equipment and measuring equipment.

PREREQUISITE: AC and DC Machines I

CREDIT HOURS: 4-3-5

COURSE CONTENT

	Student Contact Hours Class	Laboratory
I. Single-Phase Motors	6	4
A. AC series motor		
B. Repulsion motor		
C. Induction motor principle		
D. Split-phase starting		
E. Resistance-start split-phase		
F. Capacitor-start motor		
G. Repulsion start induction motor		
H. Shaded-pole motor		
I. Synchronous		
II. Variable Speed Controls	6	4
A. Variable frequency		
B. Rectifier circuit		
C. Trigger circuit		
D. Control circuit		
E. Torque and slip controls		
F. Trouble shooting procedure		
III. Variable DC Drives Using Solid State Logic	8	4
A. Speed control of a DC shunt motor		
B. Reversing a DC shunt motor		
C. Demonstrating C.E.M.F.		
D. Speed regulation of a DC shunt motor		
E. Solid-state devices controlling DC motors		
F. DIAC-SCR variable speed drive		
G. DIAC-TRIAC variable speed drive		
IV. Circuit-Protective and Switching Equipment	7	4
A. Electrical distribution systems		

	Student Contact Hours Class	Laboratory
B. Low-voltage fuses		
C. Safety switches		
D. Low-voltage air circuit breakers		
E. Panel boards		
F. Load-center unit substations		
G. Protective relays		
H. Lightning arresters		
V. Electrical Instruments and Electrical Measurements	6	4
A. Galvanometers, voltmeters, ammeters		
B. Varmeter		
C. Power factor meter		
D. Phase-angle meters		
E. Megger, Ohmmeter, wheatstone bridge		
VI. Inverter Drive AC	6	4
A. Static set-up mode		
B. BCD/Binary interface		
C. Voltage boost		
D. Slip compensation		
VII. Solid-State DC Control	4	3
A. Magnetic amplifier speed controller		
B. Switching amplifier field current controller		
C. Plugging and synamic braking		
D. SCR armature voltage controller		
E. Open-loop speed control		
F. Null detector		

STUDENT LABORATORIES

- Hook-up a speed control to a DC shunt motor with magnetic amplifier speed control.
- Reverse a DC shunt motor.
- Demonstrate counter electromotive force using DC meters.
- Demonstrate dynamic braking and plugging.
- Use solid-state devices to control DC motors.
- Hook-up DIAC-SCR variable speed drive.
- Hook-up DIAC-TRIAC variable speed drive.
- Demonstrate switching amplifier field current controller.
- Demonstrate SCR armature voltage controller.
- Connect rectifier circuit.
- Connect trigger circuit.
- Connect control circuit.
- Connect torque and slope controls.

- Demonstrate trouble shooting of rectifier, braking and amplification.

STUDENT COMPETENCIES

- Apply the fundamentals of both DC and AC principles in the operation of electric machinery.
- Demonstrate proper safety rules when using electrical equipment.
- Demonstrate the operation of a magnetic amplifier to calculate current and power.
- Verify the principles of a switching amplifier and the application of plugging and braking of DC shunt motors.
- Vertify the principles of an SCR armature control circuit.
- Demonstrate the methods of reversing a DC motor.
- Demonstrate how counter electromotive force is produced.
- Measure the power, in watts, dissipated in a DC shunt motor.
- Test solid-state devices while out of the circuit using an ohmmeter.
- Demonstrate how a DIAC is triggered; also how a DIAC triggers a SCR.
- Demonstrate how a DIAC triggers a TRIAC and in so doing controls the speed of a DC shunt motor.

RECOMMENDED TEXTS

Lab-Volt Manuals for System 80550-00.

Lister, Eugene C., Electric Circuits and Machines, McGraw-Hill.

McIntyre, Electric Motor Control Fundamentals, McGraw-Hill.

Wildi, Electrical Power Technology, Wiley.

AUTOMATIC MOTOR CONTROLS I

COURSE DESCRIPTION

Principles of motor controls from fractional horse power to large magnetic starters will be covered including starting poly phase induction, synchronous, wound rotor, and direct current motors. The use of control pilot devices, symbols for wiring diagrams, will be applied to control circuits from control of manual and automatic controls of motor controls.

PREREQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Introduction and Control Pilot Devices A. Fractional horse power manual and magnetic starters B. Pilot devices and symbols C. Wiring and schematic diagrams	14	10
II. Basic Control Circuits and AC Reduced Voltage Starters A. Two and three wire controls B. Interlocking and sequence control methods C. Resistor, autotransformer and partwinding motor starters D. Star-delta motor starters	14	10
III. Three Phase Induction, Wound Rotor and Synchronous Motor Controls A. Two-speed, two-winding and consequent pole controllers B. Wound rotor (slip ring) manual and automatic acceleration controls C. Synchronous push botton, semi-automatic and polarized field frequency controls	12	10

STUDENT LABORATORIES

- Connect a switch to operate a relay and motor (two-wire control).
- Connect a pushbutton station to operate a relay and motor (three-wire control).
- Connect a mechanically held relay to control a lightning load.

- Connect a selector switch (hands-on automatic) and pressure switch. (substitute toggle switch to operate a relay and load)
- Connect a motor starter with a start-stop and jog pushbutton control station.
- Connect a start-stop and jog control circuit using a control relay.
- Connect a start-stop jogging circuit using a two-position selector switch.
- Connect two forward and two reverse control stations with pushbutton and auxiliary contact interlock.
- Connect drum switch to reverse motor.
- Connect a two-speed control circuit using a compelling relay to start in slow speed.
- Dismantle a three phase linestarter identifying all parts and state purpose of each and reassemble.

STUDENT COMPETENCIES

- Relate the purpose and general operation of motor starters for AC and DC machines.
- Connect single and three phase motors to linestarters using standard two and three wire control circuits.
- Interpret control schemes of starters using schematic and wiring diagrams to troubleshoot problems. Actually locate faults and repair the faults in control circuits.
- Explain the use of pilot devices for control of acceleration and braking of motors and apply same on actual starters.
- Explain operation of manual and automatic control of wound rotor and synchronous motors.
- Demonstrate the operation and troubleshooting of a control circuit with forward-reversing, jogging, pushbutton and auxilary interlocking.
- Identify parts of linestarters and stating the purpose of each part and how each functions in the operation of starting motors whether full voltage or a reduced voltage method.

RECOMMENDED TEXTS

W. Alerich, Electric Motor Control, Van Nestrand Publishers.

W. Alerich, Electric Motor Control Lab Manual, Van Nestrand Publishers.

K. Rexford, Electrical Controls for Machines, Delmar

McIntyre, Electric Motor Control Fundamentals, McGraw-Hill.

NFPA, National Electrical Code Current Edition. National Fire Protection Association, Boston, MA

AUTOMATIC MOTOR CONTROLS II

COURSE DESCRIPTION:

Principles of motor controls from fractional horse power to large magnetic status will be covered including starting ploy phase induction, synchronous and direct current motors. Control pilot devices and symbols for wiring and schematic diagrams for constructing basic three phase and control circuits for operation analysis and trouble shooting problems.

PREREQUISITES: Automatic Motor Controls I

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Direct Current Controllers	14	10
A. Control relays		
B. Across-the-line starting		
C. Use of series starting resistance		
D. Manual faceplate starters		
E. Counter EMF controller		
F. Magnetic time limit controller		
G. Voltage drop acceleration		
H. Series relay acceleration		
I. Series lockout relay acceleration		
J. Dashpot motor control		
K. Pilot motor-driven timer controller		
L. Capacitor timing starter		
II. Methods of Deceleration	14	10
A. Jogging control circuits		
B. Plugging		
C. Electric brakes		
D. Synamic braking		
E. ELectric braking		
III. Motor Drives	12	10
A. Direct drives and pulley drives		
B. Gear motors		
C. Variable frequency		
D. Magnetic clutch and magnetic drive		
E. DC variable speed control - motor drives		
F. NEC 250,810,430		

STUDENT LABORATORIES

- Connect full voltage starter for a shunt motor.
- Connect full voltage reversing starter for a shunt motor.
- Connect full voltage reversing starter for a compound motor.
- Connect reduced voltage starter for a shunt motor with series cureent relay acceleration.
- Connect reduced voltage starter for a shunt motor with counter electric motor force accelerating relay.
- Connect reduced voltage starter for a shunt motor with definite time acceleration.
- Connect reduced voltage starter for a shunt motor with series current-relay acceleraclon.
- Connect full voltage starter for a shunt motor with overload lprotection.
- Connect reduced voltage reversing starter for a shunt motor with definite-time acceleration.
- Connect full voltage starter for a shunt motor with field failure protection.
- Connect full voltage start for a shunt motor with dynamic braking.
- Connect full voltage starter for a shunt motor with field accelerating relay.
- Connect two step reduced voltage starter for a shunt motor with definite-time accelerating, dynamic braking, field accelerating relays, overload and field failure protection.

STUDENT COMPETENCIES

- Explain the general operation of motor starters for AC and DC machines.
- Interpret control schematic and wiring diagrams to trouble shoot problems.
- Explain the use of pilot devices for control of accelerating and braking of motors.
- Explain operation of manual and automatic control of wound rotor and synchronous motors.
- Observe the no-load and full-load characteristics of a rotary frequency converter.
- Describe the operation of an open-loop electronic speed control for a DC motor.
- Obtain the starting characteristics of the three phase synchronous motor.
- Determine the full-load characteristics of the synchronous motor.
- Explain the construction of the three-phase squirrel cage motor.
- Explain the construction of the three-phase squirrel cage motor.
- Determine the starting, no-load, and full-load

characteristics of a squirrel cage motor.
- Determine the starting, no-load, full-load characteristics of a wound rotor motor, also synchronous speed and slip.

RECOMMENDED TEXTS

W. Alerich, Electric Motor Control

W. Alerich, Electric Motor Control Lab Manual.

K. Rexford, Electrical Controls for Machines. Delmar

McIntrye, Electric Motor Control Fundamentals. McGraw-Hill

CIRCUIT ANALYSIS

COURSE DESCRIPTION

This course provides the student with the knowledge and skills to analyze complex circuits. The course includes the following main topics: analysis of complex circuits, Resonant circuits, transformer action and three-phase systems.

PREREQUISITE: AC Circuits, Trigonometry

CO-REQUISITE: Analytic Geometry and Calculus

CREDIT HOURS: 4-3-5

COURSE OUTLINE

COURSE OUTLINE	Student Contact Hours Class	Student Contact Hours Laboratory
I. Analysis of Complex Networks	15	6
A. Superposition theorem		
B. Thevenin's theorem		
C. Norton's theorem		
D. Nodal analysis		
E. Impedance bridges		
F. Delta-wye transformation of complex networks		
G. Transients		
II. Resonance	10	6
A. Series resonant circuits		
B. Parallel resonant circuits		
C. L/C ratios		
D. Resonant response curves		
E. Q rise in voltage and current		
III. Transformers	5	6
A. Iron-core transformers		
B. Air-core transformers		
C. Tranformation ratio		
D. Reflected impedance		
E. Loading		
F. Efficiency		
IV. Three-Phase Systems	10	9
A. Polyphase systems		
B. Double-subscript notation		
C. Balanced three-phase systems		
D. Unbalanced three-phase systems		
E. Delta-connected system		
F. 4-wire wye-connected system		

STUDENT LABORATORIES

- Analyze complex impedance networks using the circuit theorems.
- Measure the change in primary current as the secondary load is varied.
- Construct a response curve for a series resonant circuit.
- Construct a response curve for a parallel resonant circuit.
- Measure the total current through a series resonant circuit.
- Analyze a delta to wye transformer action.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Analyze complex networks using the circuit theorems.
- Analyze delta-wye transformation of complex networks.
- Determine the difference between air-core and iron-core transformers and where each might be used.
- Analyze transformer action.
- Determine reflected impedance values.
- Determine transformation ratio.
- Analyze resonant circuits.
- Analyze 3-phase systems.

SUGGESTED TEXTS

Boylestad, Robert D., Introductory Circuit Analysis, Fourth Edition, Indianapolis, IN: Bobbs Merrill, 1981.

Jackson, Herbert W., Introduction to Electric Circuits, Fifth Edition, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1981.

CONTROL SYSTEM ANALYSIS

COURSE DESCRIPTION

This course is designed to provide the student with indepth knowledge and skills relating to process control loops. The student will acquire hands-on experience through the practical lab experiments.

PREREQUISITE: Instrumentation and Controls

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. What Constitutes a Process A. Introduction B. Review of types of controller action C. Types of responses which must be controlled	2	0
II. Process Characteristics - Static Conditions A. The basic problem B. Principles of energy transfer C. Resistor elements-thermal, fluid D. Capacitor elements - thermal, fluid	2	0
III. Block Diagrams A. Different types of block diagrams B. Difference between schematic and block diagrams C. Flow of information around loop D. System representation, introduction of their signals E. Feedback loops, positive and negative	4	0
IV. Feedback System-Open and Closed Loop A. Block diagrams for open loop B. Resistance and proportional blocks C. Capacitance and the block diagram D. Steady-state solution to flow level problems E. Block diagram for closed loop	4	0

	Student Contact Hours Class	Laboratory
V. Flow Control System-Pneumatic and/or Electronic	4	6
A. Determine instruments needed for system		
B. Draw system		
C. Connect system		
D. Write report on system operation		
VI. Level Control System-Pneumatic and/or Electronic	4	6
A. Determine instruments needed for system		
B. Draw system		
C. Connect system		
D. Write report on system operation		
VII. Temperature Control System Pneumatic and/or Electronic		
A. Determine instruments needed for system	4	6
B. Draw system		
C. Connect system		
D. Write report on sytem operation		
VIII. Pressure Control System		
A. Determine instruments needed for system	4	6
B. Draw system		
C. Connect system		
D. Write report on system operation		
IX. Specific Gravity System (Non-Controlling)	4	6
A. Determine instruments needed for systems		
B. Draw system		
C. Connect system		
D. Write report on system operation		
X. Combustion Controls	8	0
A. Boiler feedwater controls		
B. Flame detector		
C. Fuel-air ratio		
D. Boiler gases		
E. Master control		
F. Interlocking		
G. Lead-lag (boiler load change)		

STUDENT LABORATORIES

- Flow loop instruments
  - a. troubleshoot
  - b. repair
  - c. calibrate
- Level loop instruments
  - a. troubleshoot
  - b. repair
  - c. calibrate
- Temperature loop instruments
  - a. troubleshoot
  - b. repair
  - c. calibrate
- Pressure loop instruments
  - a. troubleshoot
  - b. repair
  - c. calibrate
- Specific gravity loop instruments
  - a. troubleshoot
  - b. repair
  - c. calibrate

STUDENT COMPETENCIES

- Define process.
- Explain principles of energy transfer.
- Explain difference between schematic and block diagrams.
- Determine instruments needed for flow control loop.
- Repair and calibrate instruments needed for flow control loop.
- Determine instruments needed for level control loop.
- Repair and calibrate instruments needed for level control loop.
- Determine instruments needed for temperature control loop.
- Repair and calibrate instruments needed for temperature control loop.
- Determine instruments needed for pressure control loop.
- Repair and calibrate instruments needed for pressure control loop.
- Determine instruements needed for specific gravity control loop.
- Repair and calibrate instruments needed for specific gravity control loop.

RECOMMENDED TEXTS

Industrial Instrumentation, McGraw-Hill, 1962

Fundamentals, Austin E. Fribance

D-C CIRCUITS

COURSE DESCRIPTION

This course provides the student with the knowledge and skills to analyze basic D-C circuits. The course includes the following main topics: Scientific notation and unit conversions, Insulators, Conductors, Sources, Resistance, Work and power, Series and parallel circuits, Series-parallel circuits, and Equivalent circuits.

PREREQUISITE: Admission to program.

CO-REQUISITE: Algebra

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Introduction to Engineering Technology A. SI units B. Scientific Notation C. Unit Conversions	4	6
II. Introduction to Electricity A. Insulators B. Conductors C. Sources D. Resistance E. Work and power	9	3
III. Series and parallel circuits A. Series circuits B. Parallel circuits C. Series-parallel circuits	8	9
IV. D-C Circuit Theorems A. Thevenin's theorem B. Norton's theorem C. Superposition theorem D. Millman's theorem E. Delta-wye transformations F. Nodal analysis G. Mesh analysis	15	9
V. Capacitance A. Capacitance reactance B. Charging and discharging C. Time constants	4	3

STUDENT LABORATORIES

- Introduce the student to Engineering Technology.
- Introduction to instruments, measurement procedures, and saftey precautions.
- Measure D-C voltage, current and resistance in series circuits.
- Measure D-C voltage, current, and resistance in parallel circuits.
- Measure D-C voltage, current, and resistance in series-parallel circuits.
- Design a basic voltmeter and current meter.
- Analyze series-parallel circuits using circuit theorems.
- Determine capacitance values by use of discharge times.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Convert from one unit of measurement to another.
- Express decimal numbers in scientific notation.
- Use SI units
- Determine resistor values from their color code.
- Convert mechanical power to electrical power.
- Use a digital and analog VOM.
- Measure the current and voltage in a D-C series and parallel circuit.
- Use D-C circuit theorems to determine the total resistance, current and voltage in resistance networks.
- Plot the charging curve of a capacitor.

RECOMMENDED TEXT

Boylestad, Robert D. Introductory Circuit Analysis, Fourth Edition, Indianapolis, IN: Bobbs Merrill, 1981.

Jackson, Herbert W., Introduction to Electric Circuits, Fifth Editions, Englewood Cliffs, NJ: Prentice-Hall, Inc, 1981.

DIGITAL APPLICATIONS

COURSE DESCRIPTION

This course is designed to introduce the student to the microprocessor. Emphasis is placed on the microprocessor's hardware.

PREREQUISITE: Digital Electronics

CO-REQUISITE: Linear Integrated Circuits

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Computer Arithmetic A. Algorithms B. Addition and subtraction C. Half and full adder D. Ones complement and twos complement addition / subtraction E. BCD F. Half and full substracters G. The ALU	8	6
II. Memory Systems A. Core memory B. Semi-conductor RAM C. The register concept D. RAM specifications E. Static RAM F. Dynamic MOS memory G. ROMS H. Shift register memory	12	9
III. Interfacing A. Bidirectional bus drivers B. Data communications line drivers and receivers C. Baud rate D. Level translators E. Serial and parallel	12	9
IV. Hardware A. The bus system B. Input and output ports C. Memory hierarchy	8	6

	Student Contact Hours Class	Laboratory
D. Prime memory		
E. Secondary and backup memory		
F. The CPU		
V. Processing Action	7	5
A. Introduction to programming and program processing		
B. Timing and multiplexing		
VI. Software	7	5
A. Data-transfer group		
B. Arithmetic group		
C. Logical group		
D. Assembly-language programming		
E. The conditional jump		
F. Interrupts		

STUDENT LABORATORIES

- Using integrated circuits, design a full adder.
- Construct a 4- bit parallel-in serial-out shift-right register and analyze its operation.
- Construct a 4 bit serial-in parallel-out shift-right-register and analyze its operation.
- Using integrated circuits design a pulse stretcher.
- Construct a digital-to-analog converter using the binary weighted ladder method.
- Construct an analog-to-digital converter.
- Construct a RAM circuit and analyze its operation.
- Given a microcomputer, determine its RAM Memroy size, type of addressing used, number of I/O ports, and clock speed.
- Design an assembly-language program to add ten numbers and using the mnemonics, execute the program on the microcomputer.
- Design a program to employ interrupts.

STUDENT COMPETENCIES

At the conclusion of this course, the student should be able to:

- Describe the operation of a half and full adder.
- Analyze the operation of a shift register.
- Describe an analog-to-digital converter.
- Analyze RAM operation.
- Interpret microcomputer specificaitions.
- Write programs using mnemonics and assembly language.

DIGITAL APPLICATIONS

COURSE DESCRIPTION

This course is designed to introduce the student to the microprocessor. Emphasis is placed on the microprocessor's hardware.

PREREQUISITE: Digital Electronics

CO-REQUISITE: Linear Integrated Circuits

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Computer Arithmetic	8	6
A. Algorithms		
B. Addition and subtraction		
C. Half and full adder		
D. Ones complement and twos complement addition / subtraction		
E. BCD		
F. Half and full substracters		
G. The ALU		
II. Memory Systems	12	9
A. Core memory		
B. Semi-conductor RAM		
C. The register concept		
D. RAM specifications		
E. Static RAM		
F. Dynamic MOS memory		
G. ROMS		
H. Shift register memory		
III. Interfacing	12	9
A. Bidirectional bus drivers		
B. Data communications line drivers and receivers		
C. Baud rate		
D. Level translators		
E. Serial and parallel		
IV. Hardware	8	6
A. The bus system		
B. Input and output ports		
C. Memory hierarchy		

	Student Contact Hours	
	Class	Laboratory
D. Prime memory		
E. Secondary and backup memory		
F. The CPU		
V. Processing Action	7	5
A. Introduction to programming and program processing		
B. Timing and multiplexing		
VI. Software	7	5
A. Data-transfer group		
B. Arithmetic group		
C. Logical group		
D. Assembly-language programming		
E. The conditional jump		
F. Interrupts		

STUDENT LABORATORIES

- Using integrated circuits, design a full adder.
- Construct a 4 bit parallel-in serial-out shift-right register and analyze its operation.
- Construct a 4 bit serial-in parallel-out shift-right-register and analyze its operation.
- Using integrated circuits design a pulse stretcher.
- Construct a digital-to-analog converter using the binary weighted ladder method.
- Construct an analog-to-digital converter.
- Construct a RAM circuit and analyze its operation.
- Given a microcomputer, determine its RAM Memroy size, type of addressing used, number of I/O ports, and clock speed.
- Design an assembly-language program to add ten numbers and using the mnemonics, execute the program on the microcomputer.
- Design a program to employ interrupts.

STUDENT COMPETENCIES

At the conclusion of this course, the student should be able to:

- Describe the operation of a half and full adder.
- Analyze the operation of a shift register.
- Describe an analog-to-digital converter.
- Analyze RAM operation.
- Interpret microcomputer specificaitions.
- Write programs using mnemonics and assembly language.

- Analyze ROM, PROM. EPROM, and EE PROM operation.
- Define software, hardware, and firmware.
- Describe the different addressing modes of the microcomputer.
- Describe a digital-to-analog convertor.

RECOMMENDED TEXTS

Bywater, Hardware/Software Design of Digital Systems, Prentice-Hall, 1979.

Coffran & Long, Practical Interfacing for Microprocessor Systems, Prentice-Hall, 1983.

Mano, Digital Logic and Computer Design, Prentice-Hall, 1979.

Tocci, Digital Systems: Principles and Applications, Prentice-Hall, 1980.

DIGITAL ELECTRONICS

COURSE DESCRIPTION

This course will introduce the student to basic digital circuits. Circuit analysis and troubleshooting techniques are also emphasized.

PREREQUISITES: Electronic Devices, Circuit Analysis

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Control Hours	
	Class	Laboratory
I. Introduction to Digital Techniques	5	10
A. Number systems		
B. Logic symbols and gates		
C. Basic Boolean operation		
D. Laws and theorems		
II. Integrated Logic Circuits	7	6
A. Types, classification, and identification		
B. Parameters and characteristics		
C. Logic famil s		
D. Practical lc circuits		
E. Simplificati techniques		
F. Decision making logic elements		
III. Flip-Flops and Registers	7	6
A. D-type		
B. T-type		
C. JK		
D. Registers		
IV. Sequential Logic Circuits	7	6
A. Counters		
B. Shift registers		
C. Clocks and one shots		
D. Adders		
E. Subtractors		
V. Combinational Logic Ci.cuits	7	6
A. Encoders		
B. Decoders		
C. Multiplexers		
D. Demultiplexers		
E. Code converters		

	Student Contract Hours	
	Class	Laboratory
VI. Memory Circuits	7	6

A. Types of memories
B. ROM
C. RAM
D. PROM

STUDENT LABORATORIES

- With the aid of Oscilloscopes, Voltmeters, Pulse Generators, Logic Probes, and Truth Tables construct and verify the function of the following Logic circuits:
  - AND
  - OR
  - NAND
  - NOR
  - Exclusive OR
  - Flip-Flops
  - Counters
  - Timers
  - Adders
  - Subtractors
  - Dividers

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Identify logic gates and functions.
- Connect various gates to produce combinational logic circuits.
- Diagram a basic logic system from a problem statement.
- Troubleshoot and repair basic logic and digital circuits.
- Interpret specifications from manufacturer's data sheets for digital circuits.
- Perform conversion between various number systems.
- Describe the characteristics of the most commonly used logic families.

RECOMMENDED TESTS

Digital Techniques, Book 1. Benton Harbor, MI: Heathkit Learning Publications.

Williams, Gerald E. Digital Technology. Chicago, IL: Science Research Associates, Inc.

Williams, Gerald E. Digital Technology, Lab manual. Chicago, IL: Science Research Associates, Inc.

ELECTRICAL POWER AND DISTRIBUTION I

COURSE DESCRIPTION

Electrical Power and Distribution presents fundamentals of polyphase, AC circuits, electrical generating equipment, transmission, and distribution systems. Emphasis is placed on equipment and components used in industrial distribution systems: transformers, switch gear, conduits, metering, etc. Fault and overload protection and reactance compensation of various loads for power factor correction and the reading/sketching of schematics is also covered. Students will examine several power systems in operation and recognize the relations of the various components and equipment.

PREREQUISITES: AC Circuits

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Three-Phase Circuits	11	7
A. Polyphase systems-review 10,30 circuits current, voltage, reactance, vector diagrams, true-apparent power		
B. Three-phase alternator - NEC article 445		
C. Power output of a 3-phase alternator		
D. Wye and Delta connection		
E. Phase sequence and unbalance circuits		
F. Unit substation - H&L voltage NEC 230-209 article 280,450, 250-94 grounding		
G. Feeder bus system, NEC article 364		
H. Panel boards 7 subfeeders, NEC article 384		
II. Transformer Construction	11	7
A. Theory of operation		
B. EMF of induction		
C. Losses in transformers		
D. Types of transformers		
E. Construction of power, distribution and current transformers, NEMA, standards, protection, NEC article 210		
F. System protection, breakers,		

	Student Contact Hours	
	Class	Laboratory
fuses, ground fault-NEC article 210		
G. System coordination		
III. Circuitry and Cooling	10	7
A. Construction of magnetic circuit exciting current load		
B. Loading AC circuits-power means of correction, synchronous condensers		
C. Current circuit-types of windings, copper loss & efficiency reactive voltage-regulation		
D. Insulating classes, ANSI & NEMA		
E. Devices: temperature, pressure oil-level		
IV. Transformers per NEC	12	5
A. General provisions		
B. Voltage levels		
C. Vaults		
D. Grounding - overcurrent protection		
E. Transmission line equipment		

STUDENT LABORATORIES

- Examine the electrical distribution and switchgear system at the school and draw a schematic to accurately represent this system, identifying major components and locations. Also draw a schematic of electrical distribution system of one building including the electrical laboratory.
- Examine an operating bus duct system and draw a representative schematic identifying all components and location.
- Hook up a single phase transformer, connect a load, record input and output current, voltages, and power. Check polarity, impedance voltage and copper losses. Calculate step-down ratio and efficiency.
- Parallel two single phase transformers and check load distribution.
- Connect three single phase transformers: delta-delta, delta-wye, and wye-wye operation. Connect load check current and voltages on primary and secondary.

* Lab-volt - #1 - Safety and the power supply.
* Lab-volt - #2 - Phase sequence.
* Lab-volt - #3 - Real power and reactive power.
* Lab-volt - #4 - Power flow and voltage regulation of a

simple transmission line.

* (or equivalent)

STUDENT COMPETENCIES

- Explain the purpose and identify the basic components of electric power transmission systems from generating plant to user.
- List and explain the purpose of basic components and arrangement of industrial electric power distribution system from the generating plant to various substations for manufacturing processes.
- Draw schematic (elementary) diagrams using proper electrical symbols of electrical power distribution systems as employed in utilities and industry.
- Define such terms as synchronizing (paralleling), phase rotation, true power, reactive (VAR) power, power factor correction.
- Describe methods for power factor correction on polyphase circuits by capacitor banks and synchronous condensers to meet utility standards and increase line capacity; actually measuring amps, watts, vars, and calculating power factor.
- Utilize National Electrical Code book to determine proper construction and application, including safety of a transmission system, including power transformers.

RECOMMENDED TEXTS

Gilbert and Edwards, Transformers, American Technical Publishing, Chicago, IL

NFPA, National Electrical Code Current Edition, National Fire Protection Association, Boston, MA

Smith, RObert L., Electrical Wiring Industrial, Delmar Publishers Inc., Albany, New York

Wilde, Theodore, Electric Power Transmission System, (Lab-Volt), BUck Engineering Co., Inc., Farmingdale, NJ

ELECTRICAL POWER DISTRIBUTION II

COURSE DESCRIPTION

Transmission of power by various transformer connection utilizing tap changes for load and line voltages will be covered. Reactors for current limiting under fault conditions, and transformer maintenance will also be covered. Efficiency of line systems will be emphasized including special transformers.

PREREQUISITE: Electrical Power and Distribution I

CREDIT HOURS: 4-3-5

COURSE CONTENT

	Student Contact Hours Class	Laboratory
I. Transformer Connections	8	6
A. Voltage transformation		
B. Polarity: single phase transformers		
C. Single-phase transformer connections-voltage vector diagram		
D. Phase transformation-three phase to two phase		
E. Polarity: three-phase transformers		
F. Transformer connection-open delta capacity voltage vector diagram		
G. Parallel operation		
H. Requirements for satisfactory operation		
II. Tap Changes	7	6
A. No-load tap changer		
B. Tap changing under load		
C. Phase-angle control		
III. Special Transformers	7	6
A. Autotransformers		
B. Operation-output rating-limitations		
IV. Reactors	7	3
A. Current-limiting reactors		
B. Inductance-reactance-construction types		
V. Transformer Maintenance	7	0
A. Safety first		

	Student Contact Hours	
	Class	Laboratory
B. Suggested transformer safety standards		
C. Purpose of transformer maintenance		
D. Inspection and maintenance		
E. Insulation tests		
F. Internal inspection of core and coils		
G. Tips on transformer maintenance		
VI. Electrical Power Transmission Systems	7	6
A. Alternator		
B. Synchronous motor		
C. Synchronous condenser and long lines		
D. Buck-boost, phase-shift transformer		
F. Transients		

STUDENT LABORATORIES

- Connect and operate two single phase transformers in parallel
- Checking polarity for correct connection.
- Connect three single phase transformers for three phase load using delta-wye connection.
- Measure load-using two watt meter method, (watts, vars, kilovolt, amps).
- Calculate step-down ratio, losses and efficiency.
- Vary reactance loads on each pases and note power factor of system.
- Use an alternator connected to a DC load.
- Observe the functioning of a synchronous motor.
- Demonstrate a synchronous condenser regulating the received voltage.
- Observe the division of power between two transmission lines in parallel.
- Demonstrate a synchronous motor under load.
- Demonstrate the shunting of a synchronous motor.
- Observe the power fluctuation under abnormal transmission line conditions.
- Observe real and reactive power flow as a function of the phase shift between sender and receiver voltages.
- Observe transmission lines faults, balanced and unbalanced.
- Observe positive, negative and zero sequence impedances of a synchronous machine.
- Observe phase-shifts of three-phase transformers.

RECOMMENDED TEXTS

Glebert and Edwards, Transformers, American Technical Publishing, Chicago, Ill.

NFPA, National Electrical Code Current Edition, National Fire Protection Association, Boston, MA

Smith, Robert L., Electrical Wiring Industrial, Delmar Publishers Inc. Albany, NY

Wilde, Theodore, Electric Power Transmission System, (Lab-Volt), Buck Engineering Co., Inc., Farmingdale, NJ

ELECTROMECHANICAL DEVICES

COURSE DESCRIPTION

Electromechanical Devices is designed to provide the student with a working knowledge of control elements in electrical circuits, transformers, generators, motors, and synchromechanisms. Topics presented include power losses in transformers, large alternators, DC motor controls and efficiency, three-phase AC motors, synchronous motors, single and three-phase induction motors, stepper motors, and classifications and applications of synchromechanisms.

PREREQUSIITE: Circuit Analysis

CO-REQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Electromechanical Devices An Introduction A. Magnetic forces and fields B. The origin of magnetism C. Magnetic fields of electric currents D. Forces of charged particles moving through magnetic fields E. Generator action F. Motor action G. Transformers	2	
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. Checking circuit breakers	4	3
III. Transformers A. The basic transformer B. Power losses in transformers C. Power transformers D. Auto transformers E. Other transformers F. Troubleshooting transformers	4	3

	Student Contact Hours	
	Class	Laboratory
IV. Generators and Alternators	4	3
A. The simple DC generator		
B. Construction of DC generators		
C. Field coil connections in DC generators		
D. Operation of DC generators		
E. The alternator		
F. Automobile alternators		
G. Large alternators		
H. Operation of alternators		
I. Maintenance		
V. DC Motors and Controls	8	6
A. The simple DC motor		
B. Construction of DC motors		
C. DC motor controls		
D. Motor efficiency		
E. Motor maintenance and troubleshooting		
VI. AC Motors and Controls	10	9
A. Three-phase AC motors		
1. rotating magnetic fields		
2. synchronous motors		
3. induction motors		
4. power factor in AC 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. Stepper Motors	4	3
A. Operation of the stepper motor		
B. Stepper motor control		

	Student Contact Hours	
	Class	Laboratory
VIII. Synchromechanisms	4	3

A. The synchro transmitter
B. The synchro receiver
C. Differential synchro transmitter and receivers
D. The synchro control transformer
E. Classification of synchromechanisms
F. Applications of synchromechanisms

STUDENT LABORATORIES

- Examine the characteristics and diagram the magnetic fields of permanent magnets and electromagnets.
- Construct common control circuits using switches and relays.
- Construct circuits and measure efficiency of a power transformer.
- Set-up a generator and an alternator and measure the output characteristics.
- Construct a motor circuit and measure the output characteristics of a shunt motor.
- Set up, operate, and determine the functioning characteristics of synchronous, induction, and universal motors.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Diagram and explain the components and relationships of basic magnetic and electromagnetic systems.
- Use the right hand rule to determine direction of force on a conductor or a current carrying a conductor in a magnetic field.
- Identify, diagram, and explain the functioning characteristics of basic types of relays used in electrical circuits.
- Identify, diagram and explain the function of basic fuses.
- Construct a relay control circuit.
- Diagram, label, and explain the functioning characteristics and the components of basic types of transformers.
- Determine primary voltage and current, secondary voltage and current, input power and efficiency of a transformer.
- Test transformers for continuity of windings, and shunted windings.
- Diagram, label, and explain the functioing characteristics of basic generators.

- Operate a DC generator and alternator and determine their operating characteristics.
- Diagram, label, and explain the components and functioning characteristics of common types of DC Motors.
- Specify appropriate types of motors for a given mechanical load.
- Diagram, label, and explain the components and functioning characteristics of common AC motors.
- Construct, test, and plot the curve of a DC motor circuit.
- Diagram, label, and explain the components and functioning characteristics of common types of AC motors.
- Given necessary data , determine the number of magnetic poles, synchronous speed, operating speed, slip speed of common AC Motors.
- Operate properly universal motor, shaded pole motor, capacitor start motor.

RECOMMENDED TEXTS

Center for Occupational Research and Development. Electromechanical Devices. Waco, TX: CORD, 1981.

Alevich, Walker, N. Electric Motor Control. New York: Van Nostrand Publishing Co., 1975.

Anderson, Edwin P. Electric Motors. Indianapolis, IN: Theodore Aide and Co., 1969.

Fitzgerald, A.E. and Kirply, Charles, Jr. Electric Machinery. New York: McGraw-Hill Book Co., Inc. 1952.

ELECTRONIC DEVICES

COURSE DESCRIPTION

This course is designed to provide the student with a working knowledge of electronic devices. This course will also develop the student's ability to connect and test basic discrete solid-state components as well as basic vacuum tube circuits. Topics include vacuum tube diode and triode, bipolar junction transistors, and other devices and integrated circuits.

PREREQUISITE: Fundamentals to Electricity and Electronics

CO-REQUISITE: Circuit Analysis

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Vacuum Tube Diode and Triode A. Introduction to active devices B. Physical characteristic C. CRT operation D. Triode characteristics E. Load resistance F. Gain G. Phase relationships H. Basic vacuum tube amplifiers	4	3
II. Semiconductor Diodes A. Atomic theory for semi-conductors B. Silicon, germanium, and PN junctions C. Diode applications	6	6
III. Zener Diodes and Other Two-Terminal Devices A. Zeners - basic circuits B. Schottsky diodes C. Varactors (varicaps) D. Photodiode E. Light-emitting diodes (LEDs) and IR emitters F. Liquid crystal diodes G. Solar cells	8	6

	Student Contact Hours Class	Laboratory
H. Thermistors		
I. Industrial devices		
IV. Bipolar Junction Transistors (BJT) and Other Active Devices	14	9

IV. Bipolar Junction Transistors (BJT) and Other Active Devices
   A. PNP and NPN atomic characteristics
   B. PJT operation
   C. Amplifying action
   D. Amplifier configurations; common base (CB), common emitters (CE), common collector (CC)
   E. Specification sheets
   F. JFET and MOSFET characteristics
   G. FET operation
   H. Amplifying action
   I. Amplifier configurations
   J. Specification sheets

V. Integrated Circuits
   A. Types of ICs
   B. Application of ICs
   C. Construction of ICs

STUDENT LABORATORIES

- Construct and test a common cathode amplifier.
- Design, build, and test a clipper and clamper circuit.
- Design, build, and test a half-wave rectifier and full-wave rectifier circuit.
- Design, build, and test a half-wave filtered power supply.
- Design, build, and test a full-wave filtered power supply.
- Construct and test the common base, common emitter, and common collector amplifier.
- Obtain characteristics of the triac, diac, SCR, and zener using the curve tracer.
- Determine output voltage of the solar cell under different load conditions.
- Construct and test common gate, common source, and common drain amplifiers.
- Identify pin configuration, package type, and characteristics of the integrated circuit using the specifications sheet.

STUDENT COMPETENCIES

Upon completion of this course you will be able to:

- Define the following terms:
  - Vacuum tube
  - Semiconductor diode
  - Zener diode
  - Schottsky diode
  - Varactor
  - Photodiode
  - LED
  - LCD
  - Solar cell
  - Thermistor
  - SCR
  - Diac
  - Triac
  - BJT
  - FET
  - Integrated Circuit
- List and explain applications for all of the above devices.
- Analyze the above devices' operation using specification sheets and characteristic curves.
- Construct and test a common cathode amplifier.
- Demonstrate the application of semiconductor diodes by constructing and testing clipper, clamper, half-wave rectifier, and full-wave rectifier circuits.
- List characteristics and applications of the common base, common emitter, and common collector amplifier.
- List characteristics and applications of the common gate, common drain, and common source amplifier.
- List characteristics and applications of the common cathode amplifier.
- List types and applications of integrated circuits.
- Identify pin configurations, package type, and characteristics of the integrated circuit with the specification sheet.
- Construct and test common base, common emitter, and common collector circuits.
- Construct and test commmon gate, common source, and common drain amplifiers.
- Use a curve tracer to obtain the characteristics of the triac, diac, SCR, and zener.
- Determine output voltage of a solar cell

RECOMMENDED TEXT

Boylestad, Robert, and Nechelsky, Louis. Electronic Devices and Circuit Theory. Englewood Cliffs, NJ: Prentice-Hall.

ELECTRONIC INSTRUMENTATION

COURSE DESCRIPTION

This course is designed to develop the skills of the student in the area of Electronic Instrumentation. Through lectures and practical applications, the student will develop the skills required to maintain electronic transmitters, recorders, and controllers.

PREREQUISITES: Instrumentation & Controls

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Electrical Safety A. General electrical safety rules B. Eliminate working on hot circuits when possible C. Removing other personnel from hot circuits	2	0
II. Auxiliary Electrical Devices and Means for Recording Data A. Timers B. Relays, contactors, and electromagnetic actuators C. Synchronous transmitters and receivers D. Electrical transducers-pressure temperature, thickness, position, light, intensity, speed	2	3
III. Electrical Control of Temperature, Energy, Speed, and Motion A. Temperature control, the heat transfer problems B. Magnetic, hydraulic, and electromechanical devices	2	3
IV. Electrical Pressure Transducer A. Spans covered by the various types of instruments B. Magnetic flow meter principles C. Differential pressure, with mechanical integrator and square root extractor D. Variable-area flow meters E. Devices for measuring the flow of dry materials	2	3

	Student Contact Hours	
	Class	Laboratory
F. Automatic weighing, transmission and totalizing		
V. Electrical Level Transducers	6	6
A. Probe-type elements		
1. Thermal		
2. Capacitive		
B. Ultra-sonic elements		
C. Capacitance		
D. Radiation		
E. Strain gauge		
VI. Electrical Temperature Transducers.	8	6
A. Span and range of the various types of electrical thermometers		
B. Resistance-type transducers		
1. Metallic		
2. Non-metallic		
C. Bridges		
D. Calculate range resistors for the measuring circuit of a class 15 recorder		
E. Thermocouple measurements, installation and use		
F. Radiation and optical phyometry		
G. Indicating and recording instruments		
1. Millivoltmers		
2. Electro-mechanical and electronic potentiometers		
3. Automatic potentiometers		
H. Temperature-measuring practices		
1. Speed of response		
2. Span		
3. Location and type of sensing element		
4. Dynamic errors		
I. Determine resistance vs. temperature for both positive and negative thermistors		
VII. Potentiometric Devices	4	3
A. Basic Theory		
B. Manual vs. automatic standardization		
C. Constant voltage unit		
D. Monitoring, scanning and supervision		

	Student Contact Hours Class	Laboratory
VIII. Indicating, Recording, and Registering Equipment A. Records, indicator, and data storage B. Central recording and control vs. remote single stations C. Monitoring, scanning, and supervision D. Compare the circular chart with the strip chart type recorders for accuracy and ease of reading		
IX. Analytical Instruments A. General types and applications B. Thermal conductivity gas analyzers C. Oxygen analyzer D. PH meters E. Gas chromatography F. Combustible-gas analyzers	4	3
X. Radiation-type transducers A. Types of radiation transducers and applications B. Thickness measurements C. Level measurements D. Density measurements	4	0

STUDENT LABORATORIES

- Repair and calibrate pressure to current transducers.
- Repair and calibrate current to pressure transducers.
- Repair and calibrate magnetic flow meters.
- Repair and calibrate electrical square root extractors.
- Construct and calibrate a Type J thermocouple.
- Troublshoot and calibrate a single point class 15 recorder.
- Troubleshoot and calibrate a multi-point class 15 recorder.
- Calibrate a PH meter using standard solution.

STUDENT COMPETENCIES

- Repair and calibrate pressure to current transducers.
- Repair and calibrate current to pressure transducers.
- Repair and calibrate magnetic flow meters.
- Calculate range resistors for the measuring circuit of a

class 15 recorder.

- Construct and calibrate a Type J thermocouple.
- Determine resistance vs. temperature for both postive and negative thermistors.
- Trouble shoot and calibrate a single point class 15 recorder.
- Calibrate a ph meter using standard solutions.

ENGINEERING GRAPHICS I

COURSE DESCRIPTION

An introductory course to provide the technician with basic skills and techniques used to communicate information and ideas graphically. Topics to include: an introduction to freehand sketching; graphic drafting techniques and procedures, schematic drawing; descriptive geometry; and computer graphics.

PREREQUISITE: Algebra

CO-REQUISITE: Trigonometry

CREDIT HOURS: 1-6-3

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Technical Sketching A. Sketching lines, circles, and arcs B. Using the box construction technique C. Sketching in isometric D. Sketching in oblique	1	9
II. Drafting Fundamentals A. Use of instruments B. Lettering C. Alphabet of lines D. Drawing reproduction E. Scale F. Dimensioning and tolerancing G. Geometric construction techniques	2	15
III. Orthographic Projection A. Third-angle projection in drawing B. Section drawing	2	15
IV. Pictorial Drawing A. Drawing objects in isometric	2	12
V. Schematic Drawing	1	6
VI. Descriptive Geometry A. True length, slope, and bearing B. Auxiliary views C. Developments	2	12

	Student Contact Hours Class	Laboratory
VII. Computer Graphics A. Drawing on CRT B. CAD introduction	1	
VIII. Overview of Engineering Graphics Drawing in Industry	1	

STUDENT LABORATORIES

- Make freehand sketches in isometric and oblique.
- Use drafting instruments to make simple drawings involving geometric construcion techniques.
- Make drawings of objects in orthographic.
- Make isometric drawings of simple objects.
- Make schematic drawings.
- Find true length, slope, and bearing of lines.
- Make developments of objects.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Make simple freehand sketches that will describe an object or a process in three dimensions.
- Use drafting instruments to make simple engineering drawings.
- Draw and interpret objects in orthographic projection.
- Draw and interpret simple objects in isometric.
- Prepare and interpret schematic drawings.
- Graphically find the true length, slope, and bearing of a line.
- Determine true shapes and sizes of surfaces from alternative vies utilizing the line and plan methods of descriptive geometry.
- Discuss the use of computer as a graphics tool.

RECOMMENDED TEXT

Luadder, Warren J., Fundamentals of Engineering Drawing. Englewood Cliff, N.J.: Prentice-Hall, 1981.

EMT PROBLEMS

COURSE DESCRIPTION

The electromechanical engineering technology problems courses are intended to tie together the knowledge and skills from the entire programs. Industrial type problems may be used with the instructor's approval. Each specialty (Industrial Controls, Robotics, Instrumentation, Electrical Power, and Generic) will have a separate problems course reflecting its special interests. The problems may be related to each other (i.e. students from various specialties may work on different aspects of implementing the same work cell). Because of the diversity of the various electromechanical options, only general guidelines are included in the catalog. (See "Suggestiong for Implementing a Problems Course")

PREREQUISITE: Consent of Instructor

CREDIT HOURS: 0-9-3

COURSE OUTLINE

I. Define Scope and Rules for Projects
   A. Instructos(s) give parameters
      1. time (1 quarter)
      2. cost
      3. effectiveness
   B. Student submits proposal
      1. preliminary sketcher/diagrams
      2. performance parameters
      3. time needed to design and build
      4. test procedures & validation
      5. cost
   C. Instructor(s) evaluate and assign projects
      1. individual projects
      2. group projects
      3. develops performance contract
         a. time required/phase
         b. progress reports
         c. grading parameters
      4. assigns suitable individual proposal writers to work with others.

II. Implement Projects
   A. Design phase
      1. student undertakes design
      2. student makes progress review against objectives
      3. instructor evaluates, advises and approves build

B. Build phase
   1. student undertakes construction
   2. student makes progress review against objectives
   3. instructor evaluates, advises and grades
C. Test
   1. student devises test and conducts it
   2. student writes test report and/or failure analysis
   3. instructor evaluates and grades
D. Engineering Report
   1. student prepares comprehensive engineering report
   2. instructor evaluates and grades

STUDENT LABORATORIES

- Prepare sketches and diagrams for submittal to instructor.
- Complete design for instructor approval and grading.
- Build, as appropriate, the project designed.
- Devise and conduct engineering tests on the project.
- Compile a comprehensive engineering report on the subject.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Define a technical problem and design a workable solution.
- Design, construct, test, evaluate and modify a functional device/circuitry/system utiliing/electrical, mechanical and/or electronic component.

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FLUID POWER

COURSE DESCRIPTION

Fluid Power is designed to give the student an overview of fluid power technology and a working knowledge of each of the componenets used in fluid circuits. Hydraulic and pneumatic systems are covered. Topics include fundamentals of fluid dynamics, coventional fluid circuits, and fluid power components.

PREREQUISITE: Physics III

CREDIT HOURS: 4-3-5

COURSE OUTLINE:

	Student Contact Hours Class	Laboratory
I. Introduction and Fundamentals of Fluid Power	5	6

A. Introduction of fluid power
   1. background and applications of fluid power.
   2. advantages and disadvantages of fluid power
   3. capabilities
   4. how fluid power works

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
   5. Pascal's Law
   6. Charles's Law

E. Basic fluid symbols

F. Summary

II. Fluid Power Properties and Characteristics

A. Properties of hydraulic fluids
   1. viscosity
   2. viscosity index
   3. lubricating ability

	Student Contact Hours	
	Class	Labortory
4. rust and corrosion prevention		
5. oxidation stability		
6. resistance to foaming		
7. flash and fire points		
B. Types of hydraulic fluids		
1. water		
2. petroleum oils		
3. water-oil emulsions		
4. water-glycol fluids		
5. synthetic fluids		
C. Replacing hydraulic oil		
III. Fluid Storage, Conditioning Maintenance	6	3
A. Reserviors 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. water rings		
7. seal materials		
E. Summary		
IV. Pumps and Compressors		
A. Theory of pumps	6	3
1. positive-displacememt pumps		
2. characteristics of positive displacement liquid pumps		
3. nonpositive-displacement pumps		

	Student Contact Hours	
	Class	Laboratory
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	6	3
A. Fluid power actuators		
1. constructon 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 tyopes		
2. hydraulic motor performance		
C. Summary		
VI. Fluid Distribution and Control Devices	6	3
A. Accumulators		
1. accumulator types		
2. accumulator applications		
B. Pressure intensifiers		
C. Fluid conductors and connectors		
1. rigid pipes		
2. semirigid tubing		
3. flexible hoses		
4. plastic tubing		
D. Fluid control devices		
1. directional control valves		
2. servo valves		
3. pressure control valves		
4. flow control valves		

	Student Contact Hours	
	Class	Laboratory
5. other control valves		
E. Summary		
VII. Fluid Circuits	6	6

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. Acutator speed
   1. pneumatic circuits
   2. hydraulic circuits

STUDENT LABORTORIES

- Construct and operate fluid circuits for single-acting hydraulic, and double-acting cylinders.
- Compare characteristics and operation of the cylinders.
- Measure volumetric efficiency of a hydraulic pump, overall efficiency of a hydraulic power system, and delivery rate of an air compressor.
- Construct and operate fluid power circuits for operation of single-acting, hydraulic and double-acting cylinders, and for operation of hydraulic and pneumatic motors.
- Construct and operate a circuit using an accumulator to power a pressure intensifier and a circuit to sequence the operation of hydraulic cylinders.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able

- Identify components and describe the function of basic hydraulic and pneumatic power systems; show all connections for operating a single-acting cylinder.
- Calcuate quantities for a fluid power system.
- Construct and operate fluid circuits for single-acting cylinder.
- Describe principles of fluid behavior and explain how they

relate to fluid power systems.

- Explain hydraulic system problems(rust, corrosion, oil viscosity too high or low, oil oxidation).
- Describe and list characteristics of hydraulic fluids.
- Construct fluid power circuits, comparing characteristics and operation of each.
- List characteristics and function of each major part of a hudraulic reservior.
- Explain the role of a compressed-air tank in fluid conditioning in a pneumatic system.
- Explain importance and methods of controlling temperature of fluid in hydraulic and pneumatic systems.
- Explain operation, advantages, and disadvantages of various hydraulic filters, and filter locations.
- Explain operation of each element in a pneumatic filter-regulator-lubricator unit.
- Draw diagrams of and list applications, and approximate operating temperature ranges of various seal materials.
- List characteristics, applications, and approximate operating temperature ranges of various types of pumps.
- Calculate delivery rate of a compressor.
- Explain importance of cooling and how cooling is accomplished with air and water in a multistage piston compressor.
- Explain operation of reciprocating compressors and of positive -displacement and nonpositive-displacement rotary air comporessors.
- Explain types of damage and maintenance to prevent these damages to pump and hydraulic compressors.
- Measure volumetric efficiency of hydraulic pump,overall efficiency of a hydraulic power system, and a delivery rate of an air compressor.
- Contrast differences in the construction components and functioning capabilities of hydraulic versus pneumatic cylinders.
- Sketch disgrams and explain operation of common types of actuators. . Describe common causes for actuator failure and malfunction.
- List procedures for troubleshooting damaged cylinders.
- Compare operating characteristics of basic hydraulic motors(gear, vane, axial piston, radial piston).
- Construct fluid circuits for operation of hydraulic and pneumatic motors and compare operating characteristics.
- List and describe the functioning of basic types of accumulators.
- Explain the importance of common types of conductors and their applications.
- List common types of control valves, their importance, and their operating characteristics.
- Construct and operate a circuit using an accumulator to power a pressure intensifier and a circuit for sequencing the operating of hydraulic cylinders.

- Explain design demands and control characteristics important in construction of fluid circuits, including actuator speed limits, slow control characteristics, synchronous motion, cylinder speed.

RECOMMENDED TEXTS

Fluid Power Systems. Waco, TX: Center for Occupational Research and Development, 1980.

Sullivan, James A. _Fluid Power Theory and Application._ Reston Publishing Company, Inc. 1982.

Vickers. _Mobil Hydraulic Manual._

Henke. _Introduction to Fluid Mechanics._ Addison-Wesley.

FEEDBACK CONTROL SYSTEMS

COURSE DESCRIPTION

This course provides the student with the classical tools to analyze closed loop control systems. Laplace transforms are used to describe the elements of a closed loop system. Bode diagrams and root locus plots are used to examine stability. The student is introduced to causes and cures for system stability problems.

PREREQUISITE: Circuit Analysis

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Open and Closed Loop System	4	3
A. Open loop control		
B. Closed loop control		
C. Block disgrams		
D. Transfer functions		
E. Servo mechanisms		
F. Process control		
II. Mathematical Models	8	6
A. Linearity		
B. Differential equations		
C. Various systems		
D. Simultaneous equations		
III. System Components	6	3
A. Transducers		
B. Power actuators		
C. Amplifiers		
IV. Transient Response	8	6
A. Input functions		
B. First order systems		
C. Second order systems		
D. Transient response characteristics		
V. Laplace Transform Analysis	8	6
A. Laplace transform theorems		
B. Application of Laplace theorems		
C. System stability		
D. Routh criterion		
E. Root locus analysis		
VI. Frequency Response Analysis	6	6
A. AC Differential equations		

B. Polar frequency response
C. Bode diagrams
D. Plots of constants, derivative, first order and second order factors
E. Frequency response
F. Stability criterion
G. Nichols chart

STUDENT LABORATORIES

- Construct an open loop system of control.
- Construct a servo machanism system.
- Write system equations for mechanical, electrical, liquid and thermal systems.
- Demonstrate the use of transducers, amplifiers and power actuators in a working system.
- Use first and second order systems to determine transient response to speed regulating system, RCL networks, and positional servomechanisms.
- Determine transfer functions for mechanical, electrical, heat and liquid systems.
- Use Routh's criterion to determine stable systems.
- Plot root-locus diagram for various open-loop systems.
- Plot Bode diagrams for various transfer functions.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Describe the performance differences in open and closed loop control systems.
- Use Laplace transform tables to convert equations from the time to frequency domain and vice versa.
- Reduce a block diagram to yeild an equivalent transfer function.
- Describe the physical implications of poles and zeros of a transfer function.
- Describe the effect of lead-lag compensation and gain on system stability (gain and phase margins).
- Recognizeconditons that can lead to system stability problems and synthesize corrective measures.
- Write mathematical equations on the behavior of systems.
- Describe the transient response of basic physical systems.
- Modify an open loop transfer function to achieve stable operation.
- Investigate the effects of gain and phase compensation on the instability of a system.

RECOMMENDED TEXTS

Weyrick, Robert C. Fundamentals of Automatic Control. New York: McGraw-Hill, 1982.

HEATING AND AIR CONDITIONING CONTROLS

COURSE DESCRIPTION

Basic principles of heating and air conditioning, including controls and their function in the system are covered.

PREREQUISITE: Instrumentation and Controls

CO-REQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Introduction to Air Conditioning	4	3
A. Air-cycle - refrigeration cycle		
B. Cooling equipment		
C. Heating equipment		
II. Cooling Equipment of Controls	8	6
A. Mechanical refrigeration and theory		
B. Cooling systems control		
C. Thermostat, pressure and temperature controllers		
D. Auxiliary equipment		
IV. Heating Systems - Gas Controls	8	6
A. Safety shut-off circuit		
B. The pilot		
C. Residential gas valves		
D. Water heater controls		
V. Flame Safeguard Controls	8	6
A. Principles of flame safeguard		
B. Flame detection system		
C. Primary controls and programmable controls		
VI. Oil Burners and Controls	8	6
A. Burner systems		
B. Flame detectors		
C. Oil primary controls		
D. Typical oil heating system		

STUDENT LABORATORIES

- Examine the heat cycle, refrigerant heating system.

- Examine the cooling cycle, refrigerant cooling system.
- Calibrate controllers for optimun operation.
- Gas controls:
  - troubleshooting safety shut-off circuitry.
  - pilot light.
  - control valve.
- Troubleshoot flame safeguard circuits.
- Troubleshoot oil burner system.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Analyze control systems and determine the function of each control component.
- Calibrate control components for optimum operation of system.
- Repair or replace malfunction components of system.
- Diagnose system problems utilizing wiring and elementary diagrams.
- Utilize a psychrometric chart to determine the properties of air as relates to system performance.

RECOMMENDED TEXT

Appropriate Manufacturer's Guide

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INDUSTRIAL CONTROLS I

COURSE DESCRIPTION

This course gives the student an understanding of the methods and analysis of electromechanical control systems. The theory and laboratory work will enable the student to adapt control components to systems found in industry.

PREREQUISITE: Electromechanical Devices

CO-REQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Protective Devices A. Fuses B. Circuit breakers C. Relays	3	3
II. Manual DC and AC Starters A. Three and four point starters B. Squirrel cage induction motor starters C. Wound rotor induction motor starters	5	3
III. Automatic DC and AC Starters A. Definite time accelerators B. Timing mechanisms C. Current limiting D. Across the line starters E. WRIM starting F. SCIM starting G. Synchronous starters	8	6
IV. DC Speed Control A. Field control B. Armature control C. Plugging D. Braking E. Jogging F. Solid state	5	3
V. Polyphase Speed Control A. Change in frequency or voltage B. Change in number of poles C. Secondary resistance control of WRIM	5	3

	Student Contact Hours Class	Laboratory
D. Concatenation and other systems		
E. Electronic controls		
VI. Singlephase Speed Control	3	3
A. Reversal		
B. Magnetic controls		
C. Electronic controls		
D. Plugging and braking		
VII. Static Controls	6	6
A. Basic logic gates		
B. Special logic gates		
C. Converting to static logic		
D. Designing static logic system		
E. Programmable controllers		
VIII. Automatic Feedback Control Systems	5	3
A. Servo mechanisms		
B. Damping types and systems		
C. Tranducers		
D. Modulators and amplifiers		
E. Automatic process control		
F. Open loop system		
G. Closed loop system		
H. Feedback		

STUDENT LABORATORIES

- Construct a simple relay circuit to investigate pull-in, drop-out properties.
- Construct and evaluate the performance of various time delay relay circuits.
- To connect three and four point starters; cam switch hand drum switch controls.
- Construct across the line magnetic starter, SCIM starters, WRIM starters.
- Construct forward, reverse, jog and braking controls.
- Construct and compare the methods for reduced voltage starting.
- Construct and compare open and close loop solid state speed controls.
- Construct and evaluate a capacitor-run motor controllers.
- Construct and evaluate alternator synchronizer and voltage regulation.
- Construct AND, OR, NOR, sealed AND/NAND functions for static controls.
- Construct and evaluate static logic motor control circuit.
- Construct and evaluate open and close loop position system.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Determine the differences between overloads and short circuits and the type of equipment that provide this protection.
- Describe and recognize the differences in DC and AC manual controllers.
- Operate automatic starters and determine components required.
- Describe methods and operation of DC speed control and braking.
- Describe the operations necessary for the various methods of polyphase speed control.
- Determine the methods of speed control for single phase motors.
- Determine the logic systems necessary for static controls.
- Determine the components and devices necessary for stable control in both open or closed loop systems.

RECOMMENDED TEXTS

Irving L. Kosow. Control of Electric Machines. Prentice-Hall.

INDUSTRIAL CONTROLS II

COURSE DESCRIPTION

The purpose of this course is to give the student an understanding of the methods and analysis of electrical control systems. The theory and laboratory work will enable the student to adapt components to control systems as found in industry. Robots will be introduced as part of more complex control systems.

PREREQUISITE: Feedback Control Systems

CO-REQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Frequency Response Analysis	6	3
A. AC differential equations		
B. Polar frequency resonse		
C. Bode diagrams		
D. Plots of constants, derivative, first order and second order factors		
E. Frequency response		
F. Stability criterion		
G. Nichols chart		
II. Control System Design	5	6
A. General considerations		
B. Control modes		
C. Lead-lag compensation		
III. Control System Testing	6	3
A. Test objectives		
B. Methods		
C. Transient resonse		
D. Frequency response		
E. Velocity-response		
F. Control system adjustment		
IV. Nonlinerarities in Control Systems	5	6
A. Small signal		
B. Discontinuous		
C. Effects		
D. Saturation		
E. Dead zones and hysteresis		
F. Control system adjustment		

	Student Contact Hours	
	Class	Laboratory
V. Robotic Systems	8	12

A. Types of robots
B. Work envelopes
C. Manipulators
D. End Effectors

STUDENT LABORATORIES

- Derive transfer functions that will solve a closed loop system for proportional control and determine offset which may be associated to a step change.
- Repeat the item above but add rate and reset modes to the controller as a means of compensation.
- Using experimentally derived data from a frequency response test on a servomechanism plot the frequency response curves and determine a transfer function for this system.
- Use approximate linear methods to solve continuous nonlinearity control problems.
- Determine the stability of a servomechanism system which has a nolinearity control problems.
- Determine the stability of a servomechanism system which has a nonlinearity such as backlash using graphical means.
- Examine comparative actuator system of typical robots. Diagram their work cylinder.
- Examine and observe the operation of hydraulic and electrical driven robots.
- Manipulate control devices under the supervision of your instructor and write a report on the possible applications of each.
- Manipulate a programmable controller to program a robot based on instructions presented by the instructor.
- Visit an industrial site where robots are in place.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Describe the design of P and P.I.D. controllers.
- Explain the compensation methods necessary to achieve system stability.
- Describe the various tests to determine the characteristics of system and its components.
- Utilize tests to establish system operation by examination of the system response.
- Describe the various methods of linearizing nonlinearities in control systems.
- Describe the development of robots and their implementation into manufacturing over the past decade.

- List and describe the elements of an industrial robot system.
- Contrast operation of the power actuator system among electrical and hydraulic robots.

RECOMMENDED TEXT

Weyrick, Robert C., Fundamentals of Automatic Control, McGraw-Hill.

INDUSTRIAL ELECTRONICS

COURSE DESCRIPTION

The student will become familiar with the parameters of various modern solid state devices and circuits, including input and output waveforms. In-depth knowledge is gained through lectures, research, and practical applications.

PREREQUISITE: Digital Applications

CO-REQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Student Contact Hours Laboratory
I. The Silicon-Controlled Rectifier	6	6
A. Construction		
1. P/N junction		
2. double diode		
B. Characteristics		
1. anode		
2. cathode		
3. gate		
C. Applications		
1. A/C		
2. D/c		
II. The Bi-Directional Triod Thyristor (TRIAC)	6	3
A. Construction		
1. two SCR's - inverse parallel		
2. two four-layer switches in parallel		
B. Characteristics		
1. static switch		
2. A/C switch		
C. Applications		
1. AC triggering		
2. DC triggering		
III. The Bi-Directional Diode Thyristor (DIAC)	4	3
A. Construction		
1. two-terminal semiconductor		
2. NPN structure		
B. Characteristics		
1. bi-direction		
2. negative resistance		

	Student Contact Hours Class	Laboratory
C. Applications 1. AC Switch 2. relaxation-oscillator		
IV. Integrated Circuits	4	6
A. General construction of IC's 1. diffused components 2. component isolation		
B. General gate circuits 1. nor gate 2. or gate 3. and gate 4. nand gate		
V. Operational Amplifiers	20	12
A. Characteristics 1. input impedance 2. output impedance 3. gain		
B. Applications 1. inverting amp 2. non-inverting amp 3. differential amp 4. summing amp		

STUDENT LABORATORIES

- Examine the SCR characteristics curves of the anode, cathode , and gate.
- Construct practical SCR circuits using CES Lab Kits and Lab Manuals.
- Examine the TRIAC characteristic curves.
- Construct practical TRIAC circuits using CES Lab Kits and Lab Manuals.
- Set up practical DIAC circuits using CES Lab Kits and Lab Manuals.
- Construct practical digital gate circuits using CES Lab Kits and Lab Manuals.
- Construct and observe waveforms in practical OP Amp circuitry using CES Lab Kit and Lab Manuals.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Set up, operate, and repair practical SCR circuits.
- Construct, operate, and repair practical TRIAC circuits.
- Construct, operate, and repair practical TRIAC circuits.
- Construct, operate, and repair practical OP Amp. circuits.

RECOMMENDED TEXTS

Driscoll, Edward F. Industrial Electronics. Chicago, American Technical Society, 1976.

Boyce, Jefferson C., Operational Amplifiers for Technology, N. Scituate, mass., Brenton Publishing, 1983.

INSTRUMENTATION AND CONTROLS

COURSE DESCRIPTION

Provides the student with practical knowledge and skills in the specification, use, and calibration of measuring devices, and in 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. Appropriate symbols must be included if Systems Drawing is not taught.

PREREQUISITE: Fluid Power

CO-REQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Student Contact Hours Laboratory
I. Principles of Process Control	8	3
A. Instrumentation and control: the concept		
1. open-loop control		
2. closed-loop control		
3. negative feedback in the control system		
B. Value operation and fail-safe conditions		
C. Controller action		
D. Valve and controller selection		
E. Process dynamics - capacity verses capacitance		
F. Pressure control		
G. Dead time and lag time		
II. Instruments for Fluid Measurements Pressure and Level	4	3
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 gauges		
6. calibration of pressure transmitters and gauges		

	Student Contact Hours Class	Laboratory
B. Liquid level measurements		
1. float-operated devices		
2. heat-type (or pressure) devices		
3. capacitance devices		
4. conductance electrodes		
5. ultrasonic detectors		
6. radiation detectors		
7. displacers		
III. Fluid Flow Measurement	4	6
A. Flow rate calculations		
B. Velocity of flowing fluid		
C. Head flow measurement		
1. calculation principles		
2. flow equations		
3. differential producers orifice place, 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 meters		
E. Square root extractors		
1. input		
2. output		
3. calibration		
IV. Instruments for Temperature Measurement	4	0
A. Temperature scales		
B. Temperature measurement		
1. electrical temperature transducers thermocouples, thermocouple applications, read-out device millivolt measurement), thermocouple reference junction compensation, special thermocouple applications		

	Student Contact Hours	
	Class	Laboratory
2. resistance-temperature measurement		
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	4	3
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 gauge		
2. pieoelectric crystal		
D. Proximity and limit detectors		
1. contact-type proximity detectors		
2. noncontact-type proximity detectors		
E. Applications		
VI. Pneumatic Controls	8	6
A. Pneumatic transmitters - force balance type		
1. flapper nole		
a. relay		
b. feedback		

	Student Contact Hours Class	Laboratory
2. force balance differential pressure		
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	8	3
A. Open-loop controls		
B. Closed-loop controls		
1. closed loop or automatic feedback control and control modes		
2. on-off control		
3. proportional control, proportional output and gain		

STUDENT LABORATORIES

- Construct and test a flow and level control system.
- Calibrate pressure gauges.
- Calibrate flow metering devices.
- Measure temperature with thermocouple and RTD.
- Operate LVDT differential pressure transducer.
- Operate a d/P cell with a variable capacitor.
- Calibrate and operate a pneumatic d/P cell.
- Bench check a pneumatic controller.
- Construct and operate an open-loop control system.
- Tune a level controller.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Define the following terms:
  - Process
  - Process control
  - Open-loop control
  - Closed-loop control
  - Feedback
  - Error signal
  - Closed-loop control components
    - Measuring means
    - Controlling means
    - Final control element
- List the advantages and limitations of the following:
  - Open-loop control
  - Closed-loop control
- Explain the objective and purpose of process measurement.
- Describe the operating principles theory, and units of an instrument that performs the measurment of the processes listed in Objective 2.
- Define inferred meausrement.
- Perform a calculation that relates pressure to level measurement.
- Calibrate representative insturments used in measuring the processes listed in Objective 2.
- Explain operating principles (including description, characteristics, and applicaitons) of various differential pressure sensing flowmeters.
- Sketch a typical differential-pressure flow-sensing device and transmission channel.
- Install an orifice plate and a venturi tube in pipes; measure pressure drops as functions of flow; calculate flows, based on nominal discharge coefficients, for each device.
- Calibrate an orifice plate and a venturi tube by making a differential pressure versus flow curve; calculate discharge coefficient.
- List and define four classes of filled thermal systems.
- Define the term "inferential measurement" and explain why temperature measurement is based on this principle.
- Measure temperature using the following types of electrical temperature measuring devices:
  - Thermocouple
  - Resistance (RTD)
  - Optical
- Explain how the devices in Objective 2 above can be used to make the following measurements:
  - Displacement:
    1) Linear

2) Angular
Velocity
Force

- Explain the operation of a pneumatic transmitter to measure the following variables:
  - Temperature
  - Level
  - Flow
  - Pressure
- Identify the component parts of pneumatic transmitter.
- Calibrate and align a pneumatic transmitter.
- Impement the operation of a closed-loop control sytem by performing the following:
  - Install closed-loop control components on a combination level-flow process.
  - Connect the instruments to perform closed-loop control function.
  - Make instrument adjustments to provide optimum process control.
  - This includes controller tuning, transmitter range selection,and adjustment.
- Describe a method of control quality evaluation and relate the effect of each control-loop component on the quality of the process. This will include a definition and explanation of the following terms:
  - Gain
    1) Process
    2) Instrument
  - Capacity
  - Dead time
  - Lag time
  - Process stability
  - Process disturbance

RECOMMENDED TEXTS

CORD, Instrumention and Controls. Waco, TX 767:0

Austin , Fribrance, Industrial Instrumentation Fundamentals. McGraw-Hill.

Kirk & Rimboi, Instrumentation, American Technical Publishers.

MECHANICAL DEVICES AND SYSTEMS

COURSE DESCRIPTION

Mechanical Devices is an introductory treatment of modern mechanical drives, combining the elements of mechanical theory with those of practicality. The topics treated includes: various gear drive configurations employing spur, bevel and helical gears, friction drives, and some selected special topics such as cams and universal joints. An attempt has been made to expose the student to a practical skill of mechanical assembly.

PREREQUISITES: None

CREDIT HOURS: 4-3-7

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Spur Gear A. Velocity ratio B. Torque ratio C. Simple trains D. Compound trains E. Reverted gears F. Internal gears	7	21
II. Special Gears A. Helical gears B. Bevel gears C. Worm gears D. Cross-helical	4	12
III. Special Applications A. Rack and pinion B. Counter rotaters C. Combined mechanisms D. Differentials	3	9
IV. Linkages A. Terms and definitions B. Types of linkages C. Linkage analysis	2	6
V. Miscellaneous Drives A. Disk drive B. Cams C. Universal joints	4	12

STUDENT LABORATORIES

- Assemble a gear and pinion.
- Compute the velocity and torque ratio.

- Construct a simple and compound gear train.
- Measure the velocity ratio of bevel and worm gear.
- Solve for the displacement in a rack and pinion set up.
- Make a counter rotater drive.
- Set up a mechanical differential and measure its speed ratio.
- Measure and calculate the mechanical properties of disk drives and rotary cams.
- Upon examination of two or more of various list of mechines, identify type of linkages used. Sketch and describe each mechanism movement using arrows to show force input and output.

STUDENT COMPETENCIES

- Computer gear speed ratios.
- Calculate torque and displacement.
- Identify types of gears.
- Explain the advantages of a worm gear.
- Discuss the purpose of bevel and helical gears.
- Sketch a simple and compund gear train.
- Analyze the angular displacement of a differential.
- Describe the operation of disk drives.
- Interpret the effects of the angle of a universal joint on its velocity output.
- Name and explain the operational characteristics and major components of common mechancal linkages.
- List and describe the used and operational characteristics of common cams and cam sytems.

RECOMMENDED TEXT

<u>Drives:</u> Center for Occupational Research and Development; Waco, Texas

<u>Mechanical Devices and Systems:</u> Center for Occupational Research and Development; Waco, Texas.

<u>Millwright and Mechanics Guide:</u> Audel

<u>Machinery Handbook</u>

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MICROCOMPUTER APPLICATIONS I

COURSE DESCRIPTION

This course is a continuation of digital applications and is designed to emphasize the interfacing of the microcomputer with peripherals.

PREREQUISITE: Digital Applications

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Mathematical Refinement	4	6
A. Multiple-precision numbers		
B. Multiplication		
C. Positive and Negative numbers		
D. BCD Addition		
II. Basic I/O and Interfacing Techniques	8	9
A. Synchronous vs asynchronous		
B. Handshaking		
C. Programmed I/O vs interrupt I/O		
D. DMA I/O		
E. Memory-mapped I/O vs isolated I/O		
F. Keyboard input		
G. Display mutiplexing		
H. Video display		
I. Data acquisition		
III. Programmable Peripheral Chips	8	3
A. Basics of programmable peripheral chips		
B. PIO		
C. Serial-parallel		
IV. Data Communication	8	6
A. Synchoronous vs asynchronous		
B. Simplex/suplex transmission		
C. Transmission codes		
D. RS-232C		
V. Controllers	12	6
A. Single-chip microcontrollers		
B. Stepper motor		
C. Stepper motor interface		

STUDENT LABORATORIES

- Write a program to handle positive and negative numbers.
- Write a program to solve problems in BCD.
- Write a program to select an address register and transfer data from the CPU to the peripheral interface bus.
- Write a program to set up the PIA as an input and output device.
- Construct a circuit using a UART for serial to parallel or parallel to serial data handling.
- Construct an interface circuit consisting of Opto-Isolators.
- Connect a microcomputer to a peripheral through a UART interfacing using a 20ma loop.
- Connect a microcomputer to a peripheral through a Y4UART interfacing using a RS-232C line.
- Connect a microcomputer to a stepper motor.
- Write a program to exercise a stepper motor.
- Construct A/D and D/A converters.
- Write a program for successive approximation using converters.

STUDENT COMPETENCIES

- Convert between decimal, binary, and hex number systems.
- Write programs to solve arithmetic problems.
- Demonstrate the use of I/O ports.
- Program the PIA control registers and use the control lines as input and output.
- Explain the input and output circuits used in current loops by means of a schematic diagram.
- Explain who opto-isolators are required in current loops used with microprocessors.
- List the basic capabilities of the RS-232C interface.
- Use a circuit diagram to explain how RS-232C signals can be converted to TTl or 20ma current loop.
- Develop methods of controlling a stepper motor with a microcomputer.
- Demonstrate how a A/D converter can be used with a microcomputer.
- Demonstrate how a D/A converter can be used with a microcomputer.

RECOMMENDED TEXT

<u>The Intelligent Microcomputer</u>, Roy W. Goody, Science Research Associates, Inc.

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PROGRAMMABLE CONTROLLERS

COURSE DESCRIPTION

Provides the technician with the basic skills and techniques used in programmable controllers. Topics to include hardware, I/O modules, power supplies, ladder diagrams, memory units, and examine instructions.

PREREQUISITES: Computer Fundamentals, Digital Electronics

CO-REQUISTITE: None

CREDIT HOURS

	Student Contact Hours Class	Laboratory
I. Introduction and Hardware A. Description and programming B. Processor and I/O modules C. Power supply - chassis assembly (I/O) D. Program panels and devices	4	3
II. Basic Concepts A. Ladder diagram/relay logic B. Memory units C. Numbering systems review D. Memory allocations/addressing E. Sequence of operation	6	3
III. Program Panels and Relay Equivalent A. Keyboard and program panels B. Examine instruction C. Output and branch instructions	8	6
IV. Timer, Counter and Data Manipulation A. Timer and counter instruction B. Cascading timers.counters C. Word manipulation	8	6
V. User Program and Editing Functions A. Rung writing and fault response B. Memory use and documentation C. Program and specific instruction D. Clearing memory and changing program	8	6

	Student Contact Hours Class	Laboratory
VI. Coding and Documentation of PC Programs A. Sequence, device testing and program entry and testing B. Simulate operation	4	3
VII. Review Program	2	3

STUDENT LABORATORIES

- Identify and list functions of the various sections of a programmable controller.
- List the three main elements involved in control by PC.
- Locate and identify the functions of the various diagnostic indicators.
- Assign an address to designated terminals.
- Identify the address of words in memory.
- Enter various rungs using PC equipment.
- Identify the various types of instructions using PC equipment.
- Troubleshoot the PC system.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Identify, by locating on the equipment, the names and functions of the basic sections of programmable controller.
- Describe the three steps of the memory scan in an PC.
- Troubleshoot the PC system using the various diagnostic indicators.
- Enter rungs using ladder diagrams.
- Convert a written description of a simple control scheme into a workable PC program.
- Enter and debug a PC program.

RECOMMENDED TEXTS

Hunter, Automatic Process Control Systems, Concepts and Hardware, Prentice-Hall, 1978.

Kuo, Automatic Control Systems, 4th Edition, Prentice-Hall, 1982.

RECOMMENDED STUDY GUIDE

"Programmable Controller Course". Instruments and Control Systems, Chilton Publishers, Radnor, PA.

PROGRAMMABLE CONTROLLER PROBLEMS

COURSE DESCRIPTION

Provides opportunity for practical application of skills and techniques acquired in Programmable Controllers. The student writes programs in ladder diagram form, enters them into the controller, and conducts tests varying the input and output operations.

PREREQUISITE: Programmable Controllers

CO-REQUISITE: None

CREDIT HOURS: 1-6-3

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Construct Simple Ladder Programs A. Industrial control loops B. Enter ladder diagrams into P.C. C. Vertify correct input D. Verity correct output	2	10
II. Construct Ladder Diagrams A. Get B. Put C. Timers D. Counters E. Zone Control	2	10
III. Auxiliary Equipment A. Printer B. Cassette tape recorder C. Report generation	6	10

STUDENT LABORATORIES

- Enter ladder diagrams into P.C.
- Vertify correct input using simulator.
- Vertify correct output using simulator.
- Construct ladder diagram, enter into P.C. , Get instructions.
- Construct ladder diagram, enter into P.C., Put instructions.
- Construct ladder diagram, enter into P.C., Timers.
- Construct ladder diagram, enter into P.C., Counters.
- Construct ladder diagram, enter into P.C., Zone Control instruction.

- Connect printer, print reports from P.C.
- Connect cassette tape recorder, enter program from P.C. to recorder.
- Enter program from tape recorder to P.C.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Construct ladder diagrams.
- Enter diagrams into P.C.
- Connect printer, print reports.
- Connect cassette tape recorder, enter program from tape to P.C.

RECOMMENDED TEXT

Manufacturer's Instruction Manual

ROBOTICS I

COURSE DESCRIPTION

An introduction to industrial robots including the various types and their applications. The course addresses the overall uses of robotic systems and deals with specific robots and their operating characteristics. Laboratories included in the course cover various vendor model robots and their basic capabilities.

PREREQUISITE: Electromechanical Devices

COREQUISITE: Instrumentaion and Controls, Fluid Power

CREDIT HOURS: 4-2-5

COURSE OUTLINE

	Student Contact Hours	
	Class	Laboratory
I. Introduction	6	0

I. Introduction
   A. Historical development
      1. tools
      2. mechanization
      3. automation
      4. robotization
   B. Robotics overview
      1. robot/human analogy
      2. industrial robot basics
   C. Current applications and distribution
      1. early automation
      2. hard vs. soft automation
   D. Current applications and distribution
   E. Projections, issues and trends in the use of robots
      1. productivity
      2. labor loss
      3. product quality
   F. State of the art research and application needs
      1. tactile sensors
      2. vision
      3. CAE/CAD/CAM
      4. collision avoidance

II. Robot Applications
   A. Typical Examples
      1. welding
      2. spray finishing
      3. forging/casting, grinding, sanding, polishing

	Student Contact Hours	
	Class	Laboratory

4. material loading/unloading
5. palletizing
6. assembly
7. inspection/Q.C.

B. Application Considerations
1. safety
2. cost
3. environment
4. strength requirements

	Class	Laboratory
III. Elements of Industrial Robot Systems	12	8

A. Robot Operating Parameters
1. human/robot analogy
2. robot performance specifications
3. coordinate systems and manipulation/workspace analysis
   a. Carterisn coordinate system
      1. degrees of freedom
      2. world coordinates
      3. joint coordinates
      4. tool coordinates
   b. Rectilinear systems
   c. Cylindrical systems
   d. Spherical systems
4. robot operational modes
   a. servo vs. non-servo
   b. point-to-point
   c. continuous path
   d. teach pendant
   e. lead through
   f. off-line programming
5. statics/kinematics/dynamics
   a. position, velocity, acceleration
   b. motion characteristics
   c. motion programming and control of industrial robots
   d. dynamic analysis of a robot arm

B. Robot hardware
1. overview
   a. analogy
   b. basic types of robots
2. power sour^es
3. robot power supplies

Student Contact Hours — Class / Laboratory

- a. electricity: AC/DC power supplies
- b. hydraulic: electric motor/hydraulic pump
- c. pneumatic: electric motor/air compressor

4. power distribution systems
5. actuators
   - a. motors
   - b. solenoids
   - c. hydraulic actuators
   - d. pneumatic actuators
6. actuator controls
   - a. electric motor controls
   - b. control feedback devices/sensors
7. drive systems
8. end of arm tooling effectors
9. sensors

C. Robotic system control
1. programmable controllers
   - a. Ladder logic language
2. microprocessor/mini-systems
   - a. high level languages
3. input/output interfaces

D. Flexible manufacturing systems
1. system considerations
2. peripheral devices
3. product design considerations

IV. Implementing Robot Systems — Class 3, Laboratory 0

A. Safety

B. Justification

C. Human Impacts

V. Comparative Robot Systems — Class 13, Laboratory 8

A. Seiko 700
1. operating characteristics
2. capabilities and limitations
3. applications
4. schematics and diagrams

B. Copperweld CR 50
1. operating characteristics
2. capabilities and limitations
3. applications
4. schematics and diagrams

C. GMF MIA
1. operating characteristics
2. capabilities and limitations
3. applications

4. schematics and diagrams
D. Cincinnati Milacron T-3/586
1. operating characteristics
2. capabilities and limitations
3. applications
4. schematics and diagrams
E. IBM 7535
1. operating characteristics
2. capabilities and limitations
3. applications
4. schematics and diagrams

STUDENT LABORATORIES

- Examine comparative actuator systems of typical robots (cartesian, cylindrical, spherical, articulated). Diagram their work cylinder and include appropriate data as specified by the instructor.
- Examine and observe the operation of hydraulic, electrical, and pneumatically driven robots. Manipulate the control device under the supervision of the instructor. Prepare a written report on the possible applications of each.
- Manipulate a programmable controller to control a robot based on instruction presented by the instructor. Make simple modifications to the procedure and re-program the robot.
- Write a simple off-line program. Load and test the program at the control console.
- Visit an industrial site where robots are in place. Determine the design requirements that were required for the development of the robot system (what factors did the users have to consider?).
- Critique the system which they selected (plusses and minuses).
- Given the schematics, diagrams, and data prepared by the vendors of selected robot models, prepare a written report which outlines the operating characteristics and systems interrelationships of each. Explain from the schematic, each system and its interface with other systems; identify potential points of malfunction and check-out procedures. Observe as many of the various types in operation as possible.

STUDENT COMPETENCIES

- Describe the development of robots and their implementation into manufacturing over the past decade.
- List the advantages and disadvantages of automated manufacturing processes to indsutry.
- List and describe the elements of an industrial robot system.

- Explain the categories of robots according to operation mode.
- Operate selected robot(s) through the manipulation of the appropriate control device.
- Constast operation of the poewr actuator system among electrical, pneumatic and hydraulic robots.
- Explain the various organization schemes through which end effectors are manipulated in space.
- Write a simple computer program to control a robot.
- Explain the various considerations that must be made in selecting a robotic system for a given application.
- Given a manufacturing problem select a specific robot to solve the problem and justify the solution in writing.
- Discuss the operating characteristics of the major vendors' models and classificaiton of robots.
- Interpret the schematics and vendor diagrams of major vendors' models of robots so as to be able to understand the function of the system involved.

* Competencies for Robotics I & II may vary based on the type of robotic equipment available.

RECOMMENDED TEXTS

Engelberger, Joseph F. Robotics in Practice, Management and Applications of Industrial Robots. Great Britian: AMACOM, 1980.

Hunt, Daniel. Industrial Robotics Handbook. New York: Industrial Press, Inc., 1983.

(Also see Robotics I & II. Support packages developed by Project Staff.)

ROBOTICS II

COURSE DESCRIPTION

Robotics II is a continuation of Robotics I and includes an in-depth study of the operation and maintenance problems associated with systems now in use in industry. Also included are methods and procedures used to operate and control robots.

PREREQUISITE: Robotics I

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Maintenance and Operation	9	12
A. Hydraulic robots		
1. controller/computer systems		
2. actuator systems		
3. mechanical system		
4. servo systems		
B. Pneumatic robots		
1. control systems		
2. actuator systems		
3. mechanical systems		
4. servo systems		
C. Electrical robots		
1. controller/computer system		
2. actuator system		
3. mechanical systems		
4. servo systems		
II. Robotics Problem Definition	10	4
A. Characteristics of specific robots		
B. Work cell organization		
C. Specifications and tolerances		
III. Programming Robots	6	8
A. Off-line programming		
B. Loading on-line		
C. Programmable controllers		
D. Lead through and teach pendant modes		
IV. Robotic Systems	9	16
A. Work cell design and set-up		
B. Synchronization of devices		
C. Utilizing controllers		
D. Work flow and material handling		
E. Quality control and inspection		
F. Problems in selecting robot types		
G. End of arm tooling		

STUDENT LABORATORIES

- Demonstrate and observe the operating charactersitics of the three basic types of industrial robots (hydraulic, pneumatic, electrical). Examine common sources of malfunction.
- Solve selected maintenance problems in a given robotic system and restore to normal operation.
- Given a specific manufacturing situation determine alternative solution method utilizing a robotic system. Propose the type of robot (including specificaitons and rationales) needed to solve the problem. Specify how work cell would be organized to accomplish the task.
- Utilize a Programmable Controller to control a robotic device to perform basic tasks. Develop a robotic control program off line, down load and test the program, debug and modify the program as needed.
- Program a robot by lead thru and teach pendant.
- Given a problem(s) by the instructor develop a robotic system to solve the problem(s). Select robot and design work cell. Develop a materials handling system design and (if possible) construct the end of arm tooling required. Program the robot to accomplish the task. Test the solution if needed.

* STUDENT COMPETENCIES

- Perform preventive maintenance procedures on representative hydraulic, pneumatic, and electrical robots.
- Troubleshoot routine maintenance problems in robotic systems (hydraulic, pheumatic, or electrical drive).
- List and explain the major industrial applications of robotic devices and systems.
- Explain the relationship of robotics to computer assisted design and manufacturing (CAD/CAM).
- Define a production problem and develop a solution to the problem which utilizes a robotic device.
- Write a program in selected computer languages to control a robot.
- Program a robot using lead thru and teach pendant methods.
- Program a robot using PLC.
- Set up a work cell and implement a robotic system to perform production tasks.
- Design a simple end of arm tool.

RECOMMENDED TEXTS

Engelberger, Joseph F. <u>Robotics in Practice, Management and Applications of Industrial Robots.</u> Great Britain: AMACOM, 1980.

Hunt, V. Daniel V. Industrial Robotics Handbook. New York: Industrial Press, Inc., 1983.

(Also see Robotics I & II support packages developed by Project Staff.)

*Student competencies in Robotics I & II may vary based on equipment available.

SOLID STATE LOGIC MOTOR CONTROLS

COURSE DESCRIPTION

Student will study the principles and practical application of industrial system control by solid state devices.

PREREQUISITE: Automatic Motor Controls I & II

CO-REQUISITE: None

CREDIT HOURS: 4-3-5

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Concepts of Static Logic Control A. Investigate the concepts of static logic control B. Fundamentals of static logic functions	8	6
II. Identify and Label Static Control Logic A. AND, OR, NOT logic functions; solid state relay B. AND-NOT, OR-NOT, and sealed/NAND function C. Memory devices and adjustable time delay	8	6
III. Static Logic Motor Control Circuits A. Start-stop jog	8	6
IV. AC Machine Control A. Variable frequency speed control B. SCR's to regulate motor speed C. Dynamic braking and plugging D. Alternator regulation E. Alternator voltage regulation	8	6
V. DC Motor Control A. Magnetic amplifiers B. SCR armature control circuits C. Dynamic braking and plugging	8	6
VI. Positional Control A. X-Y coordinate positioning control B. Angular positioning control	8	6

STUDENT LABORATORIES

- AND, OR, NOT logic functions and solid state relay.
- AND-NOT, OR-NOT, sealed, and NAND function.
- Memory devices and adjustable time delay.
- Static logic motor control circuits.
- Stepper motor, motor and drive circuits.
- Stepper motor, data entry circuits.
- Servo motor, switching amplifier, digital position error detector, closed loop positioning.
- X-Y postion control.
- Capacitor-run motor controller
- Plugging and dynamic braking.
- Three phase induction motor controller.
- Alternator synchronizer-voltage regulator.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Utilize the fundamentals of solid state motor controls.
- Test the control starting and various speeds of a motor.
- Test the control braking of a motor.
- Describe the development of control circuits and diagrams.
- Analye, test, and maintain control circuits.
- Verify the use of an off-return memory and demonstrate the off-return memory function.
- Demonstrate the use of the AND-NOT and NAND logic element and vertify.
- Explore the principle of using solid state circuitry to regulate the terminal voltage of an alternator.
- Explain the concept of automated numerical control.
- Investigate the concept of a digital position error detector circuit and a closed loop positioning system.

RECOMMENDED TEXTS

Hampden/Sellware, Lab-Volt, Static Control Training Systems, Vol.1,3,4,5.

McIntyre, Electric Motor Control Fundamentals, McGraw-Hill.

Maloney, Industrial Solid State Electronics: Devices and Systems, Prentice-Hall

Janson, Power Control Electronics, Prentice-Hall.

Humpheries and Sheets, Industrial Electronics, Brenton Publishers.

SYSTEMS DRAWING

COURSE DESCRIPTION

Students acquire the knowledge and skills required to draw and interpret standard ISA drawings. Students become familiar with various types of ISA drawings through lectures and practical applications.

PREREQUISITE: None

CO-REQUISITE: None

CREDIT HOURS: 2-6-4

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Instrumentation Symbols A. Symbols B. Identification C. Function D. Measured variable E. Manipulated variable	2	3
II. Loop Identification A. Symbols B. Numbers C. Locations D. Alternatives E. Miscellaneous F. Interlocking	4	6
III. Open Loop Control A. No-feedback B. Timed C. Sequenced D. Quantitative	2	6
IV. Closed Loop Control A. Feedback B. Feed-forward	4	6
V. Single Control Loop A. Level B. Flow C. Temperature D. Pressure		
VI. Multi-Control Loops A. Density B. Temperature C. Level D. Flow	4	30

STUDENT LABORATORIES

- Draw various ISA standard symbols.
- Draw various ISA standard symbols for primary elements, transmitters, controllers, and final operators.
- Draw open loop control system.
- Draw closed loop control system.
- Draw single control loop for level, flow, temperature, and pressure system.
- Draw multi-control loop for density, temperature, level and flow. Include at least two interlocks.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Identify standard ISA symbols.
- Identify open loop control systems.
- Identify closed loop control systems.
- Draw single loop control systems.
- Draw multi-control loop systems.

RECOMMENDED TEXTS

Kirk and Rimboi, Instrumentation, Alsip: American Technical Publishers, Inc., 1976.

Instrumentation, Symbols and Identification, ISA - 55.1

THERMODYNAMICS AND HEAT TRANSFER

COURSE DESCRIPTION

An introductory course to provide the student with an understanding of the basic laws of thermodynamics and the principles of heat transfer. Applications to solving industrial problems are stressed.

PREREQUISITE: Physics III, Trigonometry

CO-REQUISITE: None

CREDIT HOURS: 4-0-4

COURSE OUTLINE

	Student Contact Hours Class	Laboratory
I. Energy, Heat, Gas Introduction	4	0
A. Energy and work		
B. Heat and gas pressure		
C. Perfect-gas equation		
D. Measuring energy		
E. Kinetic molecular theory		
II. Energy Equation of Gases	8	0
A. Energy conversion		
B. Reversibility		
C. General gas equation		
D. System		
E. Constant-volume process		
F. Constant-pressure process		
G. Constant-temperature process		
H. Adiabatic process		
III. Entropy	6	0
A. Second low		
B. Entropy		
C. Adiabatic entropy change		
D. Constant-P entropy change		
E. Using T-S graph		
IV. Liquids and Gases	8	0
A. Fluid properties		
1. mixed gases		
2. vapor and liquids		
B. Steam processes		
C. Steam cycles		
D. Steam-cycle component		
E. Gas and vapor mixturess		
V. Heat Transfer	14	0
A. Conduction		

B. Convection
C. Radiation
D. Practical Methods for correcting thermal problems
   1. increasing heat flow
   2. decreasing heat flow

STUDENT LABORATORIES (if laboratory time is needed)

- Calculate and measure pressure, temperature and volume changes by applying Charles Law, Boyle' Law and the perfect gas equation.
- Determine the changes in energy of a falling object.
- Measure and plot rate of heat loss or gain.
- Measure and plot rate of heat flow through various materials.
- Determine the ·· ·k produced in a reversible adiabatic process.
- Draw T-S diagrams of Carnot engine with reverisble and irreversible processes.
- Through the use of steam tables and the Mollier Diagram determine temperatures, volumes, enthalphy and entropy of water and other substances.
- Calculate and detemine graphs and efficiencies of various feedwater heating cycles.

STUDENT COMPETENCIES

At the conclusion of this course, the student will be able to:

- Define energy, determine what temperature is and calculate heat quantities.
- Understand and use heat quivalents in Calories and British Thermal Units.
- Define specific heat and how that may vary.
- Determine the conversion of heat to work in constant pressure, constant volume, constant temperature, adiabatic and polytropic processes.
- Define entropy.
- Construct TS diagrams for reversible and irreversible processes.
- Define subcooling, saturation, sublimation, superheating, critical point, saturated liquid locus, and saturated vapor locus for constant pressure and temperature lines.
- Determine and calucate energy - flow equations for various steam cycle components.
- Determine wet-dry bulb readings and the equations for various steam cycle components.
- Cite consequences of the First and Second laws of thermodynamics.
- Define adiabatic and isentropic processes.

- Use the ideal gas law to calculate pressure, volume, and temperature changes in a closed system.
- Calculate heat flow rates for heat transfer by conduction, convection, and radiation, given the high and low temperatures and an appropriate reference for the thermal properties of the system component parts. (tables in a handbook).
- Describe techniques to increase and decrease heat transfer rates by conduction, convection, and radiation.
- Calcuate the insulation required to maintain a given heat transfer rate, given the internal and ambient temperature for the process.

RECOMMENDED TEXT

Look, Dwight and H. Sawyer, Themodynamics. New York: Brooks Cole Publishers, 1980.

PILOT LEVEL TEACHING EQUIPMENT INFORMATION
FOR ELECTROMECHANICAL TECHNOLOGY

Note: This is a suggested equipment list which is considered to be a minimum requirement for carrying out pilot level programs.

ELECTRO-MECHANICAL ENGINEERING TECHNOLOGY PROGRAMS - SUGGESTED EQUIPMENT INFORMATION

Basic Electricity, Electronics & Computer Fundamentals

Equipment/ Instrumentation	Training Devices/ Systems	Qty. Per School	Approximate Unit Cost	Extension
Digital Multi-Meters		30	$ 200	$ 6,000
Oscilloscopes		20	1,000	20,000
Power Supply		2	300	600
Signal Generator		20	300	6,000
	Digital Trainer	20	160	3,200
Labs & Courses shared with	Micro-computer	20	2,000	40,000
other program	Computer Printer	2	900	9,000
	Electronic Experimental Trainer/Parts	30	160	4,800
	X-Y Plotter	1	1,200	1,200
				$90,800

ELECTRO-MECHANICAL ENGINEERING TECHNOLOGY PROGRAMS - SUGGESTED EQUIPMENT INFORMATION

Motor Controls, Fluids, Industrial Electronics Applications

Equipment/ Instrumentation	Training Devices/ Systems	Qty. Per School	Approximate Unit Cost	Extension
Tool Sets and Gages		12	$ 500	$ 6,000
Electric Motors		10	70	700
Compressor Motors		4	150	600
	Hydraulic Trainers with Accessories	4	7,500	30,000
	Pneumatic Trainers	3	5,000	15,000
	Electromechanical Control Systems	10	1,000	10,000
	D/A and A/D Devices	1 set	4,000	4,000
	Transducer Systems	1 set	4,000	4,000
	Miscellaneous Interfacing Devices and Components	1 set	4,000	4,000
	Industrial Motor Control	2	2,500	5,000
	Industrial Measurement & Controls	2	1,250	2,500
	Programmable Controllers	2	5,000	10,000
Instrumentation (Torque Meas.; Speed Meas.; Position Meas.; Pressure Meas.; Flow Meas.; Temp. Meas.; etc.)		1 set	7,500	7,500
				$ 89,300

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ELECTRO-MECHANICAL ENGINEERING TECHNOLOGY PROGRAMS - SUGGESTED EQUIPMENT INFORMATION

Basic Electricity, Electronics & Computer Fundamentals

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	Digital Trainer	20	160	3,200
Labs & Courses shared with other program	Micro-computer	20	2,000	40,000
	Computer Printer	2	900	9,000
	Electronic Experimental Trainer/Parts	30	160	4,800
	X-Y Plotter	1	1,200	1,200
				$ 90,800

APPENDIX A

SUGGESTIONS FOR

IMPLEMENTING A

PROBLEMS COURSE

SUGGESTIONS FOR IMPLEMENTING A PROBLEMS COURSE

I. INTRODUCTION

The problems course is intended to be the capstone of the two years a student spends in the technical school. It should be problem/project centered and attempt to synthesize everything that has occurred throughout the curriculum. It is also possible to broaden the student's areas of understanding during this time and to cover topics not covered because of time or other constraints. An excellent strategy is to pair students from different disciplines, EMT/EET, Robotics/CAD etc., just as might happen in industry. A great deal of learning and sharing can take place through this arrangement and the experiences should as closely as possible approximate the conditions of the "real" high tech world.

II. POSSIBLE PROBLEMS TO BE ENCOUNTERED

Too often, curriculum designers suggest problems courses which sound ideal on paper, but are impossible to implement. This is due, in the final analysis, to widely uppredictable factors discovered at the time the problems course is to come togeher, such as:

A. Student numbers and distribution

The M.E./E.M.T. combination, for example, could arrive at the proper quarter for "problems" without a design student or a production student. What then?

Obviously, adjustments would need to be made. If a mechanical design student were lacking, then a on-design project should be picked - - such as replication an electromechanical device (which would increase the number of devices available for future learning labs.).

Invaluable experience would be gained in measuring the parts to be replicated, then describing them accurately on CAD. If a production student were then available, he/she could translate the CAD data into CAM operations to make the parts. In the absence of a production student, a machine student could complete the CAM cycle.

Finally, the electromechanical technology students could assemble and check out the product. If no electromechanical technology students were available, it is conceivable that the mechanical technology students could complete the project in cooperation with the electronic/electric technology students.

Chances are good that, in combining classes, numbers will seem too large and unmanageable for a single, coordinated project. In this case there are reasonable options:

1. Assign small individual projects concurrently with a coordinated, or group project.
2. Assign a group project large enough so that all students can work on a sub-assembly or detail part of the whole. (Beware of a "log jam" at test and checkout!)
3. Assign two or more group projects.

The above examples of "what-ifs" are intented to serve as a model to stimulate thinking of ways to solve number and distribution problems.

B. Student progress and distribution

Occasionally students arrive at the "problems" area somewhat weak in an area of knowledge. Seldom is distribution of this weakness such that all students have the subject deficiency. In the case of a reasonable number having a well-rounded grasp of the technology, "pairing" of the lesser skilled students with the stronger students can be beneficial.

In a case where the distribution runs to a majority weakness in an area of knowledge, the curriculum should be examined. However, to proceed with the subject group, the staff should steer the projects in such a way that they tend to remediate the lack.

C. Student creativity

It is desirable to draw first from the ideas of the student body in putting together "problems" projects. Often it is possible to assign small projects that were originated individually by the students themselves. Or, students may suggest a coordinated, or group, project that is very worthy. It is an excellent idea to work closely with local firms having tool design needs. Simple tools and equipment can be designed and built for these companies (to the great benefit of both parties). Occasionally, however, solicitation of proposals for projects produces a low number of useable ideas. It is wise to have on hand a number of both individual and group projects from which the students may choose to their liking.

III. PLANNING A PROBLEMS COURSE

A "problems" course can linger in a student's mind as the high-water mark of technical education, or be remembered as waste of time. The difference usually is in the planning done by the school staff.

A. Interdiscipline staff coordination

If "problems" are to be attempted which simulate an engineering / manufacturing environment, an interdiscipline approach should be taken (such as a problem involving M.E. and E.M.T.). The first step is for the staff in these disciplines to meet and address the following minimum issues.

1. What roles each staff member would assume.
2. What laboratories will be needed.
3. What scope of project (s) is reasonable,
4. Maximum material costs affordable.
5. General learning objectives desired.
6. Estimated number of students per group project.

B. Formulating student entry

Many approaches are possible to enlist and assign students to projects, but the staff should have planned in detail how the student be assigned to a "problems" project.

A suggested method follows:

1. Staff and students need to discuss thoroughly the rules regarding time, cost, scope, and grading.
   Give handouts.
2. Students receive a form for proposal and deadline.
3. Students submit proposals.
4. Instructors evaluate proposals, suggest changes and deadline.
5. Instructors assign individual projects and group projects.

C. Formulate engineering coordination methods

Students sharing a group design/make project across 2 or 3 disciplines will need an organized way to coordinate their design and build efforts.

They need to learn the methods employed by industry

1. Suggest that the groups elect a "project" engineer who will be responsible for total coordination of the project. Elect assistant for backup.

2. Suggest that each discipline elect a "group" engineer; i.e., a single point of contact for that group.
3. Suggest that each "group" engineer assign tasks within his/her group.
4. Establish regular coordination meetings (usually with basically a fixed format to prevent digression).
5. Empower "project" engineer to call special meetings as required.
6. Suggest weekly progress reports by "group" engineer to the "project" and a composite weekly report from the "project" engineer.
7. Suggest that "project", in conjunction with "group", prepare a master schedule and keep it current. Off-schedule reports must be accompanied by "make-up" plans and newly scheduled target dates.
8. Suggest that "group" prepare all the input data as they go to allow revision and prompt compilation of the final engineering and cost report.
9. Suggest that "project" demand as we go data to allow compilation of the final engineering and cost reports in a timely manner (project status, man hours, span time and cost, etc.)
10. Suggest that a file be set up for drawings and that it be handled professionally. Changes should be documented and routed to "group" and "project" leaders.

D. Plan the physical details

Often all the people and procedural plans are in order, but the physical and logistical plans are sketchy. They staff should give considerable thought to the following:

1. Materials. Are there adequate materials for student projects?
   Have plans been laid for timely puchases of special needs?

2. Special processes. Some special needs, such as heat-treating, may be generated in the projects. Have plans been laid to handle these needs?

3. Equipment availablity. If the project is large, or if there are multiple projects, access to machines and equipment can become a problem. Considerable thought must be given to availability and scheduling of CAD and CAM

equipment, as well as utilizing non-CAM machines.

4. Space. It is desirable to set up a simulated engineering/produciton setting. Is space available? Can "group" and "project" leaders set up a simulateed office (or work stations with pigeonholes and baskets for report and change notices)?

E. Formulate progress reviews

Obviously the coordinated, or group, project described in c above, will be supplying weekly reports at both group and project levels. They will also maintain a master schedule as well, so progress will be well documented.

It is possible, however, to have a group project going concurrently with small individual projects. The individual should learn the same discipline of reporting that is legislated for the group.

Following is a suggested method:

1. Prepare a "contract" with the student relative to completion of design, build, test and final engineering reports.
2. Discuss the progress reports and format to preclude any misunderstanding. Explain weight of progress reviews in final grade.
3. Follow up! The instructor must call for progress reviews, look at them and return them as quickly as possible.

F. Formulate a grade system

Since student projects have disinct phases it is suggested that some method be designed to grade accoridngly. Additionally, it is sometimes case that a project cannot be completed in the allotted time. If grading is done by phases in these cases, a base exists for formulating a final score.

Phases of a project and grading could be as follows:

1. Organization of the engineering/producion groups.
2. Design of engineering checkoints and controls, including forms and paperwork.
3. How effective group coordinaton actually is.
4. Aptness of the design vs. the oparameters.
5. Producability of the product.

6. How well the design fulfills the original parameters.
7. How well schedules are met
8. The test procedures

APPENDIX B

TECHNICAL SOCIETIES

TECHNICAL PUBLICATIONS OF INTEREST

TECHNICAL SOCIETIES AND ORGANIATIONS

American Automatic Control Council (AACC)
P.O. Box 12277, Research Triangle Park, NC 27709
919/549-0600

Numerical Control Society (Automatic Control) (NCS)
519 Zenith Drive, Glenview, IL 60025
312/297-5010 Responsibility for the application of numerical control techniques.

Institute of Electrical and Electronics Engineers (IEEE)
345 East 47th Street, New York City, NY 10017
212/644-7910

International Society for Hybrid Microelectronics (ISHM)
P.O. Box 3255, Montgomery, AL 36109 205/272-3191
Ceramics, thick/thin films, semiconductor packaging, discrete semiconductor devices, and monolithic circuits. Bimonthly newsletter.

National Engineering Consortium (NECO (Not an association)
1211 West 22nd Street, Oak Brook, IL 60521 312/325-5700
Provides fellowships, scholarships, grants, and endowments to engineering students for furthering electronic training.

Accreditation Board for Engineering and Technology (ABET)
345 East 47th Street, New York City, NY 10017 312/644-7685
Accredits college engineering curricula and engineering technology programs.

American Association of Engineering Societies (AAES)
345 East 47th Street, New York City, NY 10017
212/686-5676
Advance the science and practice of engineering in the public interest.

American Institute of Industrial Engineers (AIIE)
25 Technology Park, Norcross, GA 30092 404/449-0460
Design, improvement, and installation of integrated systems of people, materials, equipment, and energy.

American Institue of Plant Engineers (AIPE)
3975 Erie Avenue, Cincinnati, OH 45208
Newsletter 8 times/year; journal quarterly.

American Society for Certified Engineering Technicians (ASCET)
4450 West 109th Street, Overland Park, KS 66211 913/341-5669
Skilled technicians whose training and experience qualify them to provide technical support and assistance to registered professional engineers. Certified Engineering Technician, bimonthly.

Automated Procedures and Engineering Consultants (APEC)
Miami Valley Tower, Suite 2100, Dayton, OH 45402
513/228-2602
Application of up-to-date computer technology to building design. Journal, bimonthly.

Engineering Technologist Certification Institute (ETCI)
2029 K Street, NW< Washington, DC 20006 202/659-5773
Not a membership organization. Issues certificates for Associate Technologists and Engineers.

American Institute for Design and Drafting (AIDD)
3119 Prince Road, Bartlesville, OK 74003 918/333-1053
Design and Drafting News, monthly.

Design and Drafting Management Council (DDMC)
P.O. Box 11811, Santa Ana, Ca 92711 714/838-5800
Computer-assisted drafting. Library. Commentary, monthly.

Engineering Reprographic Society (ERS)
P.O. Box 5805, St. Louis, MO 63134 314/232-7386

American Federation of Information Processing Societies (AFIPS)
1825 North Lynn Street, Suite 800, Arlington, VA 22209
703/558-3600
Serves as national voice for the computing field, advanced knowledge of the information processing sciences.

Association for Computing Machinery (ACM)
1133 Avenue of Americas, New York City, NY 10036
212/265-6300

Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME)
Box 930, One SME Drive, Dearborn, MI 48128 313/271-1500

Instrument Society of America (ESA)
P.O. Box 1227, Research Triangle Park, NC 27709
919/549-8411
Instruments and controls in science and industry. Instrumentation Technology, monthly.

Society of Manufacturing Engineers (SME)
P.O. Box 930, Dearbor, MI 48128 313/271-1500
Library. Manufacturing Engineering, monthly.

American Society for Mechanical Engineers (ASME)
345 East 47th Street, New York City, NY 10017 212/644-7722
Sponsor for ANSI. Library. Applied Mechanics Review, monthly. Mechanical Engineering, monthly.

American Institute of Physics (AIP)
335 East 45th Street, New York City, NY 10017
212/661-9404

American Physical Society
335 East 45th Street, New York City, NY 10017
212/682-7341

American Society for Quality Control (ASQC)
161 West Wisconsin Avenue, Milwaukee, WI 53227
414/272-8575
Quality Progress, monthly.

International Institute for Robotics (IIR)
Box 21078, Dallas, TX 75211
Small library. *Robotics Newsletter*, monthly.

Robot Institute of America (RIA)
P.O. Box 930, Dearborn, MI 48128 313/271-1500
Robotics Today, quarterly.

Robotics International (RI/SME)
P.O. Box 930, Dearborn, MI 48128 313/271-1500
Library. Robotics Today, bimonthly.

American National Standards Institute
1430 Broadway, New York City, NY 10018 212/354-3300

JOURNALS AND OTHER PUBLICATIONS OF INTEREST TO THE ENGINEERING TECHNICIAN

American Journal of Physics, monthly $25
335 East 45th Street, New York City, NY 10017

American Machinist, biweekly, $25
1221 Avenue of the Americas, New York City, NY 10020

Canadian Controls and Instrumentation, monthly, $10/12
481 University Avenue, Toronto, Ontario, Canada M52 1A7

Canadian Datasystems, monthly $10/12
481 University Avenue, Toronto, Ontario, Canada M52 1A7

Canadian Electronics Engineering, monthly, $10/12
481 University Avenue, Toronto, Ontario, Canada M52 1A7

Computer, monthly, $30
5855 Naples Marine Plaza, Suite 301, Long Beach, CA 90803

Computer Decisions, monthly, $15
50 Essex Street, Rochelle Park, NJ 07662

Computers and Automation, 13 times/year, $18.50
815 Washington Street, Newtonville, MA 02160

Computerworld, weekly, $12
797 Washington Street, Newtonville, MA 02160

Data Management, monthly, $8
505 Busse Highway, Park Ridge, IL 60068

Datamation, monthly, $18
35 Mason Street, Greenwich, CT 06830

Design Engineering, monthly, $12/15
481 University Avenue, Toronto, Ontario, Canada M52 1A7

Design News, biweekly, $20
221 Columbus Avenue, Boston, MA 02116

EE - Electrical Equipment, monthly, no price listed
172 South Broadway, White Plains, NY 10605
(Instrument Society of America)

Electromechanical Design, monthly, $20
167 Corey Road, Brookline, MA 02146

Electronic Design, biweekly, $25
50 Essex Street, Rockelle Park, NJ 07662

Electronic Engineering Times, 26 times/year, $8
280 Community Drive, Great Neck, NY 11030

Electronic News, weekly, $9.50
7 East 12th Street, New York Ci 10003

Electronic Technician/Dealer, monthly, $6
757 Third Avenue, New York City, NY 10017

Electronics, biweekly, $12
1221 Avenue of the Americas, New York City, NY 10020

Engineering Education, 8 times/year, $20
One duPont Circle, Suite 400, Washington, DC 20036
(American Society for Engineering Education)

IEEE Spectrum, monthly, $3
345 East 47th Street, New York City, NY 10017
(Institute of Electrical and Electronics Engineers)

Instrumentation Technology, monthly, $7
400 Stanwix Street, Pittsburge, PA 15222

Instruments and Control Systems, monthly, $25
P.O. Box 2025, Radnor, PA 19089

Journal of the Association for Computing Machinery, quarterly, $30, 1133 Avenue of the Americas, New York City, NY 10036

Machine and Tool Blue Book, monthly, no price listed
Hitchcock Building, Wheaton, IL 60187

Machine Design, 31 times/year, $20
Penton Plaza, 1111 Chester Avenue, Cleveland, Oh 44114

Manufacturing Engineering and Management, monthly, $8.50
20501 Ford Road, Dearborn, MI 48128

Mechanical Engineering, monthly, $10
345 East 47th Street, New York City, NY 10017

Physics Today, monthly, $12
335 East 45th Street, New York City, NY 10017

Process Design, monthly, no price listed
221 Columbus Avenue, Boston, MA 02116

Production, monthly, no price listed
P.O. Box 101, Bloomfield Hills, MI 48013

Tooling and Production, monthly, $10
5821 Harper Road, Solon, OH 44139

Hewlett-Packard Journal
3000 Hanover Street, Palo Alto, CA 94303

Technology, bimonthly, $24
Technology Information Corporation, 2200 Central Avenue, Suite F, Boulder, CO 80301

Tekscope - Tektronix, Inc. (customer information)
P.O. Box 500, Beaverton, OR 97077

Federal law prohibits discrimination on the basis of race, color or national origin (Title VI of the Civil Rights Act of 1964); sex (Title IX of the Educational Amendments of 1972 and Title II of the Vocational Education Amendments of 1976); or handicap (Section 504 of the Rehabilitation Act of 1973) in educational programs or activities receiving federal financial assistance.

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The following individuals have been designated as the employees responsible for coordinating the department's effort to implement this nondiscriminatory policy.

Title II - Ann Lary, Vocational Equity Coordinator
Title VI - Peyton Williams Jr., Associate Superintendent of State Schools and Special Services
Title IX - Myra Tolbert, Coordinator
Section 504 - Jane Lee, Coordinator of Special Education

Inquiries concerning the application of Title II, Title VI, Title IX or Section 504 to the policies and practices of the department may be addressed to the persons listed above at the Georgia Department of Education, Twin Towers East, Atlanta 30334; to the Regional Office for Civil Rights, Atlanta 30323; or to the Director, Office for Civil Rights, Education Department, Washington, D.C. 20201.

Program Improvement and Evaluation
Office of Vocational Education
Georgia Department of Education
Atlanta, Georgia 30334
Charles McDaniel, State Superintendent of Schools
1984

UPD 3147/8-84